Optimising Urban Environments to Promote Active and Healthy Ageing using a Citizen Science Approach

~by~

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Abstract

As urbanization and population ageing continue to simultaneously occur, considering the ways in which urban environments can be optimised to support older adults and promote their active and healthy ageing is crucial. Across the public health and age-friendly cities (AFC) literature, it has become clear that actively engaging older adults in their local urban contexts can contribute to this, embedding their local-level and place-based needs within urban initiatives. The aim of this thesis was to engage older adults and community stakeholders through a citizen science (CS) approach in order to explore how urban environments can be optimised to promote active and healthy ageing. To inform the CS approach, a systematic scoping review was undertaken and identified urban barriers and facilitators across the global context of public health literature engaging older adults in urban environments. This review elucidated further areas across neighbourhood changes and migrant and cross-cultural communities that require extension within the age-friendly agenda. The Citizen Science Appraisal Tool (CSAT) was also developed as part of the systematic scoping review. The CSAT demonstrated ways in which CS best practices can be utilised within CS research to actively engage older adults and develop good quality CS research for public health. The CS study followed, employing four stages with older adults (N = 17; Mean Age = 72.4 (SD 7.5); Female = 11) and community stakeholders (N = 22; Female = 13). This study included a preliminary citizen social science (CSS) study, bringing together older adults community stakeholders in online discussions. The outcomes of this stage presented a collective social framing of active and healthy ageing, alongside organic connections, solution-building and potential network-building emerging. The following

three stages of the CS study, informed by the *Our Voice* CS for health equity approach, engaged older adults to collect and interpret their own data. This included Discovery Tool walks and discussion groups, followed by advocating their findings to community stakeholders during workshops. The outcomes presented contributions to the age-friendly, public health and urban planning literature through six co-produced city-wide recommendations for optimising physical social elements across the city of Birmingham. Encompassing these recommendations in a social-ecological systems (SES) approach demonstrated their interconnectedness across different urban social-ecological domains. The SES approach demonstrated the value for bringing these urban recommendations, domains and disciplines together through a 'whole' systems view to effectively implement age-friendly changes. An implementation framework for actioning the age-friendly agenda across the city of Birmingham was also developed. This framework identified how bottom-up and top-down approaches can centre on collaborative actions, presenting a middle ground that brings together older adults needs with the resources and support of stakeholders. This framework presents a transferable tool that can be utilised across other studies strengthening the age-friendly agenda. Overall, this thesis presents a demonstratable case of actively engaging older adults and community stakeholders through CSS and CS to understand their experiences and place-based needs in urban environments. This included embedding the voice of older adults into co-produced recommendations for optimising urban environments, having potential to maximise the impact of urban initiatives that target active and healthy ageing. This in turn addresses the current challenge that decision-makers face when trying to understand the determinants to alter or enhance in urban environments when promoting active and healthy ageing.

Dedication

I would like to dedicate this thesis to my grandparents, Arthur and Muriel Wood. My favourite people who supported me through the hardest times, bring me the fondest memories, and taught me to overcome obstacles through kindness and sharing joy with others.

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Publications, Conference Presentations and Grants

This thesis contains the following publications:

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2. Daw P, **Wood GER,** Harrison A, Doherty PJ, Veldhuijzen van zanten JJCS, Dalal HM, Taylor RS, van Beurden SB, McDonagh STJ, Greaves CJ. Barriers and facilitators to implementation of a home-based cardiac rehabilitation programme

for patients with heart failure in the NHS: a mixed-methods study. BMJ Open 2022; 12 (7): e060221. https://doi.org/10.1136/bmjopen-2021-060221.

3. Goodyear VA, **Wood G,** Skinner B, Thompson JL. The effect of social media interventions on physical activity and dietary behaviours in young people and adults: a systematic review. Int J Behav Nutr Phys Act 2021; 18: 72. https://doi.org/10.1186/s12966-021-01138-3.
4. de Koning J, Richards SH, **Wood GER,** Stathi A. Profiles of Loneliness and Social Isolation in Physically Active and Inactive Older Adults in Rural England. Int J Environ Res Public Health 2021; 18 (8): 3971. https://doi.org/10.3390/ijerph18083971.
5. Goodyear VA, Boardley I, Chiou S, Fenton SAM, Stathi A, Wallis GA, Veldhuijzen van Zanten JJCS, **Wood GER,** Thompson JL. Guidelines for using social media to inform behaviours related to physical activity, diet and quality of life. Birmingham: University of Birmingham; 2021. https://doi.org/10.25500/EPAPERS.BHAM.00003431.

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List of Abbreviations

AFC – Age-Friendly Cities
CBPR – Community-Based Participatory Research
CS – Citizen Science
CSAT – Citizen Science Appraisal Tool
CSS – Citizen Social Science
PAR – Participatory Action Research
SES – Social-Ecological Systems
ST – Systems Thinking
UK – United Kingdom
WHO – World Health Organization

Chapter 1 – General Introduction

1.1 Urban environments and an ageing population

Urbanization, in which there is movement of populations from rural to urban areas and a continued expansion of urban settlements [1,2], and population ageing are two global trends simultaneously occurring [3,4], creating what is known as urban ageing [5]. Whilst the 55% of the global population residing in urban environment are expected to rise to 68% by 2050 [6], 10% of the global population over the age of 65 are also expected to increase to 16% by 2050 [7]. These two trends are interconnecting, leading to the concept of 'urban ageing', in which the majority of older adults are expected to reside in urban environments such as cities [8-10]. For example, 43.2% of those aged 65 and above were residing in cities across developed countries in 2015, which is a trend that has been expected to increase [11]. This is changing the contexts in which individuals are ageing [4], bringing about a rise of age-related challenges and health needs within urban environments [12]. Urban ageing in turn requires substantial response and recognition to optimise urban environments so that they can support the health and wellbeing of individuals as they age [11-15].

Urban environments, which encompass individual, environmental, socio-cultural, economic and political elements [16-19], play a significant part in preventing or producing the opportunity for individuals to be healthy, active and fully engage within society whilst they age [12,13,20,21]. Older adults are identified to be increasingly vulnerable to their surrounding urban environments, spending more time in their local environments and relying on them to be supportive and responsive in order to promote

their health and wellbeing [22-26]. Providing inclusive and supportive urban environments can however enable older adult to have active lifestyles, access to suitable services and engagement in social, civic and economic activities. This can facilitate older adults to actively participate fully and contribute to their local urban communities [27-31]. This has led to urban environments becoming a key focus for public health, social and urban planning policy [21,32,33], exploring ways in which they can be optimised to address and support the health and wellbeing challenges that are occurring with urban ageing [32,34].

A trend of age-friendly approaches informing urban planning and public health policy has emerged to address this challenge, such as the goal of ageing-in-place that aims for individuals to live independently at home whilst they age [35]. A globally recognised approach is Age-Friendly Cities (AFC), introduced by the World Health Organization (WHO) in 2007 [21]. AFC, which focus on promoting active and healthy ageing in urban environments [17,21,36,37], are those identified to reduce barriers for those ageing in urban environments and instead provide environments, services and policies that can facilitate healthier places to age [21,36,38]. Through a bottom-up approach engaging older adults and exploring their experiences across urban environments, the AFC approach developed a holistic vision for age-friendliness. This was developed into an AFC guide [21] and checklist [39] encompassing eight interconnected topics to be considered by cities in their exploration of age-friendliness. These topics include: 1) outdoor spaces and buildings; 2) housing; 3) transportation; 4) respect and social inclusion; 5) social participation; 6) communication and information; 7) community support and health services; and 8) civic participation and employment.

Since the introduction of the AFC approach, there has been a substantial rise in global initiatives aiming to foster age-friendly urban environments [33,40,41]. This has included a global AFC network of 1333 cities and communities across 47 countries, fostering or evaluating age-friendly practices [42,43]. There has also been a wealth of public health and urban research building on these eight interconnected topics and exploring age-friendly processes and characteristics across the globe [30,44]. The knowledge provided by these initiatives and research has since been utilised to guide governments and policymakers towards considering age-friendliness in their own cities. This has included considering how urban environments impact the older population [45] and driving decision-making towards developing urban environments that support healthy ageing in a user-friendly and equitable way [17,46,47].

At the same time, understanding and fostering age-friendly urban environments is identified to present a challenge for policymakers, particularly understanding and effectively tackling the complex relationship between urban environments and older adults [5,48]. A challenge contributing towards this is the widespread plethora of urban characteristics emerging across public health and urban research that are identified to influence older adults and their relationship with urban environments [49-51]. This has included a multitude of urban characteristics impacting older adult's health and wellbeing both directly and indirectly [5,16,21,52-55], alongside being related to different needs and concerns of older adults in a range of different urban environments such as cities, neighbourhoods and urban green spaces [31,33].

Urban environments are also identified to encompass a range of different and overlapping individual, environmental, socio-cultural, economic and political domains and elements, all which can be context-specific to the urban environment and its

residents [29,56,57]. These interconnected domains and elements bring about their own influences and agendas that require consideration when developing urban environments to promote active and healthy ageing. For example, the policy domain can bring about competing political, economic and environmental agendas and governing bodies. These have been identified to influence social structures, urban development and sprawl, and financial cuts or budgets that impact ageing services and resources [31,45,56,58-61]. The influences and changes at the policy level of an urban environment can also impact older adults across other domains, such as causing changes within the environmental and social domains. These changes can include impacting the quality of infrastructure, proximity of local services, the presence of social activities and community support services across local neighbourhoods [6,29,61-70].

The experiences of older adults will also differ across urban environments, particularly in relation to their demographics, personal circumstances and other inter- and intra-personal characteristics. Older adults from different ethnicities will face different barriers in urban environments, ranging from inaccessible or culturally inappropriate services [71,72] to language issues and lack of financial and social support within their neighbourhoods [59,73,74]. Older adults can also face a range of different age-related health conditions and morbidities that impact their physical and cognitive abilities, presenting diverse needs and support that is required [75]. For example, the type of health conditions impacts the type of health care and accessible community facilities required by older adults in their urban environments [76,77]. Alongside this, there are other inter and intra-personal aspects specific to the individual, such as their attitudes, self-determination, socio-economic status or presence of a social network. These are elements that can support or prevent an individual in undertaking daily tasks

[78-81], contributing to a range of experiences and needs within urban environments. The heterogeneity present across the older population residing in urban communities therefore requires an appropriate and context-specific response when altering or enhancing urban environments to promote active and healthy ageing.

Older adults are a diverse cohort, encompassing different health and socio-economic statuses and residing in urban environments with diverse urban characteristics [17]. This has led to a multitude of urban characteristics and mechanisms to arise across public health research, which are dependent on the older adult population, urban environment and methods utilised, that underpin the relationship between older adults and urban environments [45,50,51,82]. Although this vast volume of research exploring different urban characteristics have been valuable for shaping an understanding of older adult health and wellbeing in urban environments [83], it has created a challenge for decision-makers to understand the characteristics and determinants required to be altered or enhanced when promoting older adult health [84-86].

It has since been identified that to develop effective and relevant age-friendly urban initiatives, older adults need to not only be recognised as beneficiaries but as those who play a significant role in implementing and shaping age-friendly environments [29]. Achieving this requires the direct and meaningful engagement of older adults when exploring urban environments [25,87], presenting a way to effectively align age-friendly developments with their needs [21,23,38]. This direct engagement can explore the experiences, place-based needs and opportunities and barriers older adults face in urban environments, shedding light on the real-world relationship between older adults and the urban environments they reside in [23,82]. Embedding this

engagement into public health and planning practices does however require increased effort to give these individuals a voice in relation to their local environments [21,88]. This includes building upon the bottom-up approach presented by the WHO and shifting towards stronger levels of engagement, such as co-production and co-creation, in order to allow older adults to direct urban initiatives that can effectively promote active and healthy ageing [13,34,37,82].

1.2 Engaging older adults in urban initiatives through citizen science

Facilitating the direct engagement of older adults, alongside collaborating with local stakeholders and governances, is a fundamental strategy recognised by the age-friendly agenda [21,89]. Yet older adults are argued to be neglected from urban conversations [29], including those related to age-friendly urban decision-making [5,29,55]. Lacking inclusion of older adults contributes further to the challenge of developing suitable AFC that can reduce inequalities faced by older adults in urban environments [59,90]. However, actively engaging older adults who are "ultimate experts on their own lives" [21 p.7] in the development and decision-making of urban environments has the potential to foster effective, sustainable and relevant age-friendly environments [25,54,91]. This has led to calls for engagement of older adults in public health and urban planning decision-making as a way of generating knowledge and ideas that can be meaningful and hold relevance to their health and wellbeing in urban environments [92,93].

This call has been recognised within gerontological and public health research exploring the age-friendly agenda, utilising bottom-up and community-based

participation as a way of enhancing the direct engagement of older adults in their local urban environments [13,34,58,82,94]. Engaging these individuals has effectively identified different perceptions of what constitutes 'age-friendliness', alongside a range of diverse needs, relevant physical and social urban elements and ways to promote inclusion and support, all which contribute towards creating age-friendly and cohesive urban environments [31,33,90]. This understanding has demonstrated a need to continue to strengthen the methods that utilise participation and engagement, particularly towards more 'extreme' levels of engagement in which older adults drive the processes and outcomes, as a way of embedding the experiences and needs of older adults into urban decision-making [95].

Citizen science (CS), recognised as a branch of community-based participatory research (CBPR) and participatory action research (PAR) [91,96,97], provides a methodological resident-based approach that meaningfully engages the public in scientific research. This approach engages the public to collect data based on their experiences and views [54,98-101] with the aim of developing knowledge relevant for science and society [98,101-103]. CS can effectively engage local urban residents, including through the more 'extreme' levels of engagement such as co-production and co-creation [104-106], to drive research processes, collect and interpret their own data and engage in solution-building for their own local communities [106,107]. This can address gaps within traditional scientific and regulatory approaches that lack effective engagement of the public, shifting away from researcher-driven dialogue and towards the engagement of local expertise to inform decision-making that is relevant for the public [106,108,109]. Overall, the employment of CS can actively engage local residents and community members within their local environments to identify community-focused

priorities and solutions that can effectively inform relevant local, city and policy-level decision-making [98, 110].

CS has been effectively applied in health, environmental and urban planning domains, incorporating local expertise and insights from citizen scientists to drive multi-level outcomes for altering local environments to promote healthy behaviours [98,111-113]. CS outcomes have also been able to inform urban planning and urban health domains on the relevant and suitable practices for developing and enhancing urban environments that can foster health equity [114-116]. Alongside this, older adults have been effectively engaged in CS, exploring age-friendly and urban features that influence healthy living, active ageing and physical activity [110,117-122]. This has included older adult citizen scientists identifying opportunities and constraints to healthy ageing within urban and age-friendly research and generating solutions to promote health, wellbeing and age-friendliness in their local communities [54,91,117]. The active engagement of older adults as citizen scientists has in turn been demonstrated as an effective approach for capturing new insights from those who are ageing in urban environments, leading to evidence-based solutions that reflect their real-world needs [97].

Overall, CS can strengthen the power local residents have, effectively engaging these individuals to share their experiences and generate knowledge, leading to the potential transformational and relevant changes required across society [123-125]. This has included effective progress towards the promotion of age-friendly environments across the globe, finding new ways to understand and address the impact these environments produce for older adults in their local and real-world contexts [54, 91]. It is important to continue to recognise the inclusion of older adults and their needs within

urban research and initiatives, mobilising their contributions to effectively informing age-friendly and urban changes that are required to address the challenges arising with urban ageing [126,127].

1.3 Research question, aim and objectives

The research question explored by this PhD thesis was 'How can urban environments be optimised to promote active and healthy ageing?'. To effectively answer this question, the aim of this thesis was to engage older adults through a CS approach to explore the role of urban environments for active and healthy ageing and identify ways in which they can be optimised. The following objectives were undertaken to meet this aim:

1) Systematically explore the global context of public health literature that has employed CS or participatory approaches to engage older adults to identify urban characteristics that influence active and healthy ageing (Chapter 4).
2) Directly engage older adults and community stakeholders in a four-step CS method informed by the *Our Voice* CS for health equity approach. The CS method, which includes a preliminary citizen social science (CSS) stage (Chapter 5), will explore how the city of Birmingham and its urban characteristics impact active and healthy ageing. This will inform a set of co-produced recommendations for optimising urban environments that can be actioned across the city (Chapter 6).
3) Throughout these objectives, explore ways in which the urban characteristics and co-produced recommendations identified align with, and potentially

strengthen, the WHO AFC approach and a social-ecological systems perspective.

1.4 Layout of thesis

This thesis is presented through an 'Alternative Format Thesis', which includes chapters that are suitable for or have been submitted for publication in a peer-reviewed journal. These chapters present the PhD studies, including a systematic scoping review (Chapter 4, published in Journal of Urban Health), a CSS preliminary study (Chapter 5, published in Health Promotion International) and a CS study (Chapter 6, under review in Health & Place). Following this introductory chapter, the thesis layout includes a literature review (Chapter 2) providing an overview of the role of urban environments for public health, AFC, and promoting co-production through CS. A methodological chapter (Chapter 3) is presented, introducing the key approaches and concepts of the methods, research design, and methods employed by this thesis. This is followed by the 3 PhD studies (Chapters 4, 5 & 6) and a general discussion and conclusion chapter (Chapter 7), bringing together the key contributions of this thesis and their relevance to the wider public health and age-friendly literature.

1.5 Author Contributions

Three chapters of this thesis (Chapters 4, 5 & 6) present manuscripts that have been submitted or accepted for publication in a peer-reviewed journal. These chapters present the PhD research undertaken, including a systematic scoping review (Chapter

4), a CSS preliminary study (Chapter 5) and a CS study (Chapter 6). With critical input and revision from two supervisors (AS and JP), the study designs, ethical approval, recruitment, data collection, analysis, synthesis and writing of manuscripts were undertaken by the PhD researcher (GW). Additional co-authors also contributed towards the systematic scoping review (Chapter 4, see p.119) and CS study (Chapter 6, see p.208) manuscripts, providing guidance on the CS method employed and critical input to each manuscript draft. These contributions are declared at the start of each chapter prior to the inserted manuscript.

Chapter 2 – Literature Review

2.1 Introduction to literature review

This literature review explores the wider background of urban environments in shaping health and wellbeing, bringing this into context of urban ageing and summarising the public health and urban planning literature on urban determinants of health. It includes an overview of social-ecological systems (SES), an approach informed by systems thinking (ST) that can effectively investigate the human-environment relationship. SES is employed to explore the relationship between older adults and urban environments, identifying the relevant determinants of health across the inter- and intra-personal, environmental, socio-cultural, economic and political urban domains. To further strengthen the ability for urban environments to foster health and wellbeing, this literature review also highlights the need for urban planning and governance to be informed through collaboration and place-based approaches. This includes engaging multi-level actors across urban environments, from local residents to urban planners and decision-makers, bringing together place-based knowledge and contexts with formal knowledge, structures and resources.

This chapter then brings urban complexity and the need for collaboration into the context of urban ageing, highlighting the global Age-Friendly Cities (AFC) approach introduced by the World Health Organization (WHO). This approach has been significant for designing and enhancing urban environments that address age-related health through the concepts of active and healthy ageing. Opportunities and areas for

strengthening the AFC approach are summarised, focusing particularly on the need to strengthen the engagement of older adults. This is met with citizen science (CS), an approach that focuses on the meaningful engagement of local residents in the identification of local and place-based experiences and needs. Reviewing the use of CS in public health and urban environments literature, the history, levels of engagement and strengths and opportunities are identified, alongside its use with older adults to shape age-friendly urban environments. The literature review concludes with key lessons and gaps in the literature, followed by how this thesis will address these gaps by utilising a CS approach to engage older adults to inform the development of age-friendly urban environments that can foster active and healthy ageing.

2.2 The role of urban environments for public health

Through urbanisation, a demographic megatrend driven by a combination of rural-to-urban movement of populations and urban development and growth, urban environments have rapidly become residence to the global population [2,3]. Urban environment, a term met with a variation of definitions and measurements amongst countries, settings and populations [80,128], is defined in the United Kingdom (UK) as a settlement encompassing at least 10,0000 individuals [6]. For the purpose of this thesis, urban environments refer to both the physical and social dimensions which encompass built, human-made and natural elements as well as social, cultural, economic and political elements. The combination of these elements and their interactions form settlements in which human and urban activities occur, including towns or cities [53,129-131]. Through the process of urbanisation, urban environments have become the

predominant places of residence of both the growing global and UK population, as well as being central to the majority of economic, social and cultural urban activities [6,132,133].

Cities are an example of complex urban environments that are home to over half the current global population [134], with more than 500 cities now comprising of at least 1 million inhabitants [135]. Cities are defined through a set of interchangeable criteria, including the degree of urbanisation, type of urbanised spaces [136] or population density levels [137]. However, they are differentiated from other types of environments through their larger population sizes, functional environmental, economic and social complexity and functions, and their ability to allow their residents to participate, learn, work and grow. Cities are known for their concentrated interactions and functions across social, environmental, and economic structures, political agendas, democracies, institutions and cultural, economic and technological growth [136,138,139]. They also play a multifaceted role within society, being home to diverse demographic, social and political structures and elements [140,141]. Despite the opportunities cities present, they are argued to not always operate in a sustainable, successful or health-promoting way [136], requiring consideration to the ways in which they can be altered or enhanced to foster health and wellbeing [142].

Urban environments are complex and dynamic, encompassing a multitude of urban determinants, interactions, and contexts (figure 1) that both shape and are shaped by urban residents and their activities [139,143,144]. Understanding this complexity is crucial for enhancing urban environments and their ability to foster health equity [130,144] in which continuing and prevalent health inequities are reduced or prevented [99]. Public health literature has explored urban environment determinants of health

across both the physical, built and natural determinants and the social, cultural, economic and political determinants [145,146]. Examples of physical and natural determinants include the type, quality and accessibility of infrastructure and services, density of populations and their related urban sprawl, proximity of housing to roads and subsequent air pollution and the presence of green spaces. Social, cultural, economic and political determinants include the presence of social networks, opportunities to work and access education, socio-economic differences that contribute to inequalities, political agendas and policies and the ability to take part in civic engagement [6,21,86,131,139,141,144,147,148].

These urban environment determinants all contribute to a range of different health characteristics, which become health inequalities when they are; 1) systematic and continuous health inequity patterns, such as decreased life expectancy rates continuously present for those in lower socioeconomic groups; 2) created through social situations instead of biological factors, such as individuals from lower socioeconomic levels having reduced access to healthcare; and 3) unfair circumstances in which policy and resources do not prevent these social situations [149]. In the UK, health inequalities are identified to be worsening across the older demographic group, attributed to a range of factors including socioeconomic status, gender, ethnicity, surrounding environment, accessible healthcare and discrimination [150]. Mortality rates that were decreasing in the UK prior to 2011 are now increasing by 0.3 mortalities for every 100,000 across those aged 75 and above and residing in the most deprived areas [151]. Alongside this, an expectation of two thirds of the population aged 65 and above will be facing more than one chronic health condition or disease by 2035 [152]. Similar trends are also seen for older adults in the city of Birmingham,

with those from a lower socioeconomic status background or deprived areas identified to have a reduced healthy life expectancy of 5 years in comparison to those from affluent areas. This has been attributed to reduced access to health, higher risk of health issues, and poor quality environments [153-156].

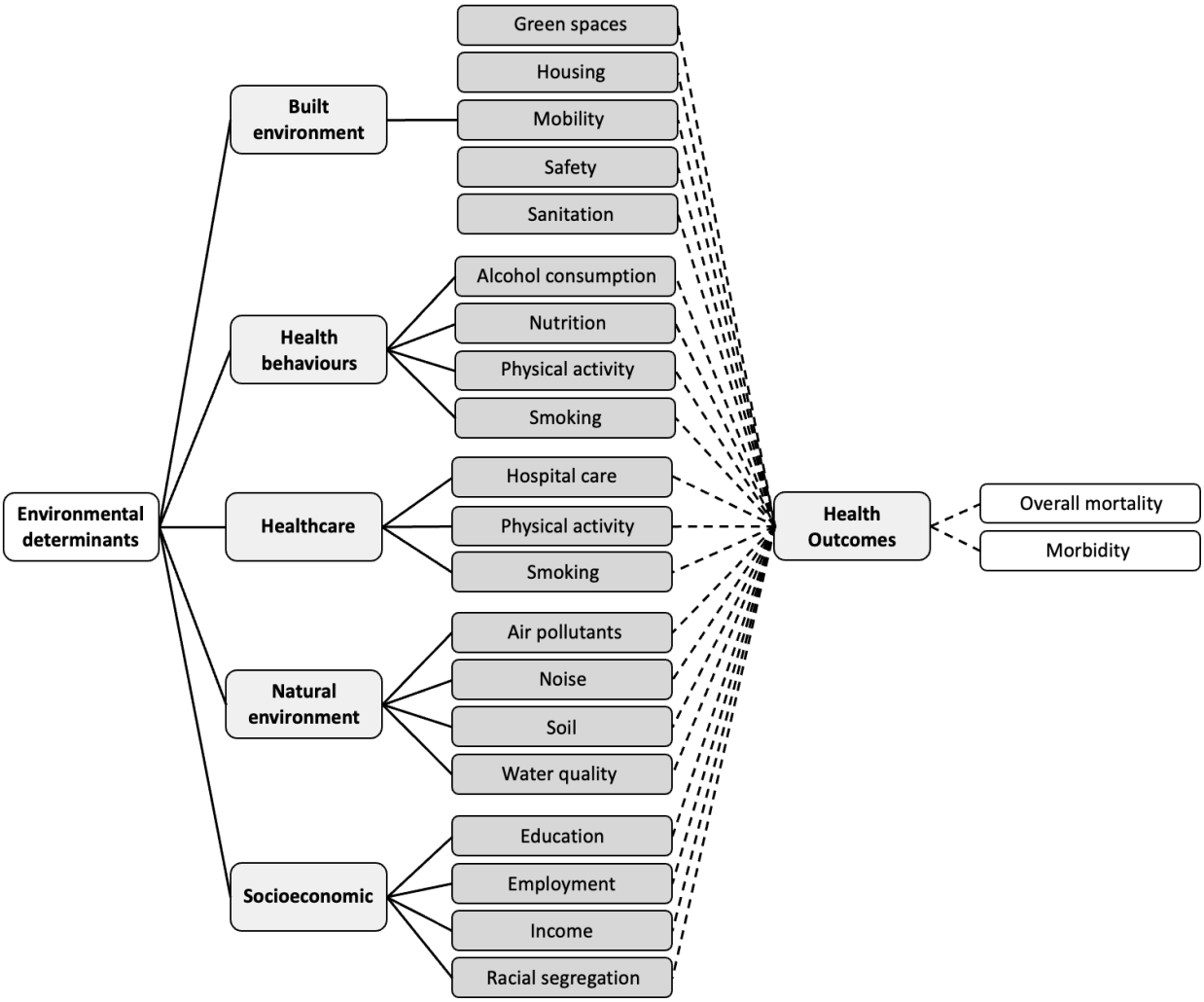


Figure 1. Urban environmental determinants influencing health of urban residents. (Adapted from Saldago et al.[131]).

Alongside the rise of urban populations, urban ageing is also occurring [5]. The majority of older adults are expected to reside in urban environments such as cities,

driving public health and planning policy to focus on the urban ageing agenda [11]. Urban environments play a significant role in preventing or producing the opportunity for individuals to be healthy, have active lifestyles and engage in society as they age [13,20,21,27]. Older adults also spend more time in their local urban residences and utilise the local services available. These local residences in turn become increasingly influential, creating both opportunities and constraints for older adults and their health [25,157]. It is therefore important to enable older adults to have access to suitable services and provisions and to fully engage within their local residences and wider society. This can foster health, wellbeing and social support for these individuals, alongside promoting the resources that older adults can offer to society by engaging in civic and economic opportunities and contributing to their local communities [27-29,94,158].

The impact of urban environments on the health of their residents differs across settings, populations and determinants, being conditional on the way these elements operate and interact [159]. Subsequently, public health research has expanded and explored a multitude of determinants and their interactions present within urban environments [144,147,160,161]. This has produced a vast volume of multidisciplinary research across a range of urban populations, settings and conditions that has been valuable for shaping an understanding of urban health and wellbeing [83]. At the same time, this has also created a challenge for public health and urban practices to navigate the plethora of urban determinants identified, making a consistent approach for developing healthy and supportive urban environments rather challenging [84,85,162]. This has led to uncertainty on which urban determinants can be altered to foster health, limiting the guidance that can be given to decision-makers to inform their choices [86].

This range of diverse and interacting urban determinants can bring about specific health issues and needs for urban residents [145,146], requiring further consideration to the urban contexts in which health and wellbeing are shaped [57,130,133]. This understanding has led to public health and urban planning practices altering their focus away from health care services only and towards place-based approaches [29,139,140,159,163]. This includes identifying the contexts, experiences and place-based values that are shaped by and shape urban environments, alongside how this information can be used to inform urban planning and governance to foster opportunities for health [133,138,141,164]. The effective recognition of these different determinants, functions and uniqueness can further guide decision-makers to plan liveable urban environments [83,136,165,166] that promote opportunities for urban residents to flourish and be healthy [141]. Continuing to strengthen and utilise place-based approaches is crucial for addressing the urban opportunities and constraints for fostering health and effectively meet the needs of the rising urban population [3].

The following sections present theoretical frameworks that have enabled urban environment determinants to be identified, alongside their contextual components and interconnections.

2.2.1 Employing social-ecological systems to explore urban environments

Social-ecological systems (SES) have been employed in public health and health promotion research to explore urban environments [19,80]. SES are informed by a 'whole' systems thinking (ST) approach [167,168], which provides a conceptual approach to objectively identifying, understanding and evaluating the elements,

structures, interactions and functions present within a system [168-170]. ST also enables an identification of elements and structures in silo and brings them together through their interconnections, behaviours and influences to consider them through a 'whole' systems perspective [168,171,172]. Utilising ST, SES highlights the interdependency between environmental and social components of a system[173], focusing on the human-environment relationships and the relevant components conducive of health [174,175].

SES can capture the ecological, environmental, human and social elements and their interconnected patterns and process that are present in urban environments [176]. This includes identifying urban environments as open systems (Figure 2) framed by a range of interactions across social and anthropological components. For example, human activities and political contexts alongside ecological and environmental components such as ecosystem and atmospheric processes [177,178]. Cities in particular are identified as one of the most interconnected human-nature systems [179] in which a range of closely connected environmental, economic, social and political processes are present [180,181]. However, these processes and elements are not always balanced. The focus on increasing economic, industrial and technological growth for example has had a significant impact on the natural environment, removing habitats and altering landscapes [19,182-184].

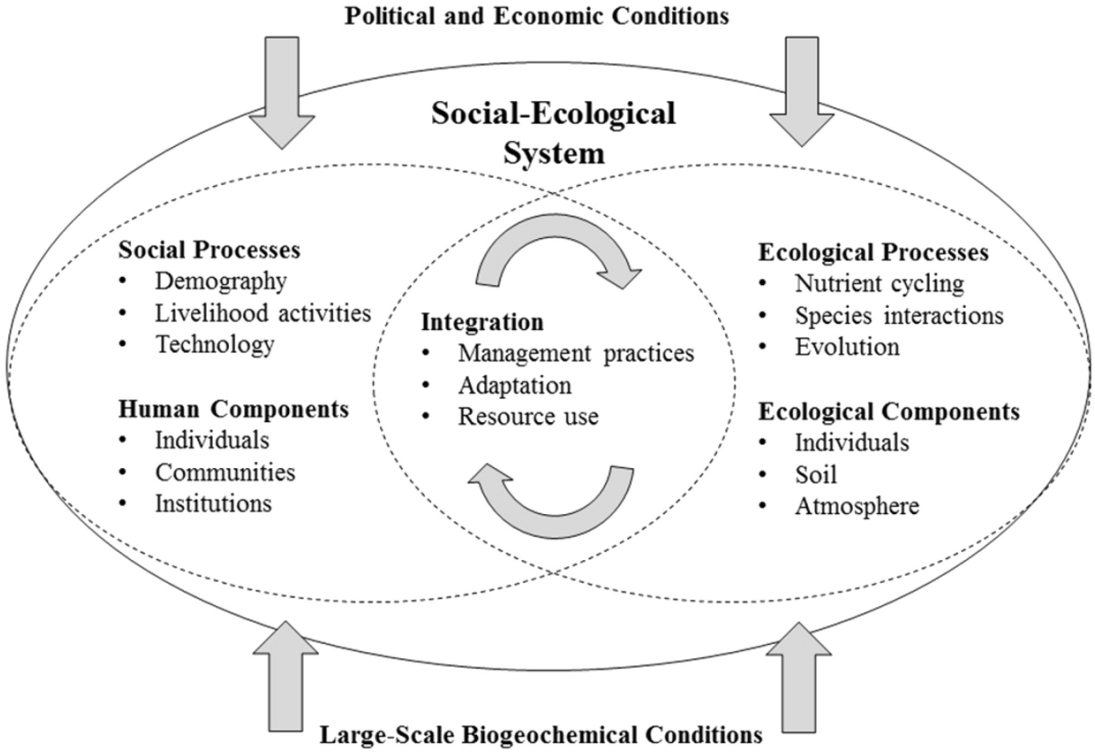


Figure 2. Representation of a social-ecological system (Taken from Virapongse et al. [177]).

The relationship between urban environments and older adults have also been explored through social-ecological urban domains that impact active and healthy ageing [185,186]. These domains have included; 1) Interpersonal including levels of mobility, social support and friends for activities; 2) Intrapersonal including demographic factors, health behaviours and conditions and self-efficacy; 3) Environmental including urban design, transportation, safety, weather, air pollution, presence of green spaces, quality of housing and suitability of surrounding neighbourhood; 4) Socio-cultural including social networks, opportunities for social contact and activities, community support, social climate and cultural norms; 5) Economic including cost and affordability of services and transportation, employment opportunities and levels of income; and 6) Political including urban and social policy,

agendas and interest groups. These domains all influence urban environments, their social and environmental structures, and the provisions of services such as healthcare, housing and transportation [79,161,185-188]. These domains are also interrelated, with accessibility, safety and presence of green spaces (environmental), for example, impacting whether an older adult walks, is mobile (*inter/intrapersonal*), and has access to social opportunities *(socio-cultural*) [79].

There are limitations when employing SES, with the universality of SES contributing to a range of definitions, empirical methods and descriptions across multiple disciplines [173,189,190]. This reduces the consensus, causality and evidence-base for SES, with disciplines employing SES through multiple frameworks, models and structures that lack cohesion [173,191]. There are also limitations in the implementation of SES. It has been claimed that public health literature can sometimes under-represent at-risk or vulnerable groups including older adults, reducing therefore the relevance of the determinants identified [161]. In the planning and management of urban systems, the SES approach can also under-represent the power and conflict present in decision-making and across the relevant actors, which are crucial for understanding how urbans systems are governed and managed [167,192-195]. For example, local urban green spaces became pertinent for members of the public during Covid-19 and provided valuable health and social benefits. Yet alterations to these spaces, via their management and design, were impacted by governance and decision-making related to urban sprawl rather than the needs of the public [183]. Capturing governance, its decision-making process and power are in turn crucial for fostering collective action that can maintain and enhance an urban system to function, adapt [196,197] and promote health [19,67,130,198].

Overall, SES provides a meaningful approach for addressing the human-environment relationship for older adults and urban environments, facilitating approaches to effectively guide urban planners in producing supportive environments [187,188]. Public health research has utilised SES and its underpinning ST approach to inform urban planning practices of the environmental and social domains present in urban environments [199], alongside ways to enhance or alter these domains to promote health [200]. For example, a strategic planning document for shaping healthier, fairer and greener spaces in the West Midlands identified a range of interconnected human-environment aspects related to health and resilience of urban communities through this approach. These included health services, homelessness, criminal justice, transportation, green spaces, waste and energy [201]. For urban environments, SES can provide a valuable approach to identifying the elements, interactions and outcomes that are present or occur within an urban system (Figure 3). This can guide urban planning and public health domains in their decision-making, demonstrating the elements and underpinning drivers that can be altered or enhanced to promote health and wellbeing [164,176,202].

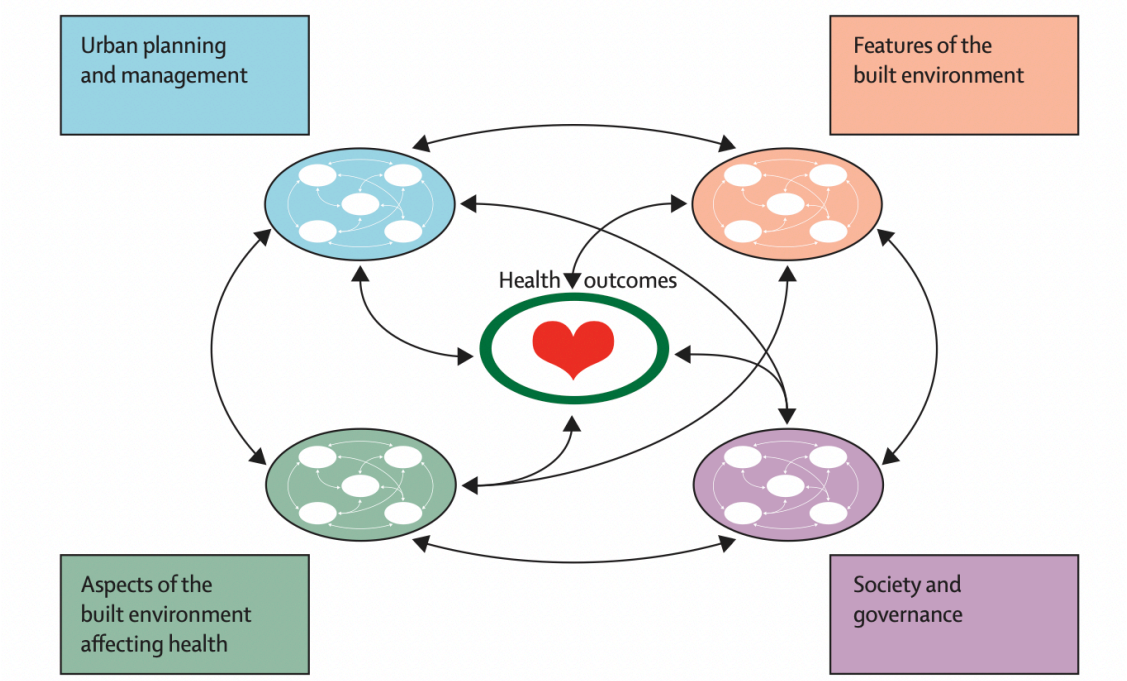


Figure 3. The impact of an urban system, its elements and interactions on the health of urban residents (Taken from Rudin et al. [130]).

2.2.2 Collaborative governance and local neighbourhood plans

Although ST and SES provide valuable approaches for framing urban environments and their interacting components, they are identified to lack elements of decision-making and governance [203,204]. In particular, the human component of SES requires further weight to encompass the behaviour and decision-making elements across the individual, wider society and political levels of a system [205-207]. This includes encompassing those that live in, use and make decisions for urban environments, alongside the governance and institutional structures where systems and their resources are managed or altered [203,205,208]. For this reason, it is argued that successful urban planning requires further consideration of the different interests, agendas, needs, conflicts and conditions, as well as the effective collaboration that can

bring these elements together to foster resilient, sustainable and health-promoting cities [209-212]. This includes effective governance and leadership that can collaborate across a range of urban domains, sectors and communities to bring together civic, public and private actors [165].

This understanding has caused urban governance to shift towards collaborative governance [213] in which civic, public and private actors and organisations collaborate across complex institutional and policy structures to achieve collective decision-making [214,215]. Collaborative governance can promote a deliberative dialogue, which brings together those who are part of or are impacted by issues or decision-making in deliberate discussions [216], through iterative and reflective discussions and debate. This is identified to facilitate voices of all actors simultaneously and allow for collective engagement and decision-making to come to light [217-219]. When utilised effectively, collaborative governance can mobilise multi-level collaborations in urban environments [220,221]. This facilitates a range of beneficial outcomes (Figure 4) such as a shift away from politically driven decision-making and towards a democratic and consensus-building approach [210,215,222-225]. Embedding collaboration across governance processes, such as laws and public maintained services [226], can advance collective action and representation of actors and their needs present within urban environments [211,215,227,228].

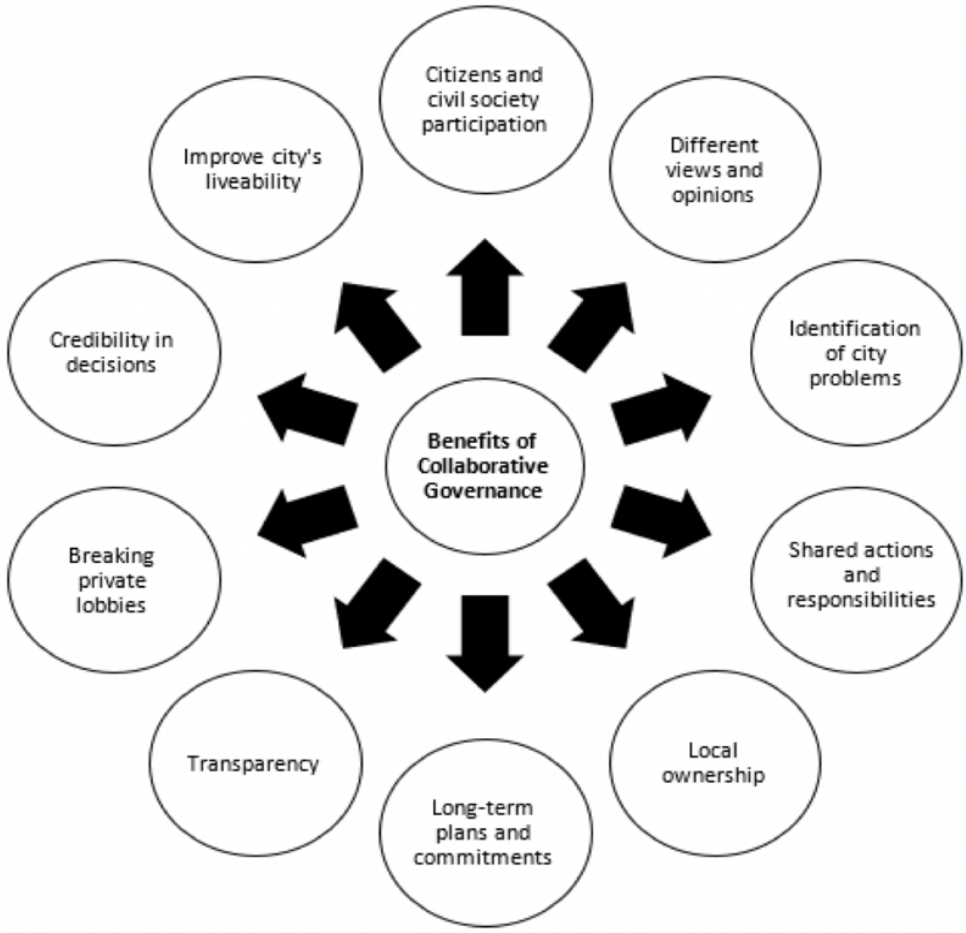


Figure 4. Beneficial outcomes of collaborative governance (Taken from Conti et al. [221]).

Despite these benefits, limitations are present for collaborative governance. Access to and redistribution of power across all actors in governance processes can be limited or unequal [215,229]. Risks and threats are also present, including unfulfilled expectations, conflicts, negative emotions and extreme positions reducing collaboration or collective outcomes [221]. Strengthening this collaboration however requires coordination and increased engagement across the democratic approaches utilised, focusing these on decentralisation, social responsibility and inclusion [230,231]. This includes local and neighbourhood scales of collaboration and engagement within

urban initiatives that can redistribute power, promote real-world implications and collaboratively inform governance on urban needs [228]. Promoting a resident-centric and local approach can mobilise local actors to identify issues and agendas that are significant for real-world urban contexts [213,232], ensuring that urban environments are enabling, democratic and address the context-specific issues that are present for those who live there [213,230,232].

Utilising collaboration across local governance is significant for promoting democracy, engaging local residents in decision-making and determining approaches that can develop urban environments suitable for their residents [221,233]. One approach that aims to address this is Neighbourhood Planning, introduced in the UK as part of the *Localism Act 2011* [234]. Neighbourhood planning is a participatory approach in which urban residents collaborate in institutional planning dialogue and applications, creating a shared vision for their local neighbourhoods and towns based on their place-based values [235-238]. Identified as localisms flagship policy [239], neighbourhood planning decentralises government power to the local-level [240-242] with an aim of increasing community control over new housing developments and overcoming opposition to new developments [236,237,240].

A strong up-take of neighbourhood plans, with over 2000 plans produced by 2017, enabled an effective identification of areas for new housing that conform to place identity and values [236,237]. Neighbourhood planning was also viewed by local groups to have merit and potential [243], allowing local concerns for housing, such as affordability, availability or suitability, to be recognised and included in planning practices [238]. At the same time, neighbourhood planning was perceived to motivate local residents to engage in urban planning practices, have a voice in their local

neighbourhoods and challenge local authority plans [241,244]. This enabled planning practices to be informed by a collective sense of place across neighbourhoods, as well as the ties and place-based values that are present between an individual and their local neighbourhood [245,246].

However, the circumstances, capacity and resources for local residents to engage and collaborate in this process can differ greatly, negatively impacting the equitable use of these plans [247,248]. Cuts across local authorities reduced the support available from planning offers, contributing to an absence of community planning skills, economic resources and a planning process difficult to navigate [243,247,249]. The power accessible for local residents is also limited, instead providing power to participate within pre-existing government agendas [236,244]. This includes matching the growth agenda and the required housing provision [250], questioning the legitimacy of this approach to provide opportunities of power that can be embraced locally [251,252] rather than being directed by politically determined influences [244,249,253,254].

Despite these limitations, the success of some neighbourhood plans has been described as a political will to promote place identity, community collaboration and the decentralisation of power [240]. Building on the strengths of neighbourhood planning, localism can be further strengthened through increased levels of collaboration, co-production and bringing together bottom-up and top-down approaches. This may provide more power to the local-level and identify place-based knowledge, including place-attachments, feelings of belonging and use of lived-in places [236,240], whilst providing formal capacity, resources and planning and political knowledge essential for urban planning initiatives [244,255]. This also requires sharing of power across all levels of actors rather than being manipulated to support political agendas. Achieving this

necessitates an understanding of the power communities need to influence governance [256], alongside utilising collaboration to share power across different actors and alter current power relations and characteristics [257]. This can enable collaboration in which shared places and goals are identified, reaching locally informed governance and shaping urban environments based on place-based values [213,229,232,258].

Having set the wider context of the role of urban environments in shaping public health, the use of SES to identify environmental and social elements and the importance of collaborative and locally informed governance, the next section sets the context for Age-Friendly Cities (AFC). This highlights the bottom-up and local-level approach taken by AFC to address the increasing age-related health and wellbeing needs in urban environments.

2.2 Age-Friendly Cities

2.3.1 Context for Age-Friendly Cities

Alongside urbanisation and the increase of urban environments, global population ageing is an occurring result of rising life expectancies and declining fertility levels [4]. Ageing presents a multifaceted process in which biological, physiological, functional, behavioural and environmental aspects of a person's life interact. These interactions create a heterogenous and sometimes inequitable process in which there are diverse impacts and outcomes to ageing [158]. As an individual ages, they become increasingly vulnerable to their surrounding environments, particularly when these environments aren't responsive to their needs. This understanding has steered urban

planning and public health practices to develop and design urban environments that can support older adults and their health [22,23]. Providing accessible environments and opportunities for older adults to be active and healthy is also argued facilitate accessibility for all age groups, further driving the need to promote healthy and active ageing that can be fundamentally equitable to all ages [27]. This has led to a trend of age-friendly approaches, such as ageing-in-place where individuals are supported to remain at home and independent [35]. A globally recognised approach is AFC [21], identified to enable governments and policymakers to consider the impact of urban environments [45] and endeavour to support ageing populations in a health-promoting and equitable way [46,47].

2.3.2 The Age-Friendly Cities approach

Leading the age-friendly agenda since the early 90s [41], the WHO has contributed to global advancements in the field of urban ageing. In the 2002 Active Ageing Policy Framework [37], the WHO defined active ageing as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life" [p.12]. The concept of active ageing has since been promoted globally, gaining relevance in social, political and gerontological discussions aiming to address the needs of ageing populations [43]. Building on this concept, the AFC approach was established by the WHO 2007 [21], guiding the global development of urban environments and cities to be supportive of older adults and promote active ageing [46].

Linking ageing with the physical and social elements of urban environments [45], the WHO developed the AFC Guide [21] and Checklist of Essential Features of AFC

[39]. The AFC guide was informed through collaborative and bottom-up research that engaged 33 cities worldwide, encompassing 1485 older adults who identified age-friendly topics and features based on their experiences and views [259]. Employing a bottom-up approach created the opportunity for older adults to identify ageing concerns and age-friendly solutions, shifting away from top-down practices in which environments and services are identified and developed for older adults [260]. This led to eight AFC topics (Figure 5) that provide a comprehensive and collective overview of age-friendly cities [8,13,21,46,259].

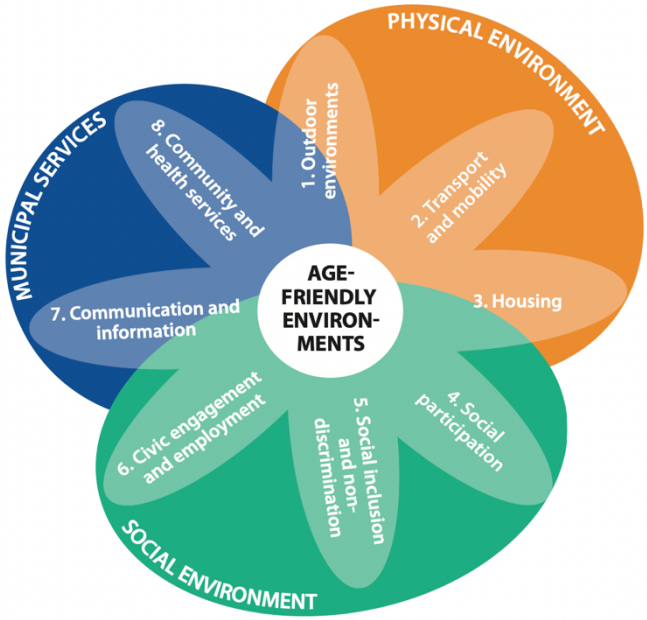


Figure 5. Eight topics for age-friendly cities and environments (Taken from World Health Organization [13]).

The AFC guide and checklist have since become globally recognised [91,259], effectively engaging cities, communities and actors worldwide to re-envisage urban environments and identify how they can promote health and wellbeing for older adults

[56]. This has also led to the development of the Age-Friendly Cities and Communities Global Network [42]. This network has catalysed age-friendly actions and practices in 1333 cities and communities across 47 countries [42,43], as well as facilitated the development of initiatives and frameworks building on the concept of active ageing, such as positive ageing or elder-friendly community frameworks [41,261].

The concept of active ageing has evolved via the age-friendly cities agenda to that of healthy ageing. This concept highlights the need for collaboration and joint action across different sectors to develop environments that can promote functional ability and wellbeing as individuals age [38,262]. Leading on from this, the Decade of Healthy Ageing was introduced by the WHO in 2020 [36], further promoting the importance of age-friendly collaborative actions to facilitate healthy ageing. This initiative highlights the significance of using community-centred approaches and joint actions to facilitate older adults to have their needs met, contribute to society, be mobile and make independent decisions, build relationships and be healthy whilst ageing [38,261].

The AFC approach has also been adopted by a range of public health, urban planning and gerontological research and initiatives [13,35,46], highlighting the importance of the eight age-friendly topics for older adults. For example, outdoor spaces and buildings were identified as an age-friendly topic that can create opportunities and constraints through their design or quality [43,263]. This understanding has facilitated public health policy to focus more on the inclusion of place-based approaches that can effectively shape the environmental, social, and cultural elements of environments that influence health and wellbeing during ageing [29,163]. Alongside this, it has facilitated a significant shift in public discourse, viewing ageing as a positive

process where older adults can play an active and integral role in society rather than being a burden on society and the economy [35]. Overall, the AFC initiative has increased recognition for the importance of urban environments in relation to healthy and active ageing and how their planning and decision-making can create both opportunities and constraints for older adults [32,34,56].

2.3.3 Challenges of the Age-Friendly Cities approach

A range of challenges and limitations have been identified for the AFC approach. The term 'age-friendly city', which is defined by the WHO as a city that has policies, services and environments that can facilitate active ageing [21], is argued to lack a commonly established definition that can identify what 'age-friendly' actually means [22,43]. Instead it is a concept that has been defined through multiple terms, including liveable, lifetime, elder or all-age communities [35,41,260] and explored through a multitude of approaches, methods and settings that frame the concept of age-friendly differently [45,163]. Subsequently, effectively identifying, measuring and standardising age-friendly approaches and outcomes, alongside their applicability and comparability, are limited [8,25,41,45,264]. This has led to an extensive number of elements and features across the eight age-friendly topics being identified [45], reducing the understanding and comparability of the pathways between age-friendly features and active and healthy ageing [22]. Subsequently, this has created a barrier for age-friendly initiatives to be effective, reducing the understanding of age-friendly outcomes and their underpinning mechanisms to the specifics of the age-friendly focus being explored [45,50,51,82].

The need for collaboration has also been identified in age-friendly research, highlighting the importance of collaborative governance and developing partnerships across a range of stakeholders, services and sectors [35]. For example, partnerships across different government actors and decision-makers, alongside private, public and civic actors, to leverage their age-friendly resources and knowledge [56]. The AFC approach promotes relations across stakeholders, communities and neighbourhoods [58] but challenges can arise from gaining commitment and interest across those required to collaborate [33]. Alongside this, a lack of sustained political and municipal involvement, social and financial resources and different sectors working in silos can be present [260]. This is argued to weaken the age-friendly approach, creating urban initiatives that lack sustainability and are inequitable across the older adults they are aimed at [265], instead creating competitive elements, tensions and reduced resources [29,46,90]. This is suggested to lead to age-friendly initiatives being guided by political agendas and discourse rather than an age-friendly focus driven by older adults [45,266]. This in turn causes urban decision-making and design to be underpinned by ageing stereotypes, alongside embedding ageism within the urban structures and services provided [8,60].

Age-friendly initiatives are also argued to simplify the actuality of urban ageing. This includes the cultural and socio-economic factors that are present for older adults in their local environments [45], alongside the larger factors of economic austerity, ageism and the related reductions in healthcare and pensions [29,265]. How older adults are perceived and recognised by age-friendly policies also creates deeper issues not explored in age-friendly initiatives, such as being viewed as an economic burden, not providing future resources and capacity and undeserving of investment [29,265,267]. This

perception of older adults is strengthened by ageing and public health policy that promotes an ideal member of society through autonomy and independency, further fostering ageism for older adults who seek care or support [265,268]. An example of this is during Covid-19 in which older adults were represented as those who were helpless, in poor health and not able to contribute [38]. The outcomes of these negative stereotypes can reduce the engagement of older adults in age-friendly and political initiatives, exacerbate significant ageing inequalities including social exclusion and cause older adults to self-regulate instead of seek support [25,94,265,269]. It is important to therefore consider how age-friendly initiatives and their related discourse can instead create further ageist constructs of older adults, portraying older adults as passive victims in urban developments and face shame related to the vulnerability of the ageing process [29,265,270].

Lastly, the broad span of the AFC approach across the eight topics is instead argued to create ambiguity that can limit its application and influence across all levels and contexts [41,90]. This includes its ability to effectively encompass individual- and community-level experiences that can be diverse across urban environments [24]. For example, lacking the ability to effectively encompass specific concerns of older individuals from different ethnic backgrounds, such as language and accessibility issues[25,73,74]. Older adults will also experience urban environments differently, particularly as they encompass context-specific challenges, political and economic agendas, social structures and ageing inequalities [8,29,41,56,58,59,260]. This was seen during COVID-19, which exacerbated the negative experiences and impacts for older adults in deprived or lower socio-economic areas, including a decrease in crucial services which were already difficult to access [56,271]. Older adults from diverse groups,

such as minority ethnic groups or those that identify as lesbian, gay, bi-sexual, transgender or questioning (LGBTQ) will also have different experiences, such as higher risks of social exclusion and ageism [94]. It is important to engage a range of diverse older adults in their own local urban contexts to identify the different perceptions of what constitutes 'age-friendliness'. In doing so, this can identify the underlying and context-specific elements and support that are required to facilitate cohesive urban environments, reduce ageing inequalities, and work towards achieving inclusive AFC [31,33,59,90].

2.3.4 Strengthening the Age-Friendly Cities approach

For active and healthy ageing to be effectively embedded in relevant and appropriate age-friendly initiatives, the mechanisms that underpin this relationship need to be further understood [272]. One way of achieving this is to employ research that directly engages older adults in their own local urban places or settings [13,34,82]. Gerontological and public health research targeting the age-friendly agenda has shifted towards this, using community-based, bottom-up and co-production approaches as a way of enhancing the direct and active engagement of older adults [58,94].

As described by Buffel et al. [25] age-friendly environments "require a radical shift from producing urban environments for people to developing neighbourhoods with and by people" [p.609]. This includes the further promotion of participatory, resident-led co-production and co-research approaches and methods to facilitate meaningful local initiatives that encompass age-friendly agendas set by older adults [45,60]. Examples

include the use of photovoice, storytelling and older adults actively collecting or identifying data, alongside engaging steering, action or neighbourhood groups in which older adults can be at the centre of age-friendly decision-making [25,29,47,273]. This includes the engagement of older adults from start to finish of age-friendly initiatives, embedding their voices and needs in the development of an initiative, identification of age-friendly concerns, and solution-building to alter or address these concerns [8,274]. In achieving this engagement and co-production with older adults, the understanding of what constitutes 'age-friendliness' can be enhanced and based on their experiences and needs [263], providing pathways to embed this context-specific understanding into age-friendly initiatives [29,33].

Alongside the meaningful engagement of older adults [25,87], the dialogue and practices around collaboration, particularly across civic, public and private actors, also requires strengthening in the age-friendly literature [22,29,35,163]. One suggested approach is the merging of bottom-up and top-down approaches, which can facilitate collaboration between local-level knowledge and experiences and stakeholder support and resources [41]. This approach aims to equally share governance, decision-making and power across local, neighbourhood and city-level actors [41], including older adults, local groups, stakeholders, private organisations and decision-makers [35,90]. Enabling stronger collaborative partnerships requires consideration to the conditions in which collaboration, interdependence and purposeful effort can be produced [56,275]. Meaningful approaches have been summarised in the age-friend literature, including community planning, cross-sector collaboration [157,260], collective dialogue and sharing of mutual objectives [47,59,90], alongside the emerging of connections through a network approach rather than a structured one [163,276,277]. Overall, facilitating collaborative

partnerships and common priorities across multi-level actors and resources is crucial for developing age-friendly initiatives that are informed, delivered, and sustained by local and city-level actors [33,90,275].

For AFC, there is currently a 'know-do' gap in their development, identified as a gap between the ideas and evidence produced by initiatives and what is actually translated into real-world practice and outcomes [278-280]. This gap has become a central challenge for urban planning and public health practices that aim to foster AFC [32,40], exacerbated by the disconnect between ageing populations, age-friendly initiatives and urban decision- and policy-making [5,29,55]. To address this, bringing together the active engagement of older adults, particularly through co-production, whilst facilitating bottom-up and top-down partnerships is key. This can enable older adults to set the age-friendly agenda, whilst support and commitment to achieving this agenda are provided through top-down capacity and resources [25,41]. In doing so, there is the opportunity to reduce the number of multi-level actors working in silo and instead build the foundations of a city-wide age-friendly network that can mobilise actors and resources to achieve and sustain locally-informed age-friendly agendas [41,47].

2.4 Promoting co-production through citizen science

Actively engaging older adults, who are experts of their own needs and experiences [21], in the development and decision-making of urban environments has the potential to foster effective, sustainable and relevant age-friendly environments [25,54,91]. However, older adults are those argued to be neglected from urban conversations [29], leading to calls for engagement of these individuals in public health

and urban practices. This includes engaging older adults in all stages of an initiative, from development to evaluation, generating knowledge and ideas that are meaningful and hold relevance [92,93]. CS is one approach to achieving this meaningful engagement, defined as an interdisciplinary approach that actively engages the public in research processes with the aim of developing knowledge relevant for scientific research and society [98,101-103]. CS is an effective and valuable approach to engaging local actors, including older adults, as citizen scientists who direct the research objectives and processes, actively collect their own data and engage in the generation of new and locally relevant knowledge [281].

2.4.1 History of citizen science

Directly engaging urban residents in public health initiatives has been achieved through participatory approaches, which encompass effective methods for actively engaging residents to drive change based on their needs and experiences [282]. A participatory approach utilised widely in public health is CBPR. CBPR employs collaborative and co-production methods to foster community-level participation with the aim of forming equitable collaboration and sharing of power across local actors. It shares principles of participatory research, particularly PAR, and utilises the equalisation of power to undertake research **with** individuals rather than **for** them [97,279,280,283,284].

Described as an endeavour of CBPR [91,96,97], CS builds on CBPR processes to engage local actors as citizen scientists to direct research objectives and processes, actively collect their own data and engage in the generation of knowledge [281],

facilitating beneficial outcomes to occur for both researchers and citizen scientists in this process[123,285,286]. In particular, CS focuses on the 'citizen', which is a term that places importance on the links and contexts between persons and the society they reside in [111]. A limitation of using the term 'citizen' however is the potential to exclude those without legal citizenship such as migrants and refugees, making it important to consider the rights of the individual related to the term [111]. For the purpose of this thesis, the term citizen within CS is used in an inclusive way, aiming to engage a diverse group of older adults regardless of legal citizenship or what is perceived as an individual's rights or status in relation to their role in society [111,287]. Overall, CS is an approach that transitions away from 'traditional' research processes and towards co-production research (Figure 6).

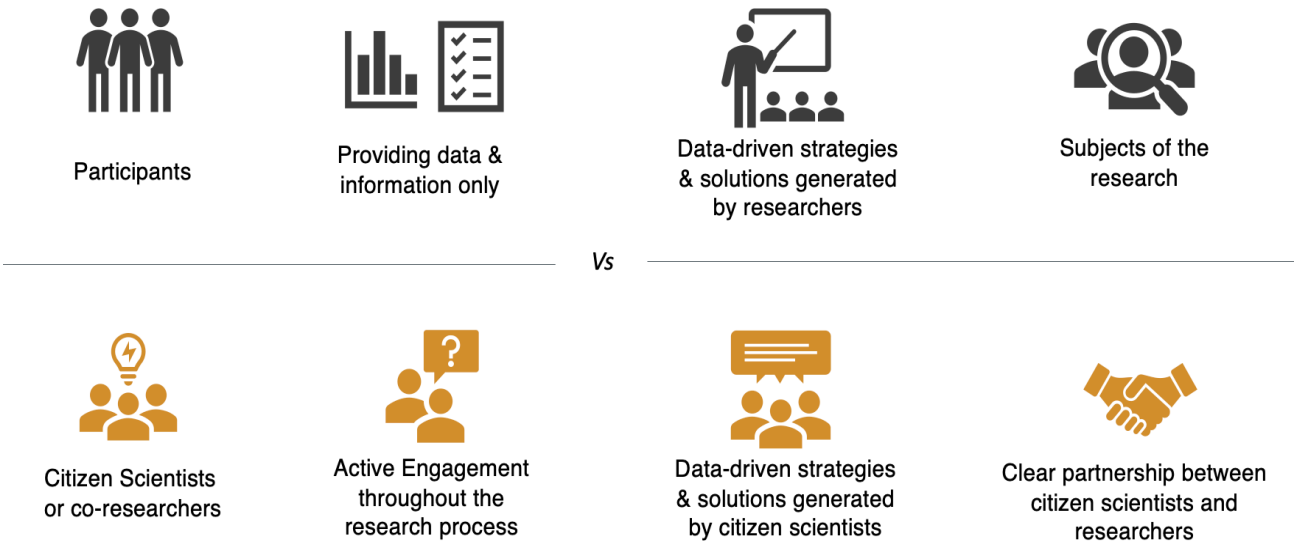


Figure 6. Overview of differences between local actors engaged in traditional scientific research (grey) and in CS co-production research (orange) (Source: Author).

Employed in fields such as the natural, environmental and ecological sciences since 1880s, CS has been effectively used to collect large datasets related to bird monitoring and weather observations. It has since gained traction for engaging the public in astronomy, biodiversity, ecology, environmental, urban health, biomedical and healthcare research and initiatives [97,107,111,123,288-292]. However, it has been argued that the term 'CS; was not coined until the 1990s as a way of further developing the ability for science to assist societal needs and empower members of society [293]. The expansion of CS has also been facilitated by the development of Information Communication Technology (ICT), allowing local actors to accessibly collect, analyse and interpret data through their own mobile devices [98,111,294]. Utilising ICT and the ability to collect large datasets has led to CS gaining further popularity [111], particularly for collecting population-based health information that can inform public health research and policy making [103]. Overall, CS is perceived as an umbrella approach in which the public engage in scientific research to progress societal good [111].

2.4.2 Citizen science levels of engagement

To effectively encompass CS in public health research, consideration to the different typologies and levels of engagement are required [290,292]. Across CS research and initiatives, a range of engagement levels have been employed to engage the public in different stages. These have ranged from the development of an initiatives and its focus to the questions asked, type of data and its collection, analysis, interpretation, and dissemination. A foundational approach informing levels of engagement is presented by Arnstein's ladder of participation [254]. This ladder identifies eight levels

of citizen participation encompassed across non-participation, degrees of tokenism and degrees of citizen power. This ranges from participation in which those with power such as researchers educated those engaged, to participation where citizen scientists can hold power, be in control and direct decision-makers. Similar to these eight levels of participation, also described as public engagement [296], CS literature have identified typologies and categories for different levels of engagement [290], which are summarised in Table 1.

Across all of these categories, the engagement of citizen scientists will differ across the research or initiatives and the field it is employed in [295]. These levels of engagement can impact the experiences and learning of those engaged [297], as well as being impacted by the motivation of individuals to engage [295]. Each level of engagement is also identified to have its strengths and weaknesses. The contributory level provides the ability to engage a considerable number of individuals whilst requiring marginal contributions. This can include contributing individual health information, biological samples and lead to population level investigations through large datasets. This approach is argued to however not utilise the full potential of engaging citizen scientists in research and instead aligns more with traditional approaches of those engaged being 'participants' [97,106,111].

Table 1. Summary of typologies and categories related to CS levels of engagement.

Typology or category	Alternate terms	Description	CS Literature
Contributory	For the people; Low contributors; Crowdsourcing; Lightweight; Led by experts	Citizen scientists provide data or samples only, with imitative leaders or researchers driving the development, data collection, interpretation and dissemination. This level of CS engagement is done ***for*** citizen scientists, where researchers will collect data for or on citizen scientists and citizen scientists are viewed as volunteers or sensors.	Aristeidou et al.[298]; Bonney et al. [107]; Den Broder et al. [290]; Eitzel et al.,[299] Eveleigh et al.[300]; Haklay et al. [301]; King et al.[106]; Rowbotham et al. [97];
Collaborative	With the people; Community-led; Distributed intelligence; Participatory	Citizen scientists actively collect their own data, but the rest of the processes are directed by initiative leaders. This level of CS engagement is done ***with*** citizen scientists and citizen scientists are viewed as data collectors and interpreters.	
Co-Creation or Co-production	By the people; High contributors; Heavyweight; Extreme CS	Citizen scientists are co-researchers and co-produce or co-create the research. This includes defining its focus and processes, actively collecting and interpreting data and advocating, sharing and actioning outcomes. This level of CS engagement is done ***by*** citizen scientists, with citizen scientists viewed to drive the focus of the project based on concerns relevant to them.	

For collaborative engagement, citizen scientists are actively engaged to collect data and collaborate with researchers to further drive the relevance of the research and its outcome. However, the control is still identified to be with researchers who direct the development, questions asked and interpretation of data, facing similar limitations to contributory engagement [106]. Lastly, the co-production or co-creation engagement is identified to utilise the full potential of CS, facilitating the sharing of power between researchers and citizen scientists who are directly influenced by or part of the topic being explored. This level of engagement enables citizen scientists to share their experiences, draw attention to specific concerns and develop novel solutions relevant to their everyday lives. By bringing together the active engagement of citizen scientists and the resident-based CS data collection, this approach facilitates citizen scientists to be embedded in the whole research process. This enables outcomes to have relevance at the local-level whilst having applicability to be scaled up to decision-making levels [97,106]. The strengths of this process include the building of trust and transparency between members of society and scientific researchers, facilitated by engaging members of the public throughout the entire process and demonstrating how outcomes are reached [97].

Overall, each level of engagement has been demonstrated to be significant for engaging the community within scientific advancement to leverage pathways for understanding the determinants of health [106,302]. However, meaningfully engaging citizen scientists and having shared power within all stages of the research process can catalyse community changes and advocacy that have relevance and extend further than the research outcomes [106,303].

2.4.3 Strengths of citizen science

CS has further advanced the traditional context in which local actors are 'participants' and engaged through passive approaches to have data collected on or for them [111]. This has also included transitioning the generation of scientific and public health knowledge by 'experts' such as academics that disregards the engagement of society [91,111]. Focusing on public health and ageing populations, a range of age-friendly topics including healthy ageing and active living [282], physical activity and healthy eating [110] and walkability and accessibility [304], have been effectively explored through CS engaging older adults [54,304]. This engagement has also included older adults from low-income [282] and ethnically diverse backgrounds[110,118], as well as across a range of different local urban neighbourhoods [110,282] and communities [304]. The use of CS in this context has led to an identification of age-friendly and community-focused priorities and solutions that can inform local, city and policy-level decision-making [110]. In particular, CS outcomes have been able to inform urban planning and urban health domains on relevant and suitable practices and age-friendly solutions that enhance age-friendly urban environments and aim to promote health equity [54,114-116].

CS has expanded the scope of outcomes produced by CBPR and participatory research, fostering beneficial outcomes for both researchers and citizen scientists (Figure 7). This include fostering citizen scientist learning, skills, confidence, self-efficacy and knowledge in both scientific research and the research topic, issue or environment being explored [123,285,286]. At the same time, the level of openness of CS, in which a range of concerns and values are effectively shared, has developed novel and diverse knowledge and solutions that would not be achieved by research alone

[97,115]. This openness also contributes to transparency, demonstrating clearly how knowledge and solutions that inform decision-making are generated with the public [290].

CS also provides an avenue for both the individual voice and the collective voice of a community to be heard [97,104]. This enables an effective approach for both local residents and communities as a collective to shape the direction and focus of research and its outcomes, alongside campaigning and actioning their own solutions in and for their local communities [91,97]. The outcomes of this provides strong potential for achieving health equity at both the individual and population level [305], identifying pathways to mobilising beneficial and relevant outcomes for both citizen scientists and the wider community [305,306]. It is however important to acknowledge that CS alone cannot be taken for granted to promote health equity. Instead, it provides a strong foundation for understanding the real-world determinants that can promote health equity and inform decision-makers towards implementing relevant and real-world changes.

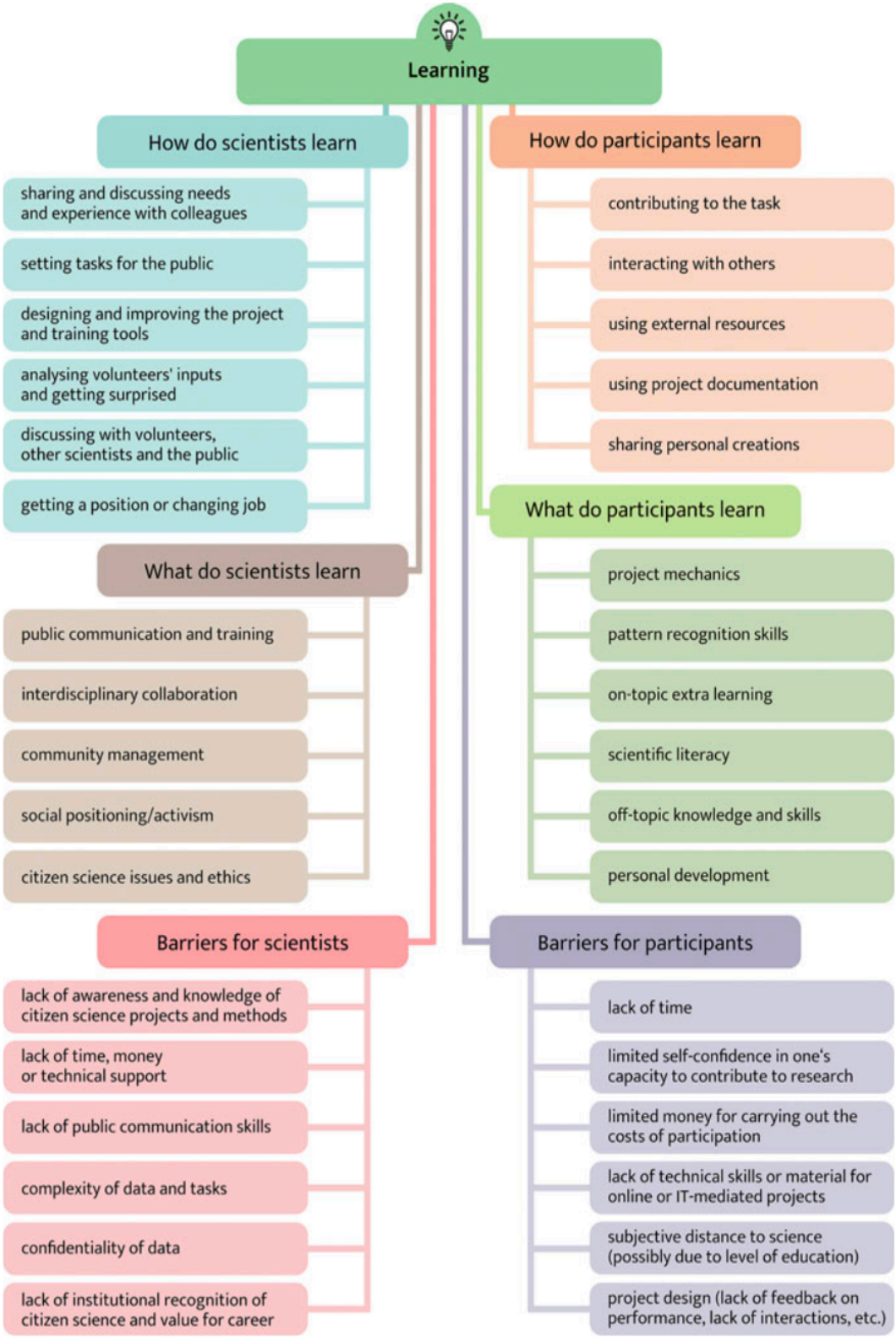


Figure 7. Learning outcomes and barriers for both citizen scientists and researchers when engaging in CS (Taken from Kloetzer et al. [307]).

The substantial growth and use of CS, attributed to a meaningful and cost-effective way for collecting relevant and novel knowledge, has led to a range of benefits being identified across the literature [97,98,103,290,308,309]. These are summarised as; 1) the promotion of research that engages those it endeavours to help, providing openness and relevance; 2) sharing of local-level knowledge and experiences that could be not be identified by research alone; 3) raised public awareness of public health initiatives employed to promote health; 4) enhanced trust through an increased transparency and understanding of the approaches employed for research and how outcomes are achieved; 5) providing an avenue away from resource and funding intense barriers, which are argued to postpone the communication between scientific research and the public; 6) identification of new and diverse experience, insights, contexts and perspectives from those engaged; 7) providing an effective research approach that can address under-served and under-researched populations, and; 8) effectively leverage networks of multi-level and multi-sector actors, ranging from local-levels to levels where influence is placed, based on a shared interest. Engagement within CS can also shift behaviours and attitudes at individual and community levels, alongside facilitating empowerment and engagement to action knowledge and develop community change [97,98,310]. Overall, the benefits that arise through CS initiatives can lead to pathways (Figure 8) that effectively influence and action change for community health [290].

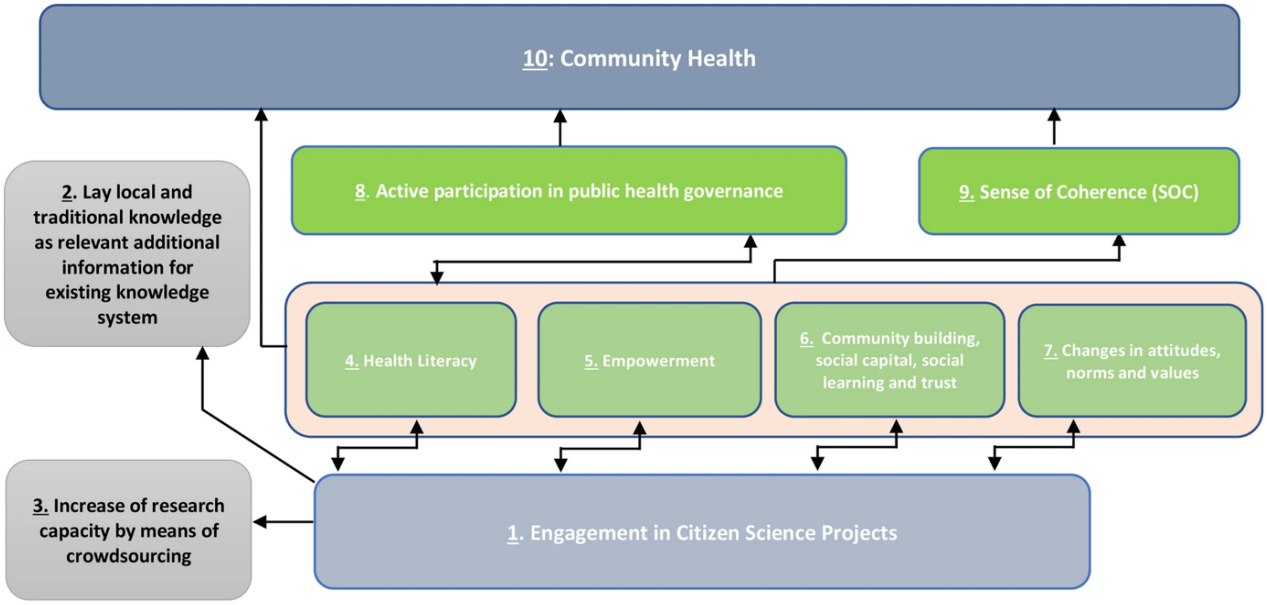


Figure 8. CS pathways and benefits for influencing community health (Taken from Okop et al.[311]).

One significant strength of employing a CS co-production, co-creation or 'by the people' level of engagement is the mobilisation of actions and continued advocacy once a research project has ended, also described as ripple effects [106]. By engaging fully in the CS process and having shared power, the subsequent outcomes can increase self-efficacy, skills, education and advocacy of citizen scientists, leading to continued engagement in community health promotion and local decision-making [98,106,123]. This continued engagement can also facilitate the ability for research to extend past its initial focus or outcomes, continuing to provide avenues for long-term changes [106]. Employing a co-production or more 'extreme' level of engagement can in turn generate knowledge and inform outcomes based on the experiences and needs of citizen scientists driving the research process. These outcomes can then be built

upon further through continued engagement to develop sustainable community-level impacts that aim to promote health equity [98,282]

2.4.4 Challenges of citizen science

The application of CS within public health research is argued to be lacking [290] and received with uncertainty due to its limitations and challenges [291]. CS is identified to encompass a wide range of collaborative, participatory and engagement terms and methods. This has led to CS being employed through different disciplines via a range of definitions, standards, methods and techniques [106,285,305,312,313], creating uncertainty on the meaningful and suitable approaches to engage local actors [314]. Terminology also differs across its employment for those engaged, including participants, volunteers or citizen scientists. This can potentially alter how individuals are engaged and their experiences, alongside presenting issues around language and historical resonance for terms such as 'citizen' that highlight inequalities related to race, power and legal citizenship [111,287,299]. This can lead to a range of CS initiatives utilising different terms and levels of engagement across the same field or topic [299], giving emphasis to some concerns or topics whilst reducing the prominence of others [111,305].

At the same time, accessibility or barriers to engagement require further consideration (Figure 7) [97]. Barriers to engagement can be present for local actors from different economic, social or ethnically diverse backgrounds, such as having levels of mistrust or lacking resources and capacity to engage [123]. This can lead to CS research having a homogenous engagement of individuals, particularly from those who are white and from a well-educated background [123,292,306], creating a

misrepresentation of populations and their concerns [290,314]. A lack of understanding around subject knowledge or methods being used, accessibility to tools to generate data and trust or relationships between researchers and citizen scientists can also exacerbate reduced engagement [292]. This absence of trust between science and society has also been perceived to be manipulated by experts or stakeholders, in which it is directed towards preferences of stakeholders rather than towards genuine understanding [290]. The development of ICT, which has been valuable for advancing CS [54,98,315], can also create barriers for some, including older adults who face age-related barriers including issues with vision or requiring further knowledge on how to use technology [316]. Considering these barriers, alongside avenues to provide support and accessibility for engagement is a way of enabling deliberate and effective CS [123,285]. This includes providing accessible engagement that can safeguard those engaged, share power effectively and embrace the ideas, cultures and epistemologies that can be present through effective engagement [290,306].

Engaging members of the public can also present further limitations in relation to the capability of individuals engaged to collect scientific and credible data [290,308]. Traditional scientific data collection methods aim to ensure data quality, repeatability and peer review, which are argued to be lacking in CS [308]. The engagement of local actors as citizen scientists is questioned by the scientific realm, related to the motivations, skills and ability to produce good quality and unbiased data [291,308]. Ethical deliberations are also present, particularly as this data may be accessing personal elements of an individual's life, alongside identifying who 'owns' the data [290]. Alongside this, it is important to consider the context in which data is collected or created and the ability for data to be reused, accessible and processed across CS

projects [317]. Despite these arguments for reduced data quality and credibility, CS literature has identified avenues for increasing trust, validity, reliability and quality of CS data within the scientific community. The training of citizen scientists, understanding their prior knowledge and skills, providing clear communication of research processes and equipment to standardise data collection have been identified as ways to address data quality and credibility. Similarly, publishing CS data in academic journals and incorporating member checking in which citizen scientists and researchers can review and confirm the representativeness, accuracy and quality of data [289,291,308,318].

Lastly, CS initiatives need to incorporate processes that can assess or evaluate their effectiveness, credibility and impact [125,308]. Evaluation can be undertaken based on criteria and indicators to demonstrate successful or unsuccessful practices, alongside evaluating outcomes that have impact and value for science and society [107,319]. Yet determining and documenting success and impact is difficult, attributed to the interdisciplinary nature of CS and lack of consistent criteria employed across projects to achieve a range wanted outcomes [319,320]. For example, CS criteria have related to scientific outcomes, levels of public engagement, individual learning outcomes, increased public knowledge and behaviour change [320,321]. This diverse range of criteria has made it difficult to establish universal and adaptable criteria that can be employed across CS initiatives [125,319]. Studies have also produced a range of CS evaluation frameworks [125,309,313,319] but it is argued by the authors of these frameworks that there is still a need for consistency, effectiveness and scope for evaluation across CS research. In turn, a suitable evaluation process is argued to be lacking, making it difficult to standardise CS approaches, guidance and achieving the

beneficial impact CS can offer [125]. Without this, there will be a continued gap in the credibility of outcomes and impact of CS initiatives, negatively impacting the contribution, value and success of CS [308,313].

2.4.5 Employing citizen science to explore active and healthy ageing in urban environments

Developing health-promoting and suitable age-friendly environments require the active engagement of older adults within urban planning and public health research and practices [25,54,91]. This includes actively engaging older adults in all stages of age-friendly initiatives or research to generate meaningful knowledge and relevant ideas [92,93]. Alongside this, it is important to find ways to support the community-development approach utilised by the WHO in which actors across society work together to develop, mobilise and sustain age-friendly changes within urban environments [87 89,94]. When considering the research question and aim of this thesis (Chapter 1), which are to explore how urban environments can be optimised to promote active and healthy ageing through the active engagement of older adults and community stakeholders, it is clear that a participatory approach that can evoke the active engagement of these individuals to co-produce the research and outcomes is required.

However, when considering further the requirements of developing and sustaining age-friendly outcomes, such as collective objectives, capacity building and collaborative partnerships across a range of actors [56,90,163,277], the participatory approach chosen by this research needs to facilitate and mobilise these elements. This is crucial for striving to produce an impact or change that can be sustained for those engaged, which meets the core focus of participatory research [287], rather than

producing outcomes for scientific research only. At the same time, it is important to employ a participatory approach that can effectively engage the target population and address the interests of all involved, ranging across those engaged, researchers and the wider community or environment being explored [285,319]. For the purpose of this thesis, this requires a participatory approach that can effectively engage older adults and community stakeholders, alongside potentially strengthen the sustainability of outcomes through fostering empowerment and capacity building of those engaged.

Exploring participatory approaches that can evoke effective public engagement in research reveals a multitude of approaches and methods [285], including Community-Based Participatory Research (CBPR) [283] and Participatory Action Research (PAR) [126]. CBPR and PAR are described as overarching approaches or orientations that employ a range of participatory methods and practices, ranging from interviews and focus groups to ethnography, photovoice and social mapping [54,97,279,280,283,284]. These two approaches vary in their level of engagement, ranging from contributory to co-production, and quality for being responsive to the appropriate engagement methods or needs of those engaged [285]. They can also be pre-set in their focus or topic being explored [290], sometimes argued to be driven by public health researchers rather than the public [97], and be underpinned by different motivations [279]. CBPR and PAR have however been fundamental in shifting the involvement of public in research as participants who contribute information, to instead recognising the public as partners who are crucial for driving research and relevant outcomes through their knowledge [278,285]. When employing a participatory approach, it is therefore important to employ one that can effectively engage the target population and address the needs and

interests of all involved, alongside facilitating ways in which the uptake of the knowledge and outcomes generated can be achieved [279,285,319].

CS utilising a co-production level of engagement is identified as an endeavour of CBPR and PAR [91,96,97], sharing the aim of embedding community engagement within research and building on similar methods for facilitating the more 'extreme' engagement of the public [91,97,99,279,311]. CS co-production is argued to also extend these approaches further, acknowledging those engaged as citizen scientists who partner in the research and have a more outward-focused role in which they play a part in addressing societal affairs [97]. This type of CS can also foster empowerment, advocacy and enhance the skills of those engaged, as well as driving capacity building and partnerships across multi-level actors relevant to a community concern or environment being explored [98,302]. This strengthens the contributory levels of engagement present in CS and participatory research, which aim to facilitate mass public participation and collect large datasets through more passive methods such as self-tracking or online websites [112,290,297,321,344]. In employing a more passive or low-level engagement continues to drive the view of the public as by-standers to a concern or topic being explored [97], as well as lacking the potential to mobilise local actors to learn about, advocate and action meaningful and relevant changes within local communities [99,106,279].

CS co-production has been identified to foster empowerment and capacity building across those engaged, which has mobilised these individuals to continue to advocate and implement local changes once a research project has finished [98,106,123]. This is attributed to citizen scientists holding shared power in the research process [99], alongside driving solution-building and fostering new skills, knowledge, autonomy and

self-efficacy [123, 285, 286]. At the same time, CS co-production facilitates capacity building across those engaged. This includes interdisciplinary collaboration between citizen scientists, stakeholders and researchers engaged in a project, bringing together a multi-disciplinary and cross-sectoral set of actors with a collective aim of identifying and improving the determinants of health inequalities [220]. By engaging these different actors, individual and community knowledge and collective goals can be generated, further promoting shared experiences and advocacy of local needs [112,306]. It can also foster commitment, sustainability [103, 293] and capacity building to address health inequalities present within a community [99, 302], with stakeholders identified to implement and sustain changes that foster age-friendly environments [118,334].

With these benefits in mind, a CS co-production approach was chosen for this thesis to effectively engage older adults and community stakeholders whilst aiming to foster empowerment and capacity building as a way of sustaining the potential outcomes in urban environments. This approach will be guided by the *Our Voice* CS for healthy equity framework (explored further in Chapter 3, section 3.2.2), which provides a four-step sequential approach that has been effective in engaging older adults from different backgrounds and a range of community stakeholders in urban environments [54,110,122]. It presents strengths in its accessibility and ease of use for older adults exploring urban environments [54,91,122], whilst also facilitating empowerment and enhanced knowledge and skills across older adults engaged [110,112,302]. Through experiencing their actions and solutions, which they advocate to community stakeholders, fostering tangible impact in their local communities has in turn fostered collective agency and empowerment across these individuals [54,91]. This has led to the development of older adult groups or networks that continue to advocate

and sustain changes in local urban communities [91,110,112,122]. Alongside this, the *Our Voice* CS framework has effectively engaged relevant community stakeholders in CS co-production, enabling communication and capacity building across these actors to develop multi-level dialogue and feasible changes within a community or environment [91,110,302]. Older adults have also been identified as receptive to the partnerships that form with stakeholders during the implementation of this framework [110], strengthening capacity and network building within local communities to action the wanted changes.

Overall, employing CS co-production guided by this framework, rather than other participatory approaches, is therefore a valuable approach that will be utilised by this PhD research. In ensuring the strengths of CS co-production are built into this thesis will foster the active engagement of older adults and community stakeholders to drive age-friendly urban research based on their needs and experiences. It also aims to foster the potential of CS co-production to facilitate empowerment, capacity building and community partnerships. These are all crucial elements required for behaviour change, community-wide impact [54,98,99] and the delivery and sustainability of age-friendly changes that can promote active and healthy ageing in urban environments [94].

2.5 Literature review conclusions

Urban environments are complex, encompassing a multitude of determinants and domains that can present both opportunities and constraints for the health of its residents. In particular, urban environments become significant for older adults who rely on these settings to be supportive and enable active and healthy ageing. The SES

approach has been employed by public health literature to explore the human-environment relationships and the relevant urban components conducive of health. This has included older adults and urban environments, providing a comprehensive overview of the social-ecological determinants that impact active and healthy ageing across the inter and intrapersonal, environmental, socio-cultural, economic and political domains. However, promoting changes that can foster health and wellbeing in urban environments is a complex goal, heavily influenced by those who live in, use and make decisions for these environments. To address this, further consideration is required to the contexts in which health and wellbeing are shaped. This includes a need for urban planning practices to utilise collaborative and place-based approaches that can engage local residents to identify the relevant urban determinants that impact their health. In particular, increased levels of collaboration and co-production are necessary to effectively engage local residents and reach a locally informed urban governance that is built on place-based values and needs.

AFC have utilised a bottom-up approach to strengthen collaboration and engagement, identifying ways in which urban environments can be enhanced to foster active and healthy ageing. Directly engaging older adults, a total of eight topics covering age-friendly elements were identified and have since become globally recognised and applied to re-envisage age-friendly urban environments. There are limitations present in the AFC approach, including its ability to encompass context-specific concerns of different groups of older adults and the associated discourse that can create further ageist constructs. However, shifting further towards resident-led and community-driven approaches and methods can strengthen the AFC approach, facilitating meaningful local initiatives that encompass age-friendly agendas driven by

older adults. This can be achieved through CS, a valuable approach to engaging older adults as citizen scientists who direct research priorities and processes, actively collect their own data and engage in the generation and sharing of locally relevant knowledge. Although facing challenges, such as barriers to engagement across different population groups and a need to ensure data quality, the use of CS can effectively identify community-focused priorities and solutions that can inform local, city and policy level decision-making, enabling pathways to effectively promote community health.

To address the gaps summarised throughout this literature review, this thesis has used a CS co-production approach to directly engage older adults to identify ways in which the age-friendly agenda can be strengthened and effectively promote active and healthy ageing. It systematically explores the SES determinants that are directly identified by older adults in their local urban environments to show the urban determinants that impact their health and wellbeing. The CS co-production approach, or 'by the people', can enable CS to be employed to its fullest potential, meaningfully engaging and sharing power with older adults who can generate novel information and solutions for enhancing the urban environments they reside in. It is important to be mindful of the limitations within the approaches used, including the need to be representative of the older adult population being explored and collecting good quality and reliable data. At the same time, this research has also examined and set out to address limitations of age-friendly initiatives. This is in relation to the lack of resources and sustainability that support these initiatives, being examined further by this thesis through the engagement of stakeholders in the CS process. This brings together the bottom-up and community-driven approach that CS provides with the top-down approach required to provide resources, capacity and sustainability for age-friendly

initiatives. In considering these concerns and engaging those at the centre of the research focus to share their place-based values, this research used CS to identify socially relevant knowledge related to active and healthy ageing in urban environments. This thesis shows how this knowledge can be embedded within the relevant decision-making and planning of urban environments, creating pathways for promoting active and healthy ageing, community health and aiming to truly democratise scientific research [299].

Chapter 3 - Methodology

3.1 Introduction to methodology

This methodology chapter describes the approaches, research design and methods employed for this research (Figure 9). Three overarching approaches informed the research design and methods, including: 1) the *Our Voice* Citizen Science (CS) for Health Equity approach and its four-step CS method; 2) a social-ecological systems (SES) approach that identified urban environments as systems with social-ecological domains; and 3) the World Health Organization (WHO) Age-Friendly Cities (AFC) approach which provided eight age-friendly topics present within cities. Employing components of these approaches, an initial systematic scoping review was undertaken to review literature employing CS or participatory methods to explore the role of urban environments for active and healthy ageing. A Citizen Science Appraisal Tool (CSAT) was developed to evaluate the quality of methods employed in the included CS studies.

Following on from this, a participatory qualitative research design was employed. This design used a systematic iterative sequence informed by the *Our Voice* CS for Health Equity approach to undertake a four-step CS method. The CS method, which included a preliminary citizen social science (CSS) stage, engaged older adults and community stakeholders across Birmingham to identify the influence of urban environments on active and healthy ageing. Data analysis for both the systematic scoping review and CS methods used an inductive and deductive thematic analysis. This was completed to identify the key urban barriers and facilitators that influence

active and healthy ageing for older adults, alongside draw comparison with the SES domains present in an urban system and the AFC eight topics.

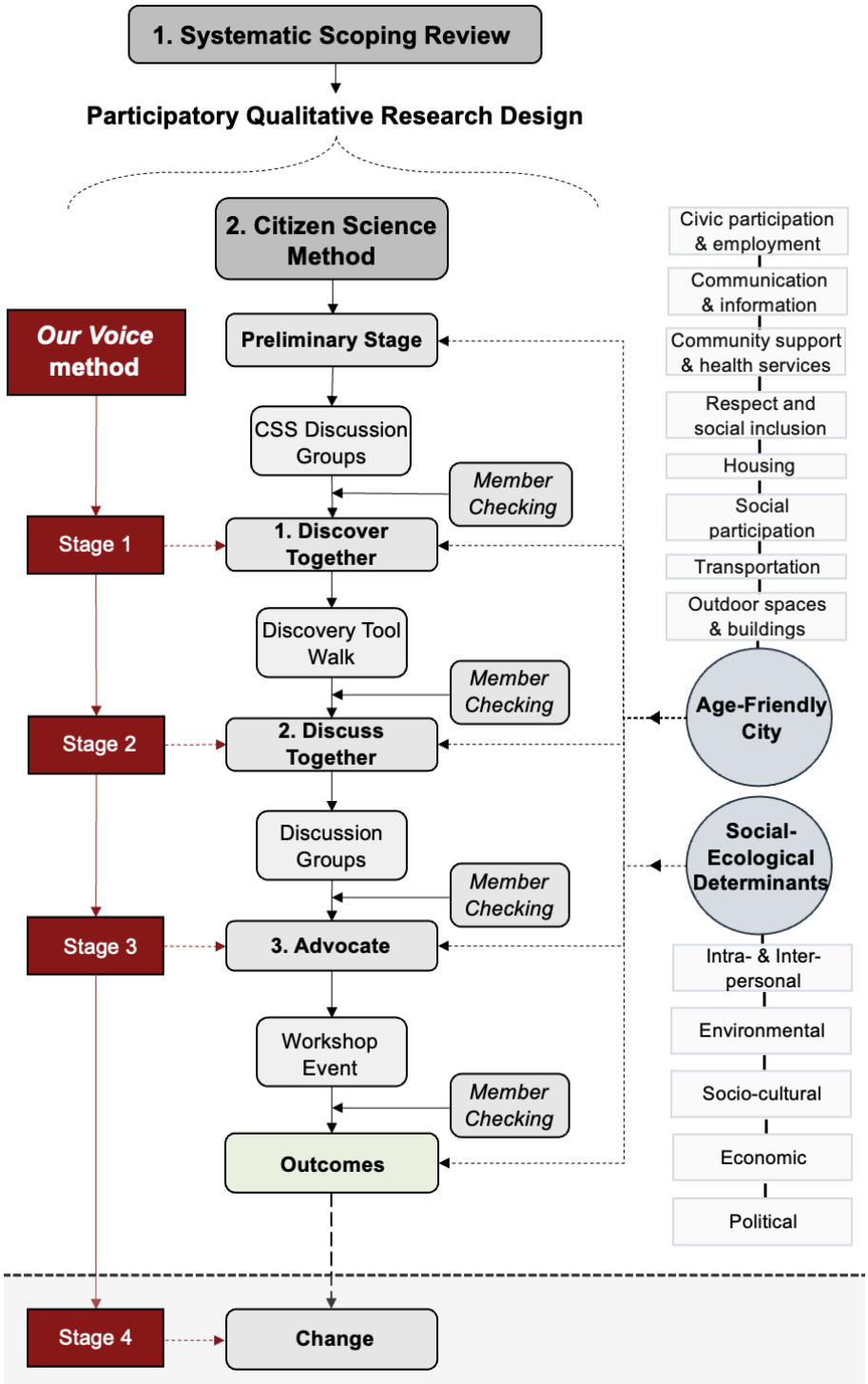


Figure 9. Diagram of the approaches, research design and methods utilised by this PhD thesis. **Red Boxes =** *Our Voice* CS for Health Equity approach; **Grey boxes =**

The methods employed in research; **Blue circles and boxes** = Approaches informing the method at each stage; **Green box** = outcomes of the research. Due to time constraints of the research, stage 4 of the *Our Voice* approach was not undertaken (Source: Author).

3.2 Approaches and concepts

For qualitative research to effectively address its focus, the appropriate methods and data are required to explore and understand the phenomenon being investigated [322]. This includes consideration to the population being explored, alongside the suitability and reliability of design and approaches informing the methods and analysis [323]. To address this, three approaches informed this research design and methods. Firstly, a CS approach was informed by the *Our Voice* CS for Health Equity approach. The *Our Voice* approach provided a systematic but iterative four-step CS method, which is built on elements of Community-Based Participatory Research (CBPR) to facilitate a community-driven CS [98,311]. To also set the context of urban environments and the age-friendly agenda, a SES approach and the WHO's AFC approach informed each stage of the methods and analysis.

3.2.1 Impact of citizen science

Employing CS effectively has the potential to beneficially contribute towards and transform both scientific research and society. Being 'effective' means enabling the inclusive engagement of the public in research processes and decision-making whilst

empowering these individuals to strengthen their knowledge and contributions around the topic explored. Enabling inclusive engagement can promote openness within scientific research, engaging those at the centre of the research focus to direct and shape the processes and outcomes. This can enhance the relevance and suitability of outcomes, having the significant potential to effectively inform local and community-level decision-making to foster health and wellbeing [104,106,290]. This effective engagement can also lead to the potential of altering attitudes and behaviours, alongside promoting continued engagement and advocacy to progress health equity both during and after a CS initiative [98,118,290].

CS has been effectively used in public health research through co-production and collaborative levels of engagement, forming equitable connections between researchers and those engaged who frame the research and its outcomes [324-326]. However, research aiming to employ CS needs to be designed with its constraints in mind. This goes beyond the consideration of engaging local actors and instead understanding the benefits, constraints and trade-offs that can arise from this approach [305]. CS should be employed with an aim of not just producing outcomes for scientific research but supporting outcomes and learning that have impact for citizen scientists. It is also important to consider accessibility, motivation and points of engagement, which can impact the ability for individuals to effectively engage in research and be equal within this approach. Alongside this, utilising training, data collection tools and member checking can also standardise data collection and address scientific research concerns by enhancing data quality and the suitability of citizen scientists to collect data [104,115,291].

Although CS faces limitations around controlling bias, which are argued to be addressed through standardised data collection tools [115,291], it is important to acknowledge that participatory research is embedded within the different viewpoints of those engaged. This identifies a need to not control for bias across the data collected and interpreted by citizen scientists, but instead allow these different viewpoints to come to light in the context and biases they occur. Considering these limitations and building on CS strengths, this PhD research employed a CS method that enabled a community-driven and interdisciplinary focus. This allowed the research to be centred on an equitable co-production with older adults, considering community context and concerns to co-produce relevant findings that are based on their experiences and views [327]. This also included the fundamental elements of collectivism, in which co-production can be enabled to develop a collective effort to identify both individual and collective views or local meanings giving to a concern or setting [328]. To employ a CS approach effectively, the following *Our Voice* CS for Health Equity approach was utilised.

3.2.2 *Our Voice* Citizen Science for Health Equity approach

The *Our Voice* CS for Health Equity approach, which is built upon CBPR, provides a four-step CS method that actively engages community members within research processes. This engagement is employed with the aim of promoting health equity by embedding the voice of community members into scientific research and outcomes. In doing so, there is potential to empower community members through their engagement in the generation of knowledge and solutions, whilst also informing

decision-makers on these real-world and relevant solutions to promote health equity. The four-step CS method brings together CS and photovoice to enable a community-driven approach in which citizen scientist advocacy and solution-building are centred upon. It is an evidence-based and well-used CS method, employed across 20 countries and diverse population groups to allow research to explore local and community-level health and environmental change [54,98,302,315,329].

A 'by the people' level of CS engagement informs the four-step CS method [106]. This level of engagement is described as co-production, co-creation and extreme CS across the literature [107,290] and engages citizen scientists through the entire research process to direct its focus, collect and interpret data, identify solutions and advocate actions [106,284,290]. Employing CS engagement to its fullest potential is crucial for meaningfully engaging and sharing power with citizen scientists and facilitating the generation of novel ideas, knowledge and solutions [106,303]. By bringing together CS, photovoice and 'by the people' engagement, the *Our Voice* method systematically enables data collection and interpretation through four iterative steps (Figure 10). These steps, considered as four stages by this PhD research, are facilitated by the researcher and summarised by the *Our Voice* literature [54,91,98,106,302,315,330] as:



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Figure 10. The *Our Voice* Citizen Science for Health Equity approach (Taken from Tuckett et al. [91]).

1) **Discover –** Citizen scientists use the Stanford Healthy Neighbourhood Discovery Tool [331] to systematically collect qualitative data on their local built and social environments. The Discovery Tool is an evidence-based mobile application that enables standardised and systematic data collection across CS initiatives. Similar to photovoice, the Discovery Tool facilitates citizen scientists to collect data whilst walking in their local areas through geo-tagged photographs, audio and textual narratives, mapping of locations and the ability to positively or negatively rate photos. The Discovery tool also provides an accessible app that is easily used by a multitude of citizen scientists from different demographic groups, allowing robust data to be collected based on their experiences and concerns. Employing this mobile application with multiple citizen scientists across an initiative can also develop a database that encompasses a range of concerns, assets and needs within a specific community or environment. Prior to collecting data, citizen scientists also receive Discovery Tool training and materials to facilitate its use.
2) **Discuss** – Employing collective participatory approaches, including discussion and focus groups, citizen scientists review and interpret the data collected via the Discovery Tool, facilitating a data-driven discussion. This includes identifying, generating and prioritising barriers and facilitators, creating a set of themes. This can include mapping exercises, brainstorming, categorising of data and identifying key decision-makers. Actions and solutions are also generated to address barriers or enhance facilitators, alongside identifying the required community-engagement to implement solutions.
3) **Advocate** – Stakeholders and decision-makers identified in stage 2 are invited to attend formal workshops or meetings, facilitating cross-sector discussions between

stakeholders and citizen scientists. This includes discussions around citizen scientist themes, actions and solutions to advocate for change and community engagement, identifying pathways for actioning solutions. Prior to this stage, citizen scientists training can be completed in advocacy and session preparation.

4) **Change –** Building on the dialogue and pathways generated at stage 3, practical solutions are shared and initiated within local communities to generate change. Citizen scientist's efficacy and knowledge around community concerns are strengthened throughout this process, which can also lead to change through ripple effects. This is where citizen scientists continue to advocate and engage in their communities to promote health equity and address local concerns.

Employing an established approach is argued to enhance the credibility of CS initiatives and their subsequent outcomes, particularly when methods are evidence-based, well-accepted and substantially developed [308]. The *Our Voice* CS approach has been utilised effectively across public health, social sciences and gerontological research, enabling age-friendly outcomes and observed changes across built and social settings to occur. This has included effectively engaging older adults as citizen scientists [304], exploring elements across the built, neighbourhood, community, social and health environments to address walkability, physical activity, accessible food, social isolation, affordable housing and age-friendly universities [54,91].

It is also important to consider the limitations identified within this approach. This includes an absence of a long-term follow-up of study outcomes and changes, alongside a need to engage a greater number of older adults from diverse backgrounds to increase representativeness of outcomes [54,304,315]. Alongside this, the change

stage is identified to place the citizen-generated solutions within the hands of stakeholders and decision-makers who can further enact change. This however requires further consideration to the relevant stakeholders and the responsibility and power they hold [332], all which can influence and impact their involvement and motivation in enacting change [333].

Although there is continued engagement and advocacy from citizen scientists, who are seen to partner with stakeholders and produce changes in their communities [118,121,304,330,334,335], *Our Voice* projects have identified challenges and barriers to the change stage. These have included a need to facilitate further partnerships with stakeholders, such as the police, local councillors and the government [336] KING , alongside acknowledging long-term evaluations and identification of changes being outside the scope of projects [54,336]. However, studies that have presented follow-ups have identified positive changes implemented by stakeholders to foster healthy [330] and age-friendly communities [118,334], as well as implementing initiatives and citizen-identified changes within school [337,338] and university environments [339]. It is therefore important to consider ways in which stakeholders can be further engaged in this four-step method, as well as ways in which the relevant stakeholders are motivated and take responsibility for the changes presented by citizen scientists.

To further build on this body of global CS research aiming to promote health equity, the *Our Voice* approach was employed within the qualitative participatory design of this PhD research to inform the CS methods. This included actively engaging older adult citizen scientists in the systematic but iterative four-step method (Chapter 6 and explored further in section 3.5.3 of this chapter). By utilising the *Our Voice* CS approach, this research endeavoured to expand the community-driven body of CS

age-friendly research. This included comparing and contrasting outcomes of the CS study (Chapters 5 & 6) with the WHO's AFC eight topics, which is required for strengthening the *Our Voice* approach and the age-friendly bottom-up agenda [54].

3.2.3 Citizen social science

CSS was employed in the preliminary stage of the CS study (Chapter 5 and presented further in Table 4 of this chapter). CSS is identified to employ CS engagement in order to engage and mobilise members of the community within research [340,341]. Building on this engagement, CSS is argued to strengthen the foundations of CS, framing it through a social research lens to engage a diverse range of societal actors and centre its focus on the collective and relevant concerns pertinent to society [340,342,343].

CSS shifts away from the original foundations of citizen scientists engaged in the natural and environmental sciences to collect data ***for*** or ***with*** scientists [106]. An example of this is Zooniverse [321,344] which used CS through a contributory level of engagement to engage over 1 million volunteers. These volunteers collect and provide large datasets through an online platform and digital application for disciplines including biology, climate, ecology and astronomy [345]. CSS however shifts away from this and towards the more 'extreme' version of CS engagement, including 'by the people [106] or co-production and co-creation [340]. This enables the engagement of diverse social actors relevant to or impacted by a specific concern within society, bringing to light their diverse perspectives, voices, experiences and in-depth life stories that can be embedded within social research [340,346,347]. Framing this CS engagement of social actors through a social lens centres the research on concerns and solutions

that are important to the individual, the collective group and potentially to wider society [340-342], generating what is described as 'socially robust knowledge' [348].

The use of CS within social science research has also been framed around identifying social concerns of those engaged and identifying ways in which CS approaches can address these concerns. This has included identifying social data across behaviours, opinions, personal views, judgements, expressions, beliefs, self-reported lifestyles, ideas, emotional perspectives and social practices [343,347, 349]. The use of CSS has also provided positive experiences for citizen scientists in a social way. It has enabled individuals to become acquainted and connected with others engaged, as well as facilitate mutual learning, support and learning about the experiences, contexts and cultures of others [350]. It also demonstrates ways in which the everyday life of individuals in society can be shared collectively to bridge together a more in-depth understanding of society [347,351].

CSS can also lay the foundations for forming relationships and networks across those engaged, as well as with scientific researchers [347], enabling the collective generation of knowledge and sharing of resources. For example, exploring mental health [348] through CSS facilitated synergy across a range of social actors including synergy across individuals with mental health conditions, carers, representatives, psychologists and researchers. This enabled a common ground based on shared social concerns to be developed, as well as the forming of relationships and a knowledge coalition centred on this common ground. Social actors engaged in CSS are also identified to further reflect on their concerns as an individual and as a collective group. This can embed what is argued to be an increasingly valid and relevant approach to centring scientific research on both the individual and collective concerns

and values identified [340-342], facilitating legitimacy within the outcomes that show relevance to the collective group and broader societal concerns [340-342,352,353].

CSS is argued to still be in its development phase [348] and currently underexplored [340,354,355], alongside just beginning to bridge the gap between CS and social science research [355]. CSS has however been employed within environmental, public health, urban health, educational and sustainable development initiatives [343,346,356], but this has led to a multitude of ways in which CSS is framed and employed. For example, CSS initiatives have described themselves as employing an interdisciplinary CSS or building on CS within social science research [343,348,355], as well as positioning CSS under the umbrella of a CS approach [357]. The literature also predominantly discusses CSS through its continued novel development [347] and as a growing field [355], presenting a multitude of approaches, methods and different levels of CSS engagement that require further strengthening [356].

This need for strengthening CSS is acknowledged across studies that have used CSS, presenting ways in which it can be strengthened [340,349,350,355,358]. This includes a need to align participation and engagement with the more 'extreme' levels of CS engagement, such as citizen-led, co-production or co-creation. Alongside this, there is a need to consider ethics in CSS projects, provide evaluation of CSS initiatives and enable an interdisciplinary or transdisciplinary approach in which the boundaries of different disciplines are merged to enable collective perspectives to come forward [341,342,349,351,352,354-357,359]. Yet even with the need to strengthen CSS, these different approaches are argued to have a shared focus on providing greater engagement of social actors to enable collective social concerns to be embedded in both scientific, social and policy outcomes [359]. This PhD research builds on this shared focus by

integrating CSS into the preliminary stage of the CS study (Chapter 5). This includes engaging social actors across older adults and a range of community stakeholders to identify community-driven concerns present in urban environments and leverage relevant social outcomes for both the individual and the collective group [104,294].

3.2.4 Social-Ecological Systems approach

A SES approach is utilised by this PhD research to represent and frame urban environments as urban systems. These systems encompass a multitude of urban components that influence active and healthy ageing across the individual, environmental, socio-cultural, economic and political domains [80,161,185]. Place-based and local-level urban barriers and facilitators identified to impact active and healthy ageing will be identified through the systematic scoping review and CS method engaging older adults. These barriers and facilitators will be presented in the context of the SES approach and the urban domains where they sit, with examples of these domains and their components presented in Table 2.

Table 2. Examples of urban domains within an SES and their components identified across the public health literature

Urban Domain	Components	Reference
Individual, personal or intra- and inter-personal	1) Demographics, including age or sex; 2) Biological, physical, and psychological health and wellbeing; 3) Health conditions or multi-morbidity; 4) The presence of family, friends and caregivers; 5) Health behaviours such as diet or smoking; 6) Self-efficacy; 7) Educational levels; 8) Social relationships or networks; 9) Perceived safety	Chaudhury et al.[187]; Frank et al.[19]; Kerr et al. [79]; Lusmägi and Aavik [81]; Moffat and Kohler [80]; Sallis et al. [161]; Wood et al.[185]; Yeom et al.[186]
Environmental	1) Quality of the built environment; 2) Suitable pavements; 3) Accessibility and proximity of infrastructure and services; 4) Aesthetics; 5) Presence of natural environment such as green spaces; 6) Air quality; 7) Housing conditions; 8) Accessibility of green spaces; 9) Weather; 10) Traffic; 11) Levels of crime; 12) Ecosystem services and habitats; 13) suitability of surrounding neighbourhood	
Socio-cultural	1) Social networks; 2) Opportunities to be social; 3) Presence of spouse or family members; 4) Social support and social climate; 5) Cultural norms or beliefs; 6) Religion; 7) Cross-cultural activities; 8) Migration; 9) Availability of social activities; 10) Socio-economic status	
Economic	1) Employment; 2) Cost of services, materials and resources such a transportation or healthcare; 3) Affordable housing; 4) Levels of income; 5) Socio-economic status; 6) Production and consumption	
Political	Policies, investment and support for: 1) Health care; 2) Urban planning; 3) Transportation; 4) Public and green spaces; 5) Housing; 6) Employment; 7) Education; 8) Land use; 9) Media regulation; 10) Business practices policies; 11) Support to migrant communities	

Placed-based approaches have been identified to ground SES in the relevant context and setting, particularly at the local-level, to enable an understanding of the local components that shape health and wellbeing [173,360,361]. Embedding a SES approach within this PhD research aims to strengthen the current understanding of urban environments as urban systems, exploring the human-environment relationship in relation to the local-level urban components and the social-ecological urban domains in which they sit. The place-based urban characteristics and the subsequent recommendations co-produced by older adults and shared with community stakeholders (Chapters 4, 5 & 6) have been explored using an SES approach (Chapter 7). This approach identified the city of Birmingham as a 'whole' urban system, identifying the social-ecological domains in which the place-based urban characteristics and recommendations sit, alongside their interconnectedness across the social-ecological domains. This approach enabled an exploration the human-environment relationship in relation to older adults and their local urban environments across the city of Birmingham.

3.2.5 Age-Friendly Cities approach

The WHO AFC Guide [21] and Checklist [39], which presents eight age-friendly topics, were utilised to inform the outcomes of this research at each stage of the methods. The eight topics and their features are identified to facilitate or prevent active and healthy ageing in urban environments and identify pathways for assessing, altering and enhancing these topics. The outcomes produced by this PhD thesis will be compared and contrasted against the eight topics to identify their similarity, relevance

and presence within the age-friendly agenda. Undertaking a comparison in the systematic scoping review (Chapter 4) and CS study (Chapter 6) identified if the outcomes aligned with current age-friendly guidance, facilitating pathways in which the age-friendly agenda can be strengthened. It also enabled ways in which the city of Birmingham can work towards becoming more age-friendly, identifying the ageing needs and concerns of older adults at the local-level that can be altered or adapted to improve urban environments.

3.3 Systematic scoping review

A systematic scoping review method (Chapter 4) was undertaken as a first step of this PhD research to inform the CS methods (described further in section 3.5 of this chapter). This review aimed to draw together the outcomes of existing literature that employed CS to explore the role of urban environments for active and healthy ageing. Utilising this approach identified and reviewed literature across a range of global urban contexts, seeking to understand how CS and participatory methods been applied in local participatory research directly engaging older adults.

The ever-increasing volume of health research, alongside the subsequent primary research outcomes, has created a challenge for identifying and understanding relevant and timely research methods, outcomes and implications [84,362]. Even with a public health and policy drive towards promoting active and healthy ageing [32,36], there is complexity within public health research exploring the relationship between urban environments and older adults [49]. This includes a multitude of components across public health research that underpins this relationship, presenting determinants that

are wide-spread, diverse and dependent on the older adult population, health condition and urban setting being investigated [51,53,55,91,363]. This makes it problematic when trying to understand how to plan, alter and enhance urban environments to promote active and healthy ageing [62,85,92,363].

Reviewing a snapshot of the current literature prior to undertaking the systematic scoping review (Chapter 4) enabled studies investigating the environmental determinants of healthy and active ageing for older adults to be explored, revealing a plethora of urban characteristics (Table 3). These characteristics included determinants across the built, neighbourhood and community environments impacting healthy and active ageing and their relevant components [21,37] such as physical activity, active living and social health. Exploring these determinants revealed their relevance to the SES characteristics, with the literature giving context to the different domains or levels present within an urban environment that can influence older adults and their ageing experience. Across these studies, it was also clear that local context was crucial for identifying the urban determinants that directly impact older adults and their experiences of healthy and active ageing. This included directly engaging older adults in research to address their individual experiences, alongside shifting away from a substantial focus on physical activity and instead allowing older adults to determine the focus of the study.

Table 3. An example of public health research exploring urban environment characteristics influencing aspects of older adults healthy and active ageing. X = Elements identified by the literature.

Socio-Ecological Level	Urban Elements	Public Health Literature											
		Annear et al. (53)	Baert et al.(364)	Barnett et al.(62)	Bonac-corsi et al.(16)	Boulton et al. (365)	Carlson et al.(366)	Clarke & Nieuw-enhuij-sen(55)	Hawke-sworth et al.(367)	Kerr et al. (79)	Sallis et al. (161)	Seah et al.(368)	Tuckett et al. (304)
Intra- and inter-personal	Demographics	X		X			X		X		X		
	Education			X		X							
	Cognitive abilities		X							X	X		
	Physical and psychological health	X	X	X		X			X	X		X	
	Socio-economic status		X	X					X				
	Companionship		X										
	Cultural Norms			X									
	Health behaviours and care advice		X								X		
Socio-cultural	Social networks and support	X				X						X	

	Social interaction or participation	X			X							X	
	Socio-economic status	X			X			X		X			
	Cultural norms and traditions	X										X	
	Religious or spiritual activities	X											
Environmen t-al	Neighbourhood walkability/prese n-ce of pavements			X	X			X	X	X	X		X
	Quality of environment	X						X					
	Facilities and services (benches, crossing signals, streetlights, shops)			X	X			X	X		X		X
	Aesthetics/attrac ti-veness	X		X	X				X	X	X		
	Recreational facilities	X		X							X		X
	Air/noise pollution	X		X				X			X	X	
	Safety/crime			X	X				X	X	X	X	
	Transportation and traffic	X		X	X			X	X	X		X	
	Green infrastructure or spaces	X		X					X	X			

	Land use type			X	X								
	Safety from traffic	X		X						X			X
	Accessibility			X		X				X	X		X
	Attractiveness			X		X					X		X
	Facilities for walking/cycling					X							
	Green/blue infrastructure			X									
	Antisocial behaviour and unattended dogs	X											
Economic	Employment	X											
Policy	Incentives and finance			X							X		
	Transport investment										X		
	Public recreation investment										X		
	Local initiatives					X							
	Information on policies											X	
	Health care											X	

Public health research has started to address this need, focusing directly on engaging older adults in their local urban environments to understand the challenges and contexts they face every day, alongside producing relevant pathways for promoting active and healthy ageing [34,36,82,274,369]. To review the public health literature directly engaging older adults, a systematic scoping review [370] was employed. Systematic reviews identify a specific topic area with the aim of addressing and critically appraising evidence, producing a clear synthesis and analysis of good quality findings to produce guidance [23,84,371,372]. On the other hand, scoping reviews are more flexible and open in their focus, mapping the current available literature irrespective of critically appraising quality in order to provide an overview of relevant evidence and gaps in the field [370,371,373,374].

Building on the peer-reviewed and standardised process of a systematic review, whilst employing the flexibility of a scoping review to capture and summarise a wide-spread and interdisciplinary focus, a systematic scoping review was deemed suitable. This allowed the broad scope of reviewing public health literature directly engaging older adults in their local urban environments to be addressed, whilst encompassing a systematic method to identify, review and critically appraise the quality of the included literature. This included the development of a critical appraisal tool (explored further in section 3.3.1 of this chapter), which facilitated the scoping review process to be systematic and consider the quality of the included literature.

To analyse the included studies within this review, a narrative synthesis [375] was undertaken due to the qualitative and broad nature of the methods of studies involved. This was completed to describe the methods, CS level of engagement and the urban environment characteristics determined by older adults across the studies. Alongside this, an inductive and deductive thematic analysis was undertaken to

explore the urban barriers and facilitators and compare these to the AFC eight topics (Further details are presented in Chapter 4 and section 3.6 of this chapter). Overall, the systematic scoping review was completed as a first step of the PhD methods. This summarised the current knowledge of active and healthy ageing in urban environments and the CS processes for engaging older adults in public health research.

3.3.1 Citizen Science Appraisal Tool

Although showing more flexibility than systematic reviews, scoping reviews are still identified to necessitate rigorous methods that can produce trustworthy and good quality outcomes [371]. Critical appraisal tools are utilised by systematic reviews to critically appraise and assess the quality of methods and evidence of included literature [371,376,377]. The development of a critical appraisal tool was included by the systematic scoping review method to facilitate a systematic process to the scoping review. This strengthened the limitations of the scoping review process, which was required for the broadness of the topic being explored, instead developing and applying a critical appraisal tool to evaluate the quality of the included literature and undertake a systematic scoping review.

There is guidance, criteria, toolkits, templates and summaries for developing and evaluating CS and participatory initiatives and their quality [125,286,309,313,317,319,378-385], as well as a tool for critically appraising crowdsourcing [386,387] and reporting best practices for participatory research[388]. There are also principles and standards available to guide CS methods, being built upon and employed throughout the growing CS community to strengthen CS initiatives [389-391]. A global leader on these standards

is the European Citizen Science Association (ECSA), an organisation that aims to promote democratisation of science, strengthen the scientific outcomes of CS and establish CS within policymaking [392]. In 2015, ECSA produced 10 principles for CS [312] that aim to foster responsible research and innovation through CS. These principles have since been rapidly built upon by the CS community as a way of setting standards, developing openness in knowledge and strengthening a science and society partnership [103,312,389-391]. However, developing these standards further is argued to require more effort to strengthen their standardisation, quality and credibility, which are crucial elements for applying CS in public health research [294,308,393]. This includes developing further methods and tools for data collection and analysis, considering the capacity of local actors to collect scientific data and a need to evaluate CS initiatives [107,290,294]. In particular, the need for an evaluation process that can assess the credibility, impact and value of CS initiatives is increasingly required [125,308].

Evaluation frameworks have also been presented for CS studies [125,286,309,313,319] that cover a range of diverse criteria. These include evaluating the CS processes employed and the outcomes produced through process-based and outcome-based criteria. Alongside this, individual learning and user outcomes, performance levels of a project and multiple elements across the citizen scientist, scientific, socio-ecological and economic dimensions are criteria presented across evaluation tools (Figure 11). Despite these tools, guidance and frameworks, the distinctiveness and interdisciplinary nature of CS studies has meant that process and success evaluation criteria lack consistency. Instead they are based upon the different participatory approaches employed, levels of engagement and the wanted outcomes of an initiative, making CS studies and their successes difficult to evaluate [313,319-321].

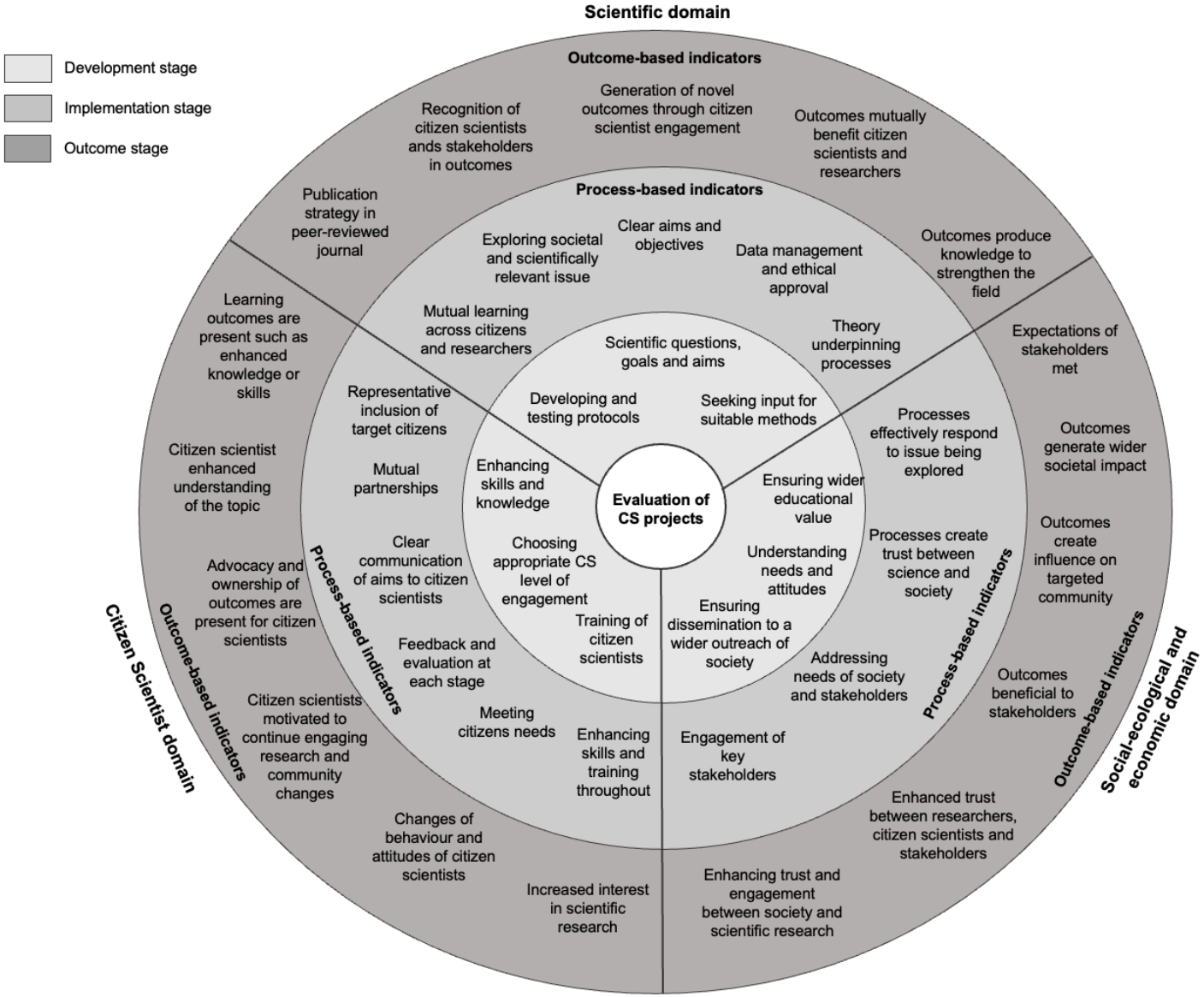


Figure 11. An overview of evaluation criteria, frameworks, indicators and domains employed in CS and participatory literature to evaluate CS projects [107,125,308,309,313,319,381] (Source: Author).

The CS community [125,294,308,313,320,393] therefore demonstrate a gap for developing an evaluation tool that can effectively and universally evaluate the effectiveness, engagement, credibility, successes and impact of CS initiatives in order to strengthen the understanding and potential of CS. To address this, the Citizen Science Appraisal Tool (CSAT) was developed as part of the systematic scoping review to evaluate and critically appraise the quality of CS studies based upon their CS and participatory methods, levels of engagement and outcomes. The CSAT builds upon the ECSA 10 principles, [312] Critical Appraisal Skills Programme (CASP) tools [394,395] and gives consideration of the level of engagement through contributory (*for the people*), collaborative (*with the people*) or co-productive (*by the people*) engagement [98,106]. The CSAT (further explore in Chapter 4 and Appendix 1) encompassed the following four sections:

1) **Science & Research** – This section identifies the aims, goals and if a CS or participatory method has been employed to demonstrate validity, suitability and quality of the design and methods [394,396]. These are factors for strengthening CS and strengthen its validity within the traditional sciences [397].
2) **Leadership & Participation** – This section recognises the active engagement of public within the research, as well as whether there is a partnership present between those engaged and researchers [312,380]. Established and clear engagement of individuals, particularly throughout all processes, presents good quality CS [380,397] and can transition those engaged towards being co-researchers [312].
3) **Data & Delivery** - This section encompasses the data collection, analysis and outputs of research, recognising if individuals have been fully engaged in these processes to promote good quality CS [98,312]. Data bias, errors and limitations are

also present in this section, identifying if studies have recognised and addressed these elements to produce robust and trustworthy findings [291,390].

4) **Outcomes, evaluation & open data** – This section considers the type of engagement employed across for, with or by the people. It also considers if a study has produced real world impact or outcomes that are sustainable, provided open dissemination in a purposeful and user-friendly way, and has undertaken a critical evaluation of the processes employed. These are all elements that can indicate good quality [312,380,397], transparency [312], participant learning [397], accessibility [312], long-term sustainability[380,397] and continued community engagement [54,98,118,121,380,397].

The CSAT has been further employed to review the quality of CS methods and outcomes this PhD thesis has produced, which are further presented in Chapter 7.

3.4 Research design

3.4.1 Participatory qualitative research design

Described as a natural fit for engaging members of the community within qualitative research [323], a participatory qualitative research design was employed to meet the aims of this PhD thesis. This included actively engaging older adults and community stakeholders in multiple participatory and co-production qualitative methods [97]. In effectively achieving this active engagement, the sharing of meaningful knowledge and co-production of solutions can be achieved and provide relevance across individual, social, environmental, economic and political contexts [325,398].

Embedding the outcomes from participatory qualitative research in this meaningful knowledge can in turn enhance the relevance and beneficial impact of outcomes for both older adults engaged and their surrounding community [326].

This design was also employed to effectively encompass local context and meaning [328], allowing older adults and community stakeholders to frame and interpret a concern or topic within an urban context [325]. This included capturing a range of urban barriers and facilitator that impact active and healthy ageing, with the participatory qualitative design effectively identifying a range of viewpoints and underlying realities of health determinants[399], as well as the individual-level and community-level context in which these occur [323]. This is particularly important for public and urban health research in which there are currently a range of widespread health determinants that create diverse experiences for urban residents [133,138,145,146] and contribute further to the complexity of trying to promote healthy and active ageing [29,40,86]. Addressing this complexity and strengthening urban and age-friendly initiatives require the direct and meaningful engagement of older adults [25,87]. This has the potential to identify the experiences older adults have in their urban environments, alongside the urban determinants that impact their health and wellbeing, presenting a local-level understanding that can be incorporated into relevant and tailored age-friendly solutions [11,97].

Within this participatory qualitative research design, a CS approach was chosen to directly engage older adults and embed their experiences and needs within the research processes and outcomes. This included a co-production level of engagement to centre on how older adults view or construct reality within an urban context [323,400] and develop meaningful outcomes that can encompass their perceptions and needs [97,401]. CS facilitates a democratic and active approach to engaging individuals in all

processes of the research [325,398], allowing older adults to collectively co-produce solutions for optimising urban environments. This was crucial for this PhD research to understand the in-depth insights, concerns and solutions relevant for older adults when promoting active and healthy ageing within urban environments, placing primary importance on their voices and viewpoints [323,326,399].

Within this research design, both CS and CSS were employed. CS was employed through a four-step method, facilitated by the *Our Voice* CS for Health Equity approach. This enabled a systematic approach for community-driven CS [311], actively engaging older adults to collectively co-produce solutions for optimising urban environments that hold relevance at both the individual and community-level. As part of the CS method (Chapter 6), a preliminary CSS stage (Chapter 5) was utilised to lay the groundwork for the CS study. This preliminary stage highlighted elements of CSS by providing a distinct pathway to centring on social concerns and the development of relationships through the direct engagement of social actors [340,402,403]. In particular, CSS enabled social issues to be identified and reflected upon by older adults and community stakeholders, enabling relationships to be formed and the collective sharing of resources and local information to occur.

The participatory qualitative research design is also informed by and takes account of a combination of contextualism, constructivist-interpretivist and transformative epistemology. The focus of this thesis is to understand how urban environments exist for older adults and how their knowledge of urban environments is pieced together. Throughout this perspective, the knowledge generated by older adults emerges from the contexts it exists (contextualism) and is constructed as they engage within urban environments. This creates valid experiences for each individual, giving rise to multiple views that have local meanings of these environments

(constructivist-interpretivist). It is also important to identify pathways to collaborate with older adults and honour their standpoints (transformative) [323,328,404-406].

There are other approaches present that are informed by these epistemological paradigms, such as realist evaluation[407], which is employed to evaluate interventions and the contexts in which they are effective [408]. However, this approach is unsuitable for the chosen participatory and community-driven design and instead would be useful for evaluating participatory research upon completion [409]. Overall, the standpoint shaping this research has an epistemological underpinning to explore; a) how older adults experience urban environments; b) how their knowledge is constructed based on their contexts and experiences; and c) how this understanding can be honoured and shared.

3.4.2 Systematic iterative sequence

Iterative elements are fundamental to participatory research, allowing for continuous deliberation to be made at each stage across the knowledge, learning and reflection that is generated or undertaken. Yet this fluidity in participatory design can require a robust and systematic approach to underpin it, particularly to enable quality and validity at each stage [326]. To address this, the participatory research design employed a systematic iterative sequence facilitating a flexible but structured approach to enquiry [325,326,410].

A systematic iterative sequence enables a systematic stepped approach to employ a specific sequence of qualitative methods whilst also allowing flexibility in which the outcomes at each stage can inform and adapt the next. This is useful for research with multiple qualitative stages, allowing the findings, understandings and

questions that arise at each stage to be reflected on and alter the subsequent stages of the methods. However, this approach is systematic in its purpose, enabling the research to continually centre on its purpose or aim whilst facilitating iteration at every stage that can shape the questions, approaches and methods explored [399].

The four-steps of the qualitative CS approach (Chapters 5 & 6) enabled a systematic and sequential approach to engage older adults and centre on the focus of active and healthy ageing in urban environments [399]. The findings emerging at each stage however shaped the study and enabled iteration to be embedded so that the questions, tools and approaches used could be altered at each subsequent stage (Figure 12). This four-step qualitative CS approach also used multiple types of qualitative methods, described as a multi-method approach [411-413].

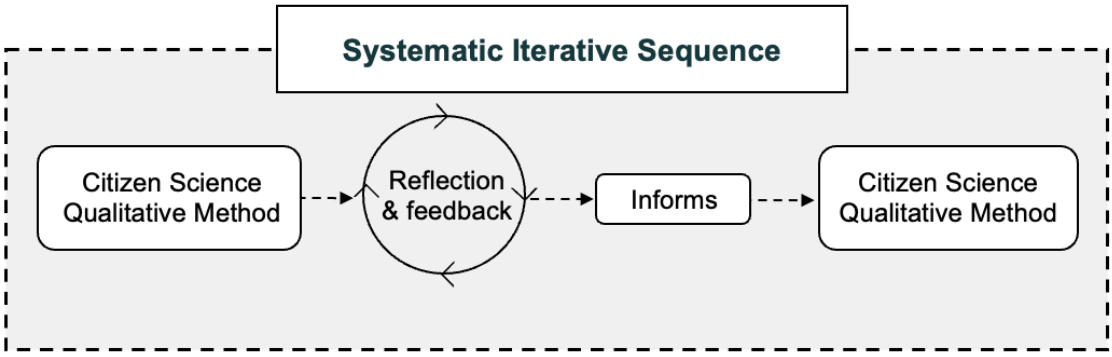


Figure 12. An example of the systematic iterative sequence that informed the participatory qualitative design (Source: Author).

Employing a multi-method approach in which methods from the same qualitative paradigm are used can reduce discrepancies that may occur across the use of different paradigms in one study [413]. It can also effectively facilitate an iterative approach in which qualitative outcomes are discovered and inform the subsequent qualitative methods [323], as well as capturing data from multiple sources or points in

time equally [404,410,414]. The use of an iterative approach enabled older adults to be engaged and collaborate in a systematic procedure of a four-step CS method, whilst enabling these individuals to continually shape and direct the findings at each iteration. This can effectively enable novel insights and knowledge to be produced based on the embodied experience of those engaged whilst upholding systematic and robust methods that can inform academic and scientific knowledge [326].

3.4.3 Researcher reflexivity

It is important to be critical and self-reflective as a researcher, particularly on the viewpoints, background and judgements of a researcher and how this can frame the research [323]. Reflexivity is also central to participatory qualitative research, enabling reflection on the positions and influences that shape research, the power dynamics present and to be critical when being an interpreter or storyteller of data collected by others [415,416]. To address this, reflexivity was conducted at each stage and included elements of critical reflection and self-awareness [399].

Being a young female from a White ethnic background and growing up in a town outside of Birmingham, my experiences have the potential to differ greatly from older adults engaged in the study. For example, my experiences of belonging and interacting with others in an urban context will differ to those of older adults or those from different ethnicities [417]. Reflecting on my own experiences, cities have been accessible and exciting places to spend time, being places where I have felt safe and welcomed. However, the experiences of older adults will differ, ranging from elements of positive multi-cultural experiences [417] to negative ageism, physical barriers [5,40] and social exclusion [418]. Therefore, my role as an active facilitator within the research

process is not neutral but instead influenced by my own experiences [419], which can impact my judgements and interpretations surrounding this PhD research.

To address this, multiple reflective practices were utilised including reflective conversations with my supervisors and academics across the *Our Voice* team. Revisiting the research at each stage with other researchers is instrumental for being reflective and self-aware of the position held. It can allow for space and dialogue to question and reflect on effectively embodying the voices of those engaged, strengthening the quality of collaborative and co-production research [415,420,421]. Alongside this, member checking was employed at each stage of the research (explored in section 3.5.7 of this chapter). This further strengthened reflexivity as a researcher, enabling those engaged to question researchers and ensure their views are accurately represented and upheld, as well as enabling the research to shift from an academic to a participant viewpoint [422].

It was also important to be reflective on the power dynamics present, with power seen to create tension and imbalance between researchers and those engaged [420]. My role as a facilitator could be viewed as an 'insider-outsider' role [423] in which there is prior in-depth knowledge of the research topic. It is important as a researcher to be aware that my knowledge should not influence the outcomes but instead interpret the needs and views of those engaged. It was important to be reflective on this and maintain an outside position where possible so that the participatory nature of the research enabled power equity in the processes. This included consideration to the topic of this PhD research being chosen prior to engaging older adults. Being continually reflective on the power to choose this topic as a researcher, alongside how those engaged may perceived this level of power was crucial.

However, those engaged also hold power through their wealth of experiences and knowledge [423]. For example, older adults held power for their local experiences and knowledge of urban environments, whilst community stakeholders held power through knowledge of resources across Birmingham and actioning the recommendations. Using a participatory approach enabled the power that older adults, community stakeholders and the researcher have to be brought together. To effectively achieve this, expectations and the roles of the researcher and those engaged were clear prior to starting the research. This information was shared through study materials, phone calls and emails. This presented clarity that the research topic was open for older adults to shape based on their collaborative dialogue, their chosen walks, interpretation of the data they collect and the outcomes they collectively co-produce. This shifted decision-making and co-production to be undertaken by older adults and allowed reflection by the researcher at each stage to ensure this meaningful level of engagement was met [424,425].

3.5 Citizen science study methods

A CS study called 'Improving Your Local Area' was undertaken from November 2020 to February 2022. This included a four-step CS qualitative method that included a preliminary CSS stage (Chapters 5 & 6), informed by the *Our Voice* CS for Health Equity approach, SES approach, and the WHO AFC approach.

3.5.1 Study location

The city of Birmingham, UK, was the core location of this study. It is the second biggest city across the UK [426], alongside being the most densely populated area within the West Midlands, encompassing a total of 1,144,9000 individuals [427]. Birmingham is also a superdiverse and multi-cultural city [88], being residence of White, Indian, Asian, Pakistani, Black and mixed ethnic groups [428]. Non-white ethnic groups make up 46.9% of the total population [429], expected to increase by a further 7.2% by 2026 [430]. Birmingham is a post-industrial city, beginning its urban development in 1765 [431] and becoming a predominantly urban setting that is now made up of 69 wards. It does however encompass 4,700 hectares of green space, being described as one of the greenest cities across Europe [432,433]. The indices of multiple deprivation places Birmingham as the 7th most deprived local authority and 3rd most deprived city in the UK, with around 43% of its residents are living within 10% of the most deprived areas across the UK [434,435]. Birmingham is also described to encompass segregated areas of ethnicity, deprivation and socio-economic levels [431].

Although identified to be a younger city, with 64% of the population aged 16 to 64, the growth of those aged 65 and above was greater from 2011 to 2021 than any other age group. This presented an increase of 8.9% during this period, compared to 7.1% for those aged 15 to 64 and 4.1% for those under 15 [427]. Alongside this, the number of older adults within Birmingham is described as large due to the Birmingham encompassing the biggest local authority across the UK [436]. The current 149,400 individuals aged 65 and above are also expected to increase by 29%, amounting to 194,100 individuals by 2040. This is greater increase than other age groups (Figure 13), particularly for those aged 75 and above where the largest growth is expected.

Alongside this, as the ethnic backgrounds of older adults continue to diversify across Birmingham, older adults from an Asian background are expected to have the largest increase[436]. This demonstrates a continued trend of a diversifying and ageing population within Birmingham [426,437,438].

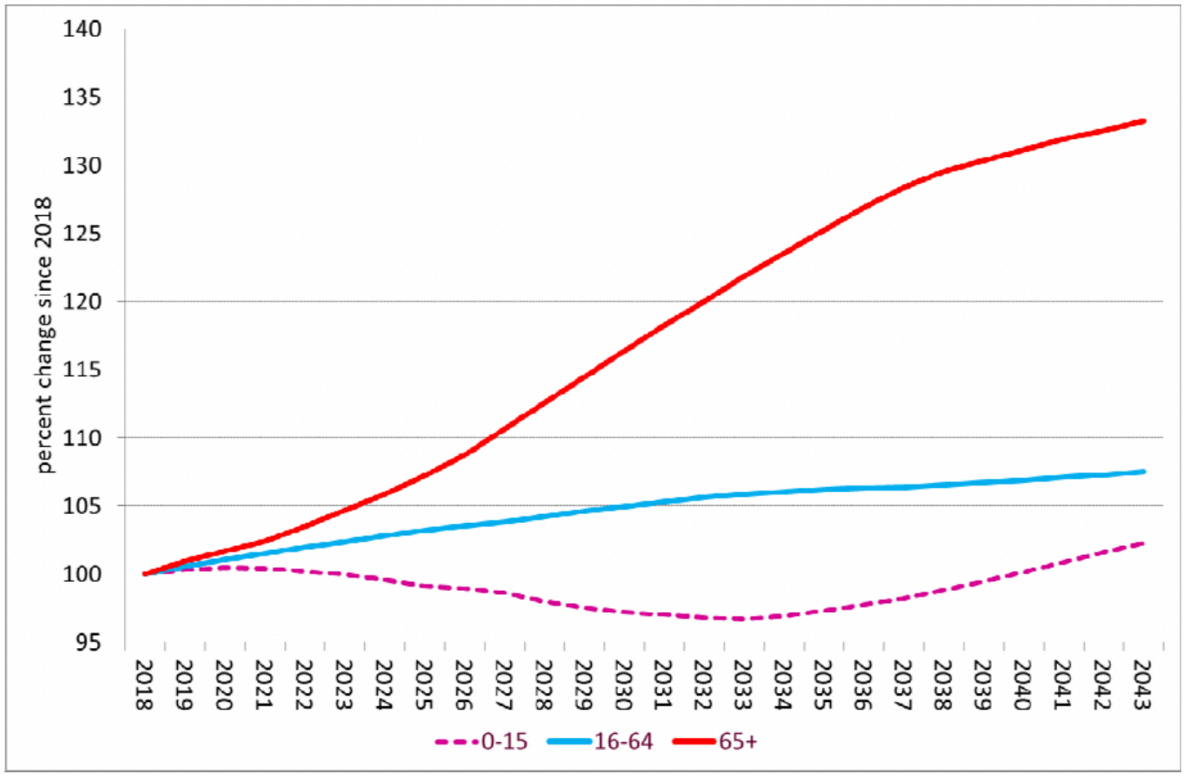


Figure 13. Birmingham population change (%) from 2018-2043 (Taken from Birmingham City Council [438]).

3.5.1.1 Ageing in the city of Birmingham

When focusing on older adults, Birmingham City Council focuses on promoting healthy ageing and ageing well through continuing to be healthy, independent and part of the community for longer [156]. This includes providing effective health and social care support, local social activities, community-based schemes and help with mobility

and specialist care [434]. There is also a strong inclination for promoting ageing opportunities. Over 400 city council grants of up to £20,000 each were awarded from 2016 and a total of £541,919 grants from Birmingham Voluntary Service Council from 2015 were also awarded to provide employment, activities, support, health care and reduce social isolation for older adults [436]. This provision of support for healthy ageing is crucial, particularly as positive ageing experiences within cities are strongly connected to the opportunities present with an individual's residence and local surroundings [431,439].

Ageing Better in Birmingham, which is a partnership across community and voluntary sectors and directed by Birmingham Voluntary Service Council, also aims to support older adults aged 50 and above and lessen the social isolation these individuals face [439]. This includes Neighbourhood Network Schemes that utilise adult social care community assets to facilitate neighbourhoods that support ageing, community cohesion and wellbeing [440]. There are also a multitude of older adult organisations and charities aiming to promote healthy ageing through staying active, social and independent whilst reducing social isolation [441-443].

Birmingham is also a member of the UK Network for Age-Friendly Communities and is aiming to become part of the WHO's Global Network of Age-Friendly Cities and Communities [15]. As part of this, age-friendly initiatives are occurring across the city, including the Age-Friendly Tyburn project. This project aimed to promote walking and cycling for older adults, with its outcomes initiating improved paths for walking, a cycling scheme, improved road crossings and promoting the use of public toilets already present. However, continuing to provide long-term delivery of this project was identified to require continued public engagement, particularly to encompass the needs of those in any further changes made [444].

Although ageing well is one of the key themes for older adults across the city of Birmingham [156] and there is a movement towards prioritising local and community-based support [445], older adults and their needs are not directly considered or mentioned with the city's strategies. The 'Our Future City Plan 2040' [446] and 'Our Future Nature City Plan 2040' [433] focuses on a green, equitable, liveable and distinctive city that engages with local communities. Similarly, the Birmingham Design Guide [447] focuses on inclusive places that are built on the city's current character and encompasses active transport, green infrastructure and healthy living places. However, all of these reports lack reference to older adults and their needs, instead focusing on designing spaces for younger age groups.

Excluding specific reference to older adults within these plans can contribute further to unequal use of space across the city. For example, Birmingham has been perceived as an urban environment for younger people, being developed to attract younger groups to reside, work and engage in the city. This has been identified to create issues in relation to accessibility and equity of spaces, assets and amenities for those outside of this younger age group [448]. This can contribute to unequal use of space, with older adults across Birmingham identified to mainly reside away from the city centre and instead living and spending time in the outskirts [436]. Within Birmingham, older adults already face conflicts between younger age groups for their needs in these spaces [449], as well as inequity across active travel, accessibility, mobility and transport-related exclusion [450]. It is therefore important to encompass the needs of older adults further in these development plans to address and improve the challenges and inequalities they face. This can allow older adults to actively participate, feel valued and contribute towards their urban communities [451].

3.5.1.2 Ageing inequalities in Birmingham

Across the city of Birmingham, urban inequalities for older adults, particularly at the local-level, have been present for quite some time [452]. Specific to Birmingham, these inequalities can be vast and related to a multitude of determinants, ranging from poverty, socio-economic factors and poor health to street connectivity, urban design, transportation, accessibility to health care and the ability to travel and be active [453-455]. Within Birmingham, the ageing population already presents a multitude of chronic health conditions, disabilities and health issues which are rising as the population ages. This includes 28,295 older adults who are unable to manage or need help with health, self-care and mobility, in comparison to 9,208 older adults in Manchester, 11,365 in Bristol, 13,367 in Liverpool, 8251 in Newcastle, and 7183 in Nottingham. It is also the greatest number of older adults unable to manage across the West Midlands Combined Authority, with this number expected to increase to 37,000 in the next 20 years [156,456]. Yet without providing correct support and care services, these limitations can further detrimentally impact an individual's health, quality of life and ageing experience [156].

Life expectancy in Birmingham is also less than the UK average, currently at 77.2 years instead of 79.5 for males and 81.9 years instead of 83.1 for females. This is attributed to heart, liver and lung diseases and infant mortality [457]. Life expectancy also differs across the city, with those residing in more deprived areas having reduced life expectancy of a further 5 years when compared to those in more affluent areas. Healthy life expectancy in Birmingham is also a total of 59 years for men and 60 years for women, meaning that years of good health will decline or stop at this age. This creates a gap between the end of healthy life expectancy and continued ageing,

creating a minimum of 18.5 years where individuals will require increasing health and social care support [156] .

Alongside this, older adults in Birmingham made up 12.7% of the population in 2018 who were impacted by psychological health conditions such as depression and anxiety [156]. Since 2013, Birmingham also has seen a 25% increase for older adult hospital admissions attributed to psychological health and wellbeing excluding dementia, amounting to 45,000 admissions so far [457]. Older adults also face a very high or high risk of loneliness in Birmingham [458], with 47,645 of 71,000 individuals aged 65 or above were living alone in 2011 [156]. Loneliness is also attributed to age-related adverse health and wellbeing issues, unhealthy lifestyles and changes [459]. For example, economic and mobility levels can decline as an individual ages, creating dependence on others for support such as families, partners and close social circles or neighbours [156].

Ageing is also not an equal experience across Birmingham, with older adults from different geographics areas, areas of deprivation or different ethnic backgrounds facing a range of exacerbated health inequalities [460]. For example, individuals living in Four Oaks, a ward that is within the least deprived 20% nationally and rated within the top five affluent wards in Birmingham, can live up to 10 years more than individuals in Shard End, a ward within the most deprived 10% nationally and rated 12th out of 69 for levels of deprivation [435,455]. This also leads to further disparities, with older adults in wards of high deprivation facing reduced access to local services[155], having reduced physically activity levels [461] and report a higher risk and prevalence of pain, anxiety, asthma, heart problems and diabetes [154]. Individuals who also live in poverty and face socio-economic inequalities during their earlier years of life are seen to continue facing this and the subsequent health inequalities throughout older age [454].

Overall, those residing in more deprived areas of Birmingham are associated with increasing poverty, health inequalities and low uptake of healthcare services [88].

The superdiverse communities within Birmingham are also reported to have different ageing experiences, attributed to factors such as cultural norms and practices [88], alongside ageing more prematurely than those from white ethnic backgrounds [460]. Those from minority ethnic groups are identified to face increasing health inequalities that negatively impact their health and wellbeing [430], creating higher rates of chronic morbidity and disabilities for these groups [460]. For example, type 2 diabetes and heart disease are more prevalent in South Asians than White ethnic groups and hospital deaths attributed to Covid-19 were higher for those from Black and Asian ethnicities [462,463]. Different health services are also used and accessed differently across ethnic groups, with Asian and Black ethnicities using direct payment for health care compared to white ethnicities who use NHS and private residential and care home services more across Birmingham [464].

Alongside this, decreasing budgets within the city council have exacerbated these inequalities, creating gaps in services and meeting the needs and expectations of the rising number of older adults in Birmingham [436,445]. For example, Birmingham has seen a significant reduction in government and community services available for older adults, attributed to austerity policies and budget cuts put in place after. This has led to ageing services and support in Birmingham shifting to a focus of older adults being enabled to 'help themselves' [445]. However, this is difficult for those who are limited by their age-related health issues, with 61% of older adults limited either "a little" or "a lot" in their daily activities due to health conditions [465]. In turn, the improvements and growth that are occurring from urban development across

Birmingham are identified to not reach all those residing in the city, creating barriers for promoting healthy ageing [446].

3.5.1.3 Addressing ageing inequalities

It is clear that health inequality and healthy ageing are intertwined, with age-related health conditions, socio-economic factors, deprivation levels and ethnicity impacting the ability for individuals to age healthily [454]. Although Birmingham is shifting towards a preventative vision, in which preventative measures are in place to reduce health and wellbeing issues [466] and promote independence [436], the increase of the older adult population in Birmingham over the coming years will create an increasing demand on ageing and health services. This presents a need to develop supportive environments across the city of Birmingham that can prevent and reduce this demand and the subsequent growing health inequalities, instead enabling individuals to have a continued and longer ageing experience that is healthy [156,437].

Producing supportive environments also requires consideration to the elements or context in which the onset of health issues occur, particularly the differences between different areas of deprivation and ethnicities [156]. Across the development plans, organisations and services within Birmingham, there has been a noticeable shift towards using community-based assets and co-production [445]. For example, The “Our Future City Plan” [446] emphasises the importance of engaging local communities to be part of the shaping the future of Birmingham as a city. The West Midlands Combined Authority plan for creating healthier places [201] aims to also embed community engagement at the centre of its plan. This need for continued public engagement, particularly with older adults, was also reflected in the 2014 Birmingham Policy

Commission for Health Ageing in the 21st century [88]. This policy commission demonstrated a need for co-production with older adults "to give older people a louder voice in respect of their environment and local community" [p.38].

Overall, it is clear that older adults face a range of health determinants, issues and inequalities across Birmingham, all which impact their ability to be active and healthy as they age. It is also clear that a preventative strategy is required that can consider the context and situations of older adults and should be informed through the direct engagement of older adults themselves [467]. However, even with this drive for co-production of urban spaces within Birmingham, there has been a lack of change within decision-making powers that relate to engagement and inclusion at the local-level [431]. In turn, further exploration of directly engaging older adults residing in Birmingham is required to identify the context-specific urban environment determinants that impact active and healthy ageing. Achieving this can identify the challenges older adults face in their everyday and incorporate their needs and views into any age-friendly solutions proposed [35].

3.5.2 Recruitment and sampling technique

To effectively promote active and healthy ageing, alongside producing relevant interventions and outcomes that can prevent or deter ageing concerns, public health research needs to incorporate older adults directly into its development and processes. This includes engaging older adults directly as a way of understanding their needs and concerns in relation to the issues or challenges they face [37,82]. This PhD research aimed to recruit older adults residing across the 69 wards of the city of Birmingham, UK. This included older adults who are aged 60 years or above, English

speaking, have been residing in Birmingham for at least 6 months and have the physical function to walk 400 metres (with or without an aid) comfortably.

To recruit older adults, a purposive sampling technique was selected [322]. This is a non-probability technique that follows a similar approach to convenience sampling where participants are recruited based on their availability and presence. However, purposive sampling determines a selection of available participants through specific criteria, characteristics or experiences [303,322,468], with the specific criteria focusing on older adults residing in Birmingham. Alongside this, a snowball sampling technique where older adults were recruited through current individuals or organisations aware of or already engaged in the research [468]. Through these sampling techniques, recruitment materials including an information sheet, risk assessment and ethical approval were shared via social media and targeted emails to multiple older adult services, groups, charities and organisations across Birmingham. Interested older adults were telephone screened for their suitability before completing a consent form to take part in the study. A similar recruitment process was followed for stakeholders, who were from urban planning and ageing well services. Stakeholders were directly emailed recruitment materials via their organisation or service emails and only took part in discussion groups or workshops, with verbal consent received before taking part.

3.5.3 Study methods and data collection

A total of 17 older adults and 22 community stakeholders were engaged in this CS study (Chapters 5 & 6). Older adults were recruited from 11 wards across Birmingham, representing some of the wards with the highest number of older adult

residents (Figure 14). These stages were informed by the *Our Voice* CS for Health Equity approach and four-step method, alongside a range of co-production, collaborative and user-centred methods and techniques [326,469,470]. A preliminary stage was undertaken employing a CSS approach (Chapter 5) and informed the following three stages of the CS project (Chapter 6), described further in Table 4. It is important to note that due to the time frame and resources of this research, it was not possible to complete stage 4 (change) of the *Our Voice* approach.

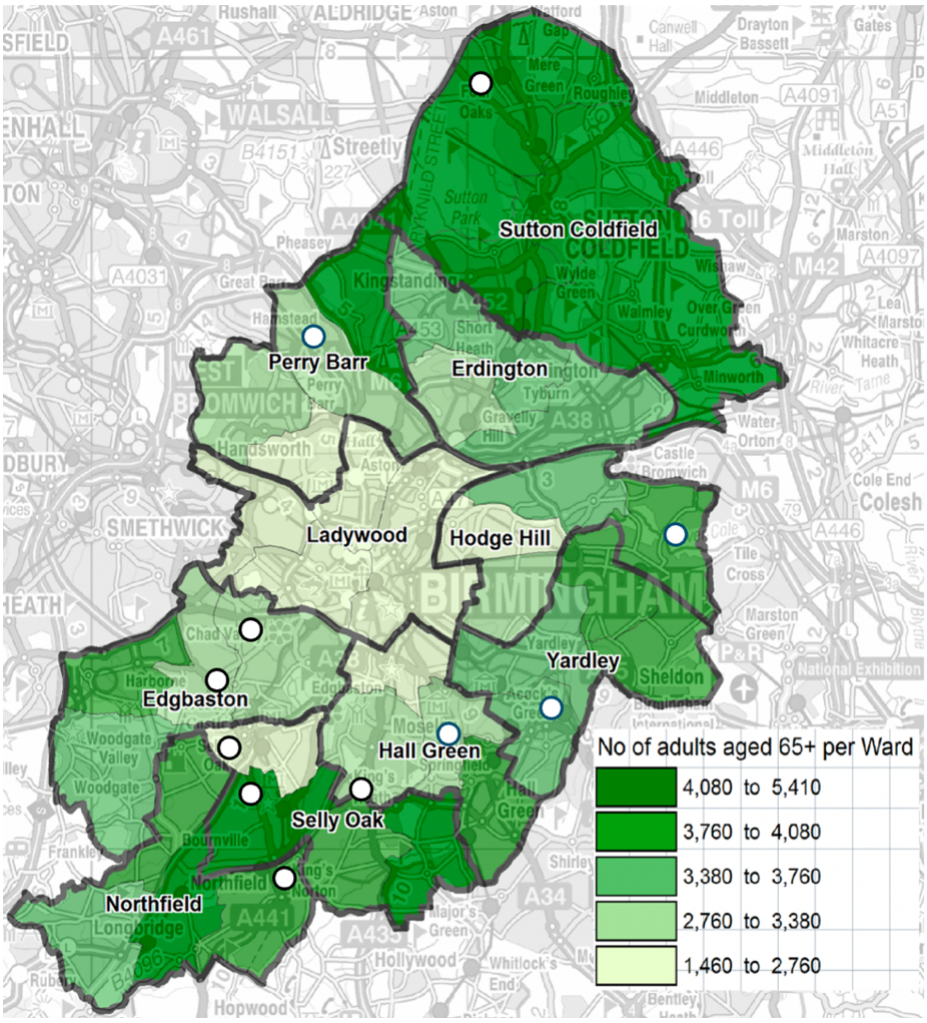


Figure 14. Older adult populations across Birmingham, with white dots representing residences of citizen scientists (Adapted from Birmingham City Council [436]).

Table 4. CS methods and stages of the 'Improving Your Local Area' study

Thesis Chapter	Citizen Science Stage	*Our Voice* Approach	General Methods	Co-production, collaborative, or user-centred techniques	Data Collection and analysis	Researcher Contributions
5	Preliminary CSS Stage	N/A	Six online discussion groups with older adults and community stakeholders were conducted via Zoom. A semi-structured approach using three open-ended questions were employed to facilitate discussions in an open and flexible way [471-473].	Discussion groups are a fundamental method to facilitating a CBPR, CS and iterative approach [401]. They are also identified to facilitate collaboration between those engaged to explore the research focus, interact and share ideas, as well as steering group dynamics and topic focus whilst still facilitating those engaged to direct discussions [325,474,475]. Discussion groups were originally in-person but shifted to online due to Covid-19. Online focus groups were identified as suitable as they are flexible, convenient and can effectively promote sharing of ideas and social presence of individuals whilst allowing a topic to be focused upon [476].	Discussions were audio recorded to collect data. Audio transcripts were transcribed verbatim and thematic inductive analysis was undertaken.	GW facilitated the online discussion groups, transcribing of audio files and thematic inductive analysis.
6	Stage 1	Stage 1-Discover	Twelve walks around the local areas of older adults using the Stanford Healthy Neighbourhood Discovery Tool. Older adults received training material on the	The Discovery Tool is designed to be easily operated by participants, regardless of age, technology experience and literature skills [91,113]. It has been effectively employed with older adults as part of the *Our CS* approach to provide a systematic and iterative approach to collecting data. It can also adapt to the needs of older adults in their local	Citizen scientists collected data using the Discovery Tool. Data was collected in the form of photos, textual narratives and maps.	GW facilitated the walks and support with discovery tool application.

			Discovery Tool prior to the walks and had time to practice using the application before the walks.	environments in order to centre of their concerns [54,315,329].		
	Stage 2	Stage 2- Discuss	Three in-person discussion groups with older adults were held to review and prioritise data collected during stage 1. At the end of the discussion group, an *Our Voice* advocacy booklet was shared for individuals interested in presenting and advocating findings at the next stage.	Discussion groups centred on a collaborative discussion [325,474] between citizen scientists as a group to explore the data collected in stage 1. This included a semi-structured approach utilising: • **Community mapping exercise**, also described as participatory mapping, where an individual recalled and shared details of their walk, alongside writing on their maps [477]. • **Appreciate inquiry** in which questions facilitating the discussion were developed as community members shared their experiences and ideas [478]. • **Barriers and facilitator mapping** where photos of key barriers and facilitators were displayed on whiteboards. This has been previously done in an *Our Voice* project with older adults to identify barriers and facilitators in local environments [91,304]. • **Brainstorming** as a collective to identify and produce actions points for Birmingham. This included a **community inventory approach** where brainstorming focuses on the	Citizen scientists co-produced recommendations based on the data they collected during stage 1. Discussions were also audio recorded. Collective co-produced recommendations were written down by the researcher and shared with citizen scientists for member checking. No further data analysis was completed.	GW facilitated the discussion groups, writing down the co-produced recommend-ations as described by citizen scientists

				strengths and weaknesses of the topic being explored [479]. **Action planning** was also utilised through *Our Voice* material to develop a statement, time frame, defined actors and approaches needed to achieve recommendations for Birmingham [480].		
	Stage 3	Stage 3 - Advocate	Collaborative workshop event sharing the co-produced recommendations for discussion with community stakeholders. Only one adult advocated their recommendation by verbally sharing their recommendation and needs with stakeholders.	The collaborative workshop event followed a semi-structured approach to facilitate discussions between stakeholders, older adults and the researcher. This included: • **Appreciate inquiry** in which questions facilitating the discussion were developed as community members shared their experiences and ideas [478]. • **Communicative Action** where deliberation and communication is facilitated amongst those engaged as a way of reaching a consensus and understanding of issues, values and norms [481]. This included taking into consideration the power and positions of those engaged, facilitating equal discussions through questions and a focus on a specific topic and related concerns [482]. This also included considering conflict that may occur and aiming to enable free and uncoerced communication that can reach mutual agreements [483].	Discussions were audio recorded and transcribed verbatim. Thematic inductive and deductive analysis were completed on discussions and the outcomes were member checked by citizen scientists.	GW facilitated the discussion groups, transcribing of audio files and thematic inductive and deductive analysis. GW also led on a user-friendly booklet produced to share the outcomes of this project with those engaged.

3.5.4 Data trustworthiness

Ensuring trustworthiness of qualitative data is crucial for ensuring credibility and confidence, particularly for those who use or are informed by the data [484]. There is a need to ensure elements of transparency, rigor and credibility within qualitative data in order to facilitate trustworthiness [400,485,486]. These elements can differ across the continually growing field of qualitative research [487] and the paradigms or stances taken by qualitative researchers [488] but can be achieved in a multitude of ways. To achieve trustworthiness in the qualitative data produced by this PhD research, transparency, standardisation in data collection, a thick description, reflexivity and member checking were utilised.

Being transparent and clearly communicating the research processes, methods and analysis can allow qualitative data to be trusted by different disciplines and actors [317]. It can also enable other researchers to follow and repeat the research processes consistently, highlighting reliability and consistency [404]. Transparency was utilised within this research through the use of a systematic iterative sequence, enabling the qualitative methods and analysis to follow a specific systematic and standardised approach to data collection and analysis. This systematic sequence, although informed by an interactive approach in which those engaged shaped the subsequent stages, enabled a four-step method to be clearly followed and communicated with those engaged (Table 4).

Ensuring standardisation across the data collection can also further facilitate transparency and credibility of qualitative data [317]. This was strengthened through the use of the *Our Voice* CS for Health Equity approach, which presents a globally employed and evidence-based approach. This informed the four-step method to follow

a specific sequence and facilitated a standardised approach to data collection through the use of the Discovery Tool. Employing a standardised approach to the methods, alongside equipment to standardise data collection, has been identified to enhance transparency and the quality of data in CS studies [291,308,317].

At the same time, data analysis was completed through thematic analysis. This employed a well-established 6 step approach utilised and tested across public health and qualitative research literature [406,416,489-491]. It is an approach that has been identified to facilitate transparency of the steps employed by researchers to analyse and interpret qualitative data, enabling rigor and the quality of data analysis to be clearly communicated [406,416,489,492]. Lastly, to ensure transparency and demonstrate the quality of the data collected by the CS study (Chapters 5 & 6), the study was evaluated by the CSAT developed during the systematic scoping review (Chapter 4). The outcomes of this CSAT evaluation are presented in Chapter 7 and provide an overview of the quality of the CS study and its data.

These different approaches to facilitating transparency were also communicated through the use of a 'thick description'. This presents a way of fully describing research across its design, rationale and ways in which quality was ensured [404,484]. The methods and data analysis were presented by this research through a thick description via the thesis and peer-reviewed published manuscripts (Chapters 4, 5 & 6). It was also presented through the study materials and processes shared with those engaged, enabling the four-steps to be clearly communicated and followed to achieve the aims of this PhD research. This presented a clear overview of the findings and how they were reached, enabling transparent pathways to be communicated and followed throughout the study duration [488].

Another approach to facilitating transparency is reflexivity [404,484,493] in which researchers can be reflective on their influence, bias and interpretation. This includes being reflexive throughout a study, alongside providing a narrative of this process, facilitating researchers to disclose their views and paradigms that may influence the research and its processes [400]. This can provide an open narrative to the readers, enabling transparency of the data collection, analysis and interpretation to embedded within the research [404]. Researcher reflexivity was utilised at each stage of this research (described in section 3.4.3 of this chapter).

Lastly, validity is a crucial element to consider in qualitative research, particularly as qualitative data can be bound within the voices of those engaged in research [493] and needs to be valid in its reflections of this [404]. Member checking is one way of addressing this validity and can build trust in the outcomes and enhance data quality [494,495]. Member checking is a widely accepted and substantially used approach for qualitative researchers [400,404,484,487,493,495,496], enabling validity in terms of reflecting the reality in which the data was collected or shared [494,495]. This approach was substantially used by this research and is presented further in the section below.

3.5.5 Member checking

Throughout the CS method, member checking was utilised. Member checking is used to strengthen qualitative research by facilitating those engaged to verify the credibility, validity, and accuracy of the data and its interpretation, alongside confirming that it represents their narrative and experiences [400,497-499]. Member checking is a key component of CS, particularly to ensure the needs of those engaged are included in the data, its analysis and the outcomes co-produced [500]. This approach was

employed by this PhD research to outline the overall research practices of participation and co-production at each stage, bringing the data and subsequent outcomes back towards a democratisation of science in which the processes and data truly reflect the voices of those engaged.

Member checking can encompass a range of practices, with a common approach presented through the sharing of raw data and its analysis as themes to allow further review [400,499]. However, it is important to recognise that member checking can also impact those engaged [501]. For example, the sharing of researcher interpreted data can potentially produce a negative portrayal of a topic or an individual, which has previously been identified to cause unintended distress to participants [497]. Participants may be influenced by a power imbalance in which researchers are viewed to be more powerful and utilise the data as they wish, or not wanting to disagree with researchers [502]. Some participants may also feel that their views are not fully represented, especially when data is analysed in a collective way to represent all participants engaged [499]. Conflict can also occur, with disagreements over analysis or outcomes reached, but this can be re-directed to reframe the data in a broader way to capture the diverse voices and disagreements of those engaged [503].

These limitations were taken into consideration, with emphasis placed on the co-production element throughout this research so that it was clear that older adults can openly share their feedback and be equal in the process [497]. To achieve this, a five step process presented by Birt et al. [499] was followed: 1) Preparing emerging themes that encompass non-scientific wording through diagrams, word documents and a booklet; 2) Contacting those engaged via email and telephone to check that they are happy to be involved in member checking; 3) Sharing the emerging themes via email, alongside clear guidance that they can openly comment on or alter on the data

so that it represents their experience; 4) Collecting responses from those engaged through emails, telephone calls and zoom calls; and 5) Ensuring that each piece of feedback is added or integrated into the next version of the data, themes or outcomes to ensure the voices and concerns were fully represented. This process was followed to allow older adults and community stakeholders to engage in member checking of the data and themes generated at each stage.

Development of the CSAT (Chapter 4) also helped to strengthen and inform the 6 steps of member checking to ensure that the CS processes were of high quality. This included placing importance on the active engagement of citizen scientists in the data processes (Q5) and ensuring that findings at each stage were a direct outcome of data-driven strategies generated by citizen scientists (Q8). During member checking of the outcomes at each stage, disagreements did emerge. Some stakeholders identified that the recommendations wanted by older adults are already happening or are not truly representative of the situation, such as the impact of low traffic neighbourhoods. To address this, any urban changes encompassed within the co-produced recommendations and were being undertaken at the time of the study were highlighted in the outcomes, alongside making it clear that the recommendations reflected older adult views only.

Overall, member checking was a useful process to undertake in order to truly reflect the democratic processes of CS research. This process enabled older adults and community stakeholders to ensure the outcomes at each stage were valid and reflective of their experiences. To further strengthen this process, it would be useful to: 1) engage older adults within the data analysis processes to demonstrate transparency and embed member checking within this stage; and 2) provide further

materials on how analysis and interpretation were undertaken by the researcher so that this could be reviewed by older adults.

3.6 Data Analysis

Data analysis methods were chosen based on their ability to analyse the qualitative nature of the research, alongside providing transparent and replicable methods that are considered crucial for public health and participatory contexts [323,328]. Qualitative data was presented by both the systematic scoping review (Chapter 4) and the CS study (Chapters 5 & 6).

Qualitative data analysis can take an iterative stance to discover, induce and understand meaning, experiences and patterns, alongside highlighting and clarifying descriptions and meaning of the phenomenon explored [504]. For this research, the barriers and facilitators of active and healthy ageing were focused upon, exploring the meaning and context that underpin these barriers and facilitators and to co-produce recommendations for altering or enhancing them. To centre the data analysis on this focus effectively, a thematic analysis method was undertaken which included both inductive and deductive thematic analysis.

Thematic analysis provides a robust but flexible method for data analysis, enabling researchers to be reflexive in their analysis and to combine their theory, qualitative methods and subsequent data in an accessible approach [416]. It is a widely used method within qualitative, community-based and health research, allowing discussion groups to be thematically analysed inductively and deductively [406,490,493]. It can also produce both academic and user-friendly outcomes that are accessible to those engaged in research [490].

To utilise thematic analysis effectively, the following approach presented by Braun and Clark [416,491], Saldaña [505] and Terry et al [489] was followed for; 1) **Familiarisation** where audio files were transcribed and re-read so that critical engagement and immersion in the transcripts was achieved; 2) **Data coding** where the entire transcript was systematically but openly and inclusively coded to produce a large set of codes; 3) **Generating initial themes** where codes were combined together to produce a meaningful overview of the data; 4) **Further development** and review of themes in which they were shared with both supervisors, and two sets of reviewers for the systematic scoping review, to validate and strengthen the coding; 5) **Refining and defining** themes in which an interpretative position was taken to ensure themes represented and captured the meaning of data, with themes shared with other researchers and older adults engaged to reach a collective agreement; and 6) **Finalising** and presenting themes in a user-friendly booklet and academic articles.

This six-step process was undertaken in NVivo, with coding being completed for both an inductive and deductive approach. For the systematic scoping review, both inductive and deductive thematic analysis were completed to identify the common urban barrier and facilitator themes present across the literature, alongside their relevance to the AFC eight topics (Chapter 4). For the CS study (Chapters 5 & 6), an inductive thematic analysis was completed to explore the data openly and for codes to emerge and evolve as transcripts were analysed. This included coding entire audio transcripts to organically capture what older adults said and codes then collapsed into common themes that represent urban barriers of facilitators.

Throughout this approach it is was important to consider the researcher's role in interpreting and coding the content of the data, particularly to make sure that the voices of those engaged are reflected in their meanings, emotions and assumptions

[416]. To address this, semantic coding was employed to provide a descriptive overview and explicit meaning of codes, particularly to reflect what those engaged directly said. To produce a more in-depth understanding and context of the code, latent coding was also employed to produce implicit meanings. This included identifying and interpreting more in-depth and underlying meanings or patterns [489]. In particular, semantic coding was utilised to reflect data-driven codes to summarise what was directly said by older adults. Latent coding followed to reflect researcher derived codes in which interpretative coding was used based to identify meaning based on what and how something was said [416,489] (Appendix 1).

3.7 Ethical considerations

The 'Improving Your Local Area' CS study received full ethnical approval from the University of Birmingham Science, Technology, Engineering and Mathematics Ethical Review Committee ERN-20-0222. This study encompassed multiple ethical considerations, particularly with the given direct engagement of older adults in research processes, meaning ethical consideration was given to the suitable methods, engagement and data management.

A range of ethical issues can emerge during participatory and community-based research, particularly through the inclusion of personal perspectives being shared through research. This necessitates consideration to the safeguarding of wellbeing and confidentially for those engaged [323]. It is also important to be open about the intrinsic motivations of the researcher and why the research is being undertaken [506]. To address this, a screening process was undertaken following a set of steps. This included sharing detailed materials of the study, its focus, the methods

and ways in which the data is stored, anonymised and disseminated with older adults prior to engaging in the study. Interested older adults were also screened prior to engaging, with information about the study and steps for the safeguarding of wellbeing and confidentially shared verbally during the telephone screening.

Older adults' identity and data collected was anonymised at each step, with names and any information relating to an individual's identify removed. Data was also stored electronically on the University of Birmingham Research Data Store and Stanford University secure server. Alongside this, it was clear in study materials that the data collected through the research would be disseminated through both academic and public reports [507]. To ensure older adults were aware of these ethical considerations, signed consent forms with information about each ethical consideration was obtained prior to beginning, with older adults aware they can withdraw at any time.

Ethical issues can also arise in participatory research through researchers upholding trust, mutual respect and the potential of obtaining or representing personal or vulnerable data from those engaged [326,399]. It was important to reflect on these elements at each stage, making sure there was open dialogue and communication with older adults throughout. This included being aware and accounting for possible mistrust, historical resonance between individuals and the research topic or institution [401] and understanding how comfortable individuals may be engaging in scientific research [506]. For example, some groups may feel that they are more researched than others without seeing an outcome or benefit from the research [419].

It is also important for research to effectively represent the community that are being engaged or at the centre of the problem being explored [506]. This includes engaging these individuals in the focus of the project, the concerns addressed and the

solution-building taking place to be meaningfully and representatively engaged [506]. This research aimed to originally engage 30 older adults across the different wards of Birmingham but faced limitations due to Covid-19. Although 17 older adults were engaged, the majority of these individuals were from a white ethnic background and female. The lack of participant diversity has been acknowledged in CS literature [123,292,306], identifying a predominant homogenous engagement of individuals who are from a white ethnic and well-educated background. It was therefore important to acknowledge and consider that the outcomes produced by this thesis will reflect the needs of older adult females from a white ethnic background, under-representing the views or needs of older adults from different ethnicities, sex, or from different wards across Birmingham.

There are also ethical considerations around the time and labour of those engaged, particularly relating to compensation and whether this should be provided to those engaged [508]. This includes taking into consideration the resources, time and accessibility to the research, which can create issues for engaging in CS research [506]. Exploitation can be present within CS initiatives, creating issues with inequity and harm for those engaged [507]. To address this, older adults received financial compensation to pay for their time and transportation. Alongside this, formal recognition of those engaged was present throughout both academic and non-academic reports and publications. Acknowledgement in reports is shown to enable accountability, be fair and equal to those engaged and promote trust between researchers and the public [509].

Overall, to address ethical concerns that arise with CS research, this study encompassed to the best of its abilities the following elements presented by Chesser et al [506]: 1) Inclusivity to recognise that there is diversity present within communities

and allowing this diversity to play a meaningful part in the research. Multiple organisations and services related to ageing well across Birmingham were contacted to engage older adults and there was a need for this research to be aware of the level of inclusivity that was actually achieved; 2) Adaptability to the cultures, languages and concerns that maybe presented from a superdiverse and ageing community, alongside providing accessible materials and training through both digital and hard copies; 3) Sensitivity to respect those engaged and their beliefs, alongside embedding this sensitivity within research processes and outcomes; 4) Safety of those engaged, with ethical approval received prior to starting the study and the researcher being present at all stages to facilitate a safe environment; and 5) Reciprocity for those engaged by providing financial compensation and acknowledging individuals in publications that were both shared with academic and non-academic audiences.

During the timeline of this study, the COVID-19 global pandemic also occurred. This was a time when older adults were self-isolating due to the high risks they faced from Covid-19. This led to multiple amendments being made to the study in relation to the ethical responsibility of the researcher regarding the health and safety of those engaged. This included following relevant government guidance, shifting the preliminary stage of the study to online discussion groups and the researcher following social distancing and wearing of face masks and suitable PPI. These amendments to the study were shared with both older adults and stakeholders, with older adults advised they did not have to continue to engage. Alongside this, older adults who were asked to shield or who were cautious to attend in-person were invited to participate in the online stages only.

3.8 Conclusions of methodological chapter

This chapter has described the participatory qualitative research design utilised by this PhD research to explore the role of urban environments for active and healthy ageing. This included a systematic scoping review (Chapter 4) which reviewed literature across a global urban context employing CS and participatory methods in urban and ageing research. The development of the CSAT as part of this review also identified good quality CS studies being undertaken and areas where CS studies could be strengthened further. Building on the outcomes of the systematic review, the CSAT and the *Our Voice* CS approach, a CSS (Chapter 5) and CS (Chapter 6) method were undertaken to actively engage older adults and community stakeholders to identify the role of urban environments for active and healthy ageing.

The use of these methods in a systematic but iterative way enabled this research to be driven by a current understanding of engaging older adults in urban research and engaging older adults and community stakeholders through a community-driven CS approach in the urban context of the city of Birmingham. To strengthen this methodology further, allowing those engaged as citizen scientists to choose the topic of focus, enabling stronger levels of power and participation and to be part of the data analysis is key. The next chapters present the systematic scoping review (Chapter 4), the CSS preliminary stage (Chapter 5) laying the groundwork for the CS study, and the Improving Your Local area CS study engaging older adults and community stakeholders (Chapter 6).

Chapter 4 – The role of urban environments in promoting active and healthy Ageing: a systematic scoping review of citizen science approaches

4.1 Summary and context

This chapter presents a published systematic scoping investigating the central focus of this PhD thesis on urban environments, active and healthy ageing and the use of participatory and citizen science (CS) methods. The aim of the systematic scoping review was to explore the role of urban environments in promoting active and healthy ageing by reviewing studies that have directly engaged older adults in CS or participatory approaches. This included drawing together processes and outcomes of public health literature utilising a participatory approach, with a particular focus on CS, to engage older adults across global urban environments.

This systematic scoping review sits within the context of public health research exploring participatory pathways and beneficial outcomes of directly engaging older adults within research [54,58,94,126,273,510,511]. This includes a current drive for engaging older adults within public health and ageing research [8,274,510,512], which is identified to be expanding and demonstrating a clear participatory shift within research processes [511,513,514]. This is attributed to a need to understand further place-based contexts and the needs of older adults in their local contexts that cannot be identified by academic research alone [515]. Engaging older adults has also been identified to provide meaningful and relevant outcomes that can enhance the support, services and decision-making that their everyday life [21,516]. Alongside this, fully encompassing these contexts and how they occur or are impacted by a local urban environment can

further promote relevant ways of strengthening the age-friendly urban agenda [8,274,510,512].

Other systematic reviews and scoping reviews have recently begun to investigate older adults as co-researchers [517], participatory designs that engage older adults [518] and how older adults are engaged in the development and implementation of health initiatives [519]. These reviews also reflect on the methods for engaging older adults in research, from study development to dissemination, identifying a need to ensure older adults are engaged within the development of an initiative and all stages of data collection. In doing so, the value and beneficial outcomes of this engagement can identify in-depth experiences and knowledge of older adults, as well as enhancing their skills and confidence. At the same time, challenges of engagement need to be addressed such as increasing rigour, reflexivity and validity in the methods of engagement, alongside strengthening longitudinal approaches that provide long-term outcomes.

The age-friendly agenda is also continually developing and strengthening the World Health Organization (WHO) Age-Friendly Cities (AFC) approach [41,520]. This includes further ways to embed the direct engagement of older adults in age-friendly initiatives and further expanding on the eight age-friendly topics identified [40,520]. For example, age-friendly initiatives have utilised co-creation, citizen-based and community-based participatory research (CBPR) techniques [516] and identified a need for a combined bottom-up and top-down approach to embed relevance and sustainability in initiatives [41]. The eight age-friendly topics have also been expanded on to encompass accessible food [521], technology and smart cities[520] and social exclusion[59]. Even with novel and diverse approaches for achieving age-friendly environments being continually developed, a key issue is still implementing this

agenda in a way that can recognise and capture the complexity of urban environments for older adults at the local-level [11,29,41]. This has created a focus on embedding the active engagement of older adults within research exploring age-friendly environments [29,38,522], particularly for breaking down this complexity and identifying the local-level and place-based needs of older adults in their urban environments.

The systematic scoping review brought together ageing, public health, urban and participatory research, drawing on an interdisciplinary focus in the context of active and healthy ageing in urban environments. The key findings of the review showed congruence within the context of this public health and ageing literature. This included identifying a range of place-based urban characteristics identified by older adults as barriers and facilitator to active and healthy ageing. These characteristics aligned to the eight topics presented by the AFC approach, demonstrating the relevance and applicability of the WHO age-friendly agenda. At the same time, evaluating the quality of CS and participatory approaches through the CSAT revealed similar findings to the reviews discussed above. This included a need to increase the active engagement of older adults in the development phases of studies and to improve the sustainability of outcomes. In undertaking this systematic scoping review, the findings contributed further to the literature threefold:

1) By highlighting the urban environment characteristics that prevent or facilitate active and healthy ageing and were directly identified by older adults in their own local urban environments.

   These urban characteristics showed relevance to the local-level context and experiences of older adults, demonstrating pathways for ways in which urban environments can be altered in a relevant way to promote active and healthy ageing. At the same time, there were similarities present for the barriers

and the facilitators identified across each of the included literature. This included similarities across accessibility, physical environment barriers and facilitators, transportation and community support. These similarities indicate urban barriers and facilitators that may be present across both the local and community-level of urban environments, with alterations made based on these common characteristics potentially producing a community-level impact. Lastly, these characteristics were also presented through an SES approach, allowing these global urban environments to be viewed as urban systems with interconnecting characteristics across different urban domains. This presents value in viewing urban environments as a system in which multiple characteristics can influence older adults across different levels and domains. This has the potential to identify interconnected characteristics and how alterations are required across these multiple and interconnected domains to produce effective age-friendly urban changes.

2) By highlighting avenues for strengthening the age-friendly agenda, which has been identified to require continual expansion and development [41,520].

Undertaking a comparison of the local-level urban characteristics identified by this review against the WHO's AFC eight topics identified ways in which the AFC approach could be strengthened and expanded further. This comparison revealed ways in which the AFC eight topics hold relevance for some characteristics identified at the local-level. However, it also demonstrated urban characteristics that were not aligned with the AFC approach, including the impact of neighbourhood alterations and the needs of older adult migrant and cross-cultural communities. These are areas that require strengthening in the age-friendly agenda, particularly to promote its relevance and suitability to

addressing the needs and constraints faced by older adults in their local urban environments.

It is important to highlight that migration and immigration are two terms often used interchangeably [523,524] but for the purpose of this thesis are defined as: 1) Migration in which an individual moves within their own country (domestic migration) or to another country temporarily (international migration), with examples attributed to work or for family; and 2) Immigration in which an individual moves to another country to relocate or become a permanent citizen, also termed an 'immigrant' [524,525]. However, an individual who migrates, both domestically and internationally, may decide to stay permanently within the new location or country they have migrated to [523,526]. This brings together similarities across the terms international migration and immigration. In relation to these continual changes of location and possibility of permanent residence through both international and domestic migration, alongside the negative connotations and discrimination surrounding the term immigrant [523,525,527,528], this thesis refers to migrants and migration only. These two terms of migrant and migration encompass both domestic and international movement and residence of migrants.

3) By exploring how older adults are engaged in public health research, pathways for evaluating good quality CS and participatory literature were identified alongside ways in which older adult engagement can be strengthened.

Although finding similarities with other reviews exploring older adults engaging in participatory literature [517-519], this review also found that a level of co-production or 'by the people' engagement is key for enhancing relevance, sustainability and translation of outcomes to both the local and community-

level. A novel contribution by this review was also the development of the Citizen Science Appraisal Tool (CSAT). This is an evaluation tool that can provide a standardised approach to allowing studies to enhance their levels of engagement and evaluate the quality of the approaches they employ. This includes embedding co-production or 'by the people' levels of engagement throughout each stage, from development to dissemination. It also includes producing robust data-driven strategies directed by those engaged, clarity and partnerships within the study roles, accessible dissemination and real-world implications and considers the long-term changes and impacts. The CSAT can in turn guide future studies in their CS and participatory initiatives, embedding meaningful levels of engagement and producing outcomes that have real-world implications for those engaged.

To build on these contributions further, the systematic scoping review manuscript is presented, with an expansion of the discussion and its wider implications for public health and ageing research in Chapter 7.

4.1.1 Author Contributions

GW led the data collection and analysis. GW, AS and JP contributed towards the study design. GW, PD, SA-B, AS, and JP were involved in the systematic scoping review process and data synthesis. GW developed the CSAT with critical input from AS, JP, AB and AK. GW drafted the manuscript, AS and JP reviewed the manuscript and GW undertook manuscript revisions with guidance from all co-authors. All authors read and approved the final draft.

4.2 The Role of Urban Environments in Promoting Active and Healthy Ageing: A Systematic Scoping Review of Citizen Science Approaches

Wood GER, Pykett J, Daw P, Agyapong-Badu S, Banchoff A, King AC, Stathi A.

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4.2.1 Abstract

Promoting active and healthy ageing in urban spaces requires environments with diverse, age-friendly characteristics. This scoping review investigated the associations between urban characteristics and active and healthy ageing as identified by citizen science (CS) and other participatory approaches. Using a systematic scoping review procedure, 23 articles employing a CS or participatory approach (participant age range: 54–98 years) were reviewed. An inductive and deductive thematic analysis was completed to (a) identify local urban barriers and facilitators and (b) map them against the World Health Organization (WHO) Checklist of Essential Features of Age-Friendly Cities. A new Citizen Science Appraisal Tool (CSAT) was developed to evaluate the quality of CS and other participatory approaches included in the reviewed articles. A range of interconnected urban barriers and facilitators was generated by residents across the personal (e.g. *perceived safety*), environmental (e.g. *unmaintained infrastructure*), socio-cultural (e.g. *cross-cultural activities*), economic (e.g. *affordable housing*) and political (e.g. *governmental support to migrant communities*) domains. Mapping the barriers and facilitators to the WHO age-friendly checklist underscored the checklist's relevance and elucidated the need to explore *barriers for migrant and cross-cultural communities* and *neighbourhood development and alterations*. The CSAT demonstrated strengths related to active engagement of residents and study outcomes leading to real-world implications. To advance the potential of CS to enrich our understanding of age-friendly environments, employing co-production to enhance relevance and sustainability of outcomes is an important strategy. Overall, employing CS highlighted the value of systematically capturing the experiences of older adults within studies aimed at promoting active and healthy ageing.

4.2.2 Introduction

The combination of increasing levels of urbanisation and an ageing population worldwide has highlighted the importance of city-level public health initiatives targeting older adults [4,529]. Urban environments and their physical and socio-ecological characteristics can significantly impact a resident's ability to age healthily [19,530]. To operationalize this knowledge globally, the World Health Organization (WHO) launched guidance in 2007 for developing age-friendly environments based on the concept of active ageing [21], targeting eight urban domains: outdoor spaces and buildings, housing, transportation, respect and social inclusion, social participation, communication and information, community support and health services, and civic participation and employment. The WHO guidelines have been influential in directing the global urban planning agenda towards developing age-friendly environments. However, successful implementation of this agenda requires a comprehensive understanding of the uniqueness and complexity of urban environments and their competing social, economic and political forces [531-533].

There is a large public health literature and policy drive towards 'age-friendliness' and 'ageing in place', which refers to ageing at home rather than in institutional care [534]. Despite this, the concept of active ageing still lacks sufficient attention to the diverse range of contextual urban socio-ecological elements required to support older adults' health and wellbeing [535]. Person-specific influences, inaccessible physical environments, migration behaviours, multiple forms of deprivation and local community cohesion are just a few urban socio-ecological elements that influence a healthy and active lifestyle [418,536-538]. As these factors vary across communities and populations, identifying and prioritising urban characteristics that contribute to developing age-friendly environments thus remains a challenge for

research and policy [520], particularly in relation to characteristics that are influential at the local-level [8]. In turn, the unique pathways between urban features and healthy ageing and the intersections between older people and their communities need to be more fully articulated. Understanding these at a local contextual level is important to effectively shape the opportunities to live and age in health-enhancing ways.

To address local-level variations and deliver more meaningfully on the age-friendly agenda, an increasing number of age-friendly strategies have focused on the need to foster effective engagement of older adults [54,522]. There are multiple participatory practices for engaging members of the public in research, which overlap in their processes but differ in the level of 'power' given to residents [254,539]. Across a variety of applications, citizen science (CS) can effectively engage laypeople in all stages of the research to co-produce its processes and outcomes [106,312]. Through its systematic application in the health and urban domains, the local expertise of residents has been successfully incorporated into multi-level outcomes for altering local urban communities to promote health and wellbeing [111-113], which has effectively advanced the development of age-friendly environments [54].

Notwithstanding these promising studies on the potential for CS, a rigorous assessment and evaluation of CS approaches is required to understand its potential for effectively engaging individuals in shaping outcomes for their local spaces [125,308,393]. Previous studies advancing CS have produced tools evaluating elements of CS methods, public participation and outputs [125,313]. However, greater attention to evaluation processes needs to be paid to the diversity of approaches within such research methodologies, including the degree to which they are contributory (*for the people*), collaborative (*with the people*) or co-productive (*by the people*) [97,106], as well

as how sustainable and significant the outcomes are from the perspective of older adult community members themselves [340,540].

Emphasising collective forms of CS to enhance age-friendly urban initiatives is especially pertinent, given what is already known about the mutually beneficial importance of social connection, walkability and physical activity in older age groups [541,542]. This systematic scoping review aimed to investigate the urban barriers and facilitators identified through CS and other participatory approaches to be associated with active and healthy ageing. The objectives of this review were to:

1. systematically review the outcomes of CS studies in which community members identify the characteristics influencing active and healthy ageing in urban environments;
2. map the outcomes of the scoping review against the WHO Checklist of Essential Features of Age-Friendly Cities [39] and explore similarities and differences; and
3. develop and apply a new Citizen Science Appraisal Tool to evaluate the quality of the CS methods included in the scoping review.

4.2.3 Methods

A systematic scoping review was chosen as a suitable approach to identify and map the key urban characteristics presented by CS studies and highlight knowledge gaps [371]. The protocol was guided by the PRISMA systematic review guidance [543] and scoping review extension checklists [544] and reviewed by academic experts in the fields of CS, healthy ageing and political geography.

Study Eligibility, Information Sources and Search Strategy

Studies were eligible if they met the criteria in Table 5. CS can take various forms and employ varying degrees of public participation and is an evolving approach with continuously changing terminology[108,299]. This review aimed to be inclusive of any studies that have directly engaged older adults in one or more stages of the research process using CS or other participatory approaches [305,539].

Table 5. Inclusion criteria and guidance

Criteria	Guidance
Studies engage residents aged 60 years or above	Residents must be aged 60 or above, or if other age groups are engaged then residents must have an average age of 60 years
Studies are completed in an urban setting	Studies include any of the following key words to represent urban settings (1) Urban (environment, area, setting); (2) Built (environment, area, setting); (3) Age-friendly (city, cities, environments); (4) City/Cities; (5) Physical (environment, area, setting); (6) Outdoor (environment, area, setting); (7) Inclusive Community/ies; (8) Neighbourhood/s. Studies that also undertake a comparison between urban and rural settings are included if there is a clear separation of results and outcomes for both settings
Studies must employ a citizen science or participatory approach in any or all stages	Citizen science is defined as resident-engaged citizen science [54]in which laypersons, in particular older adults, engage or participate in research with the intention of scientific advancement [106,305]. Studies that use the term 'citizen science' or directly engage older adults in any or all stages of the research using a participatory approach can be included
Studies are completed in an urban setting; (3)	Active ageing is defined as 'the process of optimizing opportunities for health, participation and security in order to enhance the quality of life as people age' [37].Studies include any

Studies aim to investigate the relationship between urban environments and active and healthy ageing (or a component of active ageing)	of the following key words: (1) Active Ageing; (2) Healthy Ageing; (3) Successful Ageing; (4) Ageing Well; (5) Positive Ageing; (6) Productive Ageing; (7) Meaningful Ageing; (8) Active lifestyle; (9) Healthy lifestyle. Studies that have used any of active ageing key words above and explored the following domains will also be included to incorporate the 'active' element [37]: (1) Physical activities; (2) Social activities; (3) Economic activities; (4) Cultural activities; (5) Spiritual activities; (6) Civic Affairs; (7) Labour force activities

An iterative approach [535,545] allowed the search strategy and keywords to be reviewed and revised based on the relevant literature identified throughout the review process. A preliminary trial search of databases was completed (GW) and discussed with 2 reviewers (AS, JP) to produce a refined set of keywords. The keywords combined all possible combinations, English and American spelling, Boolean operators and truncation (Appendix 2). Searches were completed on MEDLINE, Embase, PsycINFO, Social Policy and Practice, CINAHL, PubMed, Scopus and Cochrane Library between 01/03/2020 and 01/06/2020, with an updated search completed between 01/06/2020 and 19/06/2021. Articles were recorded using EndNote (X9, 2019) reference management software, and duplicates, non-English language and grey literature were excluded.

Screening and Data Extraction

Titles and abstracts were screened by the lead reviewer (GW), with a randomly selected 20% of articles independently screened by two reviewers (PD, SA). Articles that did not meet inclusion criteria were excluded. The same process was completed

for full-text screening, with a fourth reviewer (AS) present to discuss discrepancies (Figure 15). Data were extracted from the final set of included studies (GW) and independently checked (PD). The data extracted included (1) study aims, setting, design and method; (2) focus of the study (e.g. active ageing focus, urban focus); (3) participant characteristics; 4) details of CS or other participatory approaches; (4) urban environment characteristics or methodology outcomes; and (5) conclusions and recommendations.

Citizen Science Appraisal Tool

The Citizen Science Appraisal Tool (CSAT) (Table 3) was developed to evaluate the quality of CS and other participatory approaches. Quality is defined here in relation to the levels of active engagement and partnerships utilised by CS studies [380]. These two factors of engagement and partnerships are evaluated through a lifecycle approach [546] starting with the aims of a study through to its outcomes and future impacts and consider the scientific standards, participation, data quality and dissemination, which are elements of good quality CS [312,547]. The tool development was guided by the European Citizen Science Association (ECSA) 10 principles [312] and Critical Appraisal Skills Programme (CASP) tools [394,395] and encompassed three levels of engagement: contributory (*for the people*), collaborative (*with the people*) and co-productive (*by the people*)[106] (Appendix 1).

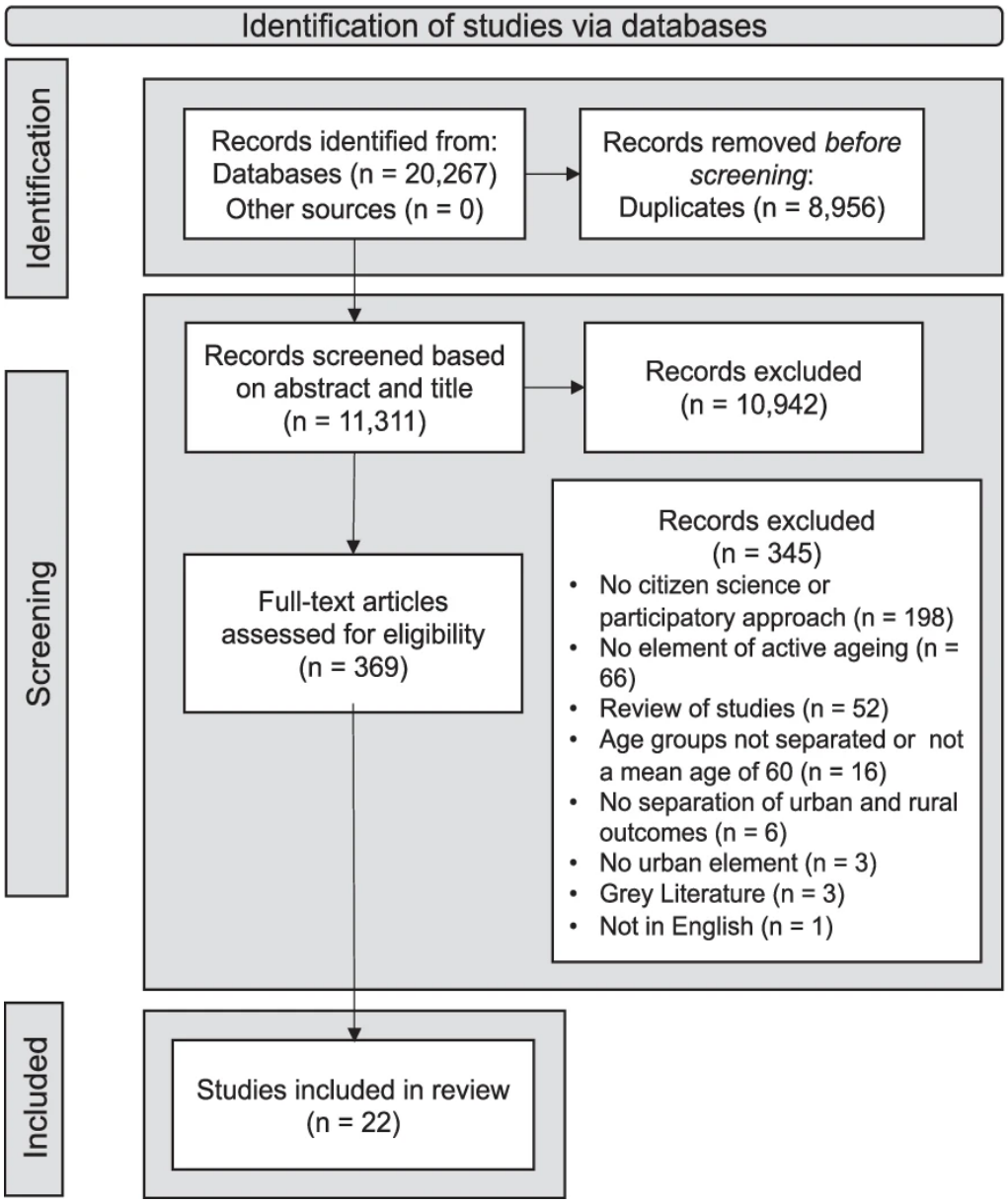


Figure 15. Flow diagram of article selection (Adapted from PRISMA flow diagram 2021[543]).

The tool gives equal weight to all questions to encompass both CS engagement and scientific standards. Active engagement and developing real-world outcomes are crucial elements of CS [380,397] alongside demonstrating validity, transparency and appropriateness of methods and data [291,390,396]. Providing equal weight enables the tool to assess the quality of CS engagement and scientific standards, which are

elements of good quality CS [312,547]. All included studies were evaluated using the CSAT (GW), with 20% of evaluations independently checked (AS, JP).

Data Charting and Analysis

A descriptive summary of the 23 included studies was completed, followed by a thematic analysis and narrative synthesis. This was deemed suitable to systematically identify, map and synthesise the qualitative nature of the methods and outcomes. An inductive thematic analysis [491,505] was completed to generate community-identified local urban barriers and facilitators of active and healthy ageing. The lead author (GW) completed initial coding, with codes, subthemes and main themes discussed with two reviewers (PD, SA). A second stage of coding was completed (GW) and discussed with three reviewers (PD, AS, JP). The final themes were confirmed by all reviewers. Following this process, two articles [369,548] were excluded from this analysis as their outcomes focused on an overview of their methodology rather than urban characteristics.

A deductive thematic analysis [491,505] was completed to map the barrier and facilitator themes against the WHO Checklist of Essential Features of Age-Friendly Cities[39]. This checklist presents 8 age-friendly features that encompass 84 relevant urban descriptors (https://www.who.int/ageing/publications/Age_friendly_cities_checklist.pdf). The lead author (GW) completed initial coding which was discussed with two reviewers (PD, SA). A second stage of coding was completed (GW) and discussed with three reviewers (PD, AS, JP) in which themes mapped against the WHO descriptors were finalised. Lastly, a narrative synthesis [375,549] was completed to provide a summary of

evidence on the CS methods and their quality and potential capacity to strengthen age-friendly urban initiatives.

4.2.4 Results

Twenty-three studies were reviewed (Table 6), with the quality of CS approaches evaluated using the CSAT (Table 3). Most studies were published between 2015 and 2020 ($n = 19$) and took place in the UK ($n = 6$), Canada ($n = 6$) and/or USA ($n = 4$), Australia ($n = 2$), Hong Kong ($n = 2$), Netherlands ($n = 1$), Sweden ($n = 1$), New Zealand ($n = 1$) and Finland ($n = 1$). Data collection duration ranged from 2 weeks ($n = 2$), 1 to 12 months ($n = 12$), 3 years ($n = 1$) and during spring or fall ($n = 2$). Duration was not reported by 7 studies. The studies included observational ($n = 20$) and cross-sectional ($n = 3$) research designs. Residents were aged between 54 and 98, with one study not reporting the age of participants [550]. Ethnicity, sex and other demographic variables are presented in Table 5.

Quality of Citizen Science and Other Participatory Approaches

The development and use of the CSAT (Table 7) highlighted the capacity for CS to further the age-friendly agenda by effectively engaging older adults to identify local urban barriers and facilitators. The CSAT also demonstrated elements of CS approaches employed in the studies that could be further strengthened to advance the level of active engagement and long-term sustainability of a study and its outcomes.

Table 6. Summary and characteristics of the 20 included studies, in order from CSAT highest to lowest quality

Author, Year, Location	Study Aim, Duration, Urban Setting & Active Ageing Element	Population	Citizen Science/ Participatory Research Design & Methods	Main Findings
Barrie et al. (2019), Australia (117)	**Aim:** To test a new smart phone-based audit tool using an innovative methodology—citizen science—in order to explore how and why older people engage with public green spaces **Duration:** Six to ten weeks data collection with focus group after **Urban Setting**: Public Green Spaces (i.e., parks, gardens) **Active Ageing Element:** Ageing Well	**N** = 15 (Female = 12, Male = 3) **Age Range** = 60-84 years **Ethnicity** = Not reported **Target Population** = Not reported	**Design:** Citizen Science Approach and Co-Created Model **Methods:** Audit of green spaces using digital audit tool, interviews & co-analysis	**1) Key design elements** of public green spaces included seating, street trees, natural bushland, park trees, and water (creeks, lakes, rivers) **2) Main reasons for visiting green spaces** included “On my way to somewhere else”, “to relax”, “to exercise” and “to meet others”. The majority of citizen scientists spent “Less than 15 minutes” in green spaces followed by “15 to 30 mins”
Gustafsson et al., (2018), Sweden (551)	**Aim:** To describe life filming as a means of participatory approach in relation to older community-dwelling persons and the design of their local environment **Duration:** Took place in the fall **Urban Setting:** One of ten urban districts in the city of Gothenburg **Active Ageing Element:** Healthy Ageing, Active Ageing	**N** = 7 (Female = 5; Male = 2) **Age Range** = 69-78 years **Ethnicity** = Not reported **Target Population** = Community-dwelling persons aged 65 years or	**Design:** Participatory Approach **Methods:** Life Filming & group meetings	**Five themes for central aspects of life filming:** 1) Anchoring the concept of participation 2) Practical application of life filming 3) The film as a product 4) Making a real difference 5) An identity as a capable older person

		older, including individuals with visual impairments		**Life films highlighted the barriers of the environment as** hazardous traffic situations, lack of or incorrect weather protection at tram stations, difficulties handling the digitalized society, barriers to a wheelchair user accessing buildings, and thoughts about future housing opportunities
von Faber et al. (2020), Netherlands (552)	**Aim:** To describe how participatory video design can add knowledge about the preferences and needs of older people about the improvement and preservation of their local environment **Duration:** One week data collection, one week workshop **Urban Setting:** Two cities, the Hague and the city of Leiden **Active Ageing Element:** Active ageing through participation in research	***The Hague*** **N** = 21 (Female = 14, Male = 7) **Age Range** = 63-90 **Ethnicity** = Dutch, Chinese Surinamese **Target Population** = Residents over 60 years or older ***The city of Leiden*** **N** = 9 (Female = 3, Male = 6) **Age Range** = Not reported	**Design:** Participatory Research **Methods:** Participatory video design and workshop	**1) Topics of the films** included outdoor spaces, housing, social participation, communication and information, and social contacts and community support **2) The process of** participation demonstrated telling a story, learning something new, forming new friendships, and owning the story were strengths of the process

		Ethnicity = Not reported **Target Population** = Residents over 60 years or older		
Tuckett et al., (2018), Australia [304]	**Aim:** 1) What are the features that help or hinder access to a seniors' centre?; 2) What are the features of the physical environment surrounding a seniors' centre that help or hinder physical activity (walking)?; 3) In what ways can older adults acting as citizen scientists bring about changes to their local environment? **Duration:** Three months **Urban Setting:** Community Centre Adjacent to Parklands **Active Ageing Element:** Active Ageing, Successful Ageing	**N** = 8 (Female = 7; Male = 1) **Age** = 65 Years or Over **Ethnicity** = Not reported **Target Population** = Member of the Burnie Brae, aged 65 years or over, able to walk unaided, actively engaged in a range of social activities	**Design:** Exploratory Citizen Science Community-Based Empowerment Approach **Methods:** *Our Voice* citizen science framework using a non-medical mobile application, discussion group and activate sessions	**Hindrances and facilitators to physical activity, walking and access:** 1) Parks/Playground – Sleeper that is a safety risks, need care to step on cement slabs, need for more covered shade over the tables 2) Footpaths - Shared pathways between bikes and pedestrians were both a facilitator and hindrance, loose gravel paths are a hindrance, damaged footpaths are a hazard, footpaths 3) Traffic related Safety/Parking – Lack of parking, cars parked blocking drivers view, need for repainting of car park lines

Ronzi et al. (2016), UK [553]	**Aim:** To stimulate collective action and advocacy to affect policy and empowerment by (i) encouraging dialogue between older people and city stakeholders at the exhibition; and (ii) by ensuring that older people's views were brought to the attention of city stakeholders so that they could include their concerns in decision making and planning processes for an AFC **Duration:** Seven months **Urban Setting:** City of Liverpool **Active Ageing Element:** Respect and Social Inclusion (Element of Active Ageing/Age-friendly Cities)	**N** = 26 (Female = 19; Male = 7) **Age Range** = 60->85 **Ethnicity** = White British (77%); Asian British (8%); Black British (12%); Other White Background (3%) **Target Population** = Older adults from four electric wards	**Design:** CBPR* **Method:** Photovoice, semi-structured interviews & focus groups	**Opportunities, challenges and solutions of using photovoice:** 1) The photo-production process as a way to raise participants' consciousness 2) Photographing negative aspects which included wanting to portray the environment in a positive light or not perceiving negative aspects 3) Photographing negative social concepts which participants found hard to photograph (i.e. social isolation) 4) Time period for taking photographs 5) Ethical aspects 6) Overcoming challenges such as addressing 'missing photographs' and photography training **Barriers and facilitators to respect and social:** 1) Bus station considered very uncomfortable due to lack of protection from the

				win and an enclosed bus and train station would be an enabler 2) Public toilets that are not accessible or inviting are a barrier to social inclusion
Buffel & Phillipson, (2019), UK [554]	**Aim:** This study explores the experiences of older residents who have lived much of their adult lives in the same locality but whose views have been largely ignored in gentrification research **Duration:** Not reported **Urban Setting:** Three Neighbourhoods in Suburb of Manchester **Active Ageing Element:** Active Ageing, Ageing Well, Ageing-in-Place	**N** =106 ***Co-Researchers*** **N** = 18 (Female = 10; Male = 8) **Age Range** = 58-74 years ***Focus Groups*** **N** = 58 (Female = 33; Male = 25) **Age Range** = 60-95 years **Ethnicity** = White British (67%); White Irish (23%); White Other (7%); Black/African/Caribbean/ Black British (3%) ***Interviewees*** **N** = 30 (Female = 14; Male = 16) **Age Range** = 61-98 years	**Design:** Co-Research; PAR** **Methods:** Focus groups and interviews conducted by older adults trained as co-researchers	**Two main themes emerged:** 1) Experiences of Community Change which related to developments affecting neighbourhoods, tension between those moving into the area and those living there, experiences of rejection or exclusion) 2) Responses to Gentrification: Strategies of Control which related to natural neighbourhood networks in terms of informal relationships that enhance wellbeing and shape everyday social world

		Ethnicity = White British (40%); White Irish (23%); White Other (7%); Asian/Asian British (13%); Black/African/Caribbean/ Black British (3%) **Target Population** = Older Residents		
Ronzi et al. (2020), England [555]	**Aim:** To explore the extent to which respect and social inclusion were promoted as the city sought to become more age-friendly, and to actively involve older adults in the research process **Duration:** One and a half months **Urban Setting:** Liverpool, UK **Active Ageing Element:** Healthy ageing, active ageing	**N** = 26 (Female = 19, Male = 7) **Age Range** = 60-85 years **Ethnicity** = White British (77%), Asian British (8), Black African British (12%), Other White Background (3%) **Target Population** = Older person aged 60+ years	**Design:** CBPR* **Methods:** Photovoice, semi-structured interviews, focus group discussions	**1) Aspects of urban environments** influential of respect and social inclusion included accessibility, affordability, and sociability of physical spaces. The physical and social environment contributed to a sense of exclusion. Communication and access to information were important aspects of social and digital inclusion **2) The physical environment** encompassed green and blue spaces, transportation, public facilities

				3) The social environment encompassed places to cultivate learning, art, culture, informal and formal relationships, negative age perceptions and neighbourhood fragmentation
Black et al. (2015), USA (556)	**Aim:** To advance our understanding of older adults' perceptions and the broader contributions of community residents in affecting dignity and independence in every-day interactions with older adults. **Duration:** Four months **Urban Setting:** Community Life/ Community-Dwelling **Active Ageing Element:** Ageing well	**N** = 484 ***Community-based forums and online participation*** **N** = 217 **Age Range** = 12-96; 12-19(10%), 20-44 (13%), 45-64 (39%), 65 and older (38%) **Ethnicity**= Not Reported ***Focus Groups*** **N** = 51 (Female = 80%; Male = 20%) **Age Range** = 65-98 years **Ethnicity** = White (83%), African	**Design:** PAR** **Methods:** Community forums, focus groups and online surveys	**Six actionable themes of ageing with dignity & independence:** 1) Meaningful involvement 2) Respect & inclusion 3) Communication & information 4) Health & wellbeing 5) Ageing in place 6) Transportation and mobility

		American (15%), Other (2%) ***E-Survey*** **N** = 216 (Female = 70%; Male = 30%) **Age Range** = 65-96 **Ethnicity** = White (98%), African American (2%) **Target Population** = Residents of local geographic community and age 65 or older		
Annear et al. (2014), New Zealand (557)	**Aim:** To develop community-generated recommendations to inform urban environmental remediation following earthquakes in Christchurch, New Zealand, and share these with local decision-makers during a PAR** process **Duration:** One month **Urban Setting**: Christchurch (City, 49,000 residents) **Active Ageing Element:** Active ageing	**N** = 355 ***Survey Phase*** **N** = 355 (No other characteristics reported) ***Qualitative Research Phase*** **N** = 66 (N = 30 for focus group phase) (Female = 41; Male = 25) **Mean Age Range** = 67-82 years **Ethnicity** = Not reported	**Design:** PAR** **Method:** Focus Group Discussions	**Six emergent themes of barriers to active ageing:** 1) Loss of activity venues; 2) Cancellation of meetings and events; 3) Confinement and isolation; 4) Fragmentation of social networks; 5) Damage to transport networks; 6) New hazards; 6) Disruptions to activities of daily living. Six recommendations for post-earthquake redevelopment: 1) Remediation of

		Target Population = Aged 65 years and older and residing in one of the 12 study areas		earthquake-affected suburbs; 2) Transportation and mobility needs in earthquake-affected suburbs; 3) Age and disability friendly rebuilding; 4) Safe and resilient communities; 5) Resilience of support agencies; 6) Access to venues for social and cultural activities
Mahmood et al. (2012), USA/Canada (558)	**Aim:** To conduct a participatory research process with community-dwelling older adults using photovoice method to identify neighbourhood physical environmental features and social aspects that influence physical activity in older adults **Duration:** Two-week photovoice activity and up to four training or discussion sessions **Urban Setting:** Four neighbourhoods in metropolitan Vancouver and four neighbourhoods in Greater Portland **Active Ageing Element:** Ageing (discusses active ageing)	**N** = 66 ***Portland*** **N** = 32 (Female = 20; Male = 12) **Age Range** = 65-92 **Ethnicity** = Not reported ***Oregon*** **N** = 34 (Female = 25; Male = 9) **Age** = 65-87 **Ethnicity** = Not reported Target Population : 65 years of age or older, living in the community	**Design:** PAR** **Method:** Photovoice and discussion group	**Seven themes emerged from photographs:** 1) Being safe and feeling secure 2) getting there 3) comfort in movement 4) diversity of destinations 5) community-based programs 6) peer support 7) intergenerational/volunteer activities

Glover et al. (2019), UK (559)	**Aim:** Provide a description of a theoretically in- formed co-creation study to investigate what it means to maintain health and wellbeing in older age and how to support this in a local context. Secondly, we offer process evaluation with reflections and recommendations on practice and effective co-working **Duration:** Three months **Urban Setting:** Northern UK City **Active Ageing Element:** Healthy Ageing	**N** = 14 ***Lay Persons*** **N** = 10 (Female = 7; Male = 3) **Age Range** = 70-79 **Ethnicity** = White British (100%) ***University Members*** **N** = 4 (Female = 4) **Age Range** = 27-57 **Ethnicity** = White British (100%) Target Population = Not reported	**Design**: An iterative co-creation approach using a qualitative approach **Methods:** Project group meetings with an open structure	**The outcomes demonstrated the following key points:** 1) Develop a shared understanding of the meaning of healthy ageing 2) Identify barriers and facilitators to adopting behaviours that would support the identified essential components of healthy ageing 3) Make recommendations for adapting local services or developing new ones that are feasible, acceptable and sustainable
Fang et al. (2016), Canada (560)	**Aim:** How applications of community-based participatory research methods, in particular, participatory community mapping workshops (PCMWs), can be used to access experiences of place, identify facilitators and barriers to accessing the built environment and co-create place-based solutions among older people and service providers in a new affordable	**N** = 54 ***Residents of Affordable Senior Housing development*** **N** = 38 **Age** = Over 60 **Ethnicity** = Not Reported ***Local Service Providers***	**Design:** CBPR* **Methods:** Participatory community mapping workshops, group walks & mapping exercises	**Three key themes for establishing opportunities for positive ageing-in-place:** 1) Identifying services and voicings needs 2) Opportunities for social participation 3) Overcoming cross-cultural challenges

	housing development in Western Canada **Duration:** Not reported **Urban Setting:** Senior Community Centre **Active Ageing Element:** Positive Ageing (not only ageing-in-place but positive ageing in the 'right' place)	**N** =16 **Age** = Not Reported **Ethnicity** = Not Reported **Target Population** = Residents of a seniors housing development and local service providers		
Buffel (2018), UK (369)	**Aim:** To provide insights into the process of co-producing a research project with older residents living in low-income neighbourhoods in Manchester, United Kingdom **Duration:** Not reported **Urban Setting:** Low-income neighbourhoods in Manchester, UK **Active Ageing Element:** Active Ageing (through the WHO Age-friendly city focus)	**N** = 86 ***Co-Researchers*** **N** =18 (Female = 10; Male = 8) **Age Range** = 58-74 **Ethnicity** = White British (9); Black British (1); White Irish (4); Asian British (2); Black Caribbean (1); Black African (1) ***Interviewees*** **N** = 68 (Female = 37; Male= 31) **Average Age** = 75	**Design:** Co-Production and Co-Research building upon partnership strategy **Methods:** Training older adults as co-researchers, who then completed interviews	**Motivations to become a co-researcher:** 1) The desirability of maintaining an active post-retirement lifestyle which included a 'busy ethic 2) Commitment to neighbourhood change which included 'contributing to neighbourhood change' 3) Opportunities for personal development which included 'learning from each other' 4) The relationship between co-researchers and interviewees which included strengths such as

		Ethnicity = Minority Ethnic Background (32%) **Target Population** = Personal experiences of ageing, links with different groups of older residents; good communication and listening skills		peer-to-peer approach in which co-researchers could empathize with interviewees experiences, and weaknesses such as co-researchers and interviewees attitudes towards ageing which may be insensitive and create pressure
Brookfield et al. (2020), UK (550)	**Aim:** To further aid older adult's involvement in environment design decisions, the aim is to provide a critical perspective on eight 'less traditional' engagement techniques **Duration:** Three years **Urban Setting:** Central Manchester, Hackney Wick (East London), Kirkwall (Orkney Islands) **Active Ageing Element:** Healthy Ageing	**N** = 93 ***Co-design workshop*** **N** = 36 (no other characteristics reported) ***Design Review*** **N** = 35 (no other characteristics reported) ***1-to-2 Interactions*** **N** =22 (no other characteristics reported) **Target Population** = Community dwelling older	**Design:** Participatory Design Events (Including Co-Design Workshops) **Methods:** Co-design workshops, design review events, photovoice, walking interviews, photo-elicitation, talking mats, model-making, participatory mapping, drawing. Within these methods, structured interviews & focus groups were implemented	**Valuable engagement techniques for aiding older adult involvement in environment design:** 1) Walking interviews due to immersion in the environment enabling important topics related to design to be discussed 2) Photovoice is easy to engage with and produced extensive material for design decisions 3) Interviews using photo-elicitation and 'Talking Mats' prompt expansive responses and are popular

		adults (stroke survivors and people with dementia included in the 1-to-1 interactions)		and novel techniques for older adults 4) Design fairs encouraged involvement due to a 'drop-in' approach
Aw et al.(2017), Hong Kong (561)	**Aim:** To identify, contrast and explain the continuum in which older people in the multi-ethnic diverse Asian context of Singapore participate in community and social life **Duration:** Four months **Urban Setting**: Outdoor neighbourhood settings **Active Ageing Element:** Active ageing	**N** = 109 ***Community Focus Groups*** **N** = 83 (Female =59 , Male = 22) **Median Age** = 65-79 **Ethnicity** = Mixed (30%), Chinese (36%), Indian (24%), Malay (10%) ***Photovoice*** **N** = 19(Female = 12 Male = 7) **Median Age** = 60-74 **Ethnicity** = Chinese (74%), Malay (26%) ***Walkthrough Spaces***	**Design:** Ethnographic approach and CBPR* **Methods:** Photovoice, 'go-along' interviews and focus group discussions	**Three ways in which older people participate in community and social life in relation to active ageing:** 1) Seeking out consistent social interactions 2) Seeking expansion of social network 3) Seeking to give back to society

		N = 7 (No other characteristics reported) **Target Population** = Older than 55 years old		
Salma et al. (2020), Canada (562)	**Aim:** To elicit perceptions of ageing and related needs of immigrant Muslim communities in an urban centre in Alberta **Duration:** Seven months **Urban Setting:** Urban centre in Alberta, Canada **Active Ageing Element:** Healthy ageing, ageing well	***Older adults*** **N** = 51 (Female = 74%, Male = 26%) **Age Range** = 55-85 **Ethnicity** = South/East Asian (49%), Arab (26%), African (21%), Other (4%) ***Stakeholders*** **N** =16 (No other demographics reported) **Target Population** = Being a community-dwelling individual, 55 years of age or older, self-identified as Muslim, and an immigrant to Canada.	**Design:** CBPR* **Methods:** Focus groups and individual interviews	**Three major themes capture experiences of growing old in Canada:** 1) Ageing while living across planes 2) Negotiating access to age-supportive resources in a time of scarcity 3) Re-envisioning Islamic approaches to eldercare

Novek et al. (2014), Canada (563)	**Aim:** To use a participatory methodology to explore older adults' perceptions of age-friendliness and to identify priorities and barriers to making communities more age-friendly **Duration:** Not reported **Urban Setting:** Manitoba (City, Population of 660,000) **Active Ageing Element:** Active Ageing, Ageing within Community Context	**N** = 30 ***Urban*** **N** =8 (Female= 7; Male = 1) **Age Range** = 54-79 **Ethnicity** = Not reported ***Rural*** **N** =22 (Female = 16; Male =6) **Age Range** = 54-81 **Ethnicity** = Not reported **Target Population** = Not Reported	**Design:** Participatory Approach **Methods:** Photovoice, interviews & group discussions	1) **Age-friendly features** included the physical environment, businesses and services, housing, social environment, activities and volunteering, community support and health services, transportation 2) **Contextual factors** included community history and identity, ageing in rural and remote communities, environmental conditions 3) **Cross-cutting themes** included Independence, affordability and accessibility
Adorno et al. (2018), USA (71)	**Aim:** To examine older adults' experiences and perspectives regarding transportation mobility Duration: Four months **Urban Setting:** Arlington, Texas (Third Largest City, Major Urban Centre) **Active Ageing Element:** Ageing Well	**N** = 60 ***Homebound*** **N** = 15 (53% Female; 47% Male) **Mean Age (SD)** = 71.2 (9.45) **Ethnicity** = White (73%), African America (13%), Hispanic (13%) ***Focus Groups***	**Design:** CBPR* **Method:** Semi-structured interview guides and demographics questionnaire	**Four transportation mobility barrier themes to ageing well:** 1) An inadequate system: I can take you, but I can't get you home 2) People and Places: Transitioning in different directions 3) Being 'Stuck': The political economy of transportation

		N = 45 (Sex not reported) **Mean Age Range** = 62.89-81 **Ethnicity** = White (38%), Vietnamese (24%), Hispanic (21%), African American (17%) **Target Population** = Arlington residents aged 55 or older		4) If we're shut out, we're stuck in (perception of larger community being unsupportive to persons who are economically and transportation disadvantaged)
Chui et al. (2019), Hong Kong[548]	**Aim:** To explore how the process of participating in a photo-voice project facilitated participants' civic participation, and propose an empowerment-based participatory photo-voice training model **Duration:** Not reported **Urban Setting:** Local Communities of Participating Older Adults **Active Ageing Element:** Active Ageing	**N** = 12 (Female = 6; Male = 6) **Mean Age** = 66.8(5.5) **Ethnicity** = Not Reported **Target Population** = Older adults who previously took part in photo-voice training	**Design:** Empowerment-based participatory training model **Methods:** Focus groups to evaluate empower-based participatory photo-voice training model (previously used)	**Six key themes for the photovoice process:** 1) Photovoice is an effective means of conveying older adults' views 2) Photovoice broadens older adults' perspectives and promotes inclusion 3) Photovoice enables knowledge acquisition and dissemination 4) Photovoice enhances older adults' civic awareness and participation

				5) Photovoice fosters a sense of confidence and empowerment among old adults 6) Photovoice fosters intergenerational relationships
Garvin et al. (2012), Canada (564)	**Aim:** 1) Delineate those characteristics of the built environment that are meaningfully different between summer and winter from the perspective of older adults; 2) ascertain which of the elements of the WHO Age-Friendly Cities Checklist are relevant to Edmonton seniors, and how; 3) Identify and critically evaluate additional characteristics seniors identify as particularly helpful to consider in low-density northern winter cities **Duration:** Two-week data collection and one focus group **Urban Setting**: Semi-Urban & Suburban Neighbourhoods in a Northerly major metropolitan area (population over 1 million) **Active Ageing Element:** Healthy Ageing	**N** = 11 ***Summer*** **N** = 6 (Female = 4, Male = 2) **Age Range** = 65-84 **Ethnicity** = Not reported ***Winter*** **N** = 5 (Female = 2, Male =2) **Age Range** = 55-84 **Ethnicity** = No reported **Target Population** = Not reported	**Design:** Photo Elicitation **Methods:** Photo-elicited focus group method (focusing on older adults telling their story)	**Summer concerns for healthy ageing included:** 1) Ramps, stairs, railings and curb cuts; 2) Fear of others; 3) Obstacles and broken pathways; 4) Seating; 5) Public Transit; 6) Aesthetics and cleanliness **Winter concerns for healthy ageing included:** 1) Ice, snow, windrows, drainage; 2) Cleanliness, litter; 3) Bus shelters; 4) Meeting places

Parekh et al. (2018), USA [565]	**Aim:** To explore the role of social capital (e.g., social support through indirect ties) and social cohesion (e.g., interdependent support among neighbours) to unravel pathways for building age-friendly communities **Duration:** Five months **Urban Setting:** Urban City in Southern U.S **Active Ageing Element:** Ageing Well Active Ageing, Successful Ageing	**N** = 60 (Homebound = 15; Classed as having a disability = 3) **Mean Age** = 68 **Ethnicity** = African American (11%), Vietnamese (17%); Hispanic (15%); Caucasian (27%) **Target Population** = At least 55 years of age and a current resident of the city	**Design:** CBPR* **Methods:** In-depth interviews and focus groups	**Three overarching themes that link social capital, social cohesion and civic engagement:** 1) Opportunities for social cohesion & civic engagement 2) Social inclusion barriers 3) Ageism
Hand et al. (2018), Canada [566]	**Aim**: 1) To describe a combined qualitative-geospatial approach for studying of older adults in neighbourhoods; 2) To investigate the qualitative-geospatial approach developed, including its utility and feasibility in exploring person–place transactions in neighbourhoods **Duration:** Not reported **Urban Setting:** Mid-sized Canadian City **Active Ageing Element:** Ageing in Context, Ageing in Neighbourhoods	**N** = 14 (Female = 11, Male = 3) **Age Range** = 66-94 **Ethnicity** = Caucasian (100%) **Target Population** = Aged 65 years or older and living in one of the target neighbourhoods for at least 1 year	**Design:** CBPR* and qualitative-geospatial approach **Methods:** Participatory Geospatial Methods including narrative interviews, go-along interviews, GPS tracking with activity diary, map-based interviews	**Findings related to the unique understanding that each method contributes including:** 1) The personal experiences provided though narrative interviews i.e. friendliness of neighbourhood encourages connections to new homes and walkability and amenities support healthy identity 2) Observing participants in the go-along interviews

				i.e. how participants interact with their social environment through greeting people and dogs, chatting with strangers in shops 3) Sense of participant's daily lives in their communities through activity/travel diaries 4) Construct further understanding of data through GPS Maps and Data
Verma & Huttunen (2015), Helsinki (567)	**Aim:** 1) To include the elderly as active participants in society; 2) To gain understanding of the user experience of the living environment integral to further local development **Duration:** Not reported **Urban Setting:** Lauttasaari (20,000 inhabitants, built environment, neighbourhood under development) **Active Ageing Element:** Active Ageing, Successful Ageing, Ageing in Place	**N** = 80 **Age Range** = 64-92 **Ethnicity** = Not reported ***Questionnaire*** **N** = 64 (Female = 81%; Male = 19%) ***Workshops*** **N** = 18 (Female = 72%; Male = 28%) ***Walk-throughs*** **N** = 18 (Female = 91%; Male = 9%)	**Design:** Participatory User Study Methods **Methods:** Workshops, walk-throughs, internet-based online questionnaire	**User experience of the living environment included:** 1) Social inclusion – Living alone in an unsuitable apartment can cause social isolation, and older adults were interested in housing models that enhance mutual aid and peer support 2) Services – To cope independently at home, it is important to be able to access services such as to

		Target Population = Elderly residents in Lauttasaari		go shopping and use public transportation 3) Green Areas – Nature and the sea are important sources of wellbeing, but older adults expressed the desire to have more common activities and sheltered sitting places in their own yards 4) Public Transportation – Lauttasaari is well connected to the city centre and older adults were heavy users of public transportation

*CBPR = Community-Based Participatory Research, **PAR = Participatory Action Research

Table 7. Citizen Science Appraisal Tool (CSAT) to evaluate the quality of citizen science studies using a 16-question scoring system with a maximum total of 32 points. (Y (Yes) = 2 points, N (No) = 0 points and ? (Unclear) = 1 point). See Appendix 2 for guidance on each question presented.

Section	Question	Y	N	?
Science & Research	1) Is there a clear statement of the aims, objectives or goals of the study?			
	2) Is it clear that the study used a citizen science approach?			
Leadership & Participation	3) Is the degree of active engagement or participation of citizens identified clearly by the study?			
	4) Are the roles, responsibilities and type of partnership between citizens, scientists and stakeholders identified and transparent?			
Delivery & Data	5) Is the extent to which citizen scientists are actively engaged or collaborate in the data collection, analysis, and use/dissemination clear?			
	6) Are citizen science data limitations or biases considered by the study?			
Outcome, evaluation & open data	7) Are the main findings of the study clearly described?			
	8) Are the study's outcomes a direct result from the data-driven strategies and solutions generated by the citizen scientists?			
	9) Do the outcomes of the study have 'real world' decision making implications or impact?			
	10) Does the study report intention to track and/or tracking of long-term impacts, changes or 'ripple effects' of the study?			
	11) Does the study report any evaluation of citizen knowledge, attitudes, actual and/or intended behaviours?			
	12) Does the publication report any accessible dissemination plans or intentional mechanism for sharing the study and its outcomes with citizens?			
	13) Are citizens invited to review or participate in the study's publication process?			

	14) Are the study's results and outcomes published in an open access format and/or shared in a publicly accessible format ?			
	15) Are citizen scientists acknowledged in the study's results and publications?			
	16) Does the publication provide any critical evaluation of the study, methods and/or examination of its limitations?			

Scores will be categorised using the following scale system, adapted from Wijewardhana et al Checklist [568]:

Low (0-6)	Low- Medium (7-12)	Medium (13-19)	Medium-High (20-26)	High (27-32)

Overview of Critical Appraisal Outcomes

The evaluative outcomes were categorised according to each study's score from the 4 sections of the CSAT. Fourteen studies were categorised as medium–high (presented below in detail), 8 studies were categorised as medium and 1 study was categorised as low-medium for quality (Table 8) (Appendix 2).

Table 8. Overview of the 23 included articles and their assigned category using the CSAT. A detailed explanation of scoring outcomes is available in Appendix 2.

Category	Total Number of Articles	Author, Year	Outcome Score *(Out of 32)*
Low (0-6)	0	N/A	
Low – Medium (7-12)	1	Verma and Huttunen (2015) [567]	11
Medium (13-19)	7	Hand et al. (2018)	14
		Parekh et al. (2018)	
		Garvin et al. (2012)	
		Chui et al. (2019)	16
		Adorno et al. (2018)	17
		Novek and Menec (2014)	19
		Salma et al. (2020)	
		Aw et al. (2017)	
Medium-High (20-26)	14	Brookfield et al. (2020)	20
		Buffel (2018)	
		Fang et al. (2016)	21

Medium-High Quality Studies

Studies in this category (*n* = 14) scored highly in the first 3 sections of the tool (Figure 16), suggesting key aspects to inform best practice. These studies provided a care overview of their CS or participatory approach, the degree of active engagement of residents in all or parts of the study, clarity about the roles or types of partnership

between CS and researchers, and the active engagement of CS in data collection and some analysis and/or interpretation. Thirteen of the 14 studies also acknowledged residents in their publication [117,304,369,550-555,557-560], 12 reported outcomes that showed 'real world' implications or pathways (e.g. pathways towards cultural and policy implications) [117,304,550-552,554-560] and 9 demonstrated outcomes that were generated directly by residents [304,369,552,554-558,560].

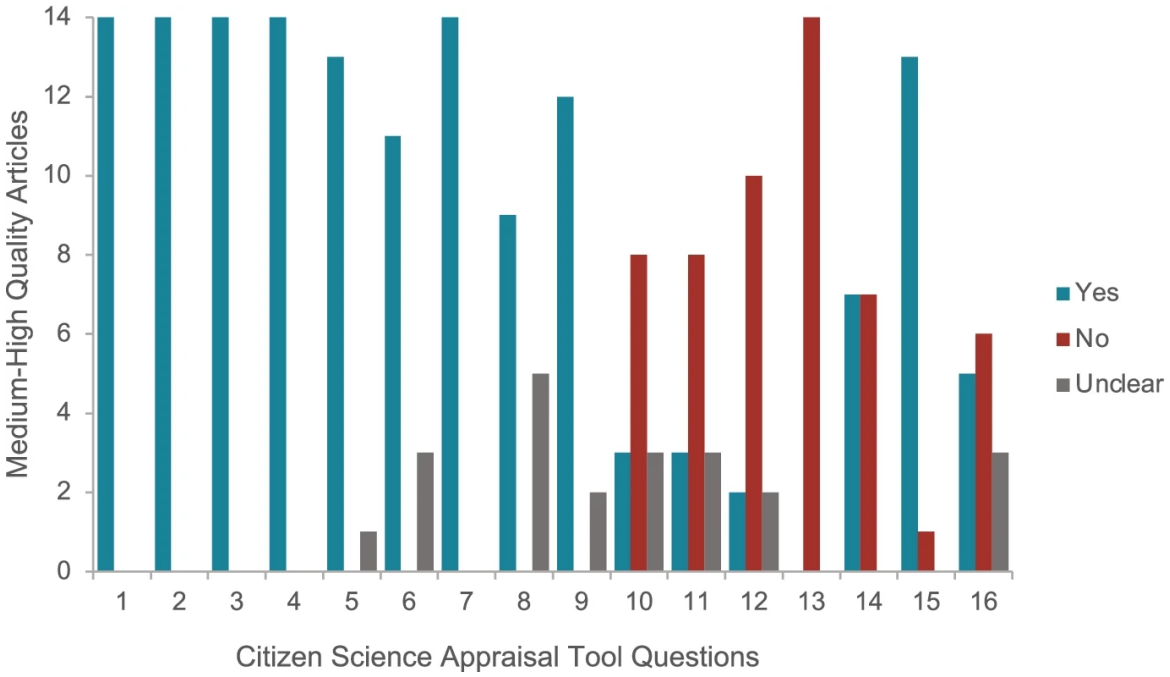


Figure 16. Citizen Science Appraisal Tool outcomes for medium-high quality articles (Source: Author).

Amongst studies rated as 'medium–high', the levels of resident engagement included partnering in all stages of the research ($n = 7$), guiding the research design ($n = 7$), actively collecting data ($n = 14$) and analysing ($n = 7$) or member checking data ($n = 10$). Two studies demonstrated a 'by the people' engagement[304,552], 1 demonstrated 'by the people' and 'for the people' [557] and 11 demonstrated a combination of 'by the people' and 'with the people' [117,369,550,551,553-556,558-560]. Studies presented strong elements of engagement by actively involving residents to partner in

all stages of the research process [304] or to co-design [550], direct [560], co-create [552] or co-conduct [369,554] the research methods. Some studies also had member checking of data [117,304,369,551,553,554,557-560] or guidance from resident advisory groups [552,556,557].

Community-Identified Urban Environment Characteristics Influencing Active Ageing

The urban environment characteristics were identified across Canada (*n* = 6) and/or the USA (*n* = 4), the UK (*n* = 5), Australia (*n* = 2), Hong Kong (*n* = 1), Netherlands (*n* = 1), Sweden (*n* = 1) and Finland (*n* = 1) and encompassed a range of cities (*n* = 9), urban or suburban neighbourhoods and residential areas (*n* = 8), urban districts or centres (*n* = 2), towns (*n* = 1) and public green spaces (*n* = 1).

Urban Environment Barriers to Active Ageing

Eight themes relating to urban environment barriers to active and healthy ageing (Figure 17) were identified (Appendix 2). These included accessibility (*n* = 14), physical environment (*n* = 13), transportation (*n* = 10), affordability (*n* = 8), social isolation and exclusion (*n* = 6), community support (*n* = 5), barriers for migrants and cross-cultural communities (*n* = 5) and safety and security (*n* = 4).

Accessibility was the most commonly identified barrier (*n* = 14), highlighting the lack of physical and disability–friendly access to local buildings, services and facilities as a key impediment to active ageing. Accessible information about services, accessible housing and the advancement of modern technology making devices difficult to use were also included in this theme. Physical environment was another

common barrier ($n = 13$), where residents documented a lack of well-maintained outdoor environments, the presence of physical obstacles and the absence of street crossing elements as barriers. Such barriers were particularly prominent during winter and for people with visual and physical impairments. Lack of available toilets and other facilities, negative aesthetics in outdoor spaces and unsuitable routes also negatively impacted active ageing according to residents.

Urban Environment Facilitators to Active Ageing

Five themes relating to urban environment facilitators (Figure 17) were identified by residents to be positively associated with active and healthy ageing (Appendix 2). These included community support ($n = 14$), physical environment ($n = 11$), social activities and participation ($n = 10$), transportation ($n = 7$) and housing ($n = 4$).

Community support was the most community-citied facilitator ($n = 14$), stressing the importance of local communities and neighbourhoods, particularly intergenerational ones, providing support and encouraging social activities. The availability of shops, cafes and public places such as libraries was a facilitator and useful for developing social links during winter. The presence of network associations, senior-specific programmes and religious institutions were all identified as sources of support that promote health, wellbeing and independence. Physical environment was also a commonly cited facilitator ($n = 11$), underscoring the importance of seating, positive aesthetics such as cleanliness and well-maintained infrastructure in both summer and winter to facilitate active ageing.

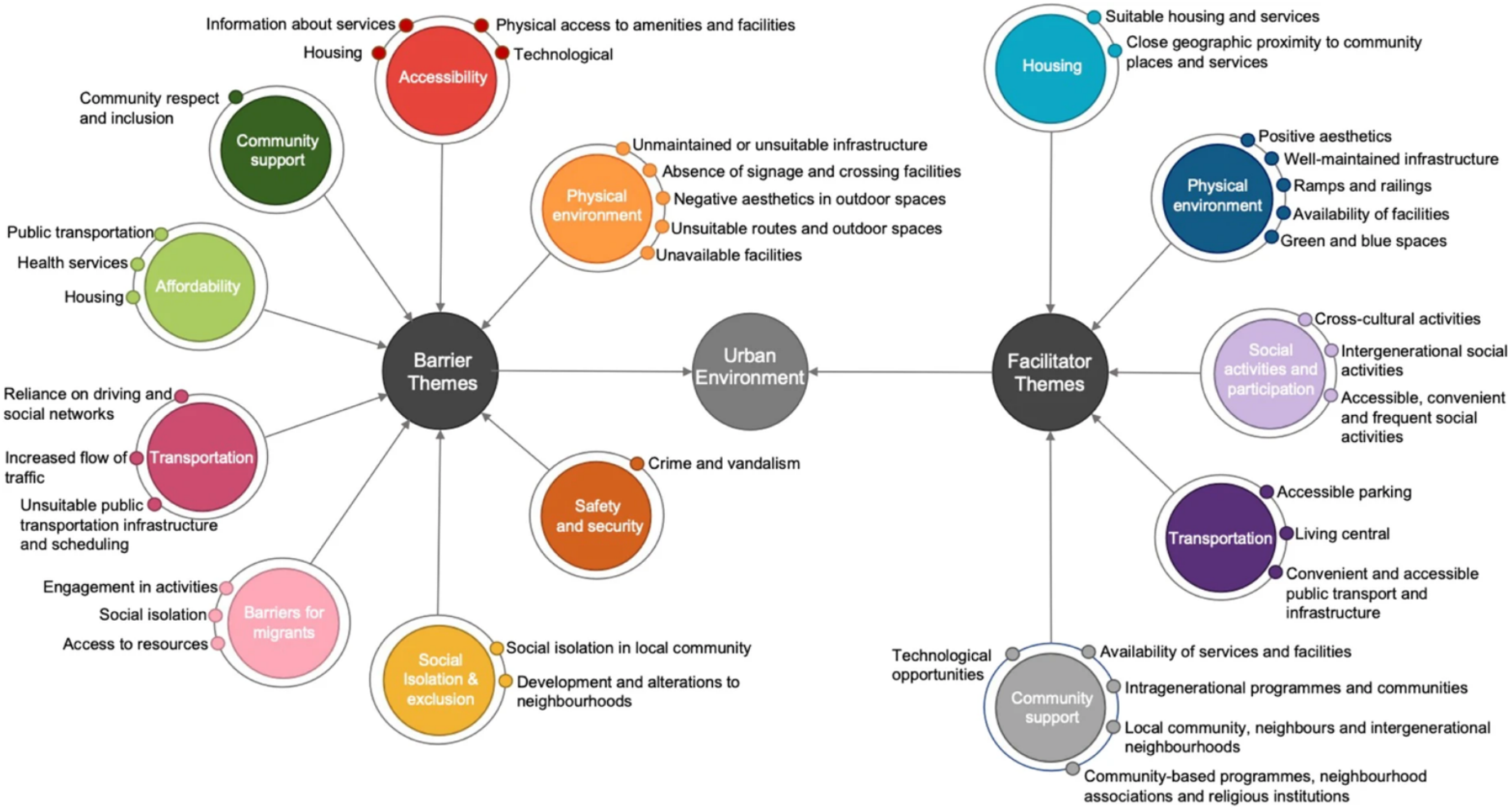


Figure 17. Urban environment barriers and facilitators. Smaller circles indicate subthemes (Source: Author).

Mapping of Community-Identified Urban Barriers and Facilitators against the WHO Checklist of Essential Features of Age-Friendly Cities

Aligning and Interconnecting Themes and Features

The 13 themes (Figure 17) significantly aligned with the WHO's 8 features and descriptors presented on the essential features of age-friendly cities checklist [39] (Figure 18) (Appendix 2). Physical environment barriers and facilitators, transportation barriers, safety and security, and accessibility were themes from this review that aligned with 9 out of the 10 WHO descriptors of the outdoor spaces and building features. Similarly, the themes of accessibility, social isolation and exclusion, social activities and participation, and community support aligned with 8 out of 11 WHO descriptors of the social participation feature. Both barrier and facilitator themes also aligned with 9 out of 12 WHO descriptors of the communication and information feature and with 10 out of 15 WHO descriptors of the transportation feature. The alignment of themes to the WHO features and descriptors indicates the ongoing relevance of bringing together local community–identified features with those presented on authoritative checklists to determine key features for developing age-friendly environments.

Unaligned Themes and Features

Despite the close alignment of WHO features and community-generated urban characteristics, the CS process did elucidate additional themes regarding age-friendliness of urban environments. Most significant amongst these were *barriers for migrant and cross-cultural communities*. This theme highlighted how ethnicity and

cultural differences can negatively impact engagement in activities outside of the home due to differences in cultural norms and social exclusion. Members of culturally, ethnically and linguistically diverse minorities themselves highlighted poor access to transportation, lack of social platforms for civic engagement, lack of suitable care facilities and lack of support from the government.

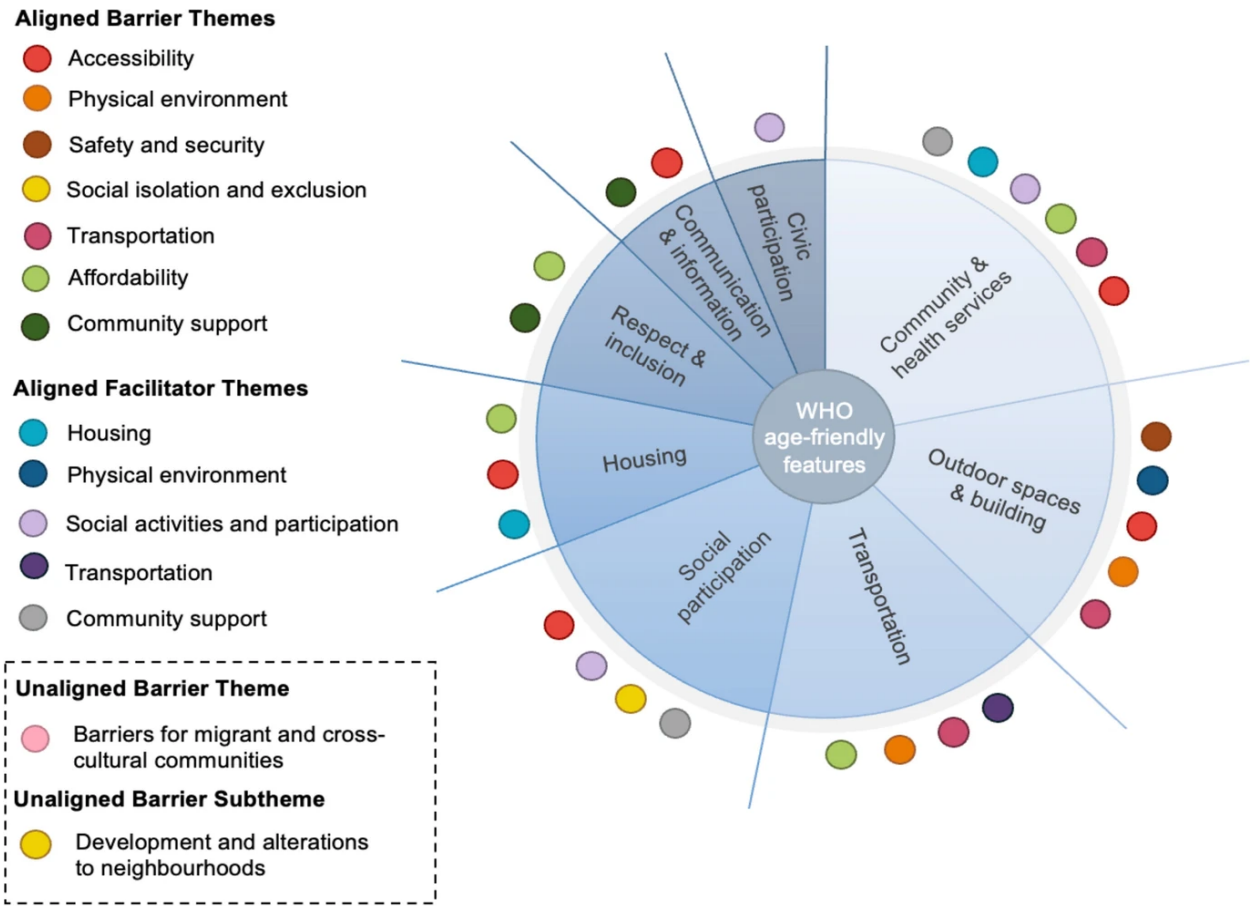


Figure 18. Visual representation of the barriers and facilitators mapped against the features presented by the WHO Checklist of Essential Features of Age-Friendly Cities [39] (Source: Author).

Similarly, *developments and alterations to neighbourhoods*, which was a subtheme of social isolation and exclusion, did not align with the features or

descriptors of the checklist. Exploration of this subtheme indicated that physical alterations to neighbourhoods, the presence of new builds and frequent relocation of neighbours negatively impacted social connections, community cohesion and the feeling of 'locality' for older adults. Considering the needs of migrant and cross-cultural communities and the impacts that new built environment developments can have on the risk of social isolation and exclusion are new dimensions that need to be further encompassed into the age-friendly agenda in order to strengthen this approach.

4.2.5 Discussion

Having systematically reviewed the literature on urban environments and active ageing, we highlight three areas for consideration: (1) the importance of a socio-ecological perspective on the local urban characteristics associated with active and healthy ageing, (2) expanding the WHO age-friendly cities agenda in light of local urban characteristics and (3) strengthening the field of CS to further its potential in capacity building the age-friendly agenda.

Social-ecological Perspective of Urban Environment Characteristics

Accessibility, physical environment features and the presence of community support were key urban characteristics associated with active and healthy ageing and require further consideration when developing age-friendly environments. Using a socio-ecological approach, which incorporates personal, environmental, social, cultural, economic and political domains [19,174,569-572], can provide a comprehensive indication of the features that influence health and active living [161,569]. This approach

also has been built into a systems perspective [18,530], which strengthens the understanding that ecosystems are multi-levelled and interacting systems governed by change and adaptations [573,574]. This review employed a socio-ecological perspective to conceptualise the urban environment characteristics. These are presented by the themes as part of an interconnected system in which there are multiple domains and complex interrelationships between individuals and their environments [22]. Rather than considering these urban characteristics in relative isolation, we provide two examples of interconnected systems relating to affordable housing and social activities.

Affordable and Accessible Housing

The review highlighted interconnected barriers and facilitators for suitable, accessible and affordable housing close to community services, which have previously been linked through a socio-ecological perspective [573,575-577]. The interpersonal relationships with neighbours, physical location or material quality of a house, and social interactions between who is being housed and the suitability of the house, as well as how these interactions change over time, all interconnect and influence the individual [573,575,578]. The economic and material resources and the development and implementation of suitable housing policy are also identified by the literature as connected and impact the presence of suitable and affordable housing [573,577,578]. To promote affordable and accessible housing in an age-friendly context, the outcomes of this review indicate a need to consider the interconnection between an individual's needs and required services, the affordability and accessibility of housing and the geographic proximity to the wanted services and facilities. This can shift the

development of housing away from considering these domains and barriers in isolation [578] and instead addressing the multiple interconnected housing influences present in order to develop suitable age-friendly housing.

Social Activities and Participation, and Social Isolation

Social activities and participation, and social isolation were themes that interconnected amongst the personal, environmental and social domains of urban environments. Across a number of studies, engagement in social activities is influenced by personal factors such as mobility[186], motivation and social values [579,580], as well as various aspects of the environmental and policy domains, which influence the presence of suitable environments [581], resources and places to participate socially [580,582]. For older adults, engaging in activities is also shown to be influenced by social factors including the presence of a social network, neighbours and/or a sense of community [583,584]. Individual characteristics and influential factors across social and environmental domains need to be considered in order to provide spaces that facilitate age-friendly social participation and accessible activities. In particular, the CS processes enabled residents to identify intergenerational and cross-cultural activities and spaces where neighbours and local communities can build community cohesion and support social participation as key facilitators.

Strengthening the Age-Friendly Cities Initiative

Whilst the WHO Checklist of Essential Features of Age-Friendly Cities provides a useful and universal guide to assessing and implementing features, such work can be supported by more attention to local urban characteristics. CS has made clear that

the subtheme '*neighbourhood developments and alterations*' and the theme '*barriers faced by migrant and cross-cultural communities*' require further exploration. Recognising contextual importance by considering the impact of neighbourhood changes on social isolation and identifying the multiple barriers faced by ethnically, culturally or linguistically diverse minorities are important for strengthening the age-friendly agenda. Whilst these two themes are considered below, it is important to recognise that strengthening this agenda requires extension to populations experiencing social exclusion such as minority ethnic groups, refugees and individuals from LGBTQ communities to inform the design of future initiatives aiming to develop inclusive age-friendly environments [47,59].

Neighbourhood Developments and Alterations

Physical alterations to neighbourhoods, new builds and rotation of neighbours were identified as negatively impacting social connections and community cohesion. Changing and gentrifying neighbourhoods can cause experiences of social isolation, insecurity and vulnerability, challenge a sense of belonging, and negatively impact mental health [554,585,586]. Although neighbourhood changes are experienced differently based on the contexts and types of residences in which individuals live, they have been found to negatively impact social and community cohesion, making it important to address the impacts these changes may have on older adults [29,553,587]. As the immediate neighbourhood environment is also vital for older adults and their social support, particularly those who are vulnerable or have limited mobility [588], the developments and alterations to neighbourhoods need to be further assessed in the planning and implementation of age-friendly initiatives.

It is important to consider the impacts of changing neighbourhoods on older adults, especially for those who wish to remain at home or in their local neighbourhoods [586] and evaluate the effect age-friendly features which in some cases have not had a real and meaningful impact [589]. Modifying the WHO guidelines to address alterations to neighbourhoods that may impact older adults could enhance the social structures and community cohesion present within urban communities [585] and could lessen the physical, social and cultural consequences resulting from these changes [29].

Barriers Faced by Migrant and Cross-Cultural Communities

Ethnicity, cultural differences and language barriers faced by migrant and cross-cultural communities were identified to be associated with social isolation, access to resources and support from governing bodies. Ageing in cities can be challenging for older adults who migrate [590]; inequalities place these individuals at an increased risk of social exclusion [510]. Age-friendly city initiatives therefore need to be tailored to local situations and serve diverse communities in order to address the context-specific factors that contribute to social isolation. For example, migration pressure, language issues, access to and lack of knowledge about existing resources and community programmes are all barriers that have been previously identified [73,74] and should be taken into consideration.

It is currently unclear if age-friendly programmes effectively address the needs of older individuals from diverse ethnic and cultural backgrounds [25]. Better understanding of urban experiences of older adults from diverse ethnic communities is needed in order to identify the inequalities and influence of racism faced by individual

ethnic groups [47,591]. To address these challenges, the use of CS approaches requires further strengthening, which is discussed in the following section.

Strengthening Citizen Science Approaches

To further the potential of CS in strengthening age-friendly initiatives, the CSAT identified that greater attention needs to be paid to (1) the diversity of approaches within such research methodologies; (2) the degree to which they are contributory (*for the people*), collaborative (*with the people*) and/or co-produced (*by the people*); (3) their potential unintended consequences; and (4) the sustainability of outcomes.

An absence of resident engagement in the scientific processes, particularly as they relate to informing study design or hypotheses, is a current gap in CS projects[297,539]. This finding was reflected in the reviewed studies, stressing the need for further engagement of older adults in the planning and research design [117,555,556,558-560] and data analysis [551,553,555,556,558,559]. A recent analysis of interviews exploring participant engagement in CS projects reported an absence of engagement in informing project design or hypotheses[297]. However, increasing opportunities for engagement in multiple processes is an ideal [312] achieved through co-creation [105,592] or a 'by the people' approach[106]. This more comprehensive form of engagement provides the greatest potential for developing and implementing relevant environment and social changes[123,539], attributed to residents embedding their knowledge into design and dissemination, and enabling a project to develop in the cultural context of a local community [104,123].

Studies have found that predominantly well-educated people from White ethnic groups rather than from minority ethnic groups engage with CS [306,593,594].This has

been linked to a lack of sense of belonging in areas where White ethnic backgrounds are a majority [595], differing volunteering motivations [596] and financial or educational barriers to participation [593,594]. The studies included in this review engaged residents across a range of populations, enabling the identification of diverse urban barriers pertaining to ageing. Without representative engagement in CS, the beneficial impacts and translatability of outcomes can be reduced [597], requiring consideration of effective strategies to foster opportunities for engaging migrant and diverse ethnic communities. This includes recognising barriers to engagement and presenting new pathways to engaging the views, beliefs and practices of under-represented groups [306,594]. For example, ensuring that CS and public engagement tools are in multiple languages can reduce such barriers to inclusion [329,593].

For future studies to strengthen their levels of co-production, the following characteristics by Hidalgo et al.[539] should be considered: (1) co-defining and focusing on real-world issues, (2) using shared language and visual materials, (3) building an equal and collaborative research community, (4) including participatory meetings led by suitable individuals who can facilitate co-creation, and (5) providing participatory tools and accessible means of communication for disseminating outcomes.

Capturing effective dissemination of results and long-term sustainability are also current challenges amongst CS projects [302]. This was identified in the reviewed studies, with a lack of accessible dissemination plans and tracking of long-term changes or ripple effects emanating from the CS activities. Tracking long-term outcomes is a key for identifying sustainability and momentum of a project once it has finished, particularly in the physical and social environments [54,302,340]. Long-term observation can showcase a commitment to maintain longitudinal outcomes [409], such as ‘ripple effects’ where citizen scientists continue to advocate for neighbourhood

improvements after a project has ended [282]. One systematic method for capturing the multi-level impacts of CS is called ripple effects mapping [598]. This qualitative method, used originally in the US Cooperative Extension field, involves citizen scientists and other stakeholders visually mapping the cumulative trajectory of intervention-related activities and outcomes—both expected and unexpected—over time [599].

To the best of our knowledge, the CSAT is a novel appraisal tool that can effectively encompass and evaluate the quality of CS research processes, the level of engagement employed, data and long-term sustainability. The CSAT can contribute to the field of CS by guiding and strengthening the development, implementation and evaluation of future CS studies. Although the tool was designed for CS approaches in the urban and ageing research field, it shows universality and can evaluate other participatory approaches across multiple disciplines. Further, the CSAT can guide researchers to foster and support citizen-driven strategies and outcomes that encompass community insights and have sustainable and real-world relevance. Whilst not within the tool's remit, it is important for CS projects employing the tool to consider the impact of their societal and scientific outcomes if diversity or representativeness of engagement across a community is missing [593]. This includes recognising barriers to engagement faced by different ethnic groups and biases from under-representing or overrepresenting different groups [594]. Previous literature has identified CS approaches for greater equality in engagement [302,600] and should be considered in detail.

Strengths and Limitations

Due to the broad nature of CS [281], the limited capacity of the keywords to identify all relevant studies was a potential liability. The chosen keywords may not have captured all CS or other participatory studies, for example the work by Buman et al. [110] and Winter et al. [118], and especially those with creative naming or novel approaches. Secondly, although the CSAT was employed to identify good quality studies, selection bias may be present. For example, requiring the mean age of citizen scientists to be at least 60 years would have led to the omission of articles involving intergenerational groups of citizen scientists (e.g. older adults and youth [282]) that did not separate outcomes based on age or described CS work targeting older adults [54].

Despite these limitations, this review followed a systematic protocol guided by the PRISMA checklist to systematically review a large volume of literature (11,311 articles), which embodies a diverse array of articles. The chosen databases also provided a diversity of health, environmental, social science and gerontology research. Furthermore, the protocol, keywords and systematic processes were informed by a multidisciplinary team of consultants in relevant fields, who also contributed to the development and implementation of the CSAT.

4.2.6 Conclusion

This systematic scoping review identified a range of urban barriers and facilitators identified by older adults engaged in CS or other participatory approaches. The interconnectedness of the barriers and facilitators was presented using a socio-

ecological perspective, reflecting the need to consider the multi-level influences and associations present when developing local age-friendly environments locally. The findings also identified a need for nuanced and culturally specific approaches to increasing feelings of social inclusion and accessibility of resources for migrant communities to strengthen the age-friendly agenda. Future studies can use the CSAT to guide their CS approach and incorporate best practices into their design and methods so that processes, strategies, and outcomes are co-produced with residents to shape the future of their local urban environments.

Chapter 5 – Active and healthy ageing in urban environments: laying the groundwork for solution-building through citizen science

5.1 Summary and context

This chapter presents the published preliminary citizen social science (CSS) stage of the citizen science (CS) Improving Your Local Area Study (Chapter 6). Although the Improving Your Local Area study was informed by the *Our Voice* CS approach, utilising a four-step CS method, a CSS approach was employed in this preliminary stage. This stage included engaging older adults and community stakeholders to collectively discuss local and broader concerns that impact active and healthy ageing in their urban communities across the city of Birmingham. Through CSS, these discussions were framed using a social research lens to develop knowledge across the individual and collective group of social actors based on their experiences that occur in their urban contexts [340,342,343,346].

Within this preliminary stage, CSS was employed as an exploratory approach to engaging and encompassing the voices and experiences of older adults and community stakeholders [340]. This was achieved by building on a CS co-production level of engagement, guided further by the CSAT and outcomes presented in the systematic scoping review (Chapter 4). By engaging older adults and stakeholders to discuss active and healthy ageing across Birmingham, collective knowledge was generated that centred on the concerns of the individuals and the collective group [105,106,346]. This enabled what is considered to be socially robust knowledge [348] to be produced across these social actors, alongside synergy to identify urban concerns and solutions that have the potential to hold relevance for wider society [340,402,403].

This preliminary stage sits within the context of the evolving field of CSS. Described as a novel approach [340,341], alongside one that is emerging from CS and participatory paradigms [359], the use of CSS has been employed with a focus of identifying social concerns or components of a research phenomenon being explored. Examples include employing CSS to explore urban stress, enabling ways in which the scientific constructs and use of technology investigating urban stress can be framed by social and emotional perspectives, as well as holding potential to address the underpinning societal elements of stress [349]. It has also facilitated a more empowered and socially contextual approach to engaging citizens to identify socially relevant concerns related to climate change [342]. Alongside this, CSS has been used to investigate multigenerational co-housing projects. This identified the needs of social actors from different generations across private and public spaces, enabling social encounters and communication to occur between those engaged [352]. CSS has also been used to explore how citizens can be engaged to identify empty houses in their neighbourhoods. This approach enabled citizens to be reflective on current social issues in their neighbourhoods, alongside producing citizen-led data that holds relevance for stakeholders and can be integrated into their existing work [341].

Across these studies, it is acknowledged that CSS can be strengthened further. This includes a need to further embed CS co-production and co-creation levels of engagement within CSS research, alongside engaging multiple disciplines to facilitate the synergy of new and interdisciplinary knowledge [341,342,349,351,352,354-357,359]. Continuing to build on this current development of CSS in the literature is in turn required, particularly identifying ways in which CSS can be applicable across different social contexts and settings [358]. The use of CSS in this PhD research places itself within this context, identifying ways in which CSS can be applied in public health

research exploring urban environments and ageing. The contributions of this study to the CSS literature, which lay the groundwork for the next stages of the CS study, are identified as the following:

1) The thesis demonstrates the value of using a preliminary CSS stage as a methodological approach within a CS study.

   Employing CSS as preliminary method contributed towards a CSS methodological approach that presents value for a CS study. The use of a CSS preliminary method facilitated those engaged to share and discuss their individual and collective concerns and knowledge related to their experiences in the city of Birmingham. This included older adults and community stakeholders identifying and discussing their experiences, alongside listening to others and reflecting on their own experiences, allowing collective concerns to emerge. In doing so, a set of collective urban characteristics (presented in section 5.2.5 of this chapter) were identified that encompassed the relevant concerns and needs of these social actors as a collective. This demonstrated the generation of multiple forms of knowledge, which has been previously facilitated through CSS [354], in which the knowledge and experience of each individual were brought together through collective discussions. This builds on the recommendation for CSS presented by Pykett et al. [349], who identified a need to develop an interdisciplinary CSS approach that encompass both individual and collective voices collaborating together. Overall, these collective urban characteristics identified through this preliminary CSS stage are centred on the individual and collective concerns, holding potential relevant to both the individual and the wider urban and ageing community [340,341].

2) This thesis develops and puts into practice a CSS approach to enable organic connections, sharing of resources and developing the foundations of a network across those engaged.

The use of discussion groups centred on the topic of active and healthy ageing in urban environments enabled a space for older adults and stakeholders to engage and interact in discussions. This facilitated the sharing of both individual and collective experiences as described above, alongside the sharing of resources and the occurrence of social encounters. This space has been previously identified in CSS initiatives to allow trust to be built, experiences to be shared and conflict to be explored [352]. These are also beneficial elements identified to strengthen CS, particularly for increasing community building, social capital and a collective shared experience of those engaged [97,305].

However, this space presented by the preliminary CSS stage went beyond the sharing of experiences and instead enabled organic connections, sharing of resources and solution-building to occur. This included those engaged connecting over shared experiences in urban environments, sharing local resources for active and healthy ageing and identifying solutions for each other's concerns (presented in section 5.2.5 of this chapter). This preliminary stage in turn not only facilitated collective discussion across diverse social actors but also engaged these social actors to draw on their resources and connect with each other through the sharing of experiences and knowledge [346]. This provided the potential foundation of developing a network of actors across those engaged that is centred on collective experiences, knowledge and a shared framing of active and healthy ageing [601,602].

3) The thesis draws on interdisciplinary literatures on ageing, urban planning and public health domains in order to develop interdisciplinary knowledge surrounding active and healthy ageing in urban environments.

There is currently a need to bring together interdisciplinary approaches and domains through CSS and provide recognition of this approach through peer-reviewed and published avenues of dissemination [340,349]. Providing an interdisciplinary approach is also crucial for engaging a diverse range of actors and their expertise that is required to effectively identify and address concerns relevant to society [354]. This preliminary stage contributed to this need by employing CSS across an interdisciplinary subject, bringing together older adults, community stakeholders and researchers across ageing well, public health and urban planning domains. This enabled the diverse views, experiences and cultures of these actors across their social and urban contexts to be shared and brought into the scientific realm [350]. In doing so, the focus of this research was framed collectively by those engaged across these interdisciplinary fields, laying the groundwork for the next stages of the CS study to be informed by this interdisciplinary collective knowledge and framing of urban environments.

4) Embedding the use of CSS, as both a preliminary stage and repeating discussion groups with the same set of social actors, within a set of cohesive steps to produce an overarching methodological approach (explored further in Chapter 7, section 7.51) that strengthens the field of CS and CSS.

CSS, which has been identified as practice or form of CS [340], has been described by literature in diverse ways. This includes the use of CS in the social sciences, engaging the public in scientific research to explore socially relevant issues, facilitating the emergence of social concerns and aspects to demonstrate

a ‘social’ element of CS, and bringing together a range of transdisciplinary social actors across society [340,341,343,346,348,352,355]. CSS has also been employed through different qualitative methods and techniques, such as focus groups, interviews and workshops, generating a collective understanding of a social concern that can contributes towards socially robust knowledge [340,341,348,352,358].

CSS was employed by this thesis as a preliminary stage to guide discussion groups to explore active and healthy ageing across a set of social actors, facilitating those engaged as both individuals and a collective group to discuss and reflect on their dialogue related to this topic. This generated relevant knowledge across these actors, as well as developing organic social connections and the foundations of capacity and network building. Through embedding this approach further within the CS study (Chapter 6), which included embedding the preliminary CSS into the *Our Voice* CS framework, the discussion groups were repeated with the same group of older adults and community stakeholders during Stage 2 and 3. The repetition of bringing these social actors back together facilitated CSS to strengthen the focus of CS, which is to actively engage these individuals to co-produce research and enhanced their knowledge and skills. Instead, it allowed these individuals to continue to reflect on their own and each other’s experiences and strengthen the collective and socially relevant understanding of active and healthy ageing. Alongside this, the foundations of organic social connections were continued, in which individuals formed social connections, supported each other and shared resources, contributing further to capacity building and socially robust knowledge (explored further in Chapter 7, section 7.3.2).

This in turn strengthened the fields of CSS and CS, alongside the use of qualitative methods in participatory research such as single discussion groups

employed as a communicative space [98,103,145]. Through the repetition of discussion groups, the 'social' elements of CSS were continued and strengthened, facilitating further connections between those engaged and contributing towards a stronger knowledge coalition. Embedding this approach of using a CSS preliminary stage and repeating discussion groups through a set of cohesive steps (Chapter 7, figure) provides a way for future CS and CSS research to consider and achieve these social elements, allowing community engagement to drive scientific research whilst facilitating social connections and capacity building that can be utilised for developing and mobilising joint actions across society [353].

To expand on these contributions and their examples further, the CSS manuscript is presented next, alongside its contributions and wider implications for public health research explored in Chapter 7.

5.1.1 Author Contributions

GW led the data collection and analysis. GW, AS and JP contributed towards the study design and AS and JP contributed towards data analysis. GW drafted the manuscript, AS and JP reviewed the manuscript and GW undertook manuscript revisions. AS obtained funding for the study. All authors have read and approved the final draft.

5.2 Active and healthy ageing in urban environments: laying the groundwork for solution-building through citizen science

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5.2.1 Abstract

Urban age-friendly initiatives strive to promote active and healthy ageing by addressing urban influences that impact individuals as they age. Collaborative community partnerships with multi-level stakeholders are crucial for fostering age-friendly initiatives that can transform urban community health. Employing a citizen social science (CSS) approach, this study aimed to engage older adults and stakeholders in Birmingham, UK, to (i) identify key urban barriers and facilitators to active and healthy ageing, and (ii) facilitate collaboration and knowledge production to lay the groundwork for a citizen science (CS) project. Older adults (*n* = 16; mean age = 72(7.5 SD); 11 female) and community stakeholders (*n* = 11; 7 female) were engaged in six online group discussions, with audio recordings transcribed and thematically analysed to present key urban barrier and facilitator themes. Ageism, winter, technology and safety were barriers identified by both groups. Outdoor spaces and infrastructure, transportation, community facilities, and Covid-19 pandemic were identified as barriers and/or facilitators. Older adults identified the ageing process as a barrier and diversity of the city, health and mobility and technology as facilitators. For stakeholders, barriers were deprivation and poverty, gender differences, and ethnicity, whereas age-inclusive activities were a facilitator. Organic and active opportunities for older adults and stakeholders to connect, co-produce knowledge on urban environments and share resources presented foundations of solution-building and future collaboration. CSS effectively facilitated a range of stakeholders across local urban spaces to collaborate and co-produce ideas and solutions for enhancing local urban environments to promote active and healthy ageing.

5.2.2 Lay summary

Planning urban age-friendly environments requires engagement with local residents, service providers and decision-makers. This is important for developing joint actions, urban initiatives and allowing these individuals to share their experiences, needs and resources. Citizen social science (CSS) can engage residents and stakeholders to directly shape social research aiming to improve urban environments. This study engaged 16 older adults over the age of 60 and 11 stakeholders to identify urban features that influence active and healthy ageing in Birmingham, UK. Using six online discussion groups, the key urban barriers and facilitators were identified by older adults and stakeholders, who also checked the findings to confirm they represent the discussions accurately. Urban barriers and facilitators included health and mobility, ageism, outdoor spaces and infrastructure, transportation, technology, Covid-19, and the lack or presence of community facilities and activities. During discussion groups, both older adults and stakeholders connected to share information about local organizations, resources, websites for free activities or research, and provide solutions for each other's barriers. CSS effectively engaged older adults and stakeholders to collaborate and create knowledge together for improving local urban environments in Birmingham.

5.2.3 Introduction

The idea of age-friendly cities has become a global movement that considers the role urban environments present for age-related challenges [264]. Urban age-friendly initiatives strive to promote active and healthy ageing by addressing urban

influences that impact individuals as they age [5,13]. Considering age-friendly elements across the environment, services, structures and policies, the age-friendly city can promote active ageing and quality of life by optimizing opportunities for health, participation and security in specific places [21].

Employing a bottom-up participatory approach, the age-friendly agenda brings together the interests from older adults and urban planners to collaborate, co-produce knowledge and foster age-friendly spaces. Yet developing and actualising inclusive and supportive age-friendly environments is argued to present a key gap for governance and public policy [29,533]. Studies engaging older residents to identify urban influences of active and healthy ageing highlighted engagement of residents during preliminary design and planning stages was missing [185,517]. This strongly suggests a missed opportunity to take a place-based and community-engaged approach to addressing the health inequalities experienced between different age groups, such as differences in physical mobility attributed to age-related impairments and physical limitations [603,604]. A lack of responsibility, intent and understanding from local and regional governments, alongside challenges of translating empowerment practices, are also undermining participatory processes and their beneficial health outcomes [45,256,265]. Without collaborative governance across all levels, a lack of understanding and municipal capacity will be present in age-friendly initiatives [605,606].

Collaborative governance and participatory initiatives have become increasingly present in the planning domain, developing public-private partnerships throughout planning processes [607]. However, the planning domain is identified as lacking opportunities and processes for local community members to participate ***and*** inform policy [244]. An example includes Neighbourhood Planning [234] which aimed to employ participatory processes to facilitate local-level decision-making in UK [244,608].

This approach was perceived as tokenistic in its collaborative practices to give power to the community, containing limitations in its democratic inquiry and the planning choices actually available to the local-level [249]. Power in this process was also viewed as highly unequal, with developers and planning experts negatively perceived to have a strong influence over plans due to being 'experts' [238,609]. For bottom-up and participatory approaches to be effective in the planning domain, a form of localism is required that prioritises interactions between citizens and key actors that can act "upon the connections of power to bring actors into different conjunctions" [257 p.253].

As the central role of urban planning now recognised in health promotion, prevention and addressing health inequalities [610,611], developing coordinated and collaborative community partnerships that can bring together and empower actors from multi-level domains is crucial for connecting localised needs with local governance [606,612]. Current initiatives aimed to empower communities are described by Popay [256] to have an overpowering inward gaze, focusing on conditions or changes related to the psycho-social, neighbourhood and everyday elements. The inward gaze overlooks the outward gaze of the wider social and political changes required for health equity, reducing the ability of communities to address health concerns as a collective. In turn, there is a need for urban health promotion to further engage in community participatory, organising and empowerment strategies that can enable shared decision-making amongst all social actors within specific governance contexts to facilitate health equity further [256,613].

To address this, shifting away from current traditional processes of connecting communities may be required to develop connections and changes that can transform community health [574]. Citizen science (CS) actively engages the public in scientific research processes, via contributory, collaborative, or co-created production levels of

engagement. This engagement can develop new knowledge and outcomes that drive environmental change and community transformation [98,119,614], alongside informing public health policy about the needs and concerns of local residents[290]. Citizen social science (CSS) incorporates community-driven CS engagement, but centres on partnerships and collective generation of knowledge from a wide range of social actors, including local residents, community members, and local authorities, to position a project around social concerns. This includes building on the engagement and empowerment of community members achieved through community-driven CS [106,311], whilst aiming to increase the understanding of societal processes and enabling citizens to raise and reflect on social issues [341,346]. To facilitate enhanced engagement of social actors, capacity building methods are crucial and require collaboration from a range of individuals and organisations with differing expertise [615]. Overall, CSS has been employed by this study to effectively achieve a collaboration that can empower residents, providers, and organisations to collaborate, forming new relationships and developing sustainable networks [341,402,403].

The forming of these networks and collaboration across social actors will then be utilised to provide insights on bringing together a range of older adults and stakeholders to collaborate and generate knowledge on urban spaces, which can lay the groundwork for a CS project. Employing a CSS approach, this study aimed to engage older adults and stakeholders to (i) identify key urban barriers and facilitators to active and healthy ageing in local urban areas of Birmingham, UK; and (ii) to build on CSS to facilitate collaboration and knowledge production in order to form the foundations of a network that can further purpose collective policy recommendations to promote an age-friendly society.

5.2.4 Methods

Context

The 'Improving Your Local Area' CS project aimed to (i) employ the *Our Voice* CS for Health Equity approach [106] to engage older adults and multi-level stakeholders, and (ii) co-create urban recommendations for promoting active and healthy ageing in the city of Birmingham, UK. As part of this CS project, this study provided a preliminary stage to lay the groundwork for the generation of local urban knowledge and the development of a network between older adults, stakeholders and the researcher. Utilizing a CSS at this preliminary stage, to form collaboration and new relationships across older adults and community stakeholders [341,402] will feed into the *Our Voice* CS approach and guide the subsequent project stages based on the views and knowledge shared directly by these individuals. This is important for centring the project and its agenda setting at each stage on the needs and experiences of these individuals in their local areas[340].

Qualitative Citizen Social Science Approach

A qualitative CSS approach was employed to actively engage older adults and community stakeholders to identify local urban barriers and facilitators and build the foundations of a network that can reflect on social concerns influencing the wider ageing urban community. The approach was deemed suitable as it employs a co-production level of CS, where individuals engage throughout all stages of a project, which can facilitate the generation of new knowledge from the individual and a

collective group of individuals engaged [105,106,346]. Employing CSS enables individual voices to change and new perspectives to be generated, with conflict navigated, so that 'citizen voice' is more than the sum of individual citizens' voices. This can centre new knowledge around broader social aspects and encompass the expectations of a range of social actors, facilitating a broader set of outcomes for society and social sciences [340].

Qualitative discussion groups called 'Discover Together Groups' were created. Discussion groups engaged older adults to openly identify, discuss and co-create knowledge around urban influences whilst connecting through shared and valued experiences in Birmingham [616,617]. Discussion groups have been identified to facilitate essential design and construction processes with multiple stakeholders, as well as stakeholder analysis for understanding stakeholder needs, in age-friendly projects [618]. Separate discussion groups following the same format were conducted for community stakeholders. Due to the Covid-19 global pandemic, the original in-person discussion groups were shifted to Zoom Video Communications (5.8.4 (2421)).

Citizen recruitment and location

Older adults aged 60 and above were recruited across the city of Birmingham. Recruitment material and Covid-19 study amendments were shared via email through local community organizations, partnerships and services across the whole of Birmingham. Convenience and snowball sampling was employed to recruit older adults. Individuals were telephone screened by GW to confirm demographic information, their length of residence in Birmingham and their ability to walk at least 20 minutes outside. Each individual was given information about the study, including

risk assessment and ethical approval, and provided written informed consent prior to study commencement. Convenience and snowball sampling was also employed to recruit community stakeholders in urban planning and ageing-well services, who were contacted directly via email. Community stakeholders took part in separate discussion groups only and provided verbal consent. Ethical approval was received prior to study commencement.

Birmingham is the second largest city in the UK and has an estimated population of 1,141,400. Older adults aged 65 and above represent 13.1% of this population, which is expected to greatly increase to 29.5% by 2038. Birmingham is a superdiverse city with White, Asian, Black and other ethnicities present. It is also the third most deprived of the UK's core cities, which refers to the 11 largest UK cities excluding London [619]. Deprivation is attributed to increasing years in poor health for older adults residing in the city [434]. Birmingham land use is mainly urban with a widespread road network but has a significant number of green spaces covering a total of 3200 hectares [446,449].

Data Collection

Sixteen older adults (age range = 60–87, female = 11) and 11 community stakeholders (female = 7) took part in 6 online discussion groups (60–90 minutes) exploring key urban barriers and facilitators to active and healthy ageing. The online discussion groups, which were held via Zoom Video Communications (5.8.4 (2421)), were separate for older adults only (n = 4 discussion groups) or community stakeholders only (n = 2 discussion groups) and were audio recorded by GW. One older adult discussion group included a community stakeholder from the same local

area. The format of the groups included a study introduction and the use of three open-ended questions to facilitate discussions. These were shared at the start of the discussion, a strategy that has shown to facilitate stakeholder engagement and partnerships in the age-friendly agenda[275]. The three questions included the following:

Older adult group questions

- Are there any barriers in your local area that impact you from being active or healthy?
- Are there any facilitators in your local area that encourage you to be active or healthy?
- In your opinion, what could be changed in your local area to provide the opportunity to be active and healthy?

Community stakeholder group questions

- Are there any barriers that may impact or prevent older adults from being active and healthy?
- Are there any facilitators that may impact or allow older adults to be active and healthy?
- In your opinion, what could be changed in urban areas of Birmingham to make an impact on older adults?

Data analysis and member checking

Discussion group audio recordings were transcribed by GW and shared with older adults and community stakeholders for member checking to confirm their accuracy. A thematic analysis was completed on the audio transcripts using NVivo 12 Software (QSR International, Australia). GW completed an inductive analysis [491,505]

using a mixture of semantic and latent coding [489] to identify barriers and facilitator themes that emerged from the transcripts. Data coding and analysis were conducted in the following stages:

Stage 1. Familiarisation and Raw Coding

GW transcribed each audio transcript to become familiar with the data. GW generated raw codes by identifying and coding all segments of a transcript to identify barriers or facilitator codes present. Both latent and semantic coding were completed based on the explicit content of what an individual said whilst applying an interpretative view to capture the meaning (Appendix 1).

Stage 2. Constructing themes from codes

GW examined each code to combine or collapse them together to produce more meaningful codes. Themes were then developed based on the combined codes that underpin each theme present for barriers or facilitators.

Stage 3. Reviewing and finalising themes

Codes and themes were initially shared with AS and JP to be examined and discussed. This discussion guided a further stage of coding completed by GW, which involved collapsing codes further to produce more meaningful themes. The second set of themes was re-shared with AS and JP to discuss and produce a final set of themes.

Stage 4. Member Checking and grouping of themes

The audio transcript and the final set of themes were shared with older adults and community stakeholders for transcript verification [620] and member checking. Member checking was employed to engage older adults and community stakeholders to establish that the data and its interpretation were an accurate representation of the online discussion groups, which can maintain the validity and credibility of data [400,497]. Themes were shared via a diagram (Appendix 3), and feedback received was used to amend themes. After this process, the themes from each discussion group were grouped together to identify the common barrier and facilitator themes across all older adults and all community stakeholder groups.

5.2.5 Results

Citizen Scientist and community stakeholder characteristics

The majority of older adults were White British (62%), married (68%), educated to university degree level or above (75%), and lived in Birmingham for a minimum of 30 years (68%). The residences of the older adults covered 11 of the 69 wards in Birmingham. The 11 wards represented the more deprived (9%), mid ranking (18%), least deprived (55%) and affluent areas (18%) across Birmingham. Ethnic groups across the wards included White British or White other (54.7%–87.8%), Asian (3.8%–30.9%), Black (1.2%–13.2%) and other ethnicities (1%–3.2%). Two of the 11 wards (18.9%) represented similar ethnic groups to Birmingham as a city, with 1 ward (9.1%)

having higher Asian ethnicities and 8 wards (72%) having higher white ethnicities[621]. The majority of community stakeholders were female (64%) and were from urban planning or ageing-well roles across community organizations, partnerships and services.

Barriers to and Facilitators of Active and Healthy Ageing

A total of 13 barrier themes and 8 facilitator themes were identified across the older adult and community stakeholder groups (figure 19). Out of these themes, 10 barrier themes and 7 facilitator themes were identified by older adults, and 12 barrier themes and 5 facilitator themes were identified by community stakeholders (Appendix 3). Overall, nine barrier themes and four facilitators matched between the two groups, and four barrier themes and four facilitator themes differed.

Matching themes between older adults and stakeholders

Nine matching barriers and four matching facilitators highlighted a range of interconnected and multi-level themes present across local urban spaces in Birmingham. The matching themes covered elements of personal (e.g. *health and mobility*, *ageism*, *crime and safety*), environmental (e.g. *outdoor spaces and infrastructure*, *transportation*, *crime and safety*), socio-cultural (e.g. *lack or presence of community support and activities*, *technology*), economic (e.g. *technology*, *transportation*, *community activities*) and political (e.g. *transportation*, *community facilities*, *technology*) domains of urban environments in Birmingham.

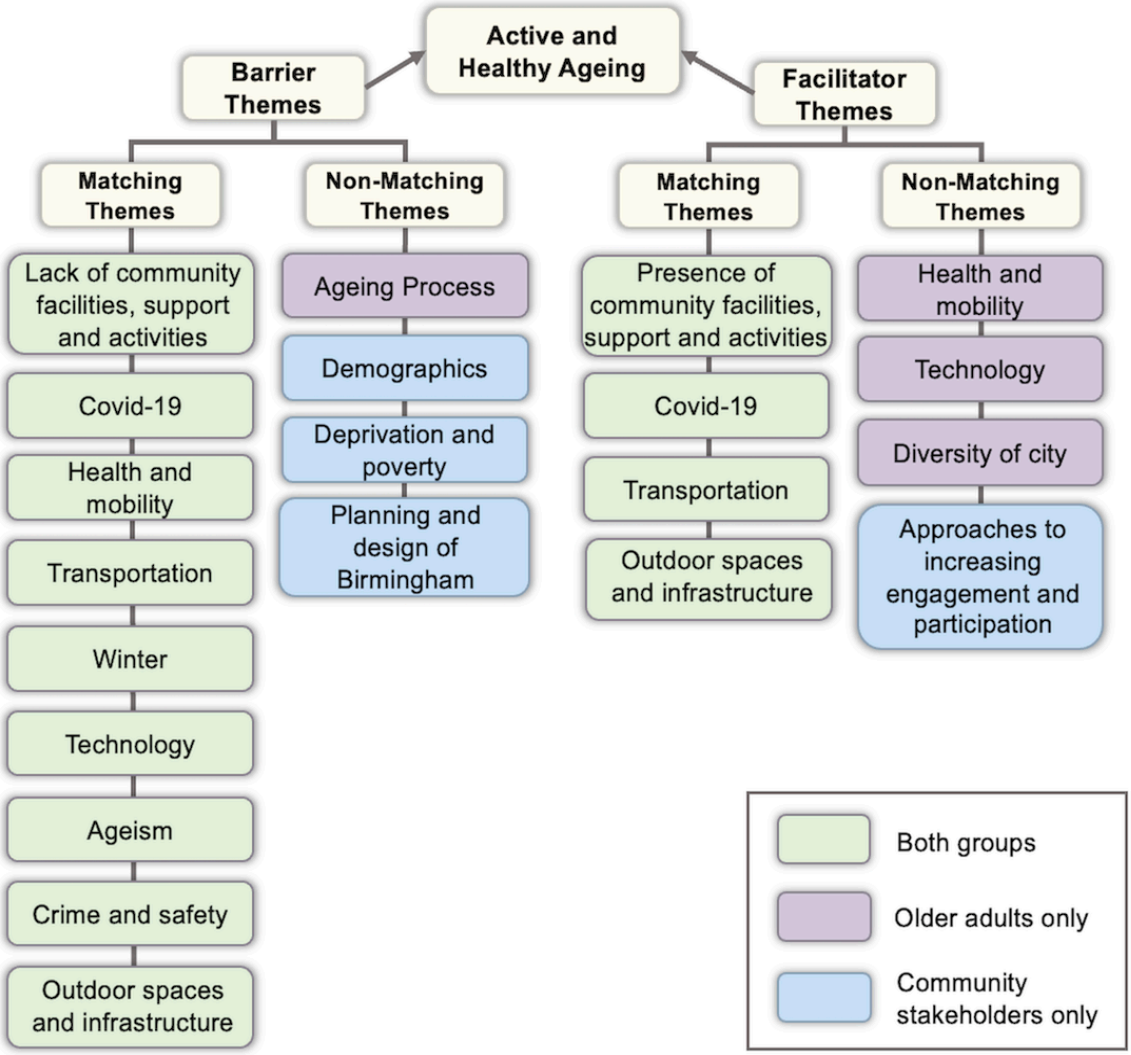


Figure 19. Barriers to and facilitators of active and healthy ageing themes. Themes highlighted in bold and italic are themes unique to older adults or community stakeholders and do not match between the two groups (Source: Author).

Themes also overlapped across multiple urban domains, with the transportation theme representing movement across local urban areas (*environmenta*l), high costs of public transportation (*economic*), and the need for policy and local regulations to make public transportation more frequent and affordable (*political*). Similarly, technology was identified to facilitate online social activities and connections (*socio-cultural*), present high costs as technology advances (*economic*), and a need for digital

exclusion strategies and policies to be put in place (*political*). *Covid-19 and winter* were also themes highlighted by both groups. *Covid-19* included barriers such as closed or lack of facilities for activities, decreased group activities, health concerns, and facilitators including increased outdoor activity and connecting through digital technology. *Winter* highlighted barriers such as darker evenings, reduced activity and fear of slipping due to bad weather.

Non-matching themes between older adults and stakeholders

Four barrier and four facilitator themes did not match between older adults and community stakeholders.

Older adults only

Ageing was a theme that encompassed a range of barriers when transitioning into the older adult demographic group. The ageing process was identified as a barrier in terms of becoming increasingly frail, which reduced an individual's self-confidence, and having reduced capacity to be active and mobile. Secondly, the resources and support available as individual's age were also highlighted as a barrier. This included a lack of support for post-retirement in relation to becoming resilient and staying active within local communities, and the need to make sure available resources such as shops are within an accessible distance. Lastly, intergenerational challenges focused on barriers with younger age groups, including difficulty to engage with younger individuals and the presence of a divide and feelings of distance with younger age groups.

Health and mobility were identified as facilitators highlighting the importance of support for walking, such as walking aids, for being active and engaging in activities. Technology was also seen to encourage activity through relevant walking apps, providing information for local activities, and enabling individuals to connect with each other and neighbours through digital platforms such as WhatsApp. Lastly, the diversity of Birmingham including a variety of people, experiences, cultures and facilities across the city was perceived as making it a vibrant, lively, and interesting place to live and participate in activities.

Community stakeholders only

Demographics was a barrier highlighted only by community stakeholders. This included how gender differences impact engagement and movement around the city and how active ageing is also characterized by ethnic differences due to different enabling factors for being active and healthy. Older women were identified to take part and engage more in activities than men, with a need to provide more comfortable and suitable places where older men can engage. The level of deprivation, economic deprivation and poverty were also seen as a barrier for older adults living in Birmingham. The index of multiple deprivation, which covers elements such as income, health and living environment, was identified to be one of the larger predictors for physical inactivity and was seen as a key barrier. Economic deprivation and poverty were also identified to limit older adults' access to resources, such as the cost of transportation limiting an individual's travel. Multiple barriers were also highlighted by community stakeholders for the planning and design of Birmingham, relating to generic planning documents that are open to interpretation, lack of specificity and sense of

direction, and present a gap between what is presented in policy and what is actually delivered on the ground.

Approaches to increase the engagement and participation of older adults in activities included gamification, age-inclusive activities, a local neighbourhood approach and participant-led activities. Alongside engaging individuals, efforts to target a range of age groups, local groups and facilities via competitive and fun elements and more activities were identified. Understanding such facilitators to social participation is important for developing the CSS method.

Developing a foundation for a CS network

Employing CSS discussion groups at this preliminary stage facilitated organic connections and sharing of resources between older adults and between community stakeholders (Figure 20). The collaborations that occurred during each group discussion led to the sharing of information, resources and fondness of local areas, as well as solution-building.

Older adults

Older adults connected throughout the online discussion groups in relation to the topics being discussed, with one individual sharing websites for playing online activities such as bridge with another who could not afford in-person activities. Another shared information about a public transportation card that provides contact details for staying safe on trains. Older adults in the same local area also connected over their fondness of local parks, the presence of badgers and wildflower meadows that are

being planted. Solution-building was also present, with an individual sharing details of a local community partnership for providing venues with another that was unable to afford venues to run self-help and exercise classes:

P3 (female, 81 yrs): ***"****I wanted a self-help group which everything was prepared, and ladies were willing to come, ladies and gents both. But I could not find, there's no community centre or anything like that…I could not get a place".*

P1 (female, 64 yrs): ***"****I'm wondering whether one of the partners in the organisation I am part of is somewhere near her, there might be an opportunity once…the church has a charity which would allow yoga so if I send you the information, it might be that there is somewhere near P3 that would be interested in what she's got to offer"*

Community Stakeholders

Collaboration between community stakeholders led to the sharing of information and resources for local programmes, groups and schemes being run. Information about local park initiatives and organizations undertaking work in green spaces was shared between one group, whilst another group invited each other to local meetings happening. One group connected over their similar goals for local urban programmes, identifying ways to adapt current work in green spaces to be applicable across all community spaces. Stakeholders also shared ways to enhance each other's schemes by sharing local research and identifying the need to put healthy ageing into an all-ages context:

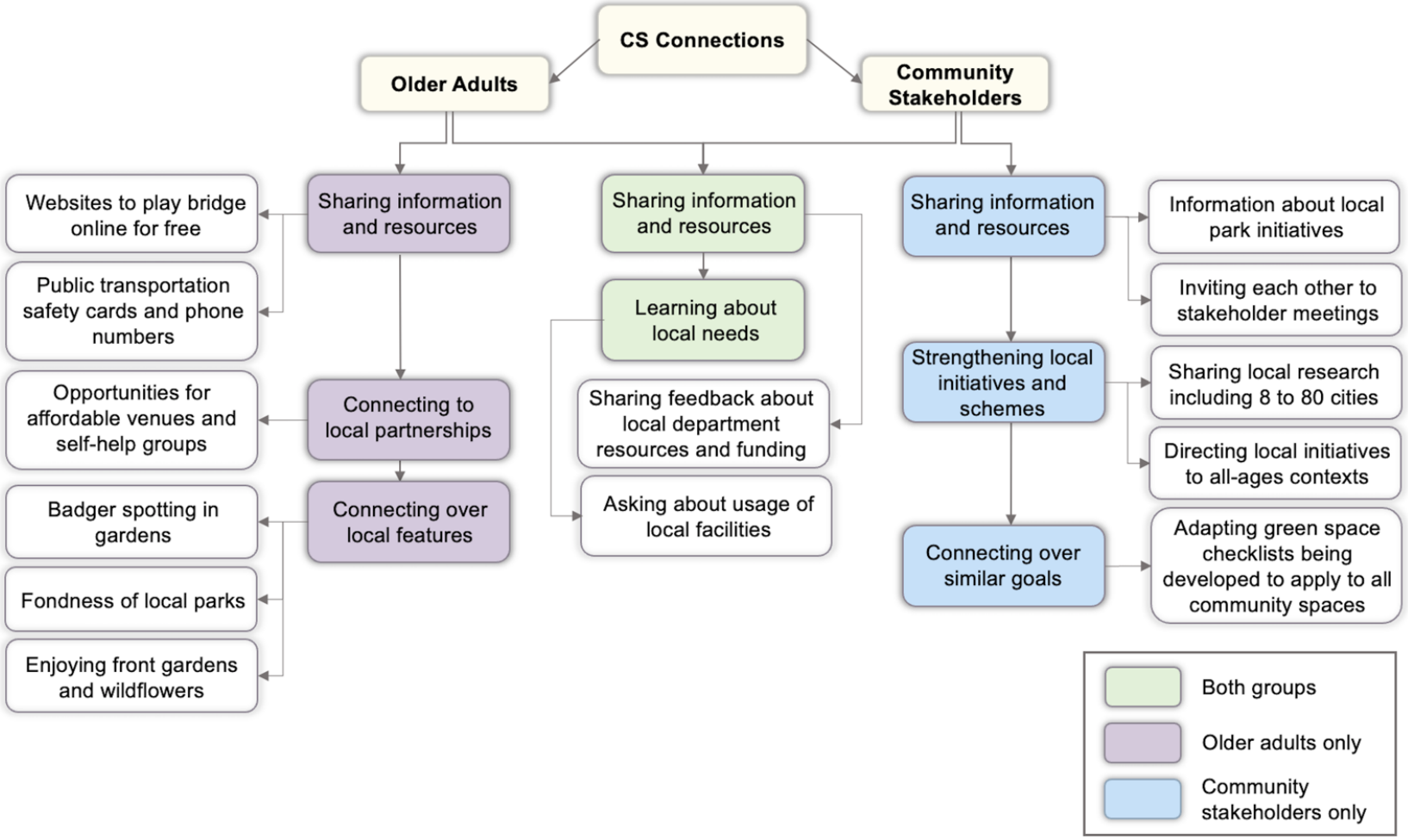


Figure 20. Overview of connections and sharing of resources between older adults only (purple), community stakeholders only (blue) and between older adults and stakeholders (green) (Source: Author).

P3 (female, non-profit community organisation): "*I think putting it in sometimes into an all-ages context might actually be more helpful in terms of moving this forward".*

P2 (female, active travel charity): ***"****On that point, have you heard of the 8 to 80 cities which is research looking at how if you make it good for eight year olds, you also make it good for a two year olds, or vice versa".*

P1 (female, non-profit community organisation): "*No, I haven't but that's exactly the point*."

5.2.6 Discussion

Employing a CSS approach, this study generated new knowledge about urban spaces in the context of social science. This knowledge was based on both the individual and collective voices of older adults and community stakeholders, alongside facilitating connections and resource sharing between these social actors. The main findings of this study demonstrate (i) the identification of urban barriers and facilitators to active and healthy ageing specific to the local-level context of Birmingham; and (ii) the suitability of CSS for enabling knowledge production and collaboration at a preliminary stage.

Urban barriers and facilitators to active and healthy ageing in local urban areas of Birmingham

Cities encompass distinct concerns at the city, community and street levels which require suitable age-friendly approaches that can address these differing needs [532,622]. The discussion groups identified 13 barrier and 8 facilitator themes that influence active and healthy ageing in urban environments of Birmingham. These themes, which covered elements of personal, environmental, socio-cultural, economic and policy domains present in urban environments, are supported by participatory research into age-friendly environments [40,54], demonstrating relevance for promoting active and healthy ageing. The agreed barrier and facilitator themes amongst each discussion group and between older adults and stakeholders suggest a shared framing of local urban spaces and concerns in Birmingham [623]. This presents a promising public and private response to urban spaces that are aligned, which is crucial for sustainable age-friendly initiatives [618,624].

Considering the local context of barriers and facilitators highlights the issues and needs of older adults at the local-level and can develop urban indicators that facilitate age-friendly processes in local urban environments [8]. The themes presented in this study show specificity to the local-level context of Birmingham, such as the theme *Covid-19* which encompassed a range of context-specific influences identified by both groups. The closing of churches and lesbian, gay, bisexual and transgender facilities was seen to have reduced social contact, whilst perceived increase in crime and limited capacity on buses due to health risks decreased outdoor activity. However, local WhatsApp groups increased neighbourhood connections, and socially distanced changes to cafés and shops were viewed to make spaces comfortable. Whilst it is

clear that older adults have been greatly impacted across their local communities and care settings by Covid-19 [625], there is an opportunity to reconsider current processes to address the needs of older adults arising from the pandemic to further promote community health [626]. For Birmingham, enhancing the public transportation system to run at full capacity and re-opening of much-needed community facilities whilst incorporating elements of social distancing may promote outdoor activity and socializing. Similarly, continuing to engage and promote technology for social activities, which will require an understanding of the specific technological needs [627], may enable social connections to continue.

The presence of community facilities, support and activities are specific local facilitators to Birmingham. All groups mentioned the importance of urban allotments and open garden events for facilitating walking, gardening activities and opportunities to socialise with other residents. Public health research evidence supports the importance of allotments for older adults, which are associated with reduced stress and better perceived social cohesion and health [628,629]. Gardening activities, or horticultural therapy, also connect individuals to nature, enhance their wellbeing and are beneficial for physical activity [630,631]. The Midlands Art Centre was another local facilitator that was noted to have promoted physical and social activities. Older adults and stakeholders would walk, cycle or take public transportation to the centre to participate in free and inclusive art and theatre activities. Engaging in these types of activities can enhance social connections, develop skills and cognitive benefits, and enrich psychological health of older adults [632,633]. Promoting the availability of urban allotments and art facilities that provide inclusive and free activities should be encouraged further to facilitate active and healthy ageing of older adults across Birmingham.

CSS for facilitating collaboration and knowledge production at a preliminary stage

Employing a CSS approach at this stage facilitated discussions between older adults and stakeholders to co-produce a set of urban barriers and facilitators, which were grounded in real-world experiences and knowledge. Having a common framing of these urban influences engaged groups further to share ideas and co-produce actions in the facilitator themes. Age-inclusive sports such as cricket and engaging further with technology to address the divide between older adults and younger age groups were collectively discussed as facilitators by both groups. This indicates a sense of value in this exploratory phase in which CSS facilitated a collaborative generation of knowledge about urban spaces that surpassed consultation. Both older adults and stakeholders were able to discuss and identify collective initiatives and actions based on social concerns and embodied experiences present across urban spaces [342,350]. This provides a strong groundwork for CSS research to be driven by localized concerns of local people through directly engaging with residents and constituents and identifying ways to answer to their needs. Furthermore, it presents the foundation for strengthening collaboration and building a network of stakeholders based on their common framing of local urban spaces, demonstrating the potential for local joint action[601,602,634].

CSS provided active opportunities to operationalize the joining of community-based knowledge and resources among older adults, stakeholders and also with the researcher. This facilitated co-production of relevant local knowledge on urban environments, rather than being solely directed by scientific practices, supporting the potential for legitimacy between these individuals for further collective and agreed-

upon actions in urban spaces [635,636]. Collaboration between older adults and between stakeholders through the sharing of resources and solution-building also suggests the incremental development towards the foundation of a collective network. Discovering the urban barriers for some individuals led to solution-building through shared discussions and resources. For example, older adults shared ideas for addressing unaffordable venue hire, whilst stakeholders provided suggestions for bringing their organizations together to make local initiatives stronger. The connection and generation of ideas and solutions indicate that CSS can effectively form the foundations of community-building [623,637], develop future interplay between stakeholders [341,350], and facilitate a supportive online environment in which collaboration and knowledge coalition are achieved [45,352]. Enabling connections, common actions and social cohesion can have indirect positive health impacts[256] and effectively contribute towards addressing social challenges present in urban spaces [352,638].

Strengths & areas for further research

A key strength of this study is the collaboration and shared knowledge resource facilitated by CSS. Older adults and a wide range of stakeholders collaborated to identify and discuss urban influences across Birmingham. This enabled a knowledge resource of ageing-well and urban planning processes to be shared, a collective identification of contextual and meaningful urban influences, and the foundations of a network to be formed.

A priority area for attention in future studies is the representation of voices and experiences of ethnically and gender-diverse groups of older adults. This study utilized

a qualitative and highly involved approach which encompassed the voices of a small group of older adults and aimed to build a community of interest around age-friendly urban change. Participants in our study were predominantly female and White English. Females are shown to have different mobility and travel needs [639,640] and pursue different physical and social activities in urban spaces [641,642]. Birmingham is also a superdiverse city, with ethnic diversity presenting a range of different urban narratives and influences [643] that require further consideration. Therefore, future research should endeavour to provide representative accounts of ethnically and gender-diverse and disadvantaged groups of older adults to further encompass and represent a wider range of voices. Further, shifting the discussion groups from in-person to online via Zoom due to the Covid-19 global excluded participants who were not digitally literate. Future research should engage with older adults both online and face to face in order to increase the representativeness of participants and outcomes.

Future steps

CSS facilitated togetherness, networking and connection between older adults and between stakeholders to present a set of matching concerns and a sense of common purpose for urban spaces in Birmingham. These are elements that can inform decision-makers about the views of older adult residents [290] that can work towards improving urban community health. Utilizing the CSS research reported here, we have further engaged with older adults and community stakeholders in the next steps of our study, which goes on to employ the *Our Voice* CS for health equity approach [106]. This aims to further co-produce knowledge on urban barriers and facilitators to active and healthy ageing in Birmingham based on their voices and experiences [352]. Once

completed, we will evaluate and assess the CS project in relation to the strengths and weaknesses of the CS approach employed, the partnerships built throughout, and the potential possibility of future ripple effects[598].

5.2.7 Conclusion

This study effectively engaged older adults and a range of stakeholders through a CSS approach to collaborate, share concerns and co-produce ideas for enhancing local urban environments across Birmingham. A set of urban barriers and facilitators were identified by both groups, presenting a range of matching features across personal, environmental, socio-cultural, economic and policy domains. Older adults and stakeholders collaborated during discussions to generate actions and solutions to further promote active and healthy ageing, including providing a range of age-inclusive activities. The emerging connections and resources shared between older adults and between stakeholders, alongside the alignment of matching urban barriers and facilitators, indicate the potential foundation for a collaborative network that can continue to be engaged further. Employing CSS shifted the focus of urban health promotion from targeting the individual to instead considering collaboration between individuals to identify community needs within urban environments, further supporting the increasing evidence base of the importance of place-based health promotion initiatives.

Chapter 6 – Employing citizen science to enhance active and healthy ageing in urban environments

6.1 Summary and context

This chapter presents the Improving Your Local Area citizen science (CS) study that engaged older adults and community stakeholders in three community-driven CS stages. The study was informed by the *Our Voice* CS for Health Equity approach, being guided by its four-step method and 'by the people' level of engagement. Three of the four-step method presented by the *Our Voice* CS approach was undertaken by this study, which included citizen-led data collection, discussions and workshops. The co-produced outcomes included area-specific and city-wide recommendations, alongside actionable pathways for their implementation. This study also builds on the preliminary CSS stage (Chapter 5), continuing to engage older adults and community stakeholders to build on the collective knowledge, sharing of resources and network-building already undertaken. Overall, the CS study presented by this chapter facilitated the effective engagement of older adults and community stakeholders, co-producing recommendations and actionable pathways for promoting active and healthy ageing across the city of Birmingham.

This study sits within the context of public health literature exploring ageing experiences in urban environments [25,29,40,53,512] and builds on the recommendations of these studies to strengthen the active engagement of older adults in public health research. This includes the globally accepted World Health Organization (WHO) Age-Friendly Cities (AFC) approach, where older adults were engaged in a bottom-up

approach and identified eight AFC topics within their cities [21]. This age-friendly agenda has continued to be developed and expanded since its introduction, identifying further methods that can strengthen the active engagement of older adults to develop meaningful age-friendly urban initiatives [35,54].

This has led to deliberative approaches to enhancing the active engagement of older adults in public health, urban, ageing and CS research, also described as a participatory turn for research [644]. The use of multiple approaches, including participatory, CS, participatory action and community-based approaches, have since been employed to explore and strengthen the age-friendly agenda [54,94,369,644-646]. These approaches have also encompassed a range of methods and terms related to engagement including co-production, co-creation, co-design and co-delivery [107,647,648], as well as being summarised as a systematic inquiry to co-producing research with those engaged [87]. There are also limitations identified across these initiatives such as the scalability and generalisation of outcomes [644]. This is particularly important for studies engaging smaller numbers of older adults [54] or needing to strengthen the engagement of those that represent a population or issue being explored [290,314]. However, across these different terms and methods, there is a common thread of centring on an individual's narrative, experience and insights, encompassing their embodied experiences within age-friendly research to further inform the age-friendly agenda [648-650].

The increasing engagement of older adults has brought these individuals to the foreground of public health research, highlighting ways in which their experiences and knowledge can identify and address urban concerns faced by the ageing population. A summary of these outcomes has been presented in the systematic scoping review (Chapter 4), demonstrating a range of urban barriers and facilitators identified directly

by older adults that impact active and healthy ageing. Alongside recognising urban barriers and facilitators, actions and solution-building developed by older adults have also effectively informed ways in which their urban environments can be enhanced. This includes ways in which social isolation can be tackled [645,651], wellbeing can be promoted [277], independence and mobility can be promoted [649] and how community development and service delivery can be senior-led and culturally sensitive [87]. These outcomes demonstrate how the direct engagement of older adults within research can be utilised to effectively inform relevant and required age-friendly initiatives and services [94,274,652].

The CS study undertaken as part of this PhD research also sits within the context of the *Our Voice* approach. This approach employs a community-driven CS four-step method to engage community members in research with the aim of fostering health equity in their local communities. The *Our Voice* approach has been used across the globe, including Israel, Mexico, America, Brazil, Canada and Alaska, to engage older adults to explore the built, social, community and health elements that impact these individuals in their local communities [54,110,113,118,304,334]. Findings from these community-driven studies have identified local and community-level urban characteristics, from quality of pavements and presence of benches to affordable food, places to socialise and the presence of LGBT venues, that prevent and promote age-friendliness [54].

Notwithstanding this growing body of public health literature, the use of co-production to engage older adults in studies focussing on age-friendly environments is argued to still require strengthening in its processes and outcomes [645]. This gap was also identified in the systematic scoping review (Chapter 4). This CS study

contributed further to strengthen the field of age-friendly and public health research through the following:

1) Facilitating the effective engagement of older adults and community stakeholders to co-produce area-specific and city-wide recommendations for promoting active and healthy ageing in urban environments.

    This was achieved through citizen-led data collection, discussions and advocacy of recommendations to stakeholders, as well as engaging in a preliminary stage to shape the study focus (Chapter 5). This community-driven CS study revealed the ageing experiences of older adults engaged and facilitated solution-building to promote active and healthy ageing across Birmingham. Co-producing area-specific recommendations identified the urban barriers or facilitators that enable those engaged to be active and healthy, alongside capturing the micro-scale characteristics and interactions that occur in an older adults daily urban life [653,654]. Micro-scale characteristics are described as those that hold local-level relevance and influence or are influenced by individuals who reside in the environments they exist [655]. For example, the closeness and suitability of facilities to an individual residence, alongside the accessibility and quality of infrastructure such as pavements, can influence interactions at the local-level such as the choice to walk to facilities or be physically active [6,61,69,70].

    The area-specific recommendations encompassed micro-scale characteristics present for older adults engaged in this study (presented in section 6.2.4 of this chapter). These recommendations encompassed the embodied experiences and experiential knowledge of older adults, presenting local context and ways in which urban environments can be altered to enhance

the ageing experience. This is something that can foster supportive and sustainable environments for older adults [656], facilitate suitable health promotion initiatives [657,658] and inform relevant urban planning and decision-making [89,126,369].

At the same time, the CS method brought older adults together as a collective group, identifying shared priorities and needs that are presented through the city-wide recommendations. Enabling community change requires the foundation of a collective group with a shared viewpoint, which can also facilitate sustainable changes [659]. The city-wide recommendations built on the area-specific recommendations, developing them into collective and scalable actions that have relevance across the city. In particular, the city-wide recommendations revealed insights on the multi-dimensional experiences of urban spaces encountered by the collective group of older adults engaged [660]. This identified a similar person-place experience between the individual and collective group of older adults engaged [661], alongside the potential foundation of wanted and shared change across the collective group that can be actioned in the city of Birmingham.

2) Developing an implementation framework that presented actionable age-friendly pathways across sectors, organisations and levels of a city.

Using a CS co-production level of engagement, this framework builds on the foundation of urban change that is directed by older adults and community stakeholders engaged in this study. The engagement of these individuals enabled place-based needs and local-level context to be embedded in collective recommendations, which were scaled up across the city through this implementation framework. Through older adult and community stakeholder

dialogue, the city-wide recommendations were discussed and embedded into actionable pathways that can take place across the city. This dialogue presented a deeper understanding of shared knowledge, resources and actions across a range of multi-level and interdisciplinary actors, alongside their diverse authority and resources which are embedded within urban governance [662]. Considering these elements identified actionable pathways across local communities, public health and planning, business and private sector and public health policy levels. This enabled ways in which the city-wide recommendations could be scaled up and mobilised across the city and its actors to action age-friendly changes.

It is important to acknowledge that the multi-level pathway presented by this framework may not consider and encompass all urban changes and contexts present, such as the political and institutional structures or behaviours of actors. However, considering the city from this scalable and multi-level perspective is important, particularly as fostering urban improvements are argued to not take place without identifying the multiple elements and actors that can support these improvements [663]. It can also identify potential capacity, governance and decision-making processes across actors that are required to action and sustain wanted change across the city [205]. Overall, the actionable pathways identified by this framework encompass the collective concerns of older adults whilst leveraging the strengths and resources of multiple stakeholders across different levels of the city. This has the potential to develop a coherent age-friendly strategy across these multi-level actors which is required to facilitate effective urban change [664] and identify the capacity across the city to action age-friendly recommendations.

3) Strengthening the WHO's AFC approach by presenting the implementation framework that can further action the needs of older adults and strengthen the age-friendly agenda.

Limitations of age-friendly initiatives in terms of scale have been recognised. Initiatives have been identified as small scaled which has reduced the understanding of systemic issues, capacities of actors and challenges faced by older adults in the wider context of the city [269]. At the same time, the universal guidance of the AFC approach has been argued to be positioned at a level that is too high to capture the smaller and more local elements of everyday life [656]. The comparison of the implementation framework to the WHO AFC guidance [21] in this chapter demonstrated relevance between the two. However, the implementation framework provides a more detailed structure of pathways for actioning age-friendly recommendations across the city. This includes the identification of multiple actors, organisations and resources across the different levels of the city where potential levers for actioning change can be presented. The framework also show specificity of identifying change at the local-level and scaling it up across city-levels to consider these elements and capacities. This presents a more coordinated process of going beyond universal age-friendly guidance and recognising where age-friendly changes informed by local needs can be actioned in a city.

To build on these contributions further, the CS Improving Your Local Area study is presented in the following section, with an expansion of the discussion and its wider implications for public health and ageing research in Chapter 7. The CS study

presented by this chapter is also evaluated by the CSAT (Chapter 4) as a way of identifying its quality, which is also presented in Chapter 7.

6.1.1 Author Contributions

GW led the data collection and analysis. GW, AS, JP, AB and AK contributed towards the study design. AS and JP contributed towards data analysis. GW drafted the manuscript, AS and JP reviewed the manuscript, and GW undertook manuscript revisions with guidance from all co-authors. AS obtained funding for the study. . All authors read and approved the final draft.

6.2 Employing citizen science to enhance active and healthy ageing in urban environments

Wood GER, Pykett J, Banchoff A, King AC, Stathi A, and on behalf of the Improving Your Local Area Citizen Scientists and Community Stakeholders

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6.2.1 Abstract

Engaging older residents in problem definition and solution building is key to the success of place-based initiatives aiming to increase the age-friendliness of urban environments. This study employed the *Our Voice* approach, engaging older adult citizen scientists (n = 14) and community stakeholders (n= 15) across the city of Birmingham, UK. To identify features impacting age friendliness, citizen scientists participated in 12 technology-enabled walkability assessments, 3 in-person discussion groups, 2 one-to-one online discussions, and 2 workshops with community stakeholders. Together, citizen scientists co-produced 12 local and six city-wide recommendations. These recommendations were embedded into an implementation framework based on workshop discussions to identify age-friendly pathways in urban environments.

6.2.2 Introduction

Population ageing and urbanization are two global demographic mega-trends that are simultaneously transforming society [6]. Whilst the 703 million individuals aged 65 years and above will more than double by 2050 [14], over half of the global population will transition to residing in urban environments [2,6]. Urban environments, referring to physical environments with built and natural features that form settlements and local places such as cities and towns [53,129], are recognised to influence health, well-being, and the ability for individuals to be active as they age [21]. As 43.2% of older adults from developed countries already reside in cities [11], alongside the expectation that the majority of population ageing will occur in urban environments [10],

understanding the pathways to creating age-friendly urban environments is crucial for promoting active and healthy ageing.

Urban environments encompass a multitude of characteristics that influence healthy and active ageing [21], including the quality of places, accessibility of services, street connectivity, well-maintained pavements, and social and economic opportunities [5,52,53,665,666]. Such urban characteristics intersect across the individual, environmental, socio-cultural, economic and political domains [19,161]. However, the characteristics and their interactions are often very specific to the places and contexts in which they occur, with neighbourhood demographics, financial circumstances, socio-economic inequalities, alterations to local places, and the availability of local destinations and services influenced by the many actors, behaviours, resources, and agendas across each social-ecological domain [29,62-64,66,667]. In turn, urban environments are hotspots for complex social-ecological and multi-level interactions that can create both challenges and opportunities for ageing residents [19,63,532].

Global agendas and frameworks have been developed to address the health and well-being needs of older adults in urban environments, including the Active Ageing Policy framework [37], the Age-Friendly Cities model [21] and policies to promote ageing-in-place [35,45]. The Age-Friendly Cities model provides guidance for altering and enhancing urban places, structures, and services to promote active and healthy ageing [668]. Eight specific topics are identified in the model: *Outdoor spaces and buildings; Transportation; Community Support and Health Services; Communication and Information; Civic Participation and Employment; Respect and Social Inclusion; Social Participation; and Housing [21].* "Ageing-in-place" when promoted across sectors, fosters opportunities to remain at home and age independently, while staying connected to local support and places [534,669]. It has been shown to be a positive policy

approach for enhancing health and quality of life and reducing health care demands [670].

These frameworks have raised increasing awareness of age-related concerns about remaining healthy in urban places [25,35,669], but their applicability across diverse urban settings, with different contexts, pressures, and local-level needs, require further attention [29,185]. Additionally, some accuse age-friendly initiatives of being ageist by implicitly or explicitly over-relying on stereotypes of older age in design planning and implementation [8, 40,267]. In other instances, tensions can arise when "age-friendly" initiatives intersect with economic discourse and political agendas [59,270], for example when critics posit that the provision of age-friendly environments is meant to reduce government responsibility and spending on the health needs of older adults [265,671]. Perhaps most fundamentally, what at times have been purported to be age-friendly policies and agendas can be ineffective in capturing and addressing the self-defined needs of older adults in urban environments. Clearly, there is a need for further consideration of ageing experiences in local places [29,669,672].

Enabling older adults to define their own lived experiences at the neighbourhood level can promote an in-depth understanding of the conditions, contexts, and everyday interactions that influence their health and well-being [11,17]. For instance, directly exploring the elements of healthy ageing valued by older adults in urban New Zealand revealed their realities of healthy ageing, including the need for physical comfort, independent decision-making, and social integration, which were identified by older adults to support meaningful participation in urban places [65]. In the United Kingdom (UK), the "15-to-20-minute neighbourhood" concept aims to create local environments in which everyday needs can be met within 20 minutes of an individual's residence. While this policy agenda aims to promote greater

accessibility of services [673], at times it has resulted in the amplification of voices of younger people to the exclusion of perspectives and insights from older adults. In one notable example, older adults in Newcastle, UK expressed increased feelings of marginalisation as the design of the 15-to-20 minute neighbourhood underscored their own lack of local opportunities relative to the younger population [17,674,675]. A place-based approach that more intentionally engages community expertise can avoid exacerbating socio-economic and spatial inequalities already present and both recognise and address local concerns and needs of older residents in their own places [673,676].

Citizen science (CS), a branch of participatory action research, is a methodological approach that engages local residents to collect data based on their perspectives and experiences [99,100]. Through various levels of engagement, including contributory, collaborative and co-production activities, CS can actively engage older adults to directly process and collect, interpret, and share their own data [105,106]. This provides the opportunity to generate real-world and locally-relevant knowledge based on the concerns of local residents and can complement and ultimately strengthen more traditional research methods [98, 311]. CS has also successfully informed urban age-friendly planning by engaging older adults in sharing their views, experiences, and co-producing solutions for their local places [54,117].

In this study, the *Our Voice* Citizen Science method [98] was used. This method aims to engage community members in a scientific process that aims to enable the creation of health-promoting environments so that all members of society have access to a healthy and vital life [329]. Developed at Stanford University, *Our Voice* comprises of four-steps, beginning with training local residents, as citizen scientists, to collect data using a simple mobile app called the Stanford Discovery Tool. The app allows

users to gather geotagged photos, audio/text comments, and ratings documenting environmental features impacting healthy living. In a facilitated process, citizen scientists then review and analyse group data and use them for collective cross-sector dialogue and solution-building with community stakeholders [106,302]. This framework has effectively engaged older adults in promoting local community health and age-friendliness across a wide diversity of cultures and contexts globally [54,91].

In the current study, we applied the *Our Voice* CS method across the city of Birmingham, UK to engage older adults as citizen scientists and community stakeholders, with the aims of 1) identifying self-described barriers and facilitators that influence older adults' active and healthy ageing in the city of Birmingham; and 2) co-producing a set of relevant and actionable recommendations for improving local urban areas to promote age-friendliness.

6.2.3 Materials and Methods

Study context

This study is part of the *Improving Your Local Area Citizen Science project*, which included preliminary work undertaken to inform location-specific adaptation of Stages 1 to 3 of the *Our Voice* CS approach. The preliminary stage consisted of 6 online discussion groups (60-90 minutes) with older adult citizen scientists (n=16) and community stakeholders (n=11), with details and outcomes published elsewhere [677]. The study reported here presents Stages 1 to 3 (Figure 21) of the *Our Voice* CS method.

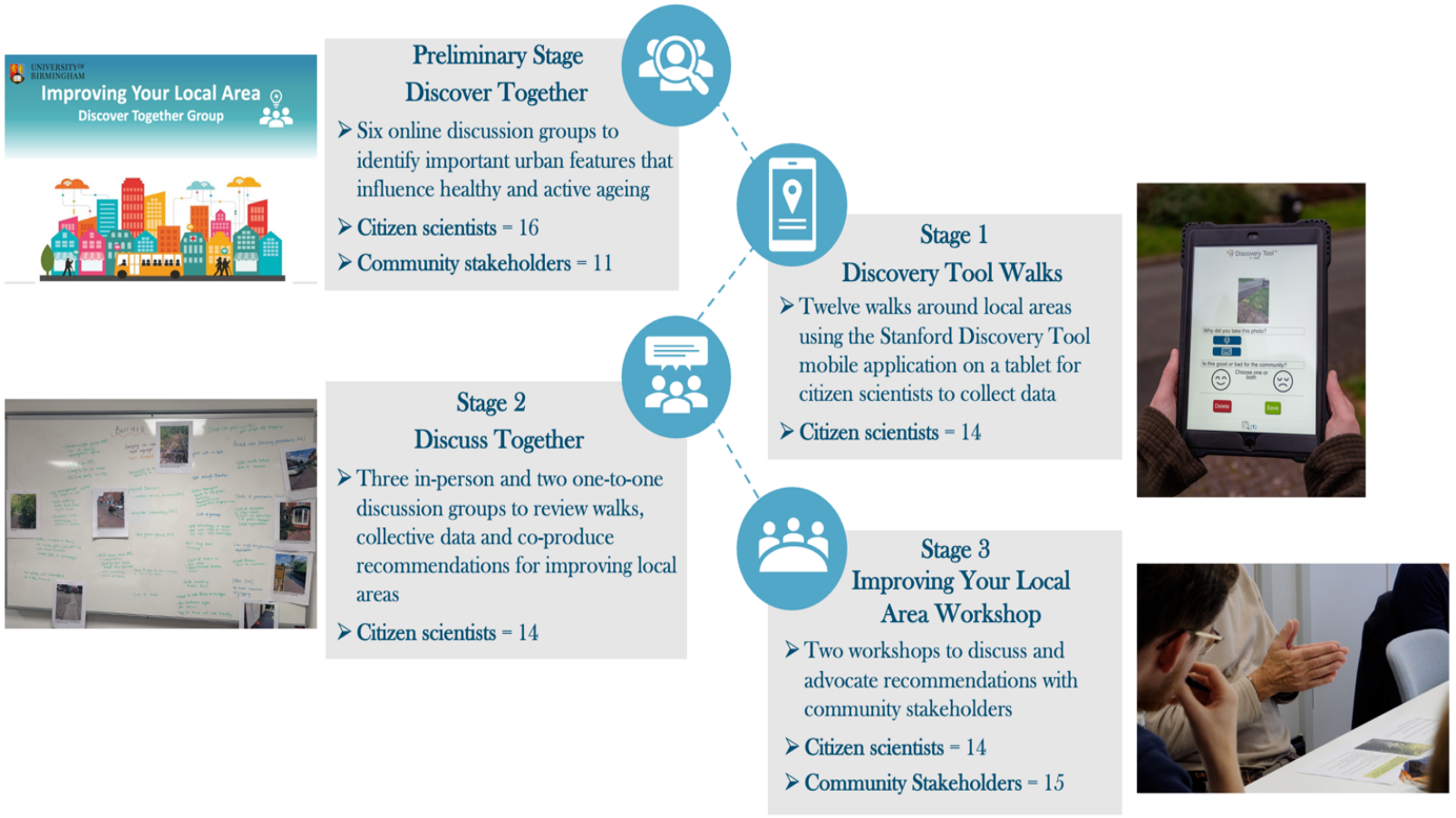


Figure 21. The stages of the "*Improving Your Local Area"* Citizen Science study *(Source: Author)*

Study setting and participants

This study took place in the city of Birmingham, UK, from August 2021 to January 2022. Birmingham is the second largest city in the UK and has a growing population of older adults aged 65 and above, with an expected rise from 150,600 to 194,100 older adults by 2040 [426]. Birmingham is characterised as a superdiverse city [88], that is a city that encompasses a diverse range of populations from different countries, migration channels, ethnicities, religions, age and sex that form multi-cultural communities without one predominant ethnic group [460]. It is the 3rd most deprived city in the UK based on indices of multiple deprivation, with 43% of the population living in 10% of the most deprived areas [434,435]. At the same time, Birmingham is an urban setting with green spaces, corridors and parks covering 4,700 hectares, making it one of the greenest European cities [432,433].

Citizen scientists aged 60 years and above were recruited through convenience and snowball sampling, with an aim of recruiting older citizen scientists across the 69 wards of Birmingham. The study and recruitment material were shared via targeted emails to urban planning and Ageing Well services across Birmingham. Interested older adults contacted the study team were telephone-screened for their eligibility and those eligible then signed consent forms prior to study commencement. Citizen scientists received £35 compensation to cover their time involvement (a total of 5 hours composing of 1 Discovery Tool walk, 2 in-person meetings and 1 preliminary online), travel and subsistence, as well as a way of supporting those who may otherwise not have been able to engage. In our study only those citizen scientists who completed all stages were eligible for compensation (n = 4 stages]) with 4 participants declining payment altogether.

During the time of this study, the global Covid-19 pandemic occurred. This was likely to have impacted the number of citizen scientists we were able to engage. Citizen scientists were recruited from 11 of the 69 wards so were not representative of older adult communities across all the different administrative and geographical areas of Birmingham. Community stakeholders in urban planning and Ageing Well services were recruited via convenience and snowball sampling through targeted emails to their organisations. Community stakeholders engaged only in the preliminary discussion groups and in Stage 3 workshops, with verbal consent given prior to participation.

Study methods informed by the *Our Voice* CS method

Stage 1 – Discovery Tool Walks

In August 2021, citizen scientists (n=14) used the Stanford Discovery Tool mobile application [331] on a project electronic tablet to complete 12 data collection walks in their local areas, with four citizen scientists completing two walks together. The citizen scientists received online Discovery Tool training materials and were able to practice using the application prior to starting walks. The objective was for citizen scientists to collect geo-tagged photos, audio or text narratives, and ratings to document barriers and facilitators to active and healthy ageing in their local areas. Each individual was asked to choose a walk that was meaningful to them, and the choice of location or length of walks was not influenced by the researchers.

GW was present during each walk, initially to provide technical support and alleviate safety concerns. Only two of the 14 citizen scientists felt comfortable using the Discovery Tool on a e-tablet whilst walking, with concerns about tripping, needing

to use a walking aid, or glare reflected from the sun impacting vision. To address this, GW carried the iPad during the walk and followed instructions from citizen scientists on when to collect data, including being instructed to take photos and write textual descriptions. Due to Covid-19 restrictions, GW was unable to pass the e-tablet back to citizen scientists when they indicated data were to be collected. At the end of each walk, GW uploaded the anonymous data to a secure Institutional Review Board-approved server at Stanford University.

Stage 2 – Discuss Together Groups

Three in-person discussion groups (n=12 participants) and two online one-to-one discussions (n=2 participants) were completed in September to October 2021, lasting 60 to 90 minutes each. The aim was for citizen scientists to discuss the urban barriers and facilitators collectively identified in Stage 1 in order to a) produce area-specific recommendations; and b) as a group, co-produce city-wide recommendations for enhancing active and healthy ageing. The in-person discussion groups were facilitated in two steps: 1) participatory mapping and photo-elicitation exercises (Brookfield et al., 2020) using photos and narratives collected during stage 1 to thematically review and prioritise data; and 2) discussion of the reviewed data to produce area-specific information and recommendations as a group for promoting active and healthy ageing city-wide. For each recommendation, citizen scientists were asked i) to identify what needed to be done and why; ii) how and when it should happen; iii) and who would need to be involved. Area-specific and city-wide recommendations were written down by both citizen scientists and GW, with GW

repeating back all recommendations at the end of each discussion group for confirmation.

Two citizen scientists were unable to attend in-person due to Covid-19 and other health reasons. One-to-one discussions (n=2) were held via Zoom (Version 5.8.4). Individual-level data collected at Stage 1 during the Discovery Tool walks were shared with each of the citizen scientists prior to these discussions. Each citizen scientist then worked on the data they had collected and used them to identify area-specific recommendations for their area of residence. The city-wide recommendations (co-produced during the Stage 2 group discussions) were also shared with the two citizen scientists unable to attend in-person and discussed to determine their relevance and suitability. At the end of all discussion groups, as per *Our Voice* guidelines, each citizen scientist received a community advocacy handbook describing generic steps and processes for engagement in advocacy activities.

Stage 3 – Discuss Together Workshops

Two public engagement workshops were held with citizen scientists (n=14) and community stakeholders (n=15) in Birmingham City Centre during November 2021. The workshop aimed to 1) facilitate discussions of the data-informed city-wide recommendations among citizen scientists, community stakeholders and researchers; and 2) strengthen the city-wide recommendations by identifying actionable routes to their implementation. GW facilitated the workshops by sharing the 6 city-wide recommendations and, for each recommendation, asking stakeholders four questions to identify barriers and facilitators to implementation and stakeholder involvement. These discussions led citizen scientists and community stakeholders to propose

actions taking into account individual- and organisational-level factors as well as partnerships and/or resources required.

Data Analysis

Data generated in Stages 1 and 2 were co-produced and interpreted directly by the citizen scientists. Discussions held during Stages 2 and 3 were audio-recorded and transcribed, with reflective and summative notes taken by GW. All audio data and transcripts were anonymised and stored securely on a University of Birmingham research data server. Using NVivo 12 Software (QSR International Australia), transcripts were analysed through inductive thematic analysis [491,505]. Both latent and semantic coding [489] were completed to capture the barriers and facilitator themes to implementing the city-wide recommendations discussed by citizen scientists and stakeholders. The themes informed the development of an implementation framework for putting the city-wide recommendations into action across the local and city levels of Birmingham, and the production of a user-friendly guide for making Birmingham more age-friendly. The implementation framework was also mapped against the World Health Organization (WHO) Age-friendly cities model [21,39] to identify similarities and differences (Appendix 4).

The area-specific and city-wide recommendations co-produced at Stage 2 and the implementation framework developed at Stage 3 were shared via email with citizen scientists and community stakeholders, with an invitation to review and provide feedback. Email, Zoom and telephone discussions were held with citizen scientists and stakeholders during this member checking process, with further clarifications made by GW to the ideas based on these discussions. Employing this type of “member

checking" allowed citizen scientists and stakeholders to review the study data, ideas guide, analysis description and interpretation for validity and accuracy of what was collected or discussed [503]. This facilitated the opportunity for those engaged to be reflective about the interactions that occurred and build a consensus towards priority findings to be disseminated to the wider public [678,679].

6.2.4 Results

Fourteen citizen scientists (Mean age = 72 [SD 7.6] years) engaged in Stages 1, 2 and 3 (Appendix 4). For Stage 1, walks ranged from 20 to 120 minutes (Average minutes = 62 (SD 34.5). Due to health reasons, one citizen scientist was unable to engage in Stage 3. Citizen scientists were predominantly women (n= 9), White British (n=8), retired (n= 12), educated to university level and above (n= 10), and lived in Birmingham for over 30 years (n= 10). Citizen scientists lived in 11 of the 69 wards across Birmingham, representing areas where older adults aged 60 and above make up 15.6% to 33.1% of the population. Based on the indices of multiple deprivation, 9 wards represented 10%-40% of the most deprived areas nationally in the UK and 2 wards represented the least deprived 50% of areas nationally (Birmingham City Council, 2019). Fifteen community stakeholders took part in Stage 3 only and were predominantly women (n= 9) and from Ageing Well and urban planning community organisations, charities, and municipal services. No other demographic information was collected from stakeholders.

Area-based recommendations

Citizen scientists created 12 area-based recommendations (Table 9). Citizen scientists highlighted green spaces in six of the 12 recommendations, underscoring the need for increased maintenance and development services to facilitate accessible green spaces. Providing accessible and good quality toilet and water facilities was also important for older residents to spend time in green spaces. Citizen scientists highlighted the importance of outdoor spaces in six recommendations, demonstrating a need to provide maintenance and repair services, such as cutting back trees and cleaning up leaves. This included mending and maintaining broken pavements, as well as using tarmac rather than slabs, to reduce falls on pavements that are caused by parked cars. The citizen scientists also recommended altering the location of a “low-traffic neighbourhood” initiative due to subsequent increase of traffic impacting air quality in diverted areas.

Private transportation and parking were express concerns of the citizen scientists in four recommendations. They highlighted a need to provide stronger enforcement of cars parking on pavements, particularly during school drop-off and pick-up times. Lastly, two recommendations underscored a need for community integration and cohesion in public and green spaces. Meeting these needs requires long-term plans and joined-up thinking for local services and spaces that could better support older adults in integrating into their communities and provide opportunities for intergenerational interaction, care, and maintenance of local and green spaces.

Table 9. The 12 area-based recommendations identified by citizen scientists

Area-Based Recommendations
1. Clear public pedestrian areas and footpaths of fallen leaves, bushy areas and cut back trees
2. Put in a café, toilets, and community hub to create a community space at the local park
3. Make public toilet facilities available in public and green spaces
4. a) Provide greater access to public conveniences b) Maintain the development of beautiful green spaces across Birmingham
5. a) Make walking areas in open and green spaces clean, pleasant and well-maintained b) Provide a needed bicycle pathway throughout the city
6. a) Mend and maintain pavements b) Use tarmac rather than paving slabs
7. a) Change the location of the current Low Traffic Neighbourhoods on the high street b) Provide stronger enforcement of drivers who park cars in local areas
8. Stop drivers who park their cars in local areas for school pick-up and drop-off in residential cul-de-sac
9. Provide stricter enforcement of speeding and a 20mph speed limit in residential areas
10. Stop drivers who park their cars on pavements
11. Encourage local communities to be proud of their green spaces and appreciate how important they are to the environment
12. a) Provide a plan for integrating communities that can a) support older and younger groups, employment services b) provide maintenance of green spaces

City-Wide Recommendations

Citizen scientists co-produced six city-wide recommendations collectively for urban spaces across Birmingham (Table 10). Five out of the six collective recommendations were similar to the area-based recommendations (Appendix 4), including features across the environmental, socio-cultural and economic domains of local urban areas.

Table 10. City-wide recommendations co-produced by citizen scientists

City-Wide Recommendations
1. Provide funding for maintenance, services, and care for public and green spaces
1. Provide funding for maintenance, services and care for public and green spaces
2. Provide toilets in public and green spaces
3. Enforce and regulate cars parked in local areas
4. Provide digital and non-digital access to local information and resources
5. Improve green spaces and communication services from the city council
6. Improve and enhance community cohesion

Implementation framework

Based on the city-wide co-produced recommendations, Stage 3 workshop discussions between community stakeholders, citizen scientists and the researcher led to the development of an implementation framework (Figure 22). The thematic analysis of workshop discussions revealed a range of barriers to and facilitators of

implementing the six city-wide recommendations (Table 9). The city-wide recommendations identified by citizen scientists to be relevant and applicable across the entire city were then discussed in detail with community stakeholders. This led to the development of actions through which urban environments across Birmingham could be altered or enhanced. Encompassing these actions, the implementation framework lays out pathways for enacting the city-wide recommendations across four levels: *local communities, public health and planning, business and private sector*, and *public health policy*. Examples of these actionable pathways and their terms are explored in the sections below.

Examples of implementation actions and actors across each of the four levels identified by this framework include: 1) *Local communities* where active residents develop a locally-focused agenda, proactively guide councils for desired services, and engage younger age groups in maintenance services; 2) *Public health and planning* where local authorities reduce their risk adversity and trust volunteers to support service delivery traditionally allocated to paid-staff. They embed the requested services into current community programmes and proactively communicate with residents about the feasible services that can be provided; 3) *Business and private sector* engagement to generate volunteers for maintenance duties and underwrite events in green spaces to generate local funding; and 4) *Public health policy* to: a) implement educational programmes for young people on the importance of maintenance of public toilets for all age groups as a way of "marrying-up" the issue of vandalism with maintenance of public toilets and b) promote a city which supports independence, confidence, connections with each other, and inclusive spaces where older adults can flourish, as a strategic policy action. Both *public health and planning* and *business and private sector* merged across certain actions. For example,

implementing the community toilet scheme requires reduction of business rates, engagement with local assets such as shops, and demonstration to local assets that older adults using their toilets may become new customers. The development of an active community infrastructure also requires the creation of safe and comfortable shared community environments that can facilitate 'bumping' places in local assets where residents can casually meet and connect.

Mapping the city-wide recommendations and their implementation framework actions against the WHO Age-Friendly Cities model and its eight topics (Figure 22) highlighted several similarities (See Supplementary Material 1), demonstrating that the WHO topics are universal and suitable for application across diverse cities. WHO Topic #5, *Respect and Social Inclusion*, for example, was an element of all six city-wide recommendations, (e.g., listening to older adult voices, facilitating intergenerational interactions, public education to raise awareness of ageing, and facilitating older adults to have an inclusive role in local places). WHO Topic #1, *Outdoor Spaces and Buildings*, was identified in five recommendations (e.g., provide pleasant, clean, and safe outdoor environments with age-friendly pavements, adequate public toilets, well-maintained green spaces, and services that are situated close together). WHO Topics #3 *Social Participation*, #6 *Civic Participation* and #7 *Employment, and Communication and Information* were identified in 2 recommendations. WHO Topic #2, *Transportation,* was identified in recommendation 3 only, and WHO Topic #8, *Community support and health services,* was identified in recommendation 6 only. Lastly, WHO Topic #4, *Housing*, was a topic not identified in any of the city-wide recommendations.

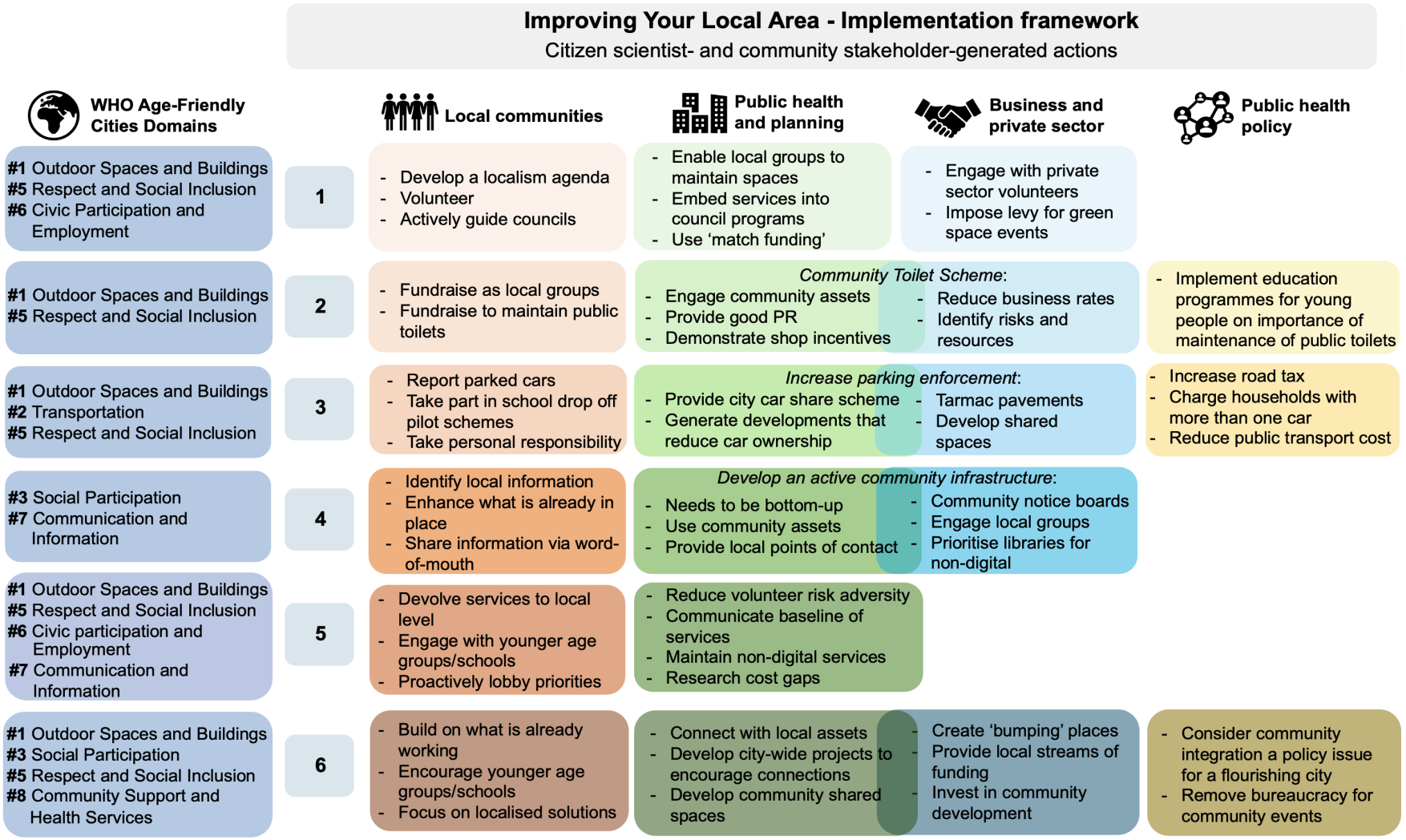


Figure 22. Implementation framework: Birmingham citizen scientist city-wide recommendations and corresponding WHO Age-Friendly Cities topics [21] (Source: Author).

Facilitating discussions of the citizen scientists' city-wide recommendations with a range of community stakeholders led to the identification of further detailed actions and pathways. This enabled the development of an implementation framework that reinforces and bring local focus to the WHO's eight topics whilst elucidating actions and pathways that can bring together different levels, stakeholders and actors across a city. For example, recommendation three for more enforcement of parking in local areas was also present in the WHO guidance, which identifies a need for enforcement of traffic rules and adequate parking for older adults. The implementation framework encompassed these factors and built on them further, including local residents reporting pedestrian barriers related to parked cars (*local communities*), providing a city car share scheme, and developing genuine shared spaces between pedestrians and cars (*public health, planning and business*), and increasing road tax and reducing costs of public transportation (*public health policy*).

6.2.5 Discussion

Informed by the *Our Voice* CS approach, this study actively engaged citizen scientists and community stakeholders to; i) identify urban barriers and facilitators and; ii) co-produce a set of actionable area-specific and city-wide recommendations for improving urban environments. . Citizen scientists directly identified urban features impacting the safety and use of everyday urban spaces, including public toilets, well-maintained green and public spaces, and enforcement of car parking. These features captured the micro-scale interactions and decisions that occur in older adults' daily life in the city.

Systematically capturing and activating the wisdom or lived experience of citizen scientists can enable stronger resilience and capacities of local urban communities, as well as cities as a whole. For example, place-based initiatives can identify both contextual and compositional elements that highlight the characteristics and relationships that occur between local places and their residents [657,658]. Integrating this micro-scale context and local-level understanding can inform suitable and timely urban actions that meet the needs of residents whilst providing relevant pathways to sustainably address these needs as cities continue to grow and develop [61,182,680]. More specifically, encompassing experiential knowledge of urban residents is crucial for providing urban planning practices that can reduce the exacerbation of exclusion, health disparities and unsustainable environments for older residents [656]. The *Our Voice* CS method enabled a step in the direction of social transformation by actively engaging citizen scientists and stakeholders in solution-building and the formation of recommendations for mobilizing improvements in local urban areas [681]. Co-producing a set of recommendations with citizen scientists and sharing these with stakeholders shifted the identification of urban features past identifying and describing urban environments only. Instead, it provided a deeper dialogue of local-level understanding that encompassed collective citizen scientist urban experiences and needs, and the actioning of potential stakeholder levers for initiating urban change [682]. Shifting the power of data generation and use to citizen scientists and community stakeholders promotes democratic processes for the improvement of urban environments, stronger connections with stakeholders that can work towards positively influencing governance, and legitimacy for delivering more beneficial and responsive features and services to meet the needs of ageing urban residents [683,684].

The implementation framework (figure 2) was built on a foundation of age-friendly change directed by citizen scientists and was further guided by community stakeholders who identified potential levers for actioning change across a city and its different levels. Positioning this framework in a social-ecological and multi-level systems perspective [173] enabled the identification of ways to activate these urban changes [147] and effectively facilitate improvements within a city and its local places [663]. For example, applying this perspective to recommendation six (enhancing community integration), actions were considered across levels of the city through local responsibility (individual), community care for green spaces (environmental), bringing together different age groups and ethnicities (socio-cultural), and providing employment opportunities and funding for local services (economic and political).

Many previous age-friendly initiatives have been small-scale, focusing on individual elements such as service provision and lacking the understanding of systemic issues, capacities of actors and the complex challenges faced by older adults in the context of urban environments [269]. In comparison, universal guidance at a level that is too high to capture the smaller yet meaningful elements of everyday life may exclude the context-specific aspects such as barriers faced by specific communities or the impact of neighbourhood alterations on social cohesion [185,531,656]. The comparison of the implementation framework with the WHO Age-Friendly Cities topics identified overlapping ideas and relevance of this framework for actioning this age-friendly agenda locally. The implementation framework is built on the values and preferences of local residents and city-level stakeholders, and identifies the potential levers for change, and opportunities for these different actors and process to collaborate together to action urban change [205,663,685].

This implementation framework will be employed in the next stage of our research, where advocacy and actioning of the identified recommendations will be targeted. These next steps could include bringing together the city-level stakeholders identified by across the four-levels of the framework to further discuss and explore the age-friendly actions and the resources or power required to achieve them. This holds potential for ways to identify responsibility for these actions, potential pathways for community-level and policy-level advocacy, and ways to develop these actions into concrete processes for enacting change to promote active and healthy ageing [311]. This is currently being explored in the city of Birmingham, with the implementation framework and a user-friendly booklet containing the co-produced recommendations and ideas guide developed with community stakeholders (Appendix 5). This has been shared with city council members currently exploring ways to achieve WHO Age-Friendly Cities accreditation.

Key strengths of this study include the direct engagement and co-production of activities with citizen scientists and community stakeholders, facilitated by the *Our Voice* CS approach. This enabled the development of area-specific and city-wide recommendations that encompassed urban features influencing active and healthy ageing and identified solutions and pathways to promoting community health. This can inform local place-based and wider city level decision-making for developing urban environments based on the needs and experiences of older adults.

Birmingham is a superdiverse city presenting a range of experiences across urban spaces [643], alongside increasing levels of health and social inequalities [460]. Future research should pay attention to the representation present across individuals engaged in CS, and in particular gender and ethnically diverse groups of individuals.

Citizen scientists engaged in this study were mainly White English and female, with ethnicity and gender identified to influence travel choices, mobility [639] and the wanted activities and services in urban environments [641]. One limitation of this study was that the Citizen scientists engaged were mainly White English and female. Future research should aim to engage more ethnically diverse individuals, ensuring the representation of voices from a wider range of communities. Feedback about the ease of use of the Discovery Tool highlighted that in the future citizen scientists should also be provided with more training to enable its effective use. In addition, having trained citizen scientists take turns using the Discovery Tool in pairs could, as found in some studies, provide additional social support for using the tool [54].

Employing CS is an approach to further addressing health equity for citizen scientists in their local places by bringing together local community insights and drawing upon stakeholder views and resources to begin to address governance issues in the context of an urban setting. However, there was insufficient time and resources to fully engage citizen scientists and the multiple participating stakeholders in the final "action" stage (Stage 4) of the *Our Voice* citizen science participatory research-to-action approach. This stage involves putting into effect the specific action plans identified as high priority and feasible in Stage 3 of this method [106]. It also involves the systematic evaluation of the cascade of impacts and outcomes that can occur over time as community members, stakeholders, and researchers together build efficacy as agents of change in their own communities. One increasingly popular method of doing so, called Ripple Effects Mapping, involves the collaborative participation of citizen scientists, stakeholders, and researchers in a qualitative method that systematically

aims to capture all of the multi-level impacts, both expected and unexpected, often accompanying this type of participatory research-to-action method over time [329].

The localised issues and recommendations highlighted by this study when shared across the city and its multi-levels and actors may instead contribute to collective concerns that can lead to wider scale change. Using CS approaches to bring individuals together as collective can also encourage further active participation, local capacity, and heightened awareness to address urban improvements [119,330]. Further consideration of the broader structural drivers of urban health inequalities is needed in order to produce substantial health equity impacts. Future research should aim to engage with a wider set of actors, including policymakers, and further evaluate the types of governance present within a city as a way of understanding how health inequities and urban changes co-occur and might be effectively impacted. To this point, the implementation framework was informed by this local placed-based approach and provided pathways for scaling up actions across social-ecological systems and multiple levels of impact. It is important to acknowledge that local places operate within a range of interacting and competing urban elements, agendas and context-specific decision-making and political structures [182,656]. Changes also made within one part of a city's system can influence another or multiple parts of the same system [662,686]. It is therefore important to consider changes made as a continual process, rather than a static end point [663].

6.2.6 Conclusion

This study engaged citizen scientists and a range of community stakeholders across Birmingham, applying the *Our Voice* CS method aimed at advancing health equity. This enabled citizen scientists to directly identify urban barriers and facilitators that influence their active and healthy ageing experiences and co-produce recommendations for improving their local areas. The similarity between the area-specific and city-level recommendations, alongside their overlapping ideas with the WHO Age-Friendly Cities topics, demonstrated interconnected features across public and green spaces in Birmingham that have local level importance and foster shared benefits for both the individuals and the collective group. Sharing these recommendations through a dialogue between citizen scientists and community stakeholders also elicited an implementation framework containing a set of actionable multi-level pathways for promoting active and healthy ageing.

Chapter 7 – Discussion and conclusion

7.1 Introduction

This chapter presents the findings and contributions of this thesis and how they achieved the aim of identifying ways in which urban environments can be optimised to promote active and healthy ageing through citizen science (CS). This includes the findings presented by the systematic scoping review (Chapter 4), citizen social science (CSS) preliminary stage (Chapter 5) and CS study (Chapter 6). These findings identified meaningful, social and diverse experiences of older adults require further extension within the Age-Friendly City (AFC) approach presented by the World Health Organization (WHO). This includes extension to social experiences that anchor older adults to their neighbourhoods and promote belonging, alongside the diverse experiences of older adults from migrant and cross-cultural communities and their active roles in strengthening community ties.

The Citizen Science Appraisal Tool (CSAT) demonstrated indicators of good quality CS studies. These indicators included studies who increase opportunities for engagement across all scientific processes through a 'by the people' or co-production approach, alongside producing outcomes with real-world implications, capturing accessible dissemination and tracking of long-term ripple effects. The findings of this thesis also demonstrated the value of employing CSS to lay the groundwork for CS research. This included strengthening collaboration and togetherness across social actors to produce a collective and transdisciplinary social framing of local urban spaces and highlight potential for joint action and network building. Building upon this, the CS

study identified the value of CS for engaging older adults and community stakeholders to collect and interpret data on optimising urban environments. This enabled the co-production of local and city-wide recommendations that are relevant for addressing active and healthy ageing in urban environments. Through further engagement of community stakeholders, potential levers for actioning the city-wide recommendations and age-friendly change was presented, showing interconnected pathways across different levels and actors of the city through an implementation framework.

These findings and their contributions are summarised and explored further within this chapter. This includes demonstrating how this thesis advances CS and CSS methodologies and aims to address the challenge for decision-makers to understand the determinants required to alter or enhance urban environments when promoting active and healthy ageing. Identifying the urban characteristics, how they are prioritised by older adults and the ways in which they interact holds potential to maximise the impact of initiatives targeting urban health. This is achieved by this thesis, identifying ways in which CSS and CS can aid in the development of an in-depth understanding of older adults' experiences in urban environments while allowing their voices to be embedded in recommendations that can inform decision-making. These findings can in turn be embedded within the relevant decision-making and planning of urban environments, creating pathways for promoting active and healthy ageing and aiming to further democratise urban decision-making [299].

7.2 Contributions of the Systematic Scoping Review

The systematic scoping review explored the global context of public health literature which engaged older adults to investigate active and healthy ageing in urban environments through CS or participatory approaches. Bringing together the outcomes of this review demonstrated two major contributions to the AFC and CS literature. This included the identification of two specific themes, 'neighbourhood developments and alterations' and 'barriers for migrant and cross-cultural communities', that require strengthening within the age-friendly agenda. Alongside this, a novel evaluation tool for evaluating and strengthening the quality and best practices of CS and participatory approaches was presented as a contribution to the CS literature.

7.2.1 Pathways for strengthening the Age-Friendly Cities approach

The AFC approach presented by the WHO [21] is one that is continually being explored, expanded and strengthened across the public health, urban planning, and gerontological literature [8,41,44,47,56,520]. Through the systematic scoping review, consistency and relevance was found between the eight topics presented by the WHO AFC guidance [21] and checklist [39] and the urban barrier and facilitator themes identified by older adults in the included studies. This highlighted how this more standardised and generalisable guidance provided by the WHO presents avenues for lifting international age-friendly standards and processes, particularly at the political and civil society levels [687], whilst still potentially holding value and relevance at the local-level.

There were however two themes that were distinct and need to be re-developed within the AFC approach as a way of strengthening its relevance and applicability to the local context. This includes the themes of 'neighbourhood developments and alterations' and 'barriers for migrant and cross-cultural communities'. Embedding these themes further within the age-friendly agenda is required to consider and address the needs of older adults experiencing changes or alterations within their neighbourhoods, alongside the barriers faced by older adults from migrant and cross-cultural communities. This includes the exploration of the individual and community experiences, particularly those related to the social and cultural needs of older adults, which can be specific to the individual and their surrounding contexts [688]. This demonstrates how the eight topics encompassed in the AFC guidance and checklist may be more objective in their application and value, instead requiring further exploration of the experiences of older adults.

7.2.1.1 Neighbourhood developments and alterations

Physical alterations, rotation of neighbours where current neighbours leave or new neighbours arrive, new builds and gentrification in which working class areas become home to upper- and middle-class residents [587,689] were identified across the included studies to negatively impact active and healthy ageing [554,555,560,566]. Neighbourhoods were identified to hold in-depth meaning to older adults across their historical and emotional experiences, connecting with their identities and being an area where their social connections and support are. However, these meaningful

connections important for healthy and active ageing were disrupted when alterations such as new builds, turnover of neighbours or gentrification occurred.

Comparing this theme to eight topics of the WHO's AFC guide [21] and its detailed checklist [39] (Appendix 2), the age-friendly topic of 'Housing' and 'Social Participation' showed consideration to this theme within the AFC guide [21]. This consideration included the importance of neighbourhoods for community integration, which identified housing and neighbourhood settings where older adults reside can foster familiarity, social connections and have suitable services within close proximity. When drawing comparison to the AFC checklist [39], there were however no clear actions or approaches across the 'housing' or 'social participation' topics on how to address or enhance elements of this theme.

Whilst the AFC approach has been useful in enhancing the global initiatives and interests for fostering age-friendly environments [33,40,41], it has also been identified as prescriptive [588]. This was highlighted by the distinct themes identified by the systematic scoping review that require re-developing within the AFC approach. For example, the topic of 'housing' requires re-development to reach past consideration of its design and location, instead being interconnected within a wider range of structures of services in the surrounding neighbourhood that can impact meaningful connections and time spent in these settings [690]. As this review sets out, alongside public health literature exploring the age-friendly agenda [554,560,691,692], these meaningful and social experiences present in neighbourhoods are missing from the AFC approach and require further exploration to address how older adults are anchored to their neighbourhoods through these social experiences [8]. This is of particular importance as age-friendly policies are currently disconnected from planning and design but can

substantially impact active and healthy ageing for older adults in their local neighbourhoods [693].

Embedding neighbourhood developments and alterations in the Age-Friendly Cities approach

Neighbourhoods were seen to hold in-depth meaning to older adults, linked to social experiences and concepts such as sense of place, belonging, social cohesion and place attachment. These social experiences underpin how an individual feels in relation to being accepted or part of the community (belonging) [534,694], alongside an individual's close social connections and meaningful or historical experiences that they share with a neighbourhood or other residents (sense of place) [695]. They also encompass interactions between social, physical and emotional aspects present for an individual in their local neighbourhood [587], enabling a meaningful bond to occur between the individual and place [692,696]. These are all elements that can influence an individual's attachment, both functional and emotional[688,697], to their neighbourhood (place attachment) [587]. Considering how older adults are attached through the deeper social connections and bonds, or form a sense of place within a neighbourhood, can potentially identify how alterations that occur within neighbourhoods may impact or disrupt these social experiences [692,696].

Physical alterations and new builds create changes within local neighbourhoods, such as changes to local facilities, physical features such as pavements, roads or buildings, or the introduction of new housing. These alterations and new builds can impact an older adult's social experiences and contexts, altering

locality and attachment to neighbourhoods [554,688,697]. For example, the presence of good quality pavements [692,698,699], facilities for activities such as community centres [700] and the placement of benches [550,701] can alter how a neighbourhood 'feels' and promote time spent outdoors developing social connections with others. Yet the removal or deterioration of local facilitates and physical features can reduce attachment to a neighbourhood, with older adults seen to be spending less time and feeling unsafe in their local neighbourhoods [585,698,702,703], alongside travelling to other neighbourhoods to meet their needs [587]. The introduction of new housing, high-rise flats and main roads can also impact social cohesion, causing a neighbourhood to become physically disconnected, reducing feelings of safety and removing opportunities for informal social interactions with neighbours [550,585,700].

The rotation of neighbours and gentrification can also impact older adults' social experiences and connections to their neighbourhood. It is important to highlight that older adults engaged in the CSS (Chapter 5) and CS (Chapter 6) study of this PhD research did not identify rotation of neighbours as a concern. They did however discuss and reflect on the need to connect further with younger age groups that are present within their neighbourhoods. This included finding ways to interact and take part in activities with individuals from younger age groups, developing stronger social cohesion and connections within their neighbourhoods. This indicates the rotation of new neighbours may not be occurring or perceived as a positive element of neighbourhood change in Birmingham. However, the potential arrival of younger age groups into neighbourhoods that may occur with gentrification over time should be considered to promote social cohesion and healthy ageing.

Public health literature has identified that older adults who have resided in a neighbourhood since they were a child [703], raised their families there [704] or have longstanding social connections with neighbours [705] form strong feelings of attachment. Similarly, older adults who take part in local community activities [554] or have gone through different ageing experiences and been supported by neighbours [566,706] are also socially connected to their neighbourhoods. The introduction of new neighbours can disrupt these connections formed by older adults and lead to fear and mistrust [561], alongside producing unstable social connections that remove attachment to their neighbourhoods [703]. Similarly, gentrification has been described as invasions in local neighbourhoods by older adults, creating tension, insecurity and displacing or socially excluding residents due to the arrival of new lifestyles and facilities [587,689]. The presence of these negative experiences can reduce the expectation older adults have to continue to age in their current neighbourhood [589].

Not all older adults are identified to be negatively impacted by neighbourhood changes, with the arrival of new or improved services [25] alongside different social groups bringing new positive connections [554,705] and social experiences [707] to neighbourhoods. However, considering how these social experiences and connections to local neighbourhoods are present for older adults is essential for identifying how alterations or developments can negatively or positively impact an individual's ageing experience in their neighbourhood [560,694,708]. This requires pathways to identifying and strengthening these meaningful social experiences that are present between older adults and their neighbourhoods, finding ways in which neighbourhood changes or alterations can instead promote or sustain these experiences.

To address this further, a potential pathway for expanding the AFC approach to explore neighbourhood development and alterations is presented (Figure 23). This includes taking a localised approach to explore how older adults are attached to their neighbourhood, alongside what they are attached to and how this will change when alterations occur [692]. A substantially used and well-cited approach [709,710] for exploring these elements of place attachment is Scannell and Gifford's framework for identifying place attachment [696]. This presents elements across the person, place and process, encompassing ways to identify personal attachment through an individual's experiences. These experiences encompass the emotional, cognitive and behavioural attachments to a place, such as memories or feelings, as well as the physical and social attachments present within a place.

Using this framework, which has previously addressed shared stakeholder attachment to a community [711] and identified physical and social attachments across residents of different communities [712], holds potential to explore the meaningful attachments of older adults in relation to their local neighbourhoods. This includes identifying their experiences within a neighbourhood, their emotional attachments that may be related to their social or historical connections and their connections to neighbours or specific physical elements such as community centres. A previous study investigating older adults belonging, place attachment and place making in the Netherlands explored these different social experiences through walking interviews. The outcomes demonstrated how older adults are place makers in their neighbourhoods, forming social experiences and attachments despite alterations occurring [585], which have also been identified for another study at the neighbourhood level [538]. This highlights the importance of actively engaging older adults in their

neighbourhoods to explore how they form these experiences and attachments and ways in which they can be strengthened when developments or alterations occur.

Engaging older adults in a similar localised and citizen-driven approach, such as walking interviews or photovoice, within their neighbours whilst utilising elements of the Scannell and Gifford's framework may in turn identify the contexts, social experiences and connections that facilitate place attachment. This may include how an older adult is connected to their neighbourhood through social experiences, alongside the elements of the neighbourhood they are attached too and how. These connections were present in the CSS (Chapter 5) and CS (Chapter 6) study of this PhD research. Older adults identified their positive social experiences with neighbours, particularly through community activities such as open gardens and in local parks where they spend time with families, indicating how these individuals were attached to their local areas and these experiences promoted their healthy ageing.

This presented pathway has potential to address how neighbourhood changes and alterations can be utilised to promote social connections, experiences and sustain attachment between older adults and their neighbourhoods [60]. This may enable the AFC approach to foster meaningful and socially connected ageing experiences within neighbourhoods [585,689]. Future studies can build upon this pathway within neighbourhoods that are experiencing alterations or gentrification to explore ways in which these changes can be used to enhance social realities that encompass experiences and attachments, rather than being detrimental to the active and healthy ageing experience.

7.2.1.2 Barriers faced by migrant and cross-cultural communities

Across the included studies highlighting this theme [71,560-562,565], it was identified that older adult migrants and those from cross-cultural communities faced barriers related to ethnicity, cultural differences and language. These barriers were seen to increase social isolation and negatively impact social engagement and integration within urban communities. The studies included in this theme explored older adult migrants in Canada and the United States [562,565], alongside older adults from different cross-cultural communities and ethnicities such as African-American, Hispanic, Chinese, Indian and Malaysian ethnicities [71,560,561]. Cross-cultural communities in context of this theme referred to urban communities encompassing older adults from diverse ethnicities, cultural backgrounds or migrating from different countries, leading to communities comprising of different religions, cultural practices, languages and social activities. This cross-cultural context has is an important aspect of locality and place attachment, bringing cultural and social meanings, connections and support for older adults from these diverse backgrounds and experiences into their local urban environments [554,588,688,713].

When comparing this theme to the WHO AFC guide[21] (Appendix 2), it highlighted consideration to the increase of migrants in the 'Social Participation' topic. This included consideration to older adults from different cultures who were at risk of being socially isolated, requiring activities that can bring together older adults from all communities and continually reach out to those who may face social isolation. Comparing this theme to the WHO AFC checklist [39], there is an action for providing activities that are appealing for different groups of older adults. There were, however,

no further approaches or actions that directly consider the needs of older adult migrants or those from diverse ethnic and cross-cultural communities. This was acknowledged by the AFC guidance that highlighted culture was considered but not a direct focus of the guide or checklist [21]. Although it was not possible to explore this theme further in the CSS (Chapter 5) and CS (Chapter 6) study due to lack of ethnic diversity among citizen scientists, the analysis undertaken in the systematic scoping review demonstrated the importance of strengthening the consideration to migrant and cross-cultural communities within the AFC approach. This is crucial for developing more inclusive and supportive age-friendly environments that can foster social engagement and inclusion for older adults from a range of diverse backgrounds and cultures. In the following subsection, the relevance of migrant experiences in AFC initiatives and pathways to direct towards a central and more inclusive agenda for future research is outlined.

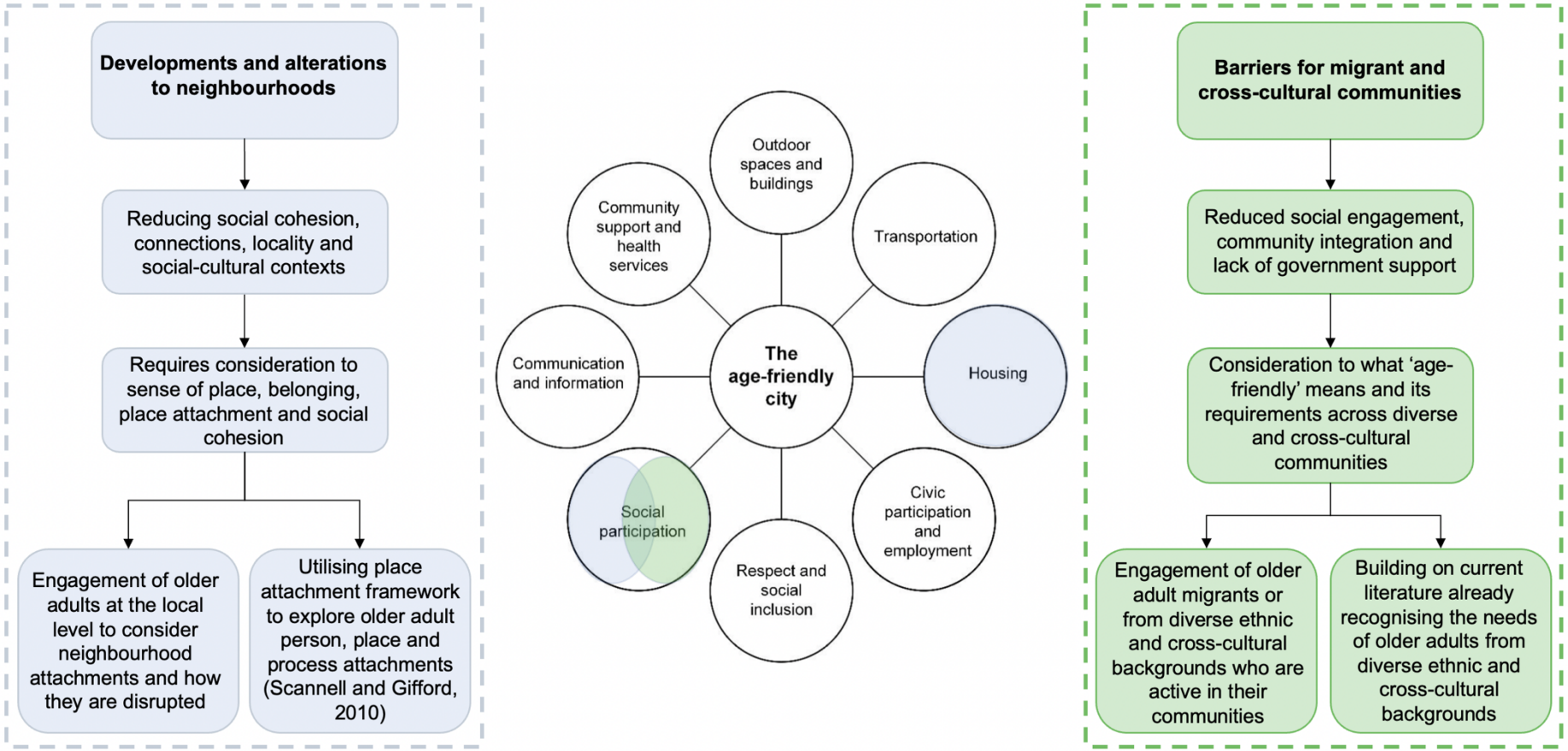


Figure 23. Pathways that the AFC topics of 'Housing' and 'Social Participation' can consider and address the themes of 'Neighbourhood developments and alterations' and 'Barriers faced by migrant and cross-cultural communities' (Adapted from Marston et al[44]; World Health Organisation[21]).

Embedding barriers for migrant and cross-cultural communities in the Age-Friendly Cities approach

Ethnically diverse and cross-cultural communities can play an important role in shaping the ageing experience. Older adults migrating to new countries or those who are from different or minority ethnic backgrounds are identified to face a range of barriers in their urban communities, particularly related to risk of social isolation and lacking vital social support [74,270,527,562,565,714-718]. For example, barriers can occur in relation to language, discrimination from current residents and lack of social or financial support within their local communities, causing social exclusion [74,527,702,715] and negatively impacting psychological and physical health [719]. At the same time, these individuals can face lack of employment, income and affordable housing, causing them to reside in unsuitable and low quality, inaccessible and polluted urban environments [720,721]. This lack of support has also been reflected through regional and policy-levels, with migrants not provided with government support such as pensions or limited access to healthcare [717], all which contribute to a negative ageing experience for these individuals.

It is important to recognise the diverse interpretations that shape what 'age-friendliness' means for older adults from diverse ethnic, migrant or cross-cultural urban communities [270]. In particular, the variety of experiences across these older adults brings to light a specific vision of what age-friendliness means, alongside the different requirements, values and cultures that are required to be embedded further within this age-friendly vision [717,722]. Older adults migrating to new countries are met with a range of barriers that would need to be considered for their surrounding environments to be

'age-friendly'. For example, older adults migrating to Amsterdam were met with a lack of employment, unaffordable housing and low-quality environments, alongside requiring social networks in their local areas to address language barriers [720]. Chinese older adult migrants residing in Canada and United States were seen to lack positive social networks and companions, exacerbated by recent migration, language barriers and lack of transportation [74]. At the same time, older migrants returning back to their country of origin in Ireland faced social isolation, attributed to a lack of close social ties and challenges to re-adapting [718]. It is therefore important to actively engage these individuals to identify what 'age-friendly' means to them (Figure 23). This is important for identifying and encompassing their context-specific needs and circumstances in their local urban environments that shape their ageing experience [715,717,720], finding pathways for promoting social connections and feelings of locality [723].

In its current 'universal' and prescriptive form [588], the AFC guidance and its standardised checklist approach is argued to be limited in its application and consideration to the increasingly ethnically and culturally diverse meaning of 'age-friendly' [74]. Instead, it requires re-development in relation to addressing the barriers faced by older adults from migrant and cross-cultural communities [47,591,724-726], exploring 'age-friendliness' that can promote active and healthy ageing across diversity, ethnicity and race in older urban populations [591]. Elaborating on the critical importance of barriers faced by migrant and cross-cultural communities within the AFC approach, one way of achieving this could be to actively engage older adult migrants or those from diverse ethnic backgrounds who are active in their urban communities and shape settings that promote social connections (Figure 24).

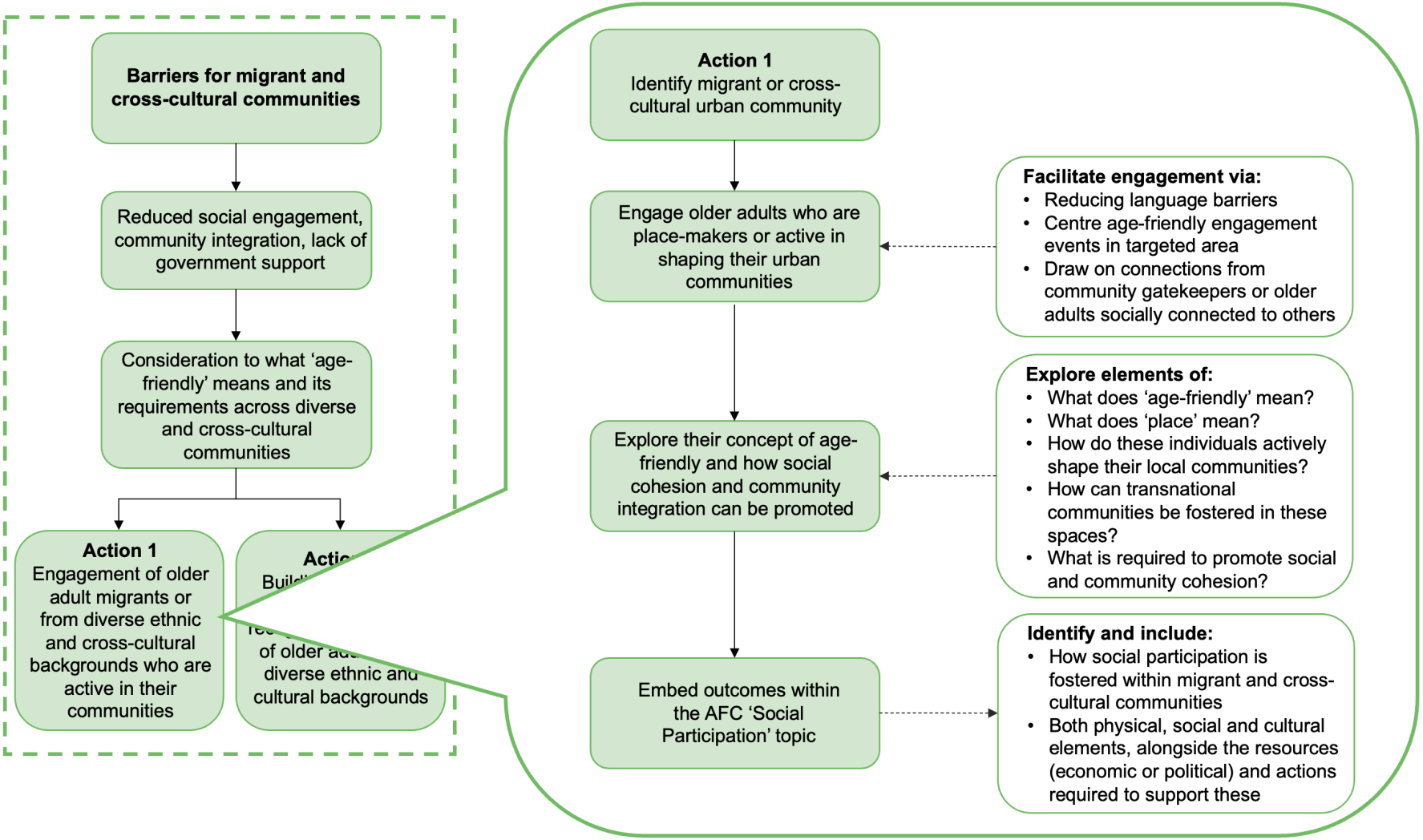


Figure 24. An example of one pathway for engaging older adult migrants or from diverse ethnic backgrounds who are active in their urban communities [33,94,565] (Source: Author).

Older adult migrants and those from diverse ethnic backgrounds who are active in their urban communities are identified to produce places that bring about comfort, transitional ties and promote social inclusion for other older adults from similar backgrounds [727,728]. For example, the migration of older adults into new areas can lead to the development of transnational communities in which individuals tie together cultures across and the original and new country. This brings together multi-cultural and social aspects that can support ageing across different ethnicities and cultures [717,722,727,729]. These are factors that can positively contribute towards community connections, facilitating comfort and feelings of locality that can foster migrants to build connections within specific places [721,723,728]. Consideration to place-making by these individuals instead demonstrates that these positive experiences occur through individuals and their social networks or experiences rather than the physical setting itself [730,731]. This demonstrates the importance of further engaging these individuals who shape these transnational communities to explore and effectively encompass their social experiences when developing age-friendly environments.

In creating these spaces, diverse groups of older adults have integrated the presence of relevant cultural activities or amenities such as religious or social opportunities and assets, alongside intergenerational opportunities which can facilitate the building of social ties and connections across commonalities [25,723]. Examples include businesses, cafés and shared spaces which are ethnically relevant and inclusive, promoting social opportunities and experiences [728]. This has also led to some cities integrating these amenities permanently within their structures. Mosques and teahouses have become fundamental aspects of urban environments in Germany, enabling Turkish migrants to continue their transnational cultures whilst promoting

economic and cultural components within the city [729]. This has also been seen in Birmingham, with the presence of diverse and multi-cultural facilities, such as an internet café and Kurdish bakery, developing commonality within this diversity and presenting opportunities to integrate more cross-cultural facilities [730]. It is therefore important to consider the pathways for engaging individuals who are place-makers and can reduce the barriers to developing attachment, social connections and sense of home or place for older adult migrants [25,717,718,721,727,728].

What can also be strengthened is building on the current literature identifying the needs of older adults who migrate, alongside the needs of adults from diverse ethnic and cultural backgrounds, in relation to urban environments. One example of this is the recognition of religious amenities and activities. Churches are seen to facilitate social connections for Hispanic older adults [565], Buddhist temples provide social support for Chinese older adults [716], whilst mosques promote belonging and connections with family for Turkish migrants [723,729]. Providing recognition of these religious amenities is in turn crucial for fostering a sense of community and familiarity for older adult migrants and from different ethnicities [527,565,700,728,729].

In the context of the city of Birmingham, which is a multicultural and superdiverse city home to migrants from over 187 countries[732], there are a number of cross-cultural communities that encompass different ethnicities and religions. For example, individuals from different religious communities include Christian (46.1%), Muslim (21.8%), Buddhist (0.4%), Hindu (2.1%), Jewish (0.2%), Sikh (3%), alongside those who have no religion (19.3%) [733]. Wards that encompass multiple religions are however identified to represents areas where individuals have low levels of trust in the community [732], requiring consideration of how to further bring together cross-cultural

communities in a cohesive way. Building on the pathway provided above and engaging organisations, such as the City of Sanctuary Network [734] or the City Council's equalities unit [732], to work together and develop their current approaches to enhancing cross-cultural social and community cohesion through their faith groups and providing suitable religious amenities. This presents the opportunity to potentially foster relevant social and cultural experiences [728], bringing older adults from both the same and different ethnicities together to socialise through religious and spiritual practices [561,562,565].

Extension of the AFC model are important for reaching older adult migrants and responding to the unequal experiences of ageing that occur in urban environments [532]. Incorporating further the barriers faced by migrant and cross-cultural communities within the AFC topic of 'Social Participation' (Figure 22) can further develop age-friendly initiatives that encompass diverse older adult populations who are at risk of social isolation or lacking support. Doing so will enable the age-friendly approach to work towards reducing the inequalities and social exclusion faced by ethnic and cross-cultural communities and instead create places that meet their needs, values and cultures [29]. This requires consideration to the local-level context and circumstances of those from different ethnic backgrounds or those who migrate, both nationally and internationally, in order to produce context-specific and suitable support, services and resources [715]. This can address the active and healthy ageing experiences of these older adults, particularly in relation to promoting social inclusion and integration, who are migrating to new urban environments [727,728].

It is important to acknowledge that this extension of the AFC model in relation to migrant and cross-cultural communities requires application across all cultures

rather than one specific ethnic group in its approach, particularly to strengthen the understanding of cross-cultural community needs. This includes shifting away from putting responsibility on migrants to enhance their own social inclusion, especially as migrants are identified to be negatively viewed by others and attributed to neighbourhood decline and crime when they migrate to new areas [702]. Instead it is important to engage a diverse range of older adults in this cross-cultural approach, exploring how place-makers from different cultures, ethnicities or countries can shape together cohesive cross-cultural environments.

This consideration also requires top-down support from policymakers, governments and even local councils to put in place culturally relevant engagement strategies and support that can facilitate cross-cultural cohesion [87]. This requires strengthening within political structures and agendas that address migration, particularly shifting away from policies that views migrants in society as problematic and counterfeit citizens and towards the cultural and societal benefits that these individuals can bring to urban communities [528,731]. This however also leads into bigger issues such as the ethnic and cultural representatives of local authorities and central governments, which is required to inform decision-making towards promoting and legitimising the diverse and multicultural uses and perspectives of urban environments and their services [731,735]. This presents further implications for how migrant and cross-cultural communities are represented within urban environments, requiring further exploration when developing inclusive AFC.

7.2.2 Contributions of the Citizen Science Appraisal Tool

Strengthening the AFC approach was identified to require the active engagement of diverse groups of older adults in order to identify and build on their meaningful experiences and needs. A further contribution of the systematic scoping review presents a way to consider and achieve this active engagement through the CSAT, which identifies ways in which local-level engagement of community members, such as older adults, can be strengthened within public health research. The CSAT was developed to evaluate CS and participatory approaches in relation to their quality and presents a standardised approach to informing and evaluating CS best practices. This includes employing and evaluating the level of engagement of community members in the data-driven strategies, solution-building and developing real-world implications and long-term impacts, presenting elements of CS best practice across the literature [106,291,312,380,390,397].

The CSAT sits within the context of public health, participatory and CS literature that have identified a gap within quality assessments and evaluations, presenting a critical appraisal tool where studies or initiatives can evaluate their own CS and participatory practices. There are a multitude of elements and guidance for evaluating different aspects of CS initiatives and their quality [125,286,309,313,317,319,378-385] but it is argued across this literature that these evaluations require further development and cohesion. This is particularly key as guidelines for participatory research are not widely or consistently employed across the literature [736], reducing the ability for CS and participatory processes to be standardised in terms of their quality.

This gap of evaluating and appraising participatory and CS quality is also highlighted by systematic and scoping reviews completed in the urban planning, gerontology, CS and participatory literature. This gap has led to systematic reviews utilising already established tools, such as the Mixed Methods Appraisal Tool and Critical Appraisal Skills Programme tools, to explore quality of studies identifying outcomes of organisational participatory research [737] and the key elements of community-based organisation engagement [736]. However, these studies identified these established tools to lack specific evaluation for participatory methods and engagement, leading to the development of individual ways to address engagement such as finding connections between participation processes and outcomes.

Systematic reviews related to CS and participatory research have also addressed quality through different processes, such as only including studies that have been peer-reviewed or met specific time or spatial criteria [102,517,738]. Two systematic reviews exploring the use of CS in urban ecological initiatives [739] and participatory practices in developing health programmes for migrants [736] did not evaluate quality. They did however differentiate between the levels of CS engagement from active and pseudo to no engagement of migrants [736], alongside five modes of engaging citizen scientists ranging from contractual to collegial [739]. The latter was informed by a previous framework exploring participation within public research [285]. This framework facilitated the systematic review of urban ecological initiatives to explore the connections between CS levels of engagement and the outcomes of studies, highlighting a lack of co-created studies. Across the reviews described in this section that addressed quality in their individual approaches, there was however no further guidance on how these approaches could be employed by further research. Lastly, a

range of systematic and scoping reviews relating to CS, community-based and participatory research [740-746] did not undertake any evaluation or appraisal of quality.

The different approaches to addressing quality appraisal presented across this small sample of systematic and scoping reviews identifies a need to present a standardised way, particularly for CS and participatory research [125,393], to rigorously evaluate the quality and credibility of a study [308,313]. This quality and credibility are required in public health research to develop trustworthy data and outcomes that are relevant and applicable to the real-world they are being applied to [747]. It is also required in the CS domain [125,291] to legitimise members of the public collecting data [290] and enhance the credibility of CS outcomes within the 'traditional' realms of scientific research [308]. Identifying ways in which CS credibility and good quality practices could be enhanced was also key for this PhD research. This was important to drive the CS study (Chapters 5 & 6) towards meaningful engagement of older adults and co-produce good quality outcomes that hold relevance and credibility within the ageing well, urban planning and public health sectors across Birmingham. Building on the individual and unstandardised elements of evaluation criteria and good quality CS approaches available, the CSAT presents a standardised contribution to promote CS best practices and meaningful engagement. This includes undertaking evaluation through a lifecycle approach [546] from the aims of a study to its dissemination, future impact and tracking.

The effective use of this tool within the systematic scoping review (Chapter 4) highlighted strengths of the included studies, alongside ways in which they can strengthen their best practices. For example, this included strengthening engagement of the public in the scientific processes, particularly to inform study design, hypothesis

and choice of methods and analysis, as well as the need to consider long-term impacts and tracking. The CSAT in turn identified ways in which meaningful and active levels of CS engagement, including a 'by the people' level of engagement [106], can be embedded within scientific research using CS [105,123]. This can further facilitate the purpose of CS to enable individuals to have a voice in decision-making and shift towards democratising traditional science [104].

Overall, the CSAT demonstrates a contribution towards the CS and participatory literature identifying gaps within the standardised evaluation of CS projects. To address this, the CSAT presents a lifecycle approach to evaluating CS and participatory practices, highlighting CS best practices to promote meaningful engagement of the public and produce accessible outcomes that have real-world implications. However, this tool presents strengths not only in evaluating a study upon completion but can also inform a study during its development and implementation, presenting momentum towards developing good quality CS practices. The application of the CSAT to these different stages are considered below, providing guidance to employing this tool to foster good quality CS and best practices from development to outcomes:

1) ***The development stage*** – studies, projects and individuals planning to undertake a CS project can review the four categories of the CSAT and utilise its questions to guide their planning. For example, studies can ask if: 1) the degree of active engagement has been clearly identified; 2) the roles and responsibilities are clear between scientists and citizen scientists; 3) the potential limitations or biases that may occur when citizen scientists collect data been considered; and 4) have the ways in which potential long-term implications can be tracked or addressing. In

asking these questions, this can build on the gap to strengthen 'early actions' [308] required for developing suitable CS engagement, methods and increasing the credibility of CS programmes. It can also enable studies to ensure that their plans and mechanisms for open dissemination, engaging citizen scientists in the publication processes, identifying suitable open access articles for publication and mechanisms in which the outcomes can be shared with citizen scientists are considered.

2) ***The implementation stage*** – Throughout a CS project, the CSAT questions can be continually asked and re-evaluated to ensure that a project is effectively addressing the different categories and implementing best practices throughout its processes. This can enable studies to ensure that citizen scientists are being effectively engaged to the level identified in the development stage, alongside ensuring that the data-driven strategies and solutions are informed by citizens scientists. It can also allow a study to continue to consider and address the potential biases and limitations that may arise during its processes and methods, alongside continuing to re-align with the aims and objectives identified at the development stage.

3) ***The outcome stage*** – A study can also evaluate its own elements to show its transparency, credibility and identify where its strengths and limitations lie. This can present valuable guidance for future CS studies to understand the limitations and build on the strengths, particularly as a way of embedding CS best practices into studies or initiatives in a standardised way. To address the outcome stage further, the CS study manuscript (Chapter 6) has been evaluated using the CSAT to demonstrate this potential.

7.2.2.1 CSAT evaluation of the Improving Your Local Area study

To further address 'the outcome stage' highlighted above, the CSAT was employed to evaluate the CS study (Chapter 6). It is however important to acknowledge that this evaluation was not undertaken by an independent reviewer but by the PhD researcher and two supervisors (AS and JP). This was therefore not an impartial evaluation but does offer transparency in identifying the CS study strengths and ways it can be improved. Overall the study scored a total of 28 out of 32, placing its processes and outcomes at high quality (Appendix 5).

High quality elements of the CS study

The CS study showed strengths in the science & research and leadership & participation sections of the CSAT. This included the clear identification of the study aims and the CS approach employed, which was informed by the *Our Voice* CS for Healthy Equity approach. The study also demonstrated its degree of active engagement of older adults in three stages, which was identified as co-production and member-checking from citizen scientists. The study also scored highly in parts of the delivery & data and outcome, evaluation & open data sections. This included clearly presenting how citizen scientists were actively engaged in data collection through each stage, collecting and discussing their own data to co-produce recommendations, alongside choosing the stakeholders to disseminate the outcomes too. Real-world implications of outcomes were also considered through the implementation framework and the scalability of the co-produced recommendations,

Accessible and open dissemination of outcomes were also considered through citizen scientists choosing which stakeholders to share their co-produced recommendations with at Stage 3 of the CS study (Chapter 6). A user-friendly booklet was also described, which presented a mechanism for sharing outcomes with citizen scientists and the wider public. The final manuscript has also been published through open access and includes acknowledgement of citizen scientists in the authorship and acknowledgement sections. Lastly, consideration to the limitations is presented, including the use of a digital application by older adults, the extent in which the health inequalities identified are driven locally and ways in which the methods can be strengthened further.

It is also important to acknowledge that an evaluation study (CSAT question 11) has been undertaken to evaluate the experiences of citizen scientists and stakeholders in relation to the processes, outcomes, successes and areas for improvement. This was undertaken outside of the PhD thesis due to time limitations and logistics of completing all proposed steps as part of a three-year timeline. Further details of this manuscript will be published elsewhere.

Strengthening the quality of the CS study

Through the CSAT, the CS study was identified to require strengthening in the data & delivery section. This included a need to strengthen the engagement of citizen scientists in the data analysis and data use and dissemination. Although citizen scientists were actively engaged in data collection and member checking of outcomes, the actual elements of data analysis were undertaken by the researchers alone which

limited citizen scientist engagement. Similarly, citizen scientists were not identified to be engaged in identifying the pathways for disseminating the final outcomes. To strengthen this study further, the inclusion of citizen scientists within the data analysis processes is required, alongside including engagement of these individuals within determining dissemination pathways for outcomes.

The CS study also required strengthening in two elements of the outcome, evaluation & open data section. This included the engagement of citizen scientists within the study publication process and the study's intention to track long-term ripple effects. Although citizen scientists were acknowledged in the publication, they were not engaged within the study publication process undertaken for the manuscript. The study also lacked clarity in its report to track or intent to track long-term impacts or changes, which was attributed to time and resources limitations. The active engagement of older adults was necessary for this study to identify the local-level needs of these individuals within Birmingham. However, this engagement may have been insufficient for developing long-term democratic change. This includes a lack of consideration to the resources or behaviour changes required from individuals at the local-level to continue to engage in long-term changes, which has been previously missing from localism agendas within urban planning. For example, the circumstances and capacity of local actors was viewed to impact engagement and motivation in local neighbourhood planning, with socio-economic situations and funding available to support long-term engagement causing an uptake of local neighbourhood plans to occur in more affluent areas [247,248,251].

Studies that have previously employed the *Our Voice* CS approach have demonstrated 'ripple effects' through the continued engagement of citizen scientists

once a study has finished [54,118,330], such as older adults continuing to engage in community changes and advocacy [118]. Similarly, studies using CS are argued to promote self-determination, bringing together a range of new perspectives and knowledge that can foster continued community action [352]. These ripple effects have been identified since the completion of the CS study. A citizen scientist and a community stakeholder have connected to discuss the community toilet scheme being implemented in a town centre, alongside the user-friendly booklet being built into the service leads agenda and actions at the city council. Similarly, the co-produced recommendations presented in the user-friendly booklet have been shared with Birmingham City Council as part of its drive towards becoming a WHO accredited AFC. To strengthen this, further consideration to how this study can provide further resources and material to support citizen scientists and track these long-term changes is required. The study did however suggest ripple effecting mapping as a potential avenue to continue to engage and track long-term changes.

Overall, the CS study presented high quality CS practices when evaluated by the CSAT, enabling this study to be transparent in its strengths and limitations. The CSAT therefore demonstrates an opportunity for studies to evaluate and embed CS best practices in a standardised way whilst still effectively employing CS across different local-level contexts and needs. This was achieved by evaluating ways in which studies can be strengthened at their development, implementation and outcome stages. It is important to acknowledge that standardised tools, such as the AFC approach, have been identified by this thesis as needing further consideration to their value and applicability at the local-level. However, the CSAT needed to represent levels of universality and standardisation to be applicable across CS studies to meet

the gap of providing comparable evaluations and outcomes [313,319-321]. It does however encompass flexibility in its questions so that it can be adapted across a study and its aims, context and the population it is engaging.

The CSAT in turn provides a substantial contribution to the CS literature, bridging the gaps for a standardised evaluation of CS studies and practices. This includes enabling CS and participatory study processes to be evaluated in a lifecycle approach across science & research, leadership & participation, delivery & data and outcome, evaluation & open data. These are elements that can foster good quality CS, particularly directing studies towards the more extreme levels of CS engagement such as 'by the people', enabling the CS community to utilise and embed best practices within their approaches and methods.

7.3 Contributions of the citizen social science and citizen science study

CSS was employed as a preliminary stage (Chapter 5) to lay the groundwork for the CS study (Chapter 6). Both older adults and community stakeholders were engaged, who were considered social actors across different social groups within the general public [340]. For the CSS preliminary stage (Chapter 5), older adults or community stakeholders engaged in online discussion groups to explore their age-related experiences and knowledge within the city of Birmingham. Although these preliminary discussion groups built upon CS co-production, CSS provided distinctions to CS by shifting past the active engagement of these individuals to co-produce data. Instead, this included further reflection on their own and each other's concerns and experiences through this process, facilitating a collective social framing of active and

healthy ageing in Birmingham. This was based upon the individual and collective concerns and experiences shared [340-342,352], alongside a range of social aspects and potential partnerships that organically emerged during discussion groups.

Building upon this, the CS study (Chapter 6) was informed by the *Our Voice* CS for Health Equity approach. It used a 'by the people' CS level of engagement through three stages to co-produce a set of recommendations for optimising the city of Birmingham. These stages included older adults collecting data in their urban environments, taking part in solution-building to co-produce recommendations for promoting active and healthy ageing and sharing these recommendations with community stakeholders. The final set of co-produced recommendations, both at the area-specific and city-wide level, captured the urban barriers and facilitators of inhabiting and moving through everyday urban settings of Birmingham directly identified by and relevant to older adults. Sharing these with community stakeholders led to the development of an implementation framework for actioning the co-produced recommendations and strengthening the age-friendly agenda across Birmingham.

Engaging a range of multidisciplinary actors outside of academic research, alongside applying this approach to explore elements of public health, gerontology, geography and social science disciplines, enabled a transdisciplinary and interdisciplinary approach to be employed, which is required for developing a more collective and merged view of 'social' research [340]. This builds upon the CSS literature exploring different avenues of CS, such as the recognition of social issues through the use of CS, the emergence of social aspects and concerns which have been utilised to demonstrate the 'social' element of CSS and bringing together transdisciplinary actors and subjects within CSS [340,341,343,346,348,349,352,354,355,748].

Bringing these CSS and CS elements together presents a strong methodological contribution that can be further embedded into a vision for CSS. This vision builds upon a shared framing of a phenomena, social connections, sharing of resources and laying the foundations of a network that holds potential for further joint action. It also utilises the collective development of place-based knowledge around urban environments, alongside ways in which this knowledge can be translated and used by community stakeholders across the city. To develop this vision for CSS further, the methodological contributions and findings of the CSS and CS study are explored below, followed by ways in which these can be considered further within the social sciences.

7.3.1 Collective knowledge generation and collaboration

The use of CSS presented a valuable contribution at this preliminary stage for enabling collective knowledge around ageing in urban environments to emerge. Discussion groups employing open-ended questions have been previously identified to enable in-depth conversations to emerge from those engaged [749]. Yet bringing together a range of social actors related to ageing across the city of Birmingham elevated these in-depth discussions further, framing them across the collective group of older adults or community stakeholders [352,750]. These social actors were identified to share, discuss and reflect on their own concerns and the concerns of others, fostering a deeper collective understanding and mutual inquiry of these concerns [352,751,752]. This enabled co-production and collective knowledge to be developed

through a set of collective urban barrier and facilitator themes (Chapter 5) that shared commonalities and embodied a diverse range of knowledge [350].

The use of CSS at this preliminary stage demonstrated a process that can strengthen CSS as a valuable methodological contribution. CSS facilitated collaboration to occur across a range of social actors, shifting the individual perspective and social concerns to ones in which broader elements and different situations across society were considered [341]. It also enabled a range of collective community values, knowledge and experiences to be vocalised and discussed, generating what is described as "socially robust knowledge" [348]. The collective knowledge and commonality that emerged also presents potential legitimacy across those engaged for fostering further collective actions [348] and presents knowledge that potentially holds relevance to the wider community [348,353]. This demonstrated ways in which the everyday life of individuals can be shared and collected to bridge together a more in-depth understanding of society that can be embedded into scientific research [340,347,351]. This preliminary CSS stage in turn presents a valuable methodological approach that can lay the groundwork to be built upon further. This groundwork includes bringing together a range of social actors to generate collective and socially robust knowledge based on both the individual and collective social concerns [342,348,350].

7.3.2 Organic connections, sharing of resources and solution-building

Organic connections, sharing of resources and solution-building occurred across both older adults and community stakeholders (Chapter 5), demonstrating a

valuable outcome that strengthens the methodological contribution of a preliminary CSS stage. The organic connections and sharing of community-based knowledge brought to light the valuable 'social' aspects of CSS [343,748]. This included the social interactions [753] and development of social cohesion through shared experiences [754] that emerged across those engaged in discussion groups. The presence of these social aspects indicates the potential for CSS to facilitate a supportive space in which social connections and interactions can occur [352]. This further facilitated new aspects of knowledge to emerge [748], such as the sharing of community-based resources and information that can potentially support others through their ageing experiences.

The presence of solution-building also identified a mutual motivation for problem solving, denoting a systematic inquiry in which an individual's knowledge or resources were shared to further identify and present solutions [755]. It is however important to acknowledge that those engaged were already active within their communities through volunteer or professional roles. The engagement of active community members may have facilitated the openness of these individuals to develop social connections and take part in solution-building, particularly as this may be part of their daily roles [756,757]. As CSS aims to build on the more 'extreme' levels of CS engagement such as co-production and co-creation [340,341], this preliminary stage should endeavour to engage community members who may not be active in their communities. This is not only to extend further these social connections, but to ensure resources and shared knowledge developed through CSS are distributed equally across all members of society.

Overall, the valuable contributions of CSS at this preliminary stage to foster social connections and solution-building based upon shared dialogue were presented.

These social encounters are important to shift away from the traditional focus of CS for community-driven data collection only and instead towards building social cohesion that can encompass collective experiences and develop a knowledge coalition [340,352]. The presence of these unexpected social aspects in turn hold potential to develop the foundations of a collective network [341,402,403,601,602,623,634] and further cohesion in which knowledge coalitions can be achieved [45,352].

As the social aspects were unexpected, they do however require further consideration in relation to the practices of participation and ways in which they can be embedded further when social actors are engaged. Future researchers could facilitate opportunities for connections prior to discussion groups occurring, bringing these actors together in an informal setting through social events or activities. These informal social events, such as lunch clubs and walking groups, have been seen to bring older adults together to socialise and learn about the experiences, contexts and cultures of others [350,542]. This may drive further what was highlighted as a more 'active' engagement of citizen scientists in these online discussion groups [758], demonstrated through the presence of social connections and solution-building that indicate elements of motivation to engage [541]. This holds potential to continue to develop a positive experience for citizen scientists that facilitate social connections with others, mutual learning and support [350], and fostering of partnerships and network building that can build upon collective concerns and experiences [759].

7.3.3 Bringing together bottom-up and top-down knowledge

The engagement of older adults and community stakeholders, although in separate discussion groups, enabled a contribution in which bottom-up and top-down knowledge generated by these different social actors was present. This included identifying the common urban barriers and facilitators across older adults and across stakeholders, alongside comparing the similarities across these themes (Chapter 5). In doing so, it was identified that older adults and community stakeholders shared a similar framing of urban environments, although presented different perspectives across the local and wider levels of the city. This demonstrated the use of CSS through elements of transdisciplinary engagement, where a range of multidisciplinary actors outside of academic research were engaged. It also brought these individuals together across an interdisciplinary focus of public health, gerontology, geography and social science disciplines. These two approaches of transdisciplinary and interdisciplinary engagement are important for developing a more collective view of 'social' research or challenges based upon the merging of different disciplinary boundaries and the relevant actors [340,358].

The engagement of stakeholders within this CSS preliminary stage enabled diverse views, experiences and concerns to be included in the generation of knowledge. It also facilitated the bottom-up knowledge identified by older adults to be placed in a wider context of top-down knowledge present across society [341]. For example, older adults identified the theme 'Covid-19' at the local-level. This theme demonstrated the closing of local facilities, reduce support for attending health care appointments and individual health concerns as barriers. Community stakeholders on

the other hand placed this theme at the wider context of the city-level. This included consideration to the larger economic impact on services and ways in which they could be re-opened, alongside how health and community services could be adapted to ensure older adults feel comfortable attending. This enabled a broader perspective of urban barriers to emerge [752], identifying how the bottom-up concerns could be met with top-down ideas and knowledge for promoting active and healthy ageing across the city.

The engagement of community stakeholders and their top-down perspective, alongside older adults and their bottom-up knowledge, developed a broader understanding of the shared urban barriers and facilitators that frame the city of Birmingham. This contributes further to the CSS literature that is identified to lack consideration to community stakeholders [748,760] who are crucial for accessing resources and capacities to action community changes [760]. This contribution also strengthens the potential of this preliminary stage to develop a collaborative network, encompassing the values and needs of older adults and the knowledge and resources of stakeholders who provide services and structures [341]. This can be built upon further to strengthen the collaborative elements of bringing together local concerns of the public and the resources of community stakeholders, which are both required for effectively developing and managing urban environments[211].

There is also potential highlighted for collaboration in urban environments, such as through collaborative governance which requires a collective vision to deliver a census-orientate and locally relevant decision-making [215,761,762]. Achieving this would however necessitate researchers to explore the limitations of previous localism agendas for collaboration, such as neighbourhood planning. This include exploring

how individuals within this social network can be supported in their resources and capacity to engage [247,248,251], alongside ensuring there is inclusive and suitable collaborative processes that are received and implemented effectively across all levels of actors engaged [215,220,763]. This potential network of older adults and community stakeholders could however provide a valuable resource for developing collective age-friendly initiatives that are centred upon meaningful local knowledge and formal capacity and support [340,353,634].

7.3.4 Developing a vision for citizen social science

As an emerging field, CSS is identified to require the development of methods, approaches and frameworks in which it can be employed effectively [348,349,352]. This also includes ways in which CS practices can be merged together with the social sciences to develop a stronger CSS approach [355,754]. The contributions presented by this preliminary CSS stage and CS study identified a methodological contribution that can be embedded into a vision for CSS. This included the development of a collective and socially robust framing of a phenomenon, alongside effectively demonstrating avenues of CSS in which the social aspects of CS emerged and transdisciplinary engagement of social actors was present [340,341,343,346,349,355,748].

Social science research has previously employed CSS as a way of developing research and outcomes centred on relevant societal issues [343]. For example, studies have engaged actors within mental health care to explore social interactions that occur [348], clinicians to co-research workplace learning [764] and neighbourhood residents to define prosperity and identify pathways to developing prosperity further [358]. These

studies, alongside others, have however utilised different definitions and approaches to achieving their use of CSS, from bringing together crowdsourcing and CS [764] to employing consultation, citizen scientist data collection and workshops [358].

The methodological contribution of this thesis however presents a specific preliminary space through online discussion groups in which the individual and collective concerns were shared and reflected upon. This builds upon CSS research employing forums, workshops and interviews as spaces for social interactions [341,348,352,358,754,765], all which identified the importance of bringing social actors together in face-to-face settings and utilising elements of reflexivity. The CSS preliminary stage of this thesis identified similar strengths through its methodological foundation but through the use of online discussion groups, laying the groundwork in which a collective social framing of a phenomena and social connections occurred. This provided a foundation as a preliminary stage to be built upon by CS co-production, continuing to engage older adults and community stakeholders who were already connected and had begun to produce knowledge on urban environments across the city of Birmingham.

The use of CSS as a preliminary stage, as well as being embedded into the *Our Voice* CS framework, allowed the same group of older adults and community stakeholders to repeatedly engage across different stages of the CS study. This facilitated a continued engagement across the same set of social actors, enabling the CSS contributions of generating collective knowledge, developing organic connections and capacity building, and interdisciplinary network building to be continued and strengthened throughout. This extends past the use of single qualitative method, such as focus group or discussion group. Although focus and discussion groups can

facilitate organic discussions and communicative spaces that are directed by those engaged [98,103,145,352,749,751], the repetition of discussion groups with the same set of actors strengthened further the 'social' elements presented in the preliminary CSS stage. This included the continued formation of connections between individuals, sharing of resources that facilitated learning, and the further contribution towards producing collective and socially robust knowledge. Examples of these are presented below, which occurred during Stage 3 of the CS study (Chapter 6). Older adults, who had engaged throughout all stages of the study, continued to discuss and reflect on each other's concerns during the final workshop stage, facilitating further collective actions and knowledge to address these concerns:

P1 (older adult, female, 62yrs) : "*Yesterday I had to go down Harborne hill for some treatment on my leg, and there were loads and loads of leaves. It was dry but had it been wet, I'd have been really nervous because with my crutches they slip on the wet and I just wouldn't have been safe at all"*

P2 (older adult, female, 77yrs): "*I have real problems when I'm walking there and back with the leaves that have come off trees in the road, and on paths in the parks, and I just never thought about it until I slipped"*

P3 (older adult, female, 63yrs): "*First thing is, get in touch with your local MP and maybe call all the MPs of the area, and maybe set up a small group of like-minded people who will help you pull things together."*

P4 (older adult, female, 67yrs): "*Don't we have a candidate, John O'Shea who is in charge of all the litter and leaves and he is the one who is actually got the budget and power to do something. A directive email to John O'Shea, who is also the supporting officer for the MP, Jess Phillips, so he has got two hats on there".*

Similarly, older adults and community stakeholders continued to develop connections and support one another during the Stage 3 workshop of the CS study:

P5 (older adult, female, 71yrs): *"How can we access community development as a small group, because a bid I wanted to put in for a small project, I was given feedback that we don't have enough community involvement as we don't have any young people in our group"*

P6 (community stakeholder, male): *"Ironically, we have had stuff rejected as there wasn't enough older people involved"*

P7 (community stakeholder, female): *"So in our local area, nearly all groups supporting younger people which was the main body of discussion, so there is people I can put you in touch with"*

This repetition of workshops has been previously undertaken in a CSS project [348], with the outcomes developing a knowledge coalition in which individuals related to mental health identified relevant community 'social' issues and joint actions. This was similarly seen by the CS study of this thesis, which continued to build on the

preliminary CSS stage through repetition of discussion groups and workshops. This repetition shifted away from discussion of a single concern or focus, such as a question that may be used to guide a single focus group, and instead towards a more reflective dialogue in which individuals continue to discuss collective concerns, sharing resources and facilitating learning, whilst also forming joint actions. These are all elements of CSS that produce socially robust knowledge and can be further utilised by a collective network for actioning change [341,342,348]. This in turn contributes further to the small number of studies utilising CSS, which have been identified as potentially contributory rather than co-production [340,348], presenting a pathway for strengthening the 'social' within CSS.

The use of CSS as a preliminary stage, alongside the repetition of discussion groups and workshops with the same set of social actors, therefore, adds value to the use of qualitative methods aiming to co-produce research and mobilise collective actions. For this thesis, this includes providing a substantial generation of socially robust knowledge across these actors that relates to promoting active and healthy ageing across the city of Birmingham. This includes producing a knowledge coalition in which older adults and community stakeholders generated actions and solutions, seen in the above quotes, that can support active and healthy ageing. It also further strengthened the connections, sharing of resources which were seen to be continued from the preliminary stage (Chapter 5) to the final workshop stage (Chapter 6) demonstrated above, and the continued capacity building across these actors that holds potential to mobilise joint actions and change across the city.

In order to strengthen this CSS vision, this methodological contribution and its subsequent co-produced outcomes require further exploration within the social

sciences. This includes embedding a social science framing further throughout the methodology, bringing together CSS and CS through this framing, as well as when interpreting the outcomes generated by social actors. For example, engaging citizen scientists to co-produce social science research and encompassing more critical reflection and investigation through a social science lens during the methodology. This would include considering active and healthy ageing through a social sciences lens at all stages of co-production, from online discussion groups to the workshop stages, to explore the different social dimensions and structures of society that contribute towards age-friendly cities.

This would however necessitate shifting away from the consideration of 'physical topics' presented by the AFC approach and instead towards exploring the social and behavioural determinants, finding ways to develop the theoretical concept of AFC further [766]. This may include exploring broader issues across society, such as socio-economic inequalities or the social and cultural norms present within society. It may also include more local-level and place-related theory such as belonging or attachment that enables older adults to develop meaningful connections and social experiences [22,32,531,766-768]. This has potential to provide a more in-depth social perspective into how older adults and their social experiences shape AFC, or alternatively how AFC shape older adults and create their social experiences [769].

Secondly, embedding the co-produced outcomes within a social science framing to further explore their interactions and interconnections occurring across both society and urban environments. For example, embedding the outcomes of this study into a social-ecological systems (SES) approach. This approach has been identified to bring further together the social sciences with environmental and ecological ones to

reflect the realities of the issues experienced by individuals within their interconnected environment and society [177,770]. It presupposes humans and their surrounding built and social environments are intertwined [174,771], facilitating the exploration of how co-produced and place-based knowledge can be embedded across these two elements of society and the environment [770].

Exploring the city-wide recommendations, which presented similarities to the area-specific recommendations and a collective overview of older adult concerns (Chapter 6), through a SES approach enabled the city of Birmingham to be framed as an urban social-ecological system (Figure 25). This approach was directed through a focus of active and healthy ageing in Birmingham, with the boundaries of the system identified as the city of Birmingham and its function centred on promoting active and healthy ageing [173]. The city-wide recommendations, which encompassed shared place-based urban characteristics across the collective group of older adults, were explored and presented across the social-ecological domains they reflected. These domains (previously explored in Chapters 2 & 3) have been identified as the individual (inter- and intra-personal), environmental (also referred to as physical), socio-cultural, economic and political domains [79,161,186-188,771-773].

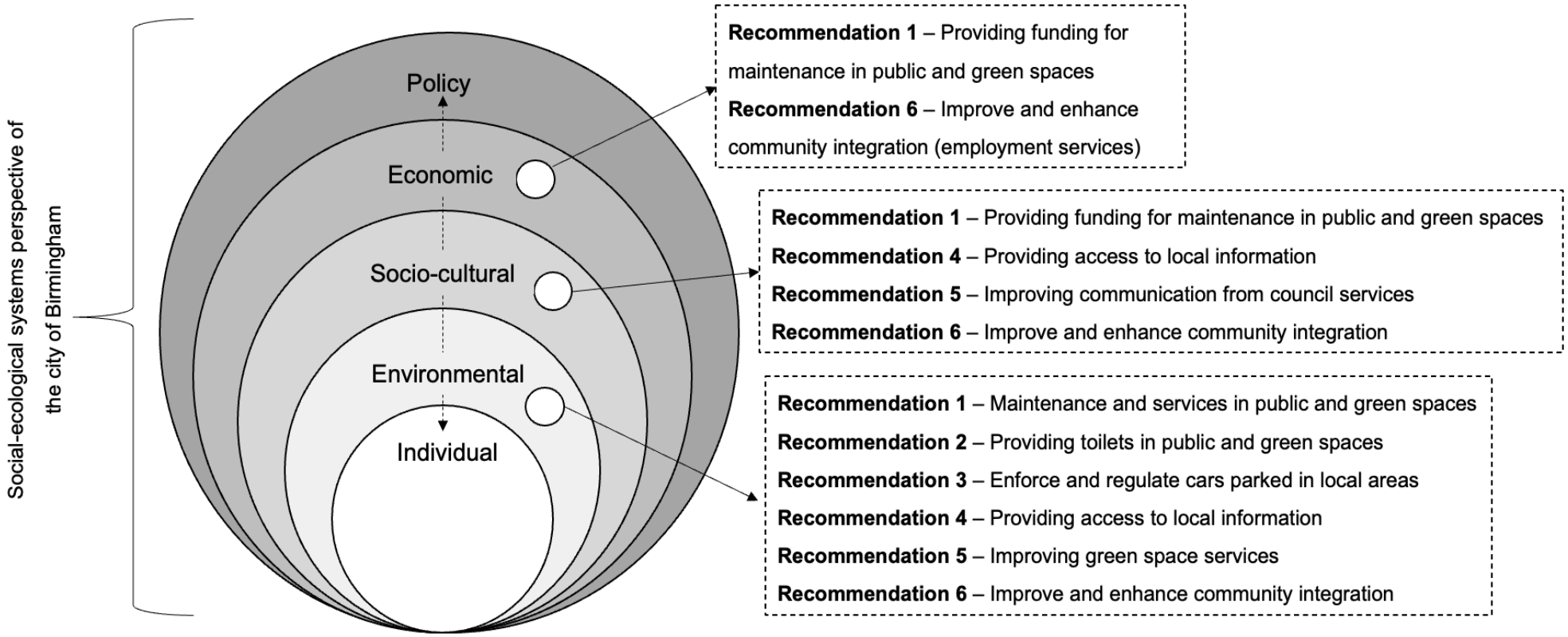


Figure 25. Social-Ecological Systems approach of the city of Birmingham, highlighted by the social-ecological elements identified in the city-wide recommendations (Adapted from Bornstein and Davis [774]; Klasa et al. [775]; Sallis et al.[161]).

Drawing on this approach, the different social-ecological domains and their urban features that impact active and healthy ageing across the city of Birmingham were presented, identifying the presence of environmental, socio-cultural and economic domains (Figure 25). For example, urban characteristics encompassed across all six city-wide recommendations reflected elements of the environmental domain. This included the physical or design elements of an urban environment, such as pavements or well-maintained green spaces, to the need for facilities such as toilets, accessibility and physical community spaces that can foster integration. Four recommendations also reflected elements of the socio-cultural domain, such as accessible communication and information of local activities, a need for community members to engage in and support local areas and improving community cohesion through intergenerational activities. Two recommendations also reflected the economic domain, identifying a need for funding to maintain public and green spaces and provision of employment support for all individuals within a community.

Some recommendations also interconnected across these three domains, showing their interacting urban features. Recommendation 6 identified a need for the physical environment to provide suitable shared spaces (environmental) that facilitate communities to foster social and community cohesion (socio-cultural), whilst also being supported economically through opportunities for employment (economic). Recommendation 1 also highlighted a need for green and local spaces to be maintained, cleaned and accessible (environmental), alongside a need for local community (socio-cultural) and economic support (economic) to undertake this maintenance.

Utilising this SES approach demonstrated the interlinked environmental, socio-cultural and economic urban domains that require consideration when altering a city to promote active and healthy ageing. Public health studies have explored the interconnected domains of SES, identifying how these different domains influence physical activity [81,776], active living [161] and time spent in local environments[79]. More specific elements have also been explored, such as a specific hospital [772] or neighbourhood setting [187] to social-ecological domains that impact mobility [186]. Across these studies, it was clear that there are interconnecting characteristics across each domain, from the individual to the policy level, that influence one another and require consideration when altering or enhancing a setting or behaviour. It is therefore important when promoting active and healthy ageing to consider alterations across the interconnected social-ecological domains reflected in the city-wide recommendations rather than considering urban changes in isolation. This can build upon the vision of CSS presented by this thesis, enabling the collective knowledge developed by social actors to be recognised across the interconnected social-ecological domains and how they interconnect within an urban system to produce the wanted function of active and healthy ageing [80].

To also strengthen the collective and socially relevant knowledge developed through this CSS vision, consideration to the social organisation and active engagement of a broader range of social actors from different social contexts and realities is required [342,350,352]. This requires consideration to who can collect, interpret and reflect on data and the way it is employed [341], shifting away from the potentially privileged and resourced communities who already have access to the scientific community. Instead, individuals from diverse social realities, including those from

diverse ethnic and socio-economic backgrounds and underserved or underrepresented communities should be engaged [354], with a potential pathway for this identified in Figure 23. This need has been highlighted within the AFC approach, which requires more inclusive engagement of older adults from diverse social realities and in particular, older adult migrant and refugees [59]. This would present opportunities to explore the social inequalities that are relevant for older adults across society [351], developing collective knowledge around issues that are based on a range of diverse narratives [343]. Achieving engagement of a diverse group of social actors can in turn develop a CSS approach that democratically develops scientific research that potentially addresses social challenges relevant for all members of society [354].

However, it is important to acknowledge the impact of the preliminary CSS study. This stage, and its discussions and data generated, has the potential to impact the data collection and outcomes co-produced during the following stages of the CS study. For example, the discussion of active and healthy ageing as a collective group may have constrained those engaged in terms of sharing their individual ideas and needs, instead being influenced by the group discussions. Alongside this, the Discovery Tool data collection undertaken during Stage 1 provides a real-time immersive and neutrally framed experience in a citizen scientist's local environment. However, the previous discussion undertaken during the CSS stage may have 'prepped' or influenced older adults prior to collecting data, subsequently altering the data they collected through the Discovery Tool.

There were strengths to employing this preliminary stage, such as facilitating citizen scientists and community stakeholders to steer the focus of the research and discuss the priorities important to both the individual and collective group in relation to

active and healthy ageing. This enabled an understanding of the barriers and facilitators to active and healthy ageing, both through diversity of these elements in different localities and as a collective overview across the city. This stage also identified and raised awareness of the diverse definitions and experiences of active and healthy ageing, providing opportunity for reflective dialogue and allowing older adults and community stakeholders to discuss the ageing experiences of others across the city. This in turn may have provided a 'warm-up' activity in which those engaged instead became embedded within the study and its focus, potentially facilitating more vigilance and awareness of urban barriers and facilitators for both the individual and for others in their community.

The iterative approach employed by this PhD research allowed the collective inquiry undertaken by those engaged at each stage to inform the subsequent stages (Chapter 5 & 6). For example, the collective needs of older adults based on the data they collected and discussed (preliminary CSS stage, stages 1 & 2) informed the discussions during the workshop stage (stage 3) and the co-produced recommendations. This holds parallel to other qualitative approaches and paradigms that aim to explore the experiences and beliefs of those engaged to inform research [617,777]. Grounded theory approach is one example, which inductively explores the interactions and comparisons between individuals' experiences, achieved through coding or comparative analysis, generating common patterns or interconnections to produce a theoretical understanding of an experience or phenomenon [406,617,778]. Similarly, Framework Analysis builds on similar principles of grounded theory but instead provides a case-based analysis of experiences. This provides a more structured method for analysing qualitative data through coding themes, being less

inductive and instead driven by an already identified idea or focus, to produce a framework in which individual experiences can be identified and compared with others [778,789].

To strengthen the preliminary CSS stage and address the potential impact this had on subsequent stages of the CS study, exploring and analysing the individual and collective experiences could be undertaken. Depending on the level of co-production or engagement, Grounded Theory Approach or Framework Analysis may provide a suitable way to analyse the individual experiences of older adults in relation to active and healthy ageing. Building on the thematic analysis already undertaken by this thesis, producing codes and themes for each individual experience and completing a comparison across experiences has the potential to produce a framework or theoretical understanding of the individual and the collective experience of active and healthy ageing [778,789]. In exploring the individual experiences further may also facilitate an understanding of how the data collected for an individual older adult during the preliminary CSS stage may change or evolve as they engage in the subsequent CS stages. This in turn may produce an understanding, such as a framework or theory, of how older adults across Birmingham experience active and healthy ageing and how this may change as they engage in each stage of the CS study.

Overall, this CSS vision presents a way in which this methodological contribution of preliminary CSS online discussion groups and co-production CS can be further embedded within social science research. This provides a concrete methodological example in which CSS studies could employ online discussion groups with a focus of further reflective dialogue across actors in order to develop a social collective framing of a phenomena, as well as build social connections to lay the

valuable groundwork for a knowledge coalition. This requires the engagement of diverse social actors and consideration to translating a social science focus to these individuals, which has been identified as a challenge when exploring more theoretical approaches than those used by natural sciences [783]. It does however present a strong methodological vision for CSS that can develop a collective social framing of active and healthy ageing in urban environments, bringing together CS and the social sciences to develop knowledge based on social realities that is relevant to the individual and wider society [348,352,760,781].

7.4 Implementation framework for city-wide action across an urban social-ecological systems approach

When altering and enhancing urban environments, it is important to employ an approach that can recognise how the needs of urban residents are interconnected across different domains and elements of these environments [179]. This is because the elements present within a system, such as an urban environment, are not independent from one another [785]. Instead, they interact and influence one another [80,132], with changes made to one element potentially creating changes and outcomes to emerge across other elements[176]. From a SES approach, this can demonstrate a specific focus on how these urban elements are connected to urban residents through a range of different urban domains, demonstrating pathways for changes to be made across these different domains that hold potential to promote health and wellbeing [774].

Utilising the place-based needs of older adults engaged in the CS study and presenting them across the different social-ecological domains highlighted how these

needs are interconnected and require consideration across the different environmental, socio-cultural and economic elements of an urban system in order to promote active and healthy ageing for older adults. This presents potential to contribute towards urban planning and decision-making that can shift away from thinking in silos to instead considering the multiple domains and their resources that are intertwined within a 'whole' urban system in order to promote active and healthy ageing. The use of SES approach in turn provided a valuable multi-level exploration of the city of Birmingham as an urban system, highlighting the domains where changes across domains are required to promote the function of active and healthy ageing [173].

It is important to also consider the individual and policy domain, which were not directly reflected across the recommendations, but have significant potential to be interconnected across the urban characteristics presented within this SES [782]. This can include the individual-level, encompassing the function, capacity and behaviour of an individual, to the policy-level and how a system is governed through policies and agendas [81,773]. For recommendation 1, the funding required to maintain public and green spaces may come from political agendas and related investment across urban environments. Similarly, the individual-level will impact recommendation 6 for improving community cohesion. This includes an individual's health [209], social and cultural norms [174], presence of social support and perceived safety [19,79,80,161,187] and how they connect with others and use their local spaces [783]. It is therefore important to recognise the different social-ecological domains of a system and how they interconnect to influence the wanted function of an urban system [80].

The SES approach employed by this PhD research could also be argued to be a simplified version of an urban system, lacking full representativeness of the dynamic

urban elements, agendas, power and complex behaviours [168,182,189,784]. This approach is however valuable for exploring a version of an urban system that focuses on a specific function, which is informed by local actors and stakeholders who identify the needs and solutions that promote this function [773], whilst still taking into consideration the 'whole' picture of an urban system [22]. The purpose of this research was also not to produce a full overview of an urban system, but instead an urban system that is relevant to older adults and their ageing experience in the city of Birmingham.

Through older adult and stakeholder dialogue, the city-wide recommendations were discussed in relation to ways they could be implemented across the city, enabling the development of an implementation framework (Chapter 6, Figure 22). This framework demonstrated actionable pathways to implementing and scaling up the city-wide recommendations across four levels of *local communities, public health and planning, business and private sector and public health policy.* Positioning this framework within a SES perspective (Figure 26), in which the city of Birmingham is an urban system, presents a contribution to identifying how these four levels of the framework and their actions are interconnected within urban SES domains (*individual, environmental, socio-cultural, economic and political*). In considering these interconnections, this demonstrated that promoting active and healthy ageing across an urban SES requires collaboration between these four levels of the implementation framework and the domains of a SES system. This highlighted the potential to support public health research to use this approach in other contexts and localities, with this framework placed in the context of Birmingham providing value for identifying the actors and resources who could action the co-produced recommendations, set out below.

Exploring the *local communities* level of the implementation framework (Chapter 6) identified a set of actions that could be undertaken by local community members for implementing the city-wide recommendations. These actions reflected the different SES domains of an urban system (defined in Chapter 2 section 2.2.1 and Chapter 3 section 3.2.4). Individuals could volunteer, report parked cars and take personal responsibility for their driving habits, reflecting elements of the individual domain such as the intra- or inter-personal elements including self-efficacy, social support and health conditions that may impact how an individual engages. Community members could also come together as local groups to lobby priorities and develop a collective localism agenda that holds relevance across the community, reflecting elements of the socio-cultural domain such as social or cultural norms or social networks that may impact how individuals come together. In undertaking these *local community* actions across the individual and socio-cultural domains of city then impacted the environmental domain, such as producing good quality, accessible and maintained local environments. This was already present within the city of Birmingham, with individuals volunteering (individual domain) and coming together as friends of park groups (socio-cultural domain) to raise support for public toilets within their local park (environmental domain).

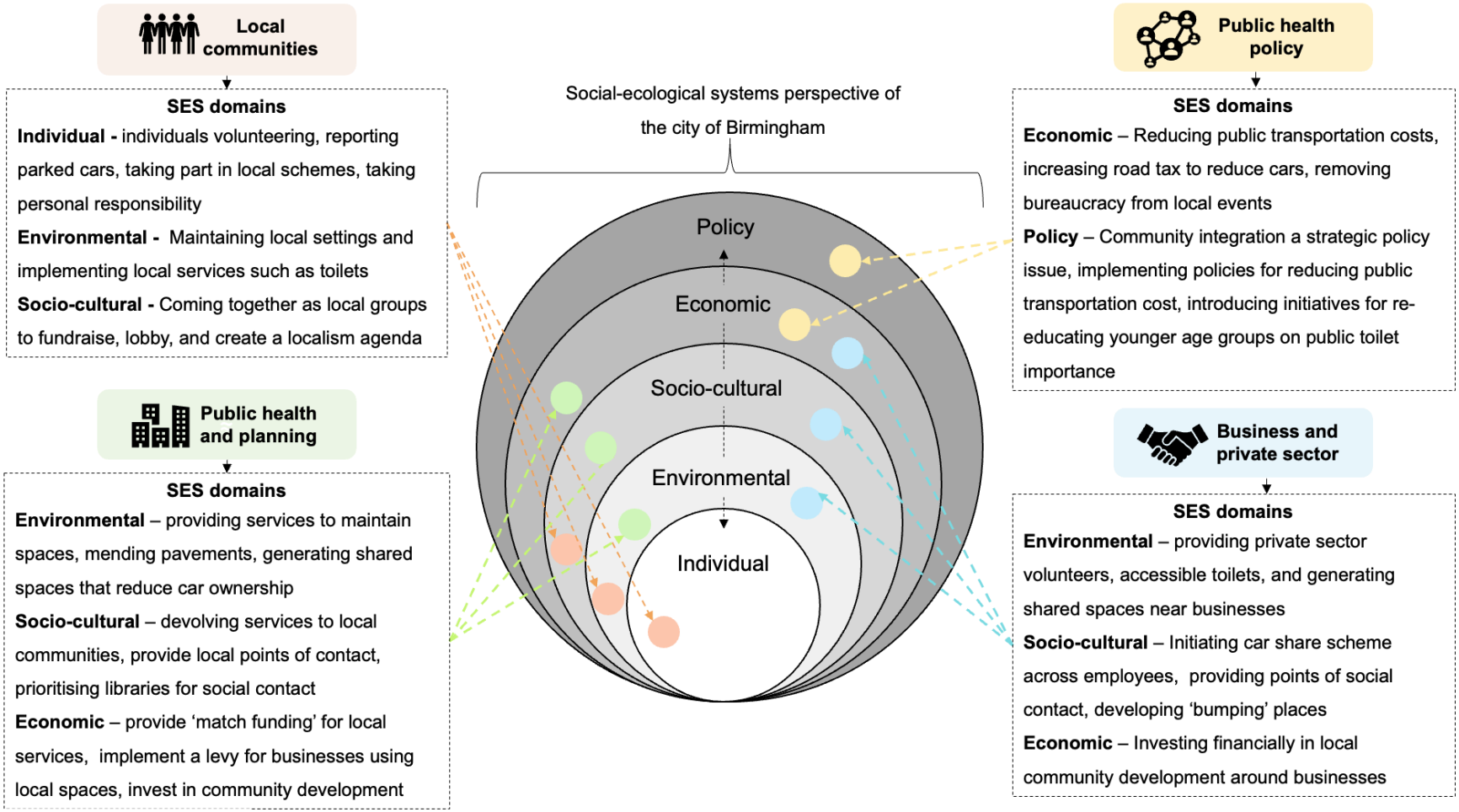


Figure 26. The four levels of implementation framework (*local communities, public health and planning, business and private sector and public health policy*) and the related actions reflected across the SES of the city of Birmingham (Adapted from Bornstein and Davis [774]; Klasa et al. [775]; Sallis et al.[161]).

At the same time, different SES domains encompassed more than one of the four levels of the framework. For example, the environmental domain encompassed *local communities, public health and planning and business and private sector*. This demonstrated that actors and their resources from these different levels, such as local community members, public health officers and business owners need to collaborate to produce environments within an urban system that can promote active and healthy ageing. This could include *local communities* volunteering to maintain their environment, *public health and planning* ensuring services are present for maintaining good quality and shared urban environments and the *business and private sector* providing volunteers to maintain environments and accessible facilities.

These interconnections presented between an individual and their environment have been valuable for further strengthening the development of AFC. An ecological perspective of AFC centring on social connectivity [22,768] identified ways in which social connectivity is determined by and interlinked across the individual, family and friends, community and policy domains. Similarly, the AFC approach has also been considered as an ecosystem that extends to bring together public health, universities, cities, states and healthy system domains [786], identifying actions across these different domains that complement and support one another. Both of these perspectives demonstrated the importance of removing separation between these domains and instead enabling coordination, collaboration and shared support when fostering AFC. To strengthen this further, exploration across localities, scales and partnerships that are present within specific urban communities are required to identify practical objectives that can implement age-friendly actions.

Other frameworks have focused on specific domains, such as age-friendly actions within the policy domain [766]. This demonstrated a need to facilitate profit for community stakeholders engaged in order to be recognised as economically sustainable in the policy domain. This reflects the current limitations across the age-friendly agenda, such as governments shifting responsibility and actions to non-profit and local volunteers in order to deliver neutral cost initiatives [269], impacting how this agenda operates at other domains of an urban system. Similarly, a framework for fostering age-friendly collaboration and connections across multi-level actors has been presented [787]. This framework identified templates in which age-friendly actions could foster collaboration through securing city-wide commitment, programmes for developing stakeholder forums and working across different actors to deliver the age-friendly initiative. This framework was however described as a potentially broad approach that lacks consideration to specific contexts [788-790].

Undertaking age-friendly change is a complex task that is substantially contextual to the specific city and its residents in which it is being applied [788]. It requires consideration to a contextual but whole city approach, finding new avenues to bring together a more in-depth recognition of both the local-level needs with the standardised approach that can guide top-down resources and actions. This includes going one step further, or presenting a ‘middle ground’, in which the bottom-up needs that are based upon the lived experience of urban residents can drive the top-down standardisation and resources required across cities. This middle ground, which is required by age-friendly initiatives that fall short when only focusing on either bottom-up relevance or top-down support [41], identifies the different domains, levels and actors

across a city that operate together, demonstrating leverage points to identify and implement relevant actions and changes [174,791-793].

The implementation framework addresses this need, identifying four levels of actors and resources that can operate together to action the city-wide recommendations. It also positions itself within a SES perspective and presents a way in which the city of Birmingham, and the four levels, can be considered as a whole urban system that encompasses different SES domains. The framework presents a potential foundation for building on and identifying further leverage points across these four levels, SES domains and the relevant actors in which age-friendly changes could be collaboratively actioned. This does require further consideration to how collaboration can occur (explored in section 7.4.2 of this chapter). Overall, the implementation framework demonstrates a contribution towards actioning age-friendly change in the context of the city of Birmingham, identifying pathways to mobilising age-friendly collaboration that can leverage actions across different levels and interconnected domains of an urban system [31,794,795].

7.4.1 Building upon the age-friendly agenda through the implementation framework

The implementation framework also demonstrated further contributions to the AFC approach. This included identifying actionable pathways that go beyond the 'universal' AFC guidance, providing potential for collaboration and a framework that can be used by other cities to action the age-friendly agenda across the four levels identified. In bringing these three contributions together, it presents a valuable 'middle

ground' previously described, identifying an approach that can go one step further in which there is a standardised framework to be used across cities that also holds more detail towards the city's context. It provides the opportunity for actors across the city to consider the bottom-up needs of their residents, the top-down stakeholders resources required and the actions built around the bottom-up context to guide and implement age-friendly changes.

Comparing the implementation framework and its actionable pathways to the AFC approach highlighted relevance to the eight AFC topics (Chapter 6). This included similarities presented across 7 of the 8 topics, demonstrating overlapping topics and actions. However, the implementation framework went beyond these similarities and AFC guidance to provide detailed pathways that encompassed different actions, actors and resources across four levels of the city. This conceptualised ways in which the age-friendly agenda can be actioned across the city, considering the context-specific needs of older adults whilst identifying the relevant actors and actions they can undertake. This is valuable for strengthening the standardised avenues for elevating international age-friendly standards [687], bringing an opportunity for further action by providing a way for actors to actually consider how they can action these standards in a relevant way to their city.

For example, the actions presented by the implementation framework for recommendation 2, which identified a need for public toilets in local and green spaces, showed similarities to two AFC topics (Figure 21). This included similarities for providing adequate public toilets, alongside providing intergenerational interactions and education to raise awareness of ageing. The implementation framework expanded beyond this universal guidance to demonstrate actionable pathways across the four

levels of the framework. This included fundraising as a local community to provide and maintain local toilets (local communities), providing a community toilet scheme in which businesses are supported by the local council to allow free use of their toilets (public health and planning, business and private sector), and re-educating younger age groups specifically on the importance of public toilets to aim to reduce vandalism. The implementation framework in turn builds further on AFC eight topics, identifying ways in which actionable pathways centred on local needs can be presented to guide actors across the different levels of the city to implement the age-friendly agenda.

The implementation framework can in turn address and strengthen the limitations presented by standardised tools such as the AFC approach, which has been described as an 'ideal' environment hard to reach by governments [25,796], alongside being too universal to capture the needs of older adults in their local urban environments [656]. At the same time, the AFC approach has also been identified to facilitate initiatives that are too small scale, focusing specifically on individual services whilst excluding systematic and wider issues across the economic and political levels [269,624,788]. The implementation framework provides strength to the WHO AFC guidance by providing bottom-up and top-down pathways to explore the middle ground in which cities can bring their actors and resources together to collaborate, action and potentially sustain local-level needs.

7.4.2 Elements of collaborative governance

Developing, implementing and sustaining age-friendly actions within an urban system requires collaboration and multi-sectoral partnerships across the different

levels, agendas and resources present [31,275,795,797,798]. This is crucial as stakeholders can be those who initiate and facilitate collaboration from the local to the policy level [31]. The implementation framework presents potential groundwork for fostering this collaboration, particularly through collaborative governance (explored in Chapter 2). Elements of collaborative governance were present in this framework, which included a shared focus of promoting active and healthy ageing, being centred on bottom-up and locally driven needs of older adults through the city-wide recommendations and identifying a range of actors that would need to be engaged [212,214,215].

Bringing these elements together holds potential to contribute towards urban planning and decision-making that can shift away from thinking in silos and instead consider the multiple domains and resources that are intertwined within a 'whole' urban system [168]. It also shows how these range of actors can actively collaborate to foster AFC across the specific actions, giving consideration to the actors within the wider systems outside of the local-level that can mobilise age-friendly actions and resources [794]. This includes actors from the local-level, such as local residents and grassroot organisations, to actors at the policy level including public health policy makers. Utilising this framework for collaborative governance does however require further consideration to the elements of collaboration. Complexity of managing different and clashing needs [210], lack of autonomy already present across different departments and sectors [230] and the relationships or historical interactions present across different actors [799] require further exploration. The individual elements required for collaboration [214], such as commitment and motivation to engage [213,215,228,229], alongside levels of power and inequity across different diverse groups within society [607] also require consideration.

However, the implementation framework provides a contribution in which a city can be considered across these multi-level and scalable perspective. This includes the potential groundwork for contributing towards collaboration across stakeholder knowledge and resources, actioning the local-level needs of older adults and aiming towards collaboration across these actors to promote the age-friendly agenda [31]. This is required to identify and engage multiple actors across these levels to support the wanted alterations[663], providing a good foundation for collaborative governance. The framework in turn presents the opportunity for the identified actors to collaborate over the shared age-friendly actions, build upon local-level contexts and needs and find pathways to actually implement and sustain age-friendly actions.

7.4.3 Transferability to other cities implementing the age-friendly agenda

Partnerships and collaboration across different actors within a city are identified to be central to achieving the age-friendly agenda [25]. These partnerships also require the merging of bottom-up context and concerns with the top-own resources, capacity, existing services, political support and responsibility required to implement and sustain age-friendly initiatives [31,89,265,269,275,786,798,800]. The implementation framework can provide a template to achieving this (Figure 27), presenting a further contribution to the age-friendly literature. The implementation framework presents a standardised framework template that can be applied across different cities, but one that is more in-depth than the AFC approach and can identify concrete actions, resources and actors to implement age-friendly change.

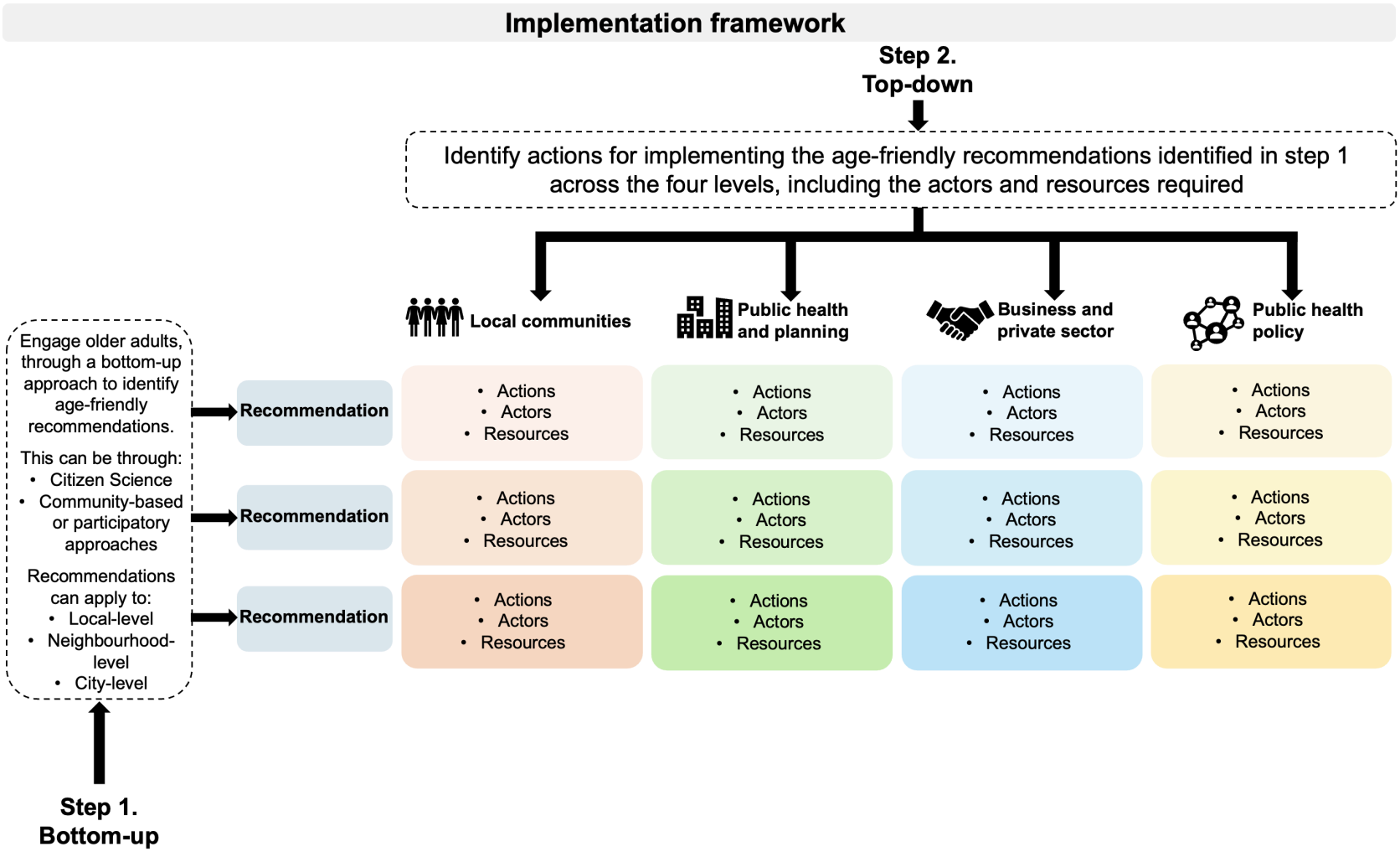


Figure 27. Example of the implementation framework that could be used as a template for other cities (Source: Author).

The implementation framework, as identified in the contributions above, can facilitate actors to identify and implement age-friendly actions across a city and its actors. Prior to using the framework, engaging older adults in a bottom-up approach to identify age-friendly recommendations is required. Once the bottom-up needs and recommendations have been identified, they can be presented within the framework to stakeholders to discuss and identify required actors, actions and resources required, presenting elements of a top-down approach. Utilising this framework can in turn bring together a bottom-up and top-down approach to establish an age-friendly initiatives that centres on local-level needs whilst identifying the actors and resources required to collaborate, implement, and sustain age-friendly changes.

The age-friendly agenda is one that requires the ability be both universal and small-scale, addressing the bottom-up and local-level needs whilst still being applied universally across different cities [269]. This framework presents a valuable contribution towards this requirement, providing a standardised approach that can be built upon the local-level needs of older adults whilst identify specific multi-level actors, resources and capacity within a city to leverage age-friendly change and foster collaboration across multi-level actors [663,794]. This is particularly valuable for presenting a transferable approach that could be considered and compared across different cities, shifting past the vast multitude of indicators from different age-friendly studies reducing comparable actions and outcome [41,801]. Overall, the implementation framework provides the opportunity for actors within one city to identify how the age-friendly actions in another city have been implemented. This includes the identification of different multi-level actors and their resources, providing potential for real-world examples of how actors within a city have collaborated together across these four levels of the framework to action the age-friendly agenda. This in turn provides a

contribution for facilitating a transferable approach in which collaboration across multi-level stakeholder knowledge and resources, that are based upon actioning the local-level needs of older adults, can be achieved when promoting the age-friendly agenda.

7.5. Advancing methods and processes to develop age-friendly urban environments

The findings of this PhD thesis present a set of cohesive contributions and steps for advancing CS and age-friendly methods in relation to developing, strengthening and actioning the age-friendly agenda within urban environments. This includes a contribution to advancing CS methods in public health and age-friendly research, alongside bringing together public health and urban planning domains through a SES approach and demonstrating the value of these contributions in the context of the city of Birmingham.

7.5.1 Advancing citizen science methods in public health research

Although the more 'extreme' co-production and co-creation of older adults in age-friendly and public health research is gaining traction [54,274,369,517], current limitations within the CS literature identify a need to expand and strengthen CS methods applied across these disciplines of research [54,290]. This includes strengthening the methodologies that actively engage older adults in CS co-production, such as co-researchers that co-produce public health knowledge [517], alongside presenting more defined and standardised techniques in which CS can be systematically employed across different disciplines [305,314]. The CS method applied

throughout this thesis addresses these gaps, presenting a way in which CS can be applied in systematic set of steps whilst encompassing the active engagement of urban residents to co-produce public health research.

Utilising the *Our Voice* CS for Health Equity approach provided a foundation which informed the CS method. This included a four-step method that was built upon, allowing an evidence-based and systematic way to employing a 'by the people' level of engagement to be followed. This approach was also integrated and informed by the CSAT, bringing with it the best practices of CS that have been identified across the CS literature. The CSAT allowed this CS method to consider how and when older adults were engaged, developing citizen-driven data collection and solutions whilst still considering data quality, the partnerships present between citizen scientists and the researcher and finding ways to provide accessible dissemination of implications that hold real-world value. Lastly, the incorporation of CSS within the CS method brought a social aspect to this method. CSS presented a way to further engage citizen scientists as both individuals and as a collective group to reflect on their contributions during data collection, alongside developing social connections, capacity and a potential network that can hold value throughout the CS method.

This presented a way for advancing CS methods that can be effectively applied in public health research, producing a systematic approach to effectively engaging citizen scientists to co-produce research that is informed by evidence-based and best practice CS approaches. This can be further utilised by future CS studies in public health research through a set of cohesive and systematic steps (Figure 28). These steps include; 1) Using the CSAT which can inform CS studies during their development and towards the more 'extreme' levels of co-production when engaging members of the public; 2) A preliminary CSS stage can follow this development,

utilising online discussion groups with a reflective dialogue, laying the groundwork for collective knowledge and social connections; 3) Drawing upon this collective knowledge, the following CS stages that are informed by the *Our Voice* CS for Health Equity approach can be employed. This includes employing the systematic four-step method provided by this approach, engaging older adults in a 'by the people' CS to collect, interpret and prioritise their data during the Discover and Discuss stages; 3a) If studies have an AFC focus, the implementation framework can be utilised during the Advocate stage to focus older adult and stakeholder dialogue on developing actions across the four levels. This includes identifying actors, resources and the interconnections within the environment being explored to present a 'whole view' that can aim towards achieving age-friendly change; and 4) Throughout and at the end of a CS study, the CSAT can be employed to evaluate the CS practices, demonstrating strengths and credibility of the study alongside areas that can be strengthened further.

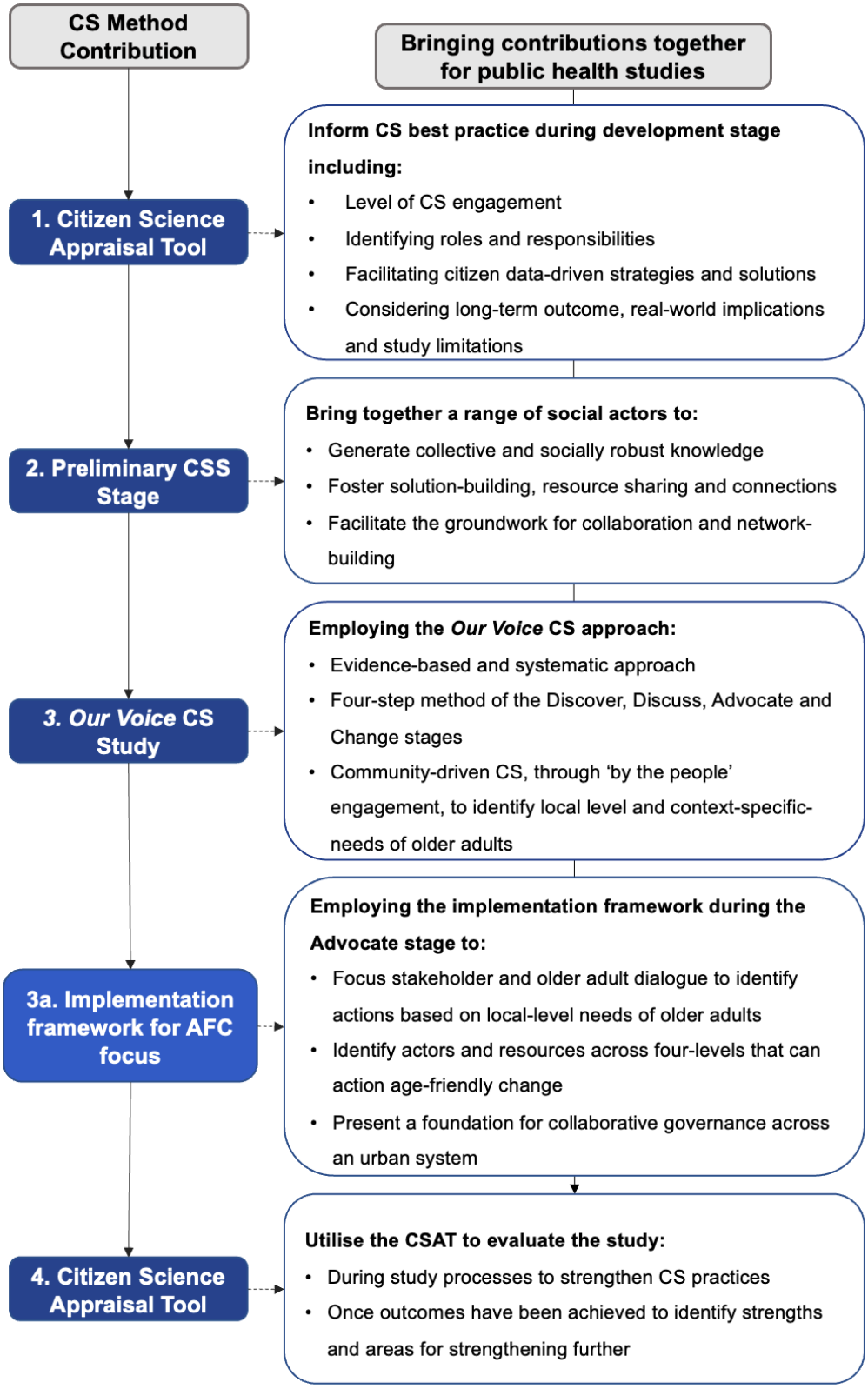


Figure 28. A set of cohesive steps that can be used by future studies exploring the age-friendly agenda through a CS approach (Source: Author).

7.5.2 Bringing urban planning and public health together through a social-ecological systems approach

Framing the co-produced recommendations through a SES approach enabled them to be conceptualised within the city of Birmingham as a whole SES system. This SES approach was adapted to explore the interconnections between older adults and urban environments, representing a human-environment relationship [168] that related to the real-world context of active and healthy ageing in Birmingham. These interconnections were presented across the different SES domains, which have been identified as interconnected and interdependent across the different levels of an urban system [180,181]. This leveraged new insights into the relationship between older adults engaged in the CS study and the city of Birmingham, demonstrating a more holistic view of an urban system. This included ways in which the urban characteristics that hold local-level value can be altered or enhanced by urban planning and public health practices to promote active and healthy ageing [80].

Urban environments have been previously explored through different approaches within the urban planning and public health practices. Urban planning has had a focus on spatial exploration, identifying ways in which built and natural settings can be used, developed or are valued and how their current form can be optimised for the future [802]. This was historically built upon more rationale and modernist theory in which the knowledge of urban planners informed the optimisation of the physical environment, utilising practical methods to achieve specific criteria related to wanted outcomes or an 'ideal' environment. These practices have since become more communicative to incorporate different knowledge and context from a range of actors

within both physical and social environments, altering the idea of an 'ideal' environment based on the needs across different community members [63,803-805].

On the other hand, public health has explored more epidemiological and positivist 'evidence', informed by quantitative and empirical approaches that strive for causal understanding. This was identified to exclude the 'social' aspects, with research focusing on elements such as medical practices or health and disease. These practices have since been further developed to encompass social sciences and explore the realties that impact health and wellbeing [806-808]. These two disciplines of urban planning and public health have been recognised within the AFC approach. Urban planning practices have been utilised to consider the design and practical elements of age-friendliness within urban environments, whilst public health practices explore how to promote health during the ageing process [809,810].

The merging of these two disciplines has become crucial to tackle health and wellbeing in urban environments [811]. This includes bringing together these two disciplines to explore how an individual within society and how urban environments are both part of this approach to promote health and wellbeing [803,806,810]. The value of employing a SES approach demonstrated a way in which these two elements can be considered through a 'whole' and interdisciplinary view. This included recognising the individual and their ageing experiences, alongside the design and planning of the physical and social urban elements, allowing the focus of active and healthy ageing to be considered through an interconnected public health and urban planning view.

Bringing these two disciplines together and finding pathways for collaboration has been argued to promote healthier cities, combining elements of strategic planning and place-making centred on health and wellbeing [812]. This was demonstrated when applying this SES approach to the co-produced recommendations. For example,

promoting active and healthy ageing required ways in which community integration across different age groups and ethnicities could be enhanced (Recommendation 6). To address this, the actors and resources across urban planning and public health need to be leveraged, working together to design urban environments in Birmingham that can promote social cohesion. Through the implementation framework situated in a SES approach, the need to design shared spaces that incorporate local community assets and actors, such as shops, community development officers, and general practitioners were identified as collaborative actions. Through this SES approach and considering the different urban domains, actors, levels and resources, the opportunity to translate this SES theory in public health and urban planning practices [174] was presented [174].

The SES approach also provided the opportunity for further consideration to different SES theory, such as trade-offs or feedback that may occur when decisions or changes are made within an urban system [179,192,813]. For example, providing stronger enforcement of cars parked on pavements (Recommendation 2) included actions for reducing car ownership, car share schemes and developments that reduce the need for cars. This may create a trade-off in which public transportation becomes more frequently used, requiring a need to promote good quality and suitable services that can meet the same needs of those who drive cars [814]. Considering all the interconnected urban elements through a SES perspective also holds potential to develop a resilient city that has capacity to handle internal and external changes whilst continuing to meet its function [182,815,816]. By actioning these interconnected alterations or enhancements identified through the co-produced recommendations within an urban system can potentially present a way to promote the wanted function of active and healthy ageing even when changes occur. For example, urban growth driven

through different economic or political agendas may create new changes within local urban environments. However, ensuring that urban elements are present that support older adults to be active and healthy, such as the presence of toilets or maintained and accessible green spaces, presents potential for a city to still meet this need whilst also encompassing other changes [19,179,816,817].

The use of a SES perspective placed the challenge of optimising urban environments to promote active and healthy ageing in an urban context that considers the whole system and its interactions that occur across the different social-ecological domains [818]. It allowed the focus to shift towards exploring the interconnected urban elements impacting active and healthy ageing and their opportunities to be altered or enhanced collaboratively across an urban system. This provided the opportunity for the urban system of Birmingham to be driven through a function of active and healthy ageing, considering the interconnected urban elements that can produce multi-level changes across different domains and demonstrating a need for collaborative action across public health and urban planning domains [167,182]. This presents a contribution for effectively guiding the collaborative management of the city of Birmingham to promote active and healthy ageing, identifying the interactions between urban environments and older adults that can be altered and enhanced and informing collaborative decision-making [167].

7.5.3 Optimising the city of Birmingham to promote active and healthy ageing

The outcomes and contributions presented throughout this chapter demonstrate ways in which urban environments can be optimised to promote active and healthy ageing. This is set in the context of the city of Birmingham, which

presented the opportunity to explore ways in which this superdiverse city that encompasses 69 wards of different socio-economic levels and demographic groups can be optimised. Using a CS approach enabled ways in which this city could be optimised, presenting urban elements across both the physical and social contexts that require consideration. This included well-maintained and clean green and public spaces, accessible public toilets, reducing cars that park on pavements, accessible (including digital and non-digital) information about local activities and resources, improving the council services for green spaces and ways in which they communicate with the public and improving and enhancing community integration between age-groups and ethnicities. The identification these urban elements builds on a small number of initiatives exploring age-friendliness in Birmingham [444,819,820], presenting a contribution in which a collective and city-wide approach can be built upon as Birmingham aims to become an age-friendly city [15].

Throughout this process, the CS approach identified local and place-based needs of older adult, which were centred upon to drive this PhD research. What became clear at the same time was the importance of also engaging community stakeholders in this bottom-up approach. This is key for extending past the identification of valuable place-based needs to include ways in which these needs could be encompassed into actionable solutions. Determining ways in which the city could be optimised across urban planning, public health and ageing well domains demonstrated how the place-based needs of older adults could be scaled up towards this top-down approach, giving power to these actions through community stakeholder knowledge. This presented a contribution of a ‘middle ground’, demonstrated through the implementation framework, in which actors from all levels of the city could collaborate together to implement age-friendly actions. This is crucial for giving power

to these local-level needs, which otherwise would potentially not extend past a context-specific checklist for promoting active and healthy ageing in Birmingham that is similar to the AFC checklist [39].

This presented an understanding of the importance of identifying place-based needs to set the foundation for relevant age-friendly actions, but also to identify ways to give power to these actions. In the context of Birmingham, the engagement of community stakeholders presented actionable contributions that developed this 'middle ground' approach, bringing with it consideration to the top-down resources that have been previously identified as crucial for actioning age-friendly initiatives [41,60]. This extends past the original drive of this PhD research in which the bottom-up and context-specific tools and methods were the predominant focus. Instead, the contribution of this thesis demonstrates the importance of reconciling the context-specific approaches with the more standardised and higher-level tools through a 'middle ground'. This presents value to future public health and age-friendly research who can build further on the contributions of this thesis to ensure that place-based needs are centred upon and given power through consideration of top-down actors and resources.

7.6 Strengths, limitations and future directions

7.6.1 Strengths

This PhD research effectively delivered a systematic scoping review, CSS study and CS study, bringing about multiple strengths. The first strength was the development of the CSAT, which effectively evaluated CS and participatory studies

engaging older adults that were included in the systematic scoping review. To the best of the authors knowledge, this is a novel tool that can critically appraise and evaluate CS studies, presenting potential for systematically evaluating a range of CS studies across different fields and engaging different populations. It also has the potential to guide studies during their development, implementation and outcome stages towards CS best practices recognised across the CS literature, providing a valuable contribution to the CS community.

The second strength was the effective engagement of older adults and community stakeholders within the CSS and CS studies. Directly engaging these individuals through a CSS preliminary stage enabled these individuals to discuss their concerns, connect with one another over shared experiences and come together as a collective to identify common urban barriers and facilitators. Further engaging older adults through the CS study identified the local-level and place-based concerns, driven through their active engagement in which they collected, discussed and prioritised their own data. Older adults also collectively identified recommendations for optimising urban environments to promote active and healthy ageing, providing a valuable foundation for actioning relevant age-friendly change across the city of Birmingham.

Strengths also emerged during the ‘advocate’ stage of this study, in which older adults and community stakeholders were brought together. Strengths of this stage included the foundations of network building, which were developed in the preliminary CSS stage, were continued to be built upon and strengthened. For example, an older adult connected with their local councillor to further discuss their concerns in their area. Another older adult connected with their local town centre manager, who are now in the process of working together to action the community toilet scheme (recommendation 2).

Another strength of the 'advocate' stage was the development of the implementation framework through older adult and stakeholder dialogue. This framework identified the capacity of a city to action age-friendly recommendations through its actors and resources. This provides potential for other cities and urban environments to utilise this framework, identifying ways in which locally driven age-friendly recommendations can be embedded into actions and implemented across different levels of the city. Overall, the direct and active engagement of older adults and community stakeholders throughout the CSS and CS study provided a strong foundation for actioning age-friendly change in the city of Birmingham. It provided local-level recommendations, network building and ways to scale these recommendations up to a city-level, identifying pathways to continue promoting the active and healthy ageing agenda.

A methodological strength of the PhD was the repeatability of the systematic iterative sequence employed, informed by the *Our Voice* four-step method. The use of CSS preliminary stage and the three steps of the *Our Voice* method demonstrated a systematic approach that has the potential to be repeated. Future studies aiming to undertake a CS study can follow the different stages of the study, which include; 1) CSS discussion groups with citizen scientists and stakeholders to identify the study focus; 2) citizen data collection, facilitated through the Discovery Tool that allows a systematic approach to data collection; 3) discussion groups to review and prioritise citizen collected data; and 4) workshop events to bringing together citizen scientists and community stakeholders to discuss the prioritised data. This repeatability could present strengths across the CS community, particularly as a current limitation is the lack of coherence across different studies and their methods [125,313,319] that is viewed to reduce the contribution and success of CS outcomes within the traditional scientific

realm [308,313]. In turn, providing a CS approach with repeatable and systematic steps, whilst still being iterative and driven by citizen scientists, is a strength that can be employed further by the CS community.

Another strength of the CS study was the development of a user-friendly version of the academic outputs of this research. Producing accessible and open outcomes is an indicator of good quality CS [312,380] to allow those engaged to have access to the outcomes they co-produced. A user-friendly booklet (Appendix 5) was developed to meet this indicator, which provided an accessible and open way of sharing the CS study outcomes with older adults and community stakeholders. The booklet, which was member checked by those engaged in the CS study, in turn provided a user-friendly avenue for sharing the co-produced recommendations and actions identified by community stakeholders.

Lastly, although not part of this PhD research, a follow-up evaluation was undertaken with older adults (n=10) and stakeholders (n=10) engaged in this research. This was undertaken to critically evaluate the CS study based on the experiences of older adults and stakeholders, exploring the processes, outcomes, successes and ways to strengthen the study. This demonstrated transparency and the quality of the CS study [312], alongside pathways for future studies to further assess their CS approach. The results of this evaluation are currently being prepared for a manuscript to be submitted to Health Promotion International, presenting future directions for CS.

7.6.2 Limitations and future directions

7.6.2.1 Methodological limitations

When considering the methods used, the main limitation of the CSS and CS study was the lack of diverse engagement of older adults, who were mainly White English, female and already actively engaged in their communities. Birmingham is however a superdiverse city [88], encompassing a range of different ethnicities including Asian, Black and mixed ethnic backgrounds within the older adult population [821]. Ageing is identified to not be an equal experience, with those from minority ethnic backgrounds ageing more prematurely than those from White ethnic backgrounds, alongside facing rising health inequalities that impact their health and wellbeing [430,460]. Across Birmingham, different ethnic groups are viewed to face different health inequalities and levels of accessibility to ageing and health services [72,462-464]. At the same time, ethnic minority groups are identified to be removed from civic engagement and decision-making, which can exacerbate the inequalities and exclusion already faced by these groups [270]. This requires extension to the different experiences of ageing across ethnicities within Birmingham, particularly exploring the health inequalities present and how these may be impacted by cultural practices, religion, language barriers and lack of culturally appropriate services [72,88,460].

The engagement of mainly females may have also limited the representativeness and applicability of the co-produced recommendations across Birmingham. Males and females, alongside individuals who identify as non-gender or other [822], are identified to experience urban environments differently. Males and females face different health outcomes [823] accessibility levels and socio-cultural

experiences in urban environments [824]. Active travel is also different for men and women within urban environments [825-827], with the presence of social environments facilitating walking for men and the presence of accessible amenities for women [828]. Lifestyle differences are also present, with females identifying personal safety as an important element of health and wellbeing, whilst males identifying transportation infrastructure and presence of public amenities crucial [829,830]. The differences across studies have been attributed to the context of the city, whether it is developed or developing, alongside the socio-economic and health status of older adults, requiring further consideration to the specific populations and context of the city being explored [831].

No other demographic information, such as socio-economic status or sexual orientation, was collected from older adults engaged in the CSS and CS study. However, Birmingham has been ranked 14 out of 184 for levels of income deprivation [832], with 26% of older adults reported to be facing income deprivation [435]. Older adults also living in more deprived areas in Birmingham have a reduced life expectancy of 5 years [156], are less likely to be physically active [461] and report a higher risk and prevalence of pain, anxiety, asthma, heart problems and diabetes [154]. At the same time, differences in gender identity and sexual orientation, including those from LGBTQ communities, are identified to be removed from decision-making processes within cities but their needs differ greatly to other groups in urban environments [270]. Collecting this demographic information would have enabled a more comprehensive and representative overview of how the city of Birmingham impacts diverse older adult populations and their active and healthy ageing experience. It would have also provided the opportunity for a potential comparison between different demographic information and urban characteristics, such as a

comparison of the urban characteristics identified by older adults from different socio-economic status or sexual orientation.

Having low representation of older adults from different ethnic minority groups (n=2), alongside being mainly female and collecting no other demographic information, presented a limitation in which the applicability of the co-produced recommendations was reduced. For the city of Birmingham, this is a significant limitation for providing age-friendly outcomes that are relevant to the more diverse ageing experiences of individuals from a superdiverse community. Future research should endeavour to engage individuals that are representative of the community being explored. This includes engaging both males, females and individuals who identify as non-gender or other, as well as considering more detailed demographic information to identify the applicability and relevance of outcomes produced.

It is however important to acknowledge that representativeness was not the focus of this study, but instead directly engaging older adults with the purpose of identifying citizen-driven outcomes that hold local-level relevance and context to those engaged. These outcomes, which may be viewed as smaller-scale, are also important for developing feasible and realistic ways in which environments can altered, with these smaller-scale ideas viewed to be cost-effective and enable some quick wins whilst longer term changes are implemented [26]. Future studies can use the processes and co-produced recommendations as foundation for exploring their representativeness across older adults from different ethnic and socio-economic backgrounds. This may identify their applicability and ways in which they could be extended to be more inclusive to the older adult population across Birmingham.

Methodological limitations were also present in the form of lacking engagement of older adults in data analysis, limitations of online discuss groups and the lack of

resources to undertake the ‘change’ stage and long-term tracking of ripple effects. Firstly, the CSS and CS study lacked engagement of older adults in the data analysis stages. This created limitations to their full engagement in the ‘whole’ process, which is required to present transparency of processes and outcomes, alongside improving the disconnect that is currently present between citizens and researchers [833]. Although citizen scientists were engaged to collect, interpret, discuss and member check their own data, viewed as a way to engaged citizen scientists in the analysis process [329], the CSS discussion group and CS workshop event were audio recorded and thematically analysed by the researcher. To strengthen the use of CS and engaging citizens in each step, future studies should consider training and engagement of citizen scientists in the data analysis. This may produce more accurate insights and outcomes through citizen-led data analysis, enhancing the quality of data produced [834] that may differ from those identified by the researcher.

Limitations were also present through the CSS discussion group, which was shifted from in-person to online. Limitations to online discussion groups have been presented across the literature. These include the value of in-person interaction and dialogue that occur through visual and social cues and language [835,836], alongside reducing the ability to identify how an individual’s setting influences their dialogue and sharing of experiences [352,751,837]. The use of an online platform did not seem to limit these cues or interactions, which may be attributed to the use of video and audio [838], alongside competence of using online platforms due to Covid-19 [839]. However, future studies could strengthen this limitation by exploring the interactions that occur through online platforms. For example, recording or taking note of visual and non-verbal interactions and cues [836] may reveal further insights of how this communication and collaboration occurred.

It is important to also acknowledge that the PhD study coincided with the global COVID-19 pandemic, which impacted the methods and outcomes of the research. The presence of COVID-19 and the related measures to protect the health and well-being of the population caused significant changes to everyday life, and in particularly for older adults. Older adults were identified to be at a higher risk from illness and death from COVID-19, meaning periods of self-isolation and 'lockdown', reduced socialising and less time outdoors became prominent in older adults' lives. This impacted older adults in both local communities and care settings, with these individuals becoming reliant on social distancing, support from others and shielding measures [625,840]. This led to older adults being identified to face greater loneliness, a decline in psychological health, and unable to meet their everyday personal and social requirements [840,841].

The impact of COVID-19 and the related health measures were present across the methods and findings of all stages of the PhD study (Chapters 5 & 6). COVID-19 shifted the preliminary CSS stage from in-person to online, alongside social distancing guidelines and protective measures such as face masks were implemented at each stage of the study. The Discovery Tool walks during Stage 1 also required social distancing between the researcher and older adults. Older adults who were unsure of holding the Discovery Tool (explored further in Chapter 6) were unable to pass the tablet between themselves and the researcher when required, meaning the researcher collected data when instructed. The presence of social distancing and other shielding measures across each stage of the study in turn impacted the methods and type of data collected. This may have differed if the original methods, where in-person data collection without social distancing would have been followed, were employed.

The outcomes of each stage also reflected elements of COVID-19 and its impact, with both older adults and community stakeholders identifying barriers and

facilitators attributed to the pandemic. This included closed community facilities, decreased local activities and reliance on technology, alongside social distancing making spaces more comfortable, green spaces being important during lockdown and technology improving social connections. The presence of COVID-19 in the outcomes indicates a potential increased sensitivity to the physical and social aspects of urban environments that were impacted by the pandemic. For example, the identification of spaces where social distancing can be followed or using technology more than usual to facilitate social connections were identified as key facilitators for active and healthy ageing in urban environments.

When considering the age-friendly agenda, the global pandemic has presented an opportunity for age-friendly approaches or processes to be reconsidered and strengthened [626], particularly as COVID-19 is now a part of daily life. When considering the COVID-19 facilitators identified by this study, such as the use of technology to promote social connections or the identification of green spaces as comfortable for physical and social activities, provides the opportunity to further embed these facilitators into age-friendly initiatives. For example, exploring further how social connections can continue to be strengthened for technology may promote age-friendliness for older adults who cannot attend in-person social activities. This would however require future age-friendly initiatives to understand the technological needs and resources of older adults [627]. Overall, COVID-19 altered and impacted the type of urban features identified by older adults during this study. It is however important to continue to adapt and develop urban environments so that they can support older adults through the continuing global pandemic, and potential future disruptions that may occur. The outcomes of this PhD research in turn provide a valuable foundation

for strengthening the resilience and suitability of urban environments to support older adults as COVID-19 continues.

Lastly, time and resource constraints of undertaking the CS study through a PhD meant that the 'change' stage was not employed and explored further. This created limitations to identifying if changes were implemented, alongside lacking the ability to track long-term changes and potential ripple effects. Previous *Our Voice* projects have identified ripple effects, such as changes that are implemented or continue to be advocated once a study has finished [118,334]. Similarly the use of participatory research engaging older adults to explore their deprived neighbourhoods led to elements of ownership for the preliminary ideas and improvements made [26]. This ownership and ripple effects had the potential to be present for the CSS and CS study, including an older adult and community stakeholder connecting to implement the community toilet scheme (recommendation 2) within a town centre. Similarly, the recommendations have also been encompassed within a town's business plan, the workplan of a city council service lead for older adult and have been shared with the commissioning manager at the city council who is aiming to gain WHO AFC accreditation for Birmingham. It is important that future studies plan for their ability to undertake the 'change' stage and provide resources to enable long-term tracking to occur.

7.6.2.2 Disciplinary and wider-context limitations

Although this study provided a way to consider optimising urban environments to promote active and healthy ageing, this was achieved through an interdisciplinary approach considering CS, public health, age-friendly cities and urban planning

disciplines. This approach provided a snapshot view of the city of Birmingham based on the needs of a specific set of older adults through this interdisciplinary lens. This however lacks consideration to ways in which active and healthy ageing and age-friendly environments are explored through other disciplines. For example, consideration to the more physiological, neurological and even psychosocial domains that impact healthy ageing, such as exploring how those with neurological disorders experience healthy ageing [842], was not explored. Although this creates disciplinary limitations to what could be explored, the choice of an interdisciplinary approach was important to explore how age-friendly actions within the city of Birmingham could be shifted away from disciplinary silos and towards multi-level collaboration that can action the age-friendly agenda [168,179,846].

There were also limitations present within this PhD research that relate to the wider contexts of ageing in urban environments. Firstly, the PhD research already had a chosen focus on exploring active and healthy ageing in Birmingham. By focusing on this topic, it removed consideration to the wider context of what 'ageing', 'age-friendly' or 'urban environments' actually mean to older adults or how they define these aspects. Both 'ageing' and 'age-friendly' are aspects that are experienced differently across different groups of older adults [31,844]. For example, ageing is experienced differently across different older adult age groups, ethnicities and socio-economic status, alongside the life events or health conditions that occur for an individual as they age [31,270,703,713].

Considering what 'age-friendly' means has been explored within the city of Manchester, identifying how this term can be applied to urban environments through the presence of older adult partnerships, activities such as older adult night clubs and cultural engagement with older men. This has also enabled the age-friendly initiatives

in Manchester to focus on delivering age-friendly neighbourhoods, services and promoting age equality that relates to how older adults define 'age-friendly' [845]. At the same time, considering what 'ageing' means to those from different backgrounds have been able to embed these processes and their outcomes that are context-specific within age-friendly initiatives. Future studies should endeavour to explore what 'ageing' and 'age-friendly' mean as a way of further identifying the in-depth and context-specific differences that are present for older adults. This approach can explore what these aspects actually mean to these individuals and their experiences in urban environments, promoting ways to further develop inclusive and more equitable urban environments that consider the ageing process and alterations that can develop meaningful age-friendly environments [31,706,844].

At the same time it is important to consider how age-friendly needs are met with competing priorities and agendas of a city [844]. This requires further consideration to the complexity of urban environments and the different political, economic, social and environment domains that influence their development and growth [270]. For example, the AFC agenda has been identified to require further consideration in the context of economic agendas and budget cuts, which increase competition across different agendas and needs within the city [56,714,726]. These limitations have been identified across Birmingham, with significant reduction in government support and community services for older adults, attributed to austerity policies and budget cuts after the global recession. This has led to ageing services in Birmingham to focus on promoting pathways that enable older adults to help themselves [445]. It is therefore important to consider these wider political and economic agendas and resources that are present for a city, particularly as these can influence the success of age-friendly initiatives [270].

Limitations must also be considered in relation to urban planning and how the age-friendly can be successfully embedded within this sector [844]. It is argued that urban planning is currently informed by a top-down approach in which policies and plans lack the experience of those who actually reside in urban environments [846]. Instead their design and structures are argued to centre on heterogenous needs of residents [847] and promote a one size fits all approach where resident needs are generalised [848,849]. Urban planning is also identified to focus on a problem-solving approach [266], with urban environments identified as an upstream element where planners can make alterations to reduce or prevent inequalities downstream. However, this lacks consideration within urban planning to the structural causes, such as policies or economic agendas, that formed health inequalities in urban environments downstream [850,851].

These limitations within urban planning have been recognised by the age-friendly agenda. Age-friendly conversations at the policy-level are viewed to be driven by this problem solving approach, aiming to produce an environment that can universally support all residents and presenting unwillingness to change current planning structures [266]. The planning and development of urban environments has also been perceived to foster specific development outcomes rather than places, leading to cities lacking places that are suitable for its residents to be socially and physically engaged [855]. Achieving these places are however identified to require a shared vision in which there is equality, accessibility and affordability for all residents [853]. Within this context of a shared vision, the inclusion of older adults is key for fostering the age-friendly agenda. This is particularly important as older adults are the residents who rely on these spaces to be supportive and accessible in order to undertake daily tasks, be active and healthy and engage in society [21,853,854]. Alongside

this, designing spaces for older adults has the substantial potential to produce inclusive and accessible environments for all age groups [21,855], although it is important to explore this further in order to avoid 'universal' design principles from being reinvented and embedded in urban planning again [267].

Addressing these limitations within urban planning requires consideration to the context of the urban environment and its residents, as well as how this context evolves over time [852], that is being planned, designed or altered by urban planners. One way of achieving this understanding of context is to embed authentic engagement of urban residents within urban planning processes [850]. This is particularly important to identify the ways in which urban planners can develop and alter urban environments to effectively address the local-level contexts and needs of urban communities within their plans [266]. This requires collaboration with urban planners, alongside more creative processes for urban planning such as socially engaged designers [266] and equity planners across different disciplines and actors [850], to identify new ways of planning and designing urban environments. It is important for future research to identify ways in which planning can authentically engage older adults in their processes whilst finding novel and more creative processes to developing urban environments that can be age-friendly.

7.7. Conclusions of thesis

In conclusion, the aim of this PhD thesis was to identify ways in which urban environments can be optimised to promote active and healthy ageing through the use of CS. Employing a systematic scoping review and a qualitative participatory research design encompassing a CSS and CS method, informed by the *Our Voice* CS for Health Equity approach, addressed this aim as follows. Firstly, a set of urban barriers and

facilitators were identified across the global context of urban literature (Chapter 4) and the context of the city of Birmingham (Chapters 5 & 6). This included maintenance of public and green spaces, presence of public toilets, accessible facilities, affordable transportation, regulation of cars parked in local areas, communication of local information and enhancing community integration and cohesion. The global literature also identified that neighbourhood developments and alterations and barriers faced by migrant and cross-cultural communities also required further consideration within the age-friendly agenda. Overall, this range of urban characteristics, which encompassed local context and place-based needs of older adults, demonstrated ways in which urban environments can be optimised to promote active and healthy ageing.

This thesis also advanced pathways for optimising urban environments through the use of CS. The CSAT presented a novel appraisal tool that evaluated CS approaches, demonstrating a need for older adults to be further engaged in a study's development alongside strengthening consideration and tracking of long-term outcomes. This tool also presented ways in which CS studies could evaluate and embed CS best practices at the development, implementation and outcome stages. Bringing together a range of social actors through a preliminary CSS stage facilitated collective knowledge, social connections and solution-building, laying the groundwork for network building that can be drawn upon further during the CS study. Building on this groundwork, a set of area-specific and city-wide recommendations were co-produced with older adults to promote active and healthy ageing in the city of Birmingham. Lastly, an implementation framework positioned within a SES approach contributed toward a set of 'middle ground' pathways for optimising urban environments. This framework, developed through older adult and stakeholder dialogue, centred on the place-based needs of older adults whilst identifying multi-

level actors, resources and the interconnected social-ecological domains required when actioning age-friendly change. This highlighted specific actions and pathways in which bottom-up and age-friendly actions can be given top-down power to promote active and healthy ageing in urban systems.

Further consideration is required to the limitations present within this thesis, including lack of diverse engagement of older adults within the CSS and CS study and a need to consider the wider contexts of competing urban agendas and limitations within urban planning processes. However, this thesis provided demonstratable cases and tools in which urban environments can be altered or enhanced, both globally and locally, through the direct engagement of older adults using CSS and CS. This enabled an in-depth understanding of older adult experiences in urban environments, identifying the characteristics in Birmingham that require alteration or enhancement to promote active and healthy ageing. This strengthens the current need for decision-makers to understand the determinants required to alter or enhance urban environments to promote urban resident health. The findings of this thesis present a strong foundation of locally relevant urban characteristics and methodological strengths that can potentially maximise the impact of initiatives targeting active and healthy ageing, alongside being built upon further to action age-friendly changes to optimise urban environments.

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Appendices

Appendix 1

Introduction to the CSAT

The Citizen Science Appraisal Tool (CSAT) (Table 3) was developed to evaluate the quality of CS and other participatory approaches. Quality is defined here in relation to the levels of active engagement and partnerships utilised by CS studies [380]. These two factors of engagement and partnerships are evaluated through a lifecycle approach [546] starting with the aims of a study through to its outcomes and future impacts, and considers the scientific standards, participation, data quality, and dissemination, which are elements of good quality CS [547,312]. The tool development was guided by the European Citizen Science Association (ECSA) 10 principles [312], critical Appraisal Skills Programme (CASP) tools [394,395] and encompassed three levels of engagement: contributory (*for the people*); collaborative (*with the people*); or co-productive (*by the people*) [98].

The tool gives equal weight to all questions to encompass both CS engagement and scientific standards. Active engagement and developing real-world outcomes are crucial elements of CS [380,550] alongside demonstrating validity, transparency and appropriateness of methods and data [291,390,396]. Providing equal weight enables the tool to assess the quality of CS engagement and scientific standards, which are elements of good quality CS [547,312].

Background of CSAT section descriptors

(1) Science & Research

Section 1 identifies the aims, objectives, and/or goals of the study and clarifies that a CS approach has been used. This can demonstrate the validity and appropriateness of the research design and methods [394,396], and if studies have intentionally designed their approaches to demonstrate good quality CS. The presence of these aspects can strengthen CS and transition it towards being viewed as 'genuine' science in the traditional scientific community [397].

(2) Leadership and Participation

Section 2 demonstrates the degree of active engagement of citizens within the study and the presence of a partnership between citizens and scientists, which are both principles presented by ECSA [380,312]. Clear and planned engagement of citizens, with engagement of citizens throughout the entire process preferential, can demonstrate good quality [380,397]. A transparent partnership and expectations can further strengthen the level of CS engagement, as it can shift citizens from 'participant' to 'active researcher' [312].

(3) Data and delivery

Section 3 identifies studies who have fully engaged citizens in the data collection, analysis and dissemination processes. This level of active engagement is encouraged in CS approaches and demonstrates good quality CS [98,312]. This section also identifies if studies have considered the quality and reliability of data, as well as

any biases, errors or limitations that may be present, which is important for CS findings to be integrated and trusted within the scientific community [291,390].

(4) Outcomes, evaluation, and open data

Section 4 identifies the level of CS engagement throughout the study processes, the presence of sustainable or 'real world' outcomes, critical evaluations of citizens or the study processes, and intentional mechanisms for disseminating outcomes, which are all indicators of good quality CS [380,397,312]. Fully engaging and empowering citizens, such as through co-production, aligns with ECSA CS values for preferred levels of engagement [380,312]. The presence of 'real world' impacts or pathways can demonstrate sustainability of CS activities, such as through the continuation of community-engage CS activities [54,98,118,121], which are key for strengthening CS projects [340]. Providing a critical evaluation of a study's processes can demonstrate quality, trustworthiness, and transparency, 4 and the evaluation of citizen knowledge or intended behaviours can indicate quality assurance of a project's delivery and ensuring participant understanding or learning [397]. Lastly, having accessible and open dissemination of outcomes is good practice [547,312] and can provide the opportunity for citizens to 'see' their data, which can lead to long-term sustainability of CS studies [380,397,312].

CSAT Levels of Engagement

The CSAT evaluates three different types of citizen science participation to guide the review identified by King et al. [106] These are:

1) 'For the people' – Contributory level of citizen science where citizens have limited engagement and are only involved to provide data (i.e. usually in the form of personal

information or a biological sample). All other aspects of the research process are directed by the researchers.

2) 'With The People' - A type of collaborative citizen science where citizens actively and systematically collect data on a specific phenomenon (i.e. citizens involved in bird counts or online crowdsourcing). The data is then analysed, interpreted and disseminated by researchers and not citizen scientists.

3) 'By the people' – Produces a partnership or collaboration between citizen scientists and researchers in which citizens actively engage in the entire research process to drive and steer questions, objectives, collection, and interpretation of data, and developing and advocating outcomes and changes.

Studies may use the following methods, approaches or key words to describe this participation at any stage of design or methods to be included: (1) Citizen science (2) Citizen scientist/s or Citizen engagement; (3) Participatory (research, approaches, methods); (4) Participatory Action; (5) Collaborative/Collaboration; (6) Engagement; (7) Partnership; (8) Resident-engaged; (9) Community-Based Participatory Research (CBPR); (10) Advocacy/Advocate; (11) '*Our Voice*'; (12) Co-production; (13) For the people; (14) By the people; (15) With the people.

Familiarisation and Raw Coding

Table 11. Example of audio transcript statements and the latent and semantic coding elements. *Location anonymised

Audio Transcript Data	Semantic Coding *(Descriptive)*	Latent Coding *(Interpretative)*	Code
"We need to be able to walk on the pavement, quite often is blocked by cars parked…cars parking on pavement smashes them up and it makes me very, very annoyed".	The presence of cars parking on pavements stops walking and damages pavements.	Cars parking on pavement is a barrier to active ageing as the individual is "***very, very annoyed"*** by this as they "***need to be able to walk"*** but the parked cars prevent them from doing so.	Pavement blocked by parked cars.
"I love our tree lined streets…it's quite leafy and pleasant here".	Trees are aesthetically pleasing and a positive feature.	Tree lined streets are a facilitator as the individual ***loves*** the tree lined streets and it makes it more ***pleasant*** when spending time outside.	Pleasant tree lined streets.
"it is so bad with transport. Some people not even following the rules, they are like going zigzags. It's so scary to take your car from entering into from area 1* all the way to area 2*, it is horrendous and people are not following the proper rules".	Drivers' behaviour on the road negatively impacts the time spent outside.	Drivers and their behaviour are a barrier as the individual finds it ***scary*** to go out in their car and ***horrendous*** that other drivers don't follow the rules.	Drivers not following rules.

Appendix 2

Table 12. An example of the keyword search and combination when searching Medline

Database	Keyword search
Medline	(((“Citizen Scien*”) *OR* (Participat*) *OR* (Collaborati*) *OR* (Engage*) *OR* (Partnership*) *OR* (“Community-based”) *OR* (Advocacy) *OR* (Photovoice) *OR* (Communit*) *OR* (“Citizen Engage*”) *OR* (CBPR) *OR* (“Community-Based Participatory Research”) *OR* (“*Our Voice*”) *OR* (Co-production) *OR* (“Participatory Action”) *OR* (“Public Participation”) *OR* (“Public Engagement”) *OR* (“Participatory Research”) OR (“Community Engage*”) *OR* (Community-led) OR (Co-production) OR (“Active Engage*”)) ***AND*** ((Urban*) *OR* (Built*) *OR* (“Urban Environment”) OR (“Built Environment”) OR (Outdoor*) *OR* (City) *OR* (Cities) *OR* (Age-Friendl*) *OR* (“Inclusive Communit*”) *OR* (“Physical Environment”) *OR* (Neighbourhood)) ***AND*** ((“Active Ageing”) *OR* (“Healthy Ageing”) *OR* (“Successful Ageing”) *OR* (“Ageing Well”) *OR* (“Positive Ageing”) *OR* (“Productive Ageing”) *OR* (“Meaningful Ageing”) *OR* (Ageing)) ***AND*** ((“Older Adult”) *OR* (Older) *OR* (“Older Woman”) *OR* (Older Women) *OR* (Older Man) *OR* (Older Men) *OR* (Senior) *OR* (Elder) OR (Community-dwelling))) kw, ti, ab.

<u>CSAT Medium and Low-Medium Quality Studies</u>

CSAT Medium Quality

Studies in this category (n=8) scored highly in parts of the first three sections of the tool (Figure 29). All studies provided a clear description of aims, objectives and main findings. Six studies (75%) presented the degree of active engagement of citizens and the roles and type of partnership between citizens and researchers [71,561-

564,566) considered their data limitations or biases(71,548,561-563,565), and demonstrated 'real world' implications or pathways for their outcomes (71,561-565).

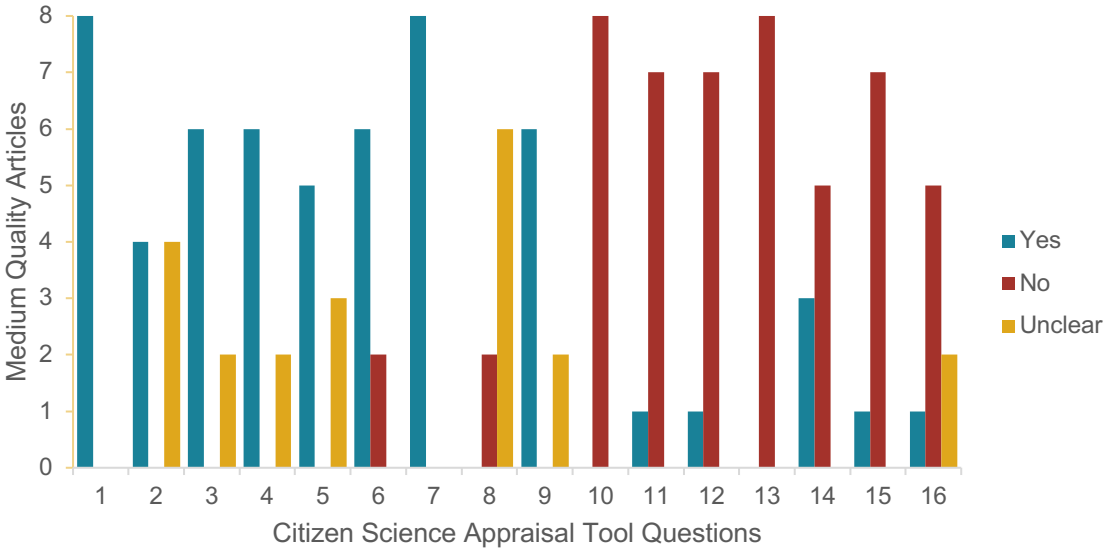


Figure 29. Citizen Science Checklist Tool Outcomes for Medium Quality Articles

Studies in this category could be further strengthened in the outcomes and knowledge section by providing intention to track long-term or 'ripple effects', acknowledging citizens in the publication, and inviting citizens to review or participate in the publication process. Studies could also provide accessible dissemination plans or mechanisms for sharing outcomes and provide an evaluation of citizen knowledge or behaviour, and methods or limitations.

The level of citizen science engagement varied, with 6 studies demonstrating 'by the people' and 'with the people' (71,562-566), and 2 demonstrating 'with the people' only (548,561). Citizens were actively engaged in the data collection in all 7 studies, with those demonstrating a 'by the people' approach engaging citizens to member check data (71,563,564,566), and take part as community liaisons (71,565) or advisory group (562,566). These studies could strengthen their CS approaches by actively engaging citizens

further in the planning and design, directing of the research methods, and taking part in data analysis and dissemination of outcomes.

Low-Medium Quality

One study [567] provided a clear statement of its aims and outcomes, and its findings showed a pathway to 'real world' decision making implications. This study could be strengthened in all sections of the tool by providing a clear overview of the citizen science or participatory approach used and facilitate further the degree of active engagement of citizens. The study could also provide tracking of long-term impacts or ripple effects, an evaluation of citizen knowledge or behaviours and methods or limitations, acknowledge citizens in the publication, and provide accessible dissemination plans for sharing outcomes.

A 'with the people' engagement was present in this study as older adults were actively engaged in the data collection processes by sharing their experiences or views. However, researchers also collected by part of the data through observations and did not engage citizens in any other stages of the research process. Although this study defined its participatory approach as user methods, it could strengthen this approach by actively engaging citizens further throughout the entire research process.

Citizen Science Appraisal Tool Question Guidance

Table 13. Citizen Science Appraisal Tool (CSAT) with full guidance for each question.

Section	Question	Y	N	?	Guidance
Science & Research	1) Is there a clear statement of the aims, objectives or goals of the study?				See CASP qualitative checklist [394] and cohort study checklist [395].
	2) Is it clear that the study used a citizen science approach?				***ECSA Principle 1*** - Citizens actively participate as contributors, collaborators, or study leaders to have a meaningful role in the study's scientific endeavour to generate new knowledge. Citizens may be involved in refining the study processes, materials and protocols. The main characteristics are (1) citizens are actively involved in research, partnership or collaboration with scientists or professionals; and (2) there is a genuine outcome, such as new scientific knowledge, conservation action or policy change"[312,856].
Leadership & Participation	3) Is the degree of active engagement or participation of citizens identified clearly by the study?				**ECSA Principle 4 -** Citizens can engage and participate in multiple stages of the scientific/research process, which can include developing the research question or focus, designing the methods, data collection and analysis and communicating the outcomes.[380,312] Active engagement of citizen scientists in multiple stages of scientific/research process is preferred. Q) Has the study clearly identified its approach in terms of contributory (for the people), collaborative (with the people), or co-production (by the people)? [106].
	4) Are the roles, responsibilities and type of partnership between citizens, scientists and stakeholders identified and transparent?				The roles and expectations should be made transparent, and citizens should be aware of their contribution to the research. Depending on the context of the study, it may be appropriate for citizens, scientists and stakeholders to have an equal partnership in the research. Q) Is the shift from participant to an active researcher made clear to citizens involved and has the study addressed this? [380].

Delivery & Data	5) Is the extent to which citizen scientists are actively engaged or collaborate in the data collection, analysis, and use/dissemination clear?				***ECSA Principle 4 –*** Citizens can engage and participate in multiple stages of the scientific/research process, which can include developing the research question or focus, designing the methods, data collection and analysis and communicating the outcomes[312, 380]. Q) Have citizens been engaged through a co-production or collaborative approach in the data collection, analysis and dissemination? During these processes, is there a clear partnership between citizen scientists with scientists and/or practitioners? [98,106].
	6) Are citizen science data limitations or biases considered by the study?				***ECSA Principle 6*** - Citizen science data can contain bias or error, influence by factors such as variability among participants in relation to ability, commitment and effort. Accounting for this error and bias can mitigate this and can be addressed through well-developed protocols, appropriate and good design of activities or tasks that meet the study purpose, and good participant support [312,380]. Multiple types of data and knowledge generation can be present in citizen science meaning studies should seek appropriate disciplinary standard which can include data quality and quality assurance standards, and peer-review of publications or any materials [291].
Outcome, evaluation & open data	7) Are the main findings of the study clearly described?				See CASP qualitative checklist [394] and cohort study checklist [395].
	8) Are the study's outcomes a direct result from the data-driven strategies and solutions generated by the citizen scientists?				A co-creation (by the people) [106] approach has been used and citizen scientists have been active collaborators throughout the study, which has ensured the relevance of the scientific endeavour and developed realistic outcomes or solutions [97,312,380]. Q) Have citizen scientists been fully engaged and empowered "not only as data collectors, but also as active collaborators" [98] in producing the strategies and outcomes of the study?
	9) Do the outcomes of the study have 'real world' decision making implications or impact?				**ECSA Principle 2** - Alongside answering a research question, outcomes such as informing actions, management decisions or policy are presented [312]. Q) Can the results be applied to the local population? Can the results be directly taken into real-world decision making? Is there a clear pathway to outcome and impact? [394,397].

	10) Does the study report intention to track and/or tracking of long-term impacts, changes or 'ripple effects' of the study?				Q) Rather than decision making implications, has the study reported any long-term tracking of what has continued or happened after the study? This may include; (1) Impact of the study on citizen scientists that has led to ripple effects for these individuals or their community; (2) Sustainability of citizen science processes through ripple effects that have led to a continuation of community-engaged citizen science activities; (3) If outcomes or changes produced have led to long-term changes or impacts for citizens or their community after the study has finished; (4) The study reports a foundational partnership or longitudinal relationship with citizens with the intention to return and/or track impacts, changes or ripple effects [54,98,121,282]. *Ripple effects are described further in Jagosh et al.* [409].
	11) Does the study report any evaluation of citizen knowledge, attitudes, actual and/or intended behaviours?				***ECSA Principle 3*** – Both scientists and citizens benefit from taking part, such as learning opportunities and personal enjoyment [312]. Evaluating participant knowledge can demonstrate if training and/or the project has been successful (in both content and skill) and can ensure sustained quality through participant understanding and engagement of tasks being completed correctly. Evaluating behaviour changes or intended behaviours may demonstrate intention to continue with CS activities [397].
	12) Does the publication report any accessible dissemination plans or intentional mechanism for sharing the study and its outcomes with citizens?				***ECSA Principle 5 –*** Clear communication or dissemination of the study and its outcomes are provided to citizens [312]. This may include how their data are being used, what the research, policy or societal outcomes are, or given the opportunity to 'see' their own data and its contribution (in suitable text and graphical forms) [380,397].
	13) Are citizens invited to review or participate in the study's publication process?				Inviting citizens to participate or review the publication process will further strengthen the co-production and transparency of CS processes and dissemination. Q) Have studies reported any involvement of citizens in the publication process.
	14) Are the study's results and outcomes published in an open				***ECSA Principle 7 –*** Data from CS projects are publicly available and if possible, published in open access format [312].

	access format and/or shared in a publicly accessible format ?				
	15) Are citizen scientists acknowledged in the study's results and publications?				***ECSA Principle 8 –*** Citizens are acknowledged in project outcomes and publications[312].
	16) Does the publication provide any critical evaluation of the study, methods and/or examination of its limitations?				**ECSA Principle 9-** Q) Is the study evaluated in any way for its scientific output, data quality, participant experience, wider societal impact, or policy impact? This may be to highlight trustworthiness, transparency or evaluation i.e. does the study report the citizen scientists evaluating the methods they have used and providing feedback? [312].

Scores will be categorised using the following scale system, adapted from Wijewardhana et al.[568]:

Low (0-6)	Low- Medium (7-12)	Medium (13-19)	Medium-High (20-26)	High (27-32)

Detailed explanation of CSAT scores for the 23 included articles

Table 14. Detailed Overview of the Critical appraisal Outcomes of 23 included studies

Author, Year	Question	Answer	Reason	Point
Barrie et al. (2019)	1	Yes	This pilot study aimed to test a new smart phone-based audit tool using an innovative methodology—citizen science—in order to explore how and why older people engage with public green spaces.	2
	2	Yes	A citizen science approach with a co-created model was used to evaluated public green spaces not based on researchers valued judgement	2
	3	Yes	Co-created whereas citizen scientists, older people not only collected data but were also engaged in preliminary analysis of the data and, most importantly, contributed feedback and ideas on the methods, process, audit tool and the design of the proposed larger project.	2
	4	Yes	Clear that citizens have the role of being trained as citizen scientists, collect data using the data tool and preliminary analyse of data and feedback of the tool.	2
	5	Yes	Citizen Scientists were engaged in collecting data in their own chosen locations using an online tool (or paper-based tool) and were engaged in the interpretation of this data through interviews and pre-liminary analysis. No dissemination was discussed by the paper.	2
	6	Yes	This pilot engaged a small, self-selected group of adults interested in participating in citizen science and may not represent the general older population. Further work needs to be done with wider groups of older adults, including those with reduced mobility, greater frailty and/or poorer health, and from different cultural backgrounds to test both the potential and reliability of the audit tool.	2
	7	Yes	Broken down into use of tool, audit of data and participant reflection on senior citizen science.	2

	8	Unclear	The main findings of the project are based on the data collected by citizen scientists using the online/paper tool in their chosen locations and provided an understanding of key design elements for these individuals. However, it was unclear if they were actively engaged in the development of the project and no solutions provided to this but instead the focus was on evaluating the citizen scientists' experiences in the study and the use of the tool.	1
	9	Yes	The findings provide a pathway to real-world decision making in terms of the design elements citizens highlighted in green spaces, alongside information of technology and becoming comfortable with it.	2
	10	Unclear	Although the article says 'Participants showed a keenness to be further engaged with future citizen science projects beyond just data collection, indicating that whenever possible they would like to be involved in all stages of future research projects' which shows a sustainable element of the citizen science process, it does not report any 'ripple-effects' or highlight any projects participants have been involved in since.	1
	11	Yes	Citizens were involved in evaluating the tool and citizen science approach.	2
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	Open access	2
	15	Yes	Participants acknowledged in acknowledgements section.	2
	16	Yes	Citizens evaluated the project and the tool experience which were included in results and discussion.	2
Total Score = 26 (Medium-High)				
Mahmood et al. (2012)	1	Yes	The purpose of this study was to conduct a participatory research process with community-dwelling older adults using photovoice method to identify neighbourhood physical environmental features and social aspects that influence physical activity in older adults.	2
	2	Yes	Participatory research & participatory method called photovoice was used where citizens are actively involved.	2

	3	Yes	The study clearly reports and identifies the level of active engagement from citizens throughout the initial session, data collection and discussion of findings. – 'In the initial session, the participatory nature of photovoice method was emphasized and training was used to identify three important reasons for engaging community. For the photovoice activity, participants photographed physical and social aspects that they perceived as barriers to physical activity behaviour, and they had two weeks to do so and mail back the camera. Photos were printed and participants were asked to select 6-8 photographs that best reflected the issue trying to be captured. Participants also attended a discussion session where participants discussed and reflected on their photos and was facilitated by the researcher who summarised the group findings. Key issues and recommendations were generated at the discussion by participants. The final dataset was analysed by the researchers.'	2
	4	Yes	In the initial session, it is clear that the engagement element was communicated to participants and their roles were clear in collecting data and discussing it to create recommendations.	2
	5	Yes	Participants were directly engaged in the photovoice data collection and used this to highlighted facilitators or barriers in their neighbourhoods. Participants were also engaged in selecting the photos that reflect the issues they were trying to highlight, as well as discussing the pictures in group discussions with other participants to produce recommendations. However, it is also clear that researchers undertook the overall data analysis, and no dissemination of the findings were reported.	2
	6	Yes	The study considers it limitations - 'The findings were not analysed in relation to any information on the participants' actual physical activity. However, the participants included individuals with variability in individual- and neighbourhood characteristics and the consistency of the findings from the two cities suggests that the barriers and	2

			facilitators were real and important. Data were collected in only eight neighbourhoods… potentially limiting the generalizability of our results'	
	7	Yes	Clear main outcomes of the project are described in terms of the barriers and facilitators.	2
	8	Yes	The seven themes of the study (outcomes and recommendations) are directly generated by the photovoice methods and groups discussions that participants were actively engaged in.	2
	9	Yes	Seven clear themes that can be included in altering urban environments as well as information about peer support and community-based groups.	2
	10	Unclear	The study reports 'Several participants expressed the desire to form a seniors' coalition to create change in their neighbours using their photographs and joining with others from the study. In order to successfully create these senior advocate groups, more resources are needed to continue the project on the local-level.' This shows an approach to sustainable citizen science but does not report any further actions or impacts on citizens or their local community.	1
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	No	Not open access.	0
	15	Yes	Participants acknowledged in acknowledgements- 'The authors are grateful to the older adult research participants in Vancouver and Portland metropolitan areas for their enthusiasm, efforts, and time.'	2
	16	No	None reported.	0
Total Score = 21 (Medium-High)				
Adorno et al. (2018)	1	Yes	The purpose of this article is to present findings about transportation mobility using a social justice and social equity lens. We focus on the perceptions and experiences of older adults regarding the meaning of transportation to them as they age in their current environment.	2
	2	Yes	Uses 3 older adults as peer researcher /community liaison (with a researcher, for some interviews) involved in: planning, recruitment,	2

			data collection and analysis phases and described as community-based methods.	
	3	Yes	Yes 3 older adults (not all participant) involved in: planning, recruitment, data collection and analysis phases	1
	4	Yes	It is clear that citizens will be involved in peer research, interviewing, translation.	2
	5	Yes	Yes – peer research, interviewing, translation	2
	6	Yes	Strategies were described to address bias in the data analysis and limitations were considered i.e. “iterative, consensus coding process to identify researcher bias and continuous clarification about their meaning with participants during interviews and focus groups”; “member checks with study participants and the community liaison to obtain feedback on the preliminary themes, to establish trustworthiness of the data and to increase the credibility of the findings” also acknowledge selection bias and lack of LGBT participants	2
	7	Yes	Broken down into the different themes that were clear and related to the study focus. Qualitative verbatim quotes provided, covering a range of scales/locations.	2
	8	Unclear	Although 3 older adults and community liaisons were present in the planning, recruitment, data collection and analysis phases, it is unclear their level of active engagement in the interviews/focus groups and guides used for this, as well as the direct engagement of all other older adults involved in the project.	1
	9	Yes	Implications for pathway for decision making rather than impact: for WHO liveable communities initiative 2007a, for understanding older people’s transportation mobility and challenges, issues of social equity, need for collective action, past policy failures	2
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0

	14	No	Not open access	0
	15	No	No acknowledgement.	0
	16	Unclear	Evaluation was completed in the sense of considering the value of citizen engagement for supporting urban change, but in no other way.	1
Total Score = 17 (Medium)				
Annear et al. (2014)	1	Yes	(For the four stages as well as for the stage described in this paper)- To develop recommendations for urban environmental change following a natural disaster, based upon the findings of three research phases, and disseminate to key stakeholders.	2
	2	Yes	Described as a participatory investigation and collaborative process with older adults and has involved including older adults in photovoice investigation and focus group with older adults and 8 older adult advisors to create and critique solutions. Described as a collaborative process and participatory investigation - “rationale for involving older adults in the research process is the imperative to inform change and connect community members with more powerful actors”	2
	3	Yes	Described as a collaborative process with older adults where older adults (including 8 older adult advisors who provided guidance) create and critique solutions based on data collected during the photovoice stage. - ‘with the people’ collaborative research, PAR method, not explicitly identified as citizen science	2
	4	Yes	Older adult advisors provide guidance and critique to the research process and results and older adults were engaged in the focus group stages to create and critique solutions.	2
	5	Yes	The first two stages of data collection were driven by researchers to build an understanding of the geographical area and where older adults resides. The last two stages were driven by participants who were engaged in activity diaries and photovoice procedures to collect data and group discussions with other participants to create and critique solutions for rebuilding the city. Participants were also engaged in the data analysis and were presented themes that were	2

			used in discussions to create recommendations and a proposed timeframe.	
	6	Yes	Considered but not controlled for: Reference/advisory group from varying socio-economic backgrounds high level of education, not intended to be representative	2
	7	Yes	Included barriers and recommendations produced by older adults	2
	8	Yes	Participants were directly engaged in collecting data, analysing the data, and using this to produce recommendations and solutions as well as time frames. Emergent themes with examples from empirical data; specific and detailed recommendations	2
	9	Yes	Although there's no concrete link expressed with policy makers with decision making powers, although some members of advisory group were volunteers in the Elder Care Canterbury Consumer Group, which "report problems and issues to the Canterbury District Health Board and other agencies", there are pathways present with the findings and citizens to producing real world decision making.	2
	10	No	None reported.	0
	11	No	No evaluation of the participatory methods or citizens knowledge is documented	0
	12	Yes	the participatory phase described in this paper addresses this and gives participants opportunity to make recommendations based on research interpretations of data	2
	13	No	None reported.	0
	14	No	Not open access.	0
	15	Yes	Acknowledged in the acknowledgements section.	2
	16	No	None reported.	0
Total = 22 (Medium-High)				
Aw et al. (2017)	1	Yes	This study aims to identify and explain the continuum in which older people in Singapore participate in community and social life, highlighting the influence of culture and policy context on social participation.	2

	2	Yes	Described as three qualitative methods that integrated ethnographic approaches with methodological approaches of community-based participatory research. These methods included photovoice documentation and discussion groups , (b) Walking Through Spaces or ‘go-along’ inter- views and (c) Community Focus Groups Discussions which tapped into participatory learning for action (PLA) exercises. Citizens are actively engaged in the methods. The study describes a structural ethnographic approach in order to capture social behaviours of older adults in the community, and the influence of cultural and retirement context. It describes itself as using methodological approaches of CBPR in order to allow participants to interact with their community to record information and to allow the research to observe the community through the eyes of participants.	2
	3	Yes	Participants are engaged in the three methodological stages(photovoice, ‘go-along’ interviews, group discussions) to focus on topics relating to participation in community activities, and other ways of social participation and expand these perspectives using photovoice by asking elder participants to photo-document for one month, anything they felt showcased ‘lives of elders’ in Whampoa.	2
	4	Yes	Participants are engaged with the researchers throughout the methodological stages in their community to show how they participate in community and social life	2
	5	Yes	Methodological approaches of community-based participatory research are used which actively engage citizens in data collection. However they are not engaged in any other stages of the research such as solution-building or data analysis.	2
	6	Yes	Appropriate and good design of activities or tasks have been used to meet the study purpose (i.e. We also used a neighbour-level ethnographic and participatory approach, combining three qualitative methods in such a way to focus, expand then compare perspectives for triangulation) and they identify a limitation of not managing to interview the more vulnerable older adults, though we nonetheless	2

			tried to ac- count for their perspectives through older adults who went around speaking to them in Photovoice, and community leaders who worked directly with these older adults.	
	7	Yes	Five themes are shown to emerge from the data collected by citizens that highlight how they participate in their community and social life.	2
	8	Unclear	Although the outcomes are achieved through a CBPR methods that engaged citizens, they were not actively engaged in other aspects such as building solutions or data analysis.	1
	9	Yes	The study highlights how their findings prove a pathway towards cultural and policy implications and how this could be achieved.	2
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	None reported.	2
	15	No	None reported.	0
	16	No	None reported.	0
Total Score = 19 (Medium)				
Black et al., 2015	1	Yes	This study aims to advance our understanding of older adults' perceptions and the broader contributions of community residents in affecting dignity and independence in everyday interactions with older adults.	2
	2	Yes	"Using participatory action research, multiple methods of qualitative inquiry, and tenets of appreciative inquiry, this article reports on a community-based initiative aimed to better understand the positive aspects of aging with dignity and independence". Described as "The process is collaborative and equitable in that partners are included throughout the research, from study design, data collection, analysis, and dissemination". This included community forums, focus groups and online surveys. The tools used were endorsed by the community advisory group. PAR and multiple methods of qualitative inquiry were utilized to gain an in- depth understanding of how older adults, and the	2

			broader community of persons of all ages, view and promote aging with dignity and independence in the context of everyday life. PAR is a systematic approach to inquiry in which those affected by an issue under study are included in the research for the purpose of social action. Described as “The process is collaborative and equitable in that partners are included throughout the research, from study design, data collection, analysis, and dissemination”.	
	3	Yes	An advisory group was comprised of 20 community members that leveraged key community-based providers, volunteers, experts, and stakeholders in aging (one third of this were older adults) and the project was discussed with this group throughout five meetings during the project duration. Data collection tool used for community forums were based on participants providing a narrative based on ‘tell your story’. The focus group and open-ended surveys were developed to elicit older adults’ perceptions and followed a semi-structured interview guide but allowed participants to expand further on points. The interview guide was pretested with older adults. Data were shared with older adults who participated in the interviews as a source of member checking to enhance trustworthiness of the data and with the advisory group throughout the ongoing analysis.	2
	4	Yes	Individuals and older adults are recruited for advisory groups to discuss and direct the project, collect data, and be engaged in the data analysis.	2
	5	Yes	The advisory group (which includes older adults and community members) are actively engaged in directing the project, older adults are engaged in the two stages of data collection, and the data they provide in the community forums and focus groups are member checked by them. The data analysis is also shared with the advisory group.	2
	6	Yes	The credibility of the data was enhanced through a number of practices: (1) triangulation of data occurred by maintaining and recording events throughout data collection and analysis; (2) the use	2

			of a multidisciplinary research team (social gerontology, social work, and graduate students from different social behavioural and aging disciplines) involved in the data analysis and interpretation of themes; (3) multiple researchers analysed the data independently; (4) researchers reviewed the findings at different stages of analysis; (5) the process of data collection was enhanced by careful documentation and organized record keeping so that data were maintained in retrievable and easily audited form by peers (Miller & Crabtree, 1999); (6) multiple modalities of qualitative methodologies; and (7) data were shared with older adults who participated in the interviews as a source of member checking to enhance trustworthiness of the data.	
	7	Yes	8 clear actionable themes are produced in the findings	2
	8	Yes	The project outcomes are co-created with community members and older adults, and developed through collaboration with these individuals collecting, checking, and analysing the data.	2
	9	Yes	The outcomes highlight pathways for micro and macro-level community-based actions and real-world decision-making impacts.	2
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	2
	13	No	None reported.	0
	14	Yes	Open Access.	2
	15	No	None reported.	0
	16	No	None reported.	0
Total Score = 22 (Medium-High)				
Brookfield et al. (2020	1	Yes	“We draw on of the eight techniques as they were employed at various participatory design events, as well as on feedback collected from the older adults (typically over 60 years old) who participated in these events, to reflect on the value each might have as a mechanism for including older people in environmental design decisions.”	2
	2	Yes	Citizens were engaged in multiple approaches and stages of the methods which were called co-design workshops. “We organized a	2

			series of participatory design events across the United Kingdom (UK) over a three-year period. These included three co-design workshops, three design review events, and 22 one-to-one interactions with diverse older adults. Within these, we implemented a collection of more “traditional” techniques, including structured interviews and focus groups, as well as more “novel” engagement techniques. For example, at the co-design workshops held in central Manchester and Hackney Wick, we combined the techniques of walking interviews and photovoice in a single “Walk and Talk” activity. This meant that, at each location, participants took one walk around the neighbourhood in which we worked and, on this walk, completed a walking interview and, addressing the concerns of photovoice, took photographs of the environments traversed and then discussed these photographs at the end of the walk. The study used co-design workshops in which there were ‘novel’ engagement techniques used. These included photovoice, walking interviews, photo-elicitation, town hall meetings, talking mats, model-making, participatory mapping, drawing, design fair which were all participatory design events across the UK. These techniques engaged older adults within the methods of the study.	
	3	Yes	Throughout the methods of the study, the ‘novel’ engagement techniques were clearly described and how citizens were engaged at each stage as well as providing feedback on these engaged and integrated activities. ‘With the people’ but not by the people are citizens were also observed and there is no clear explanation on the analysis of the results.	2
	4	Yes	It is clear that citizens were engaged in the methods and providing feedback whereas researchers organised the events and observed participants	2
	5	Unclear	Although it is clear how the citizens were actively engaged in the methods of this study and providing feedback, it is unclear on how or if they were engaged in the analysis section (as this is not reported) and the dissemination of outcomes and feedback provided.	1

	6	Yes	The study discusses and considers their limitations but not focused on data quality/bias - *Limitations* of our work include the relatively small numbers of participants engaged in the co-design events and one-to-one interactions, and the relatively small (although diverse) number of contexts within which the engagement techniques were trialled. Future iterations of the work could usefully implement a set of novel engagement techniques in a wider range of contexts with a larger number of diverse older adults. This could support firmer conclusions on the potential for more novel forms of engagement to facilitate the involvement of diverse older adults in environmental design decisions.	2
	7	Yes	The outcomes provide a clear reflection and overview of feedback on each of the engagement methods used at the co-design workshops.	2
	8	Unclear	It is unclear how much the strategies and solutions are a direct result for citizen data-driven strategies. Citizens were actively engaged in the methods of this approach and providing feedback on the methods. However, they were not actively engaged or collaborating at any other stage, so the outcomes are a result of their engagement in the methods but not through any other strategies or solutions.	1
	9	Yes	The results of this study of how these engagement techniques could be used with older adults (based on their own feedback) could be applied to further engaging these individuals in environmental and community concerns and decisions and could provide a pathway to engaging these individuals in informing these decisions.	2
	10	No	None reported.	0
	11	No	Although citizens perspectives were asked for feedback, citizens were not tested or evaluated on their knowledge of the tools use or their implementations etc.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	Open Access.	2
	15	Yes	The authors thank the reviewers and the older adults and design students who participated in this element of the project.	2

	16	Unclear	Citizens provided feedback on the tool but unclear on the level of evaluation.	1
Total Score = 21 (Medium-High)				
Buffel (2018)	1	Yes	The purpose of this article is to provide insights into the process of co-producing a research project with older residents living in low-income neighbourhoods in Manchester, United Kingdom. The project was unique in involving and training eighteen older people as co-researchers who took a leading role in all phases of a study aimed at developing “age-friendly” communities.	2
	2	Yes	Yes, older adult citizens are co-researchers in a study aimed at developing the “age-friendliness” of their communities. The project is co-led by older adults and includes their experiences of older peoples as they step beyond the traditional role of consultee to that of interviewer, researcher, exploring the co-researchers, motivation for participant in the project. They are engaged in multiple stages of the study as co-researchers and co-designers.	2
	3	Yes	Citizens are actively engaged through the study - This research is by the people where co-researchers participate in co-designing the research objective, co-producing research materials, collecting data, analysing data, co-producing findings, training sessions, reflection meetings, dissemination workshops. However, the other older adults engaged in the process are only engaged in providing data in the focus group and interviews.	2
	4	Yes	Older adults are clearly identified as co-researchers and are part of workshops that aimed to agree on roles and responsibilities and develop a peer support network.	2
	5	Yes	Older adults are clearly engaged in a ‘by the people’ approach where they are co-researchers throughout and actively engage in the data collection analysis and dissemination. However, the other older adults engaged in the process are only engaged in providing data in the focus group and interviews, demonstrating a ‘with the people’ approach.	2

	6	Unclear	The study identifies challenges that were outcomes of the co-production methods used such as developing collaborative partnerships and negotiating power relationships, as well as projects creating a divide between privileged and disadvantaged groups. However they do not discuss limitations of their study, population used or data quality.	1
	7	Yes	The outcomes of the study demonstrate the experiences and motivations behind becoming a co-researcher for older adults, including motivation, community engagement, personal development and understanding, relationship between co-researcher and interviewees. The outcomes also highlight opportunities and challenges in developing work around co-production with older people.	2
	8	Yes	Older adults were engaged throughout the entire process so that outcomes are a direct result from the questions and data they co-produced and generated.	0
	9	Unclear	Although the results demonstrated the experiences, motivations and skills undertaking co-research, these were based on those specifically of older adults in Manchester and may differ for other older adults in different age & ethnicity groups, locations etc. So it may provide a pathway to have implications for further research and informing actions from co-production research, but it is unclear.	1
	10	Yes	The study reports that the co-researchers have now formed a permanent group and are applying for funding for age-friendly activities. They also reported that further evaluation and research will be needed to track the impact of the group.	2
	11	Unclear	Reflection meetings were held to understand co-researcher's involvement and motivation but there was no evaluation of the study methods or citizen knowledge etc.	1
	12	No	Although the results are disseminated with stakeholders and action plans fed into Manchester age-friendly program, the study does not report dissemination plans or sharing the outcomes of findings with citizens.	0

	13	No	None reported.	0
	14	No	None reported.	0
	15	Yes	The author would like to express gratitude to the School of Social Sciences at the University of Manchester; the Age-Friendly Manchester team at the City Council, Chorlton Good Neighbours, Whalley Range Community Forum, the Manchester Institute for Collaborative Research on Aging and all of the co-researchers and participants in the study.	2
	16	Unclear	The study reports 'a strategy for evaluating the impact of the initiatives and strengthening the links between University and co-researchers was also developed' but no further information was reported on this.	1
Total Score = 20 (Medium-High)				
Buffel & Phillipson(2019)	1	Yes	This article explores the experiences of older people living in an urban neighbourhood undergoing residential and commercial gentrification.	2
	2	Yes	The research in this article derives from a study which aimed to train older people as co-researchers in developing 'age-friendly communities; the project used a participatory action research (PAR) framework, centred around three principles: participation; collaboration; and community action. A 'co-research' approach was adopted to allow older people's active participation as *partners* in the research process.	2
	3	Yes	Older people took a leading role both in developing and implementing the study as well as translating findings into policy recommendations and action; Eighteen people (10 females and eight males), aged between 58 and 74 years, were recruited and trained as co-researchers who collaborated on the development of the research design. However, the other older adults engaged in the process are only engaged in providing data in the focus group and interviews.	2
	4	Yes	Citizen scientists were co-researchers and trained/took part in reflecting meetings to address relevant stages of the research cycle (from design to collecting, analysing, and disseminating findings).	2

	5	Yes	Yes, it is clear that citizens are co-researchers and engaged in all stages (through a 'by the people' approach) in collection analysing and disseminating data.	2
	6	Yes	Although this study identifies important dimensions to the experiences of older people in a gentrifying neighbourhood, the research also has some limitations (study highlights three limitations of location, PAR methodology limitations, under-representing particular groups in the community. Study considers methodology limitations.	2
	7	Yes	The outcomes and findings of the study are themes that are clearly described and meet the focus of the paper.	2
	8	Yes	Citizens were trained in collecting data and undertook data collection, analysis, and the choice of quotes for the findings. They were directly engaged and empowered in these stages as co-researchers.	2
	9	Yes	'Studying the lives of older people in gentrifying areas contributes a great deal both to the broad picture about the impact of urban change, and about the various ways in which people develop strategies for managing their lives'- the study provided an overview of experiences of older adults and urban change and highlight factors (such as cost of housing, changes in types of shops etc) and the impact of this that could provide a pathway to real life decision-making for these individuals in this area related to urban change.	2
	10	Yes	Following their involvement in the study, the co- researchers developed as 'ambassadors' for the co-production model, promoting the age-friendly approach through activities such as: contributing to the development of policies within the local authority; speaking at (inter)national conferences; participating in new research projects; and contributing to change within the community, including the restoration of a much-valued bus service within one of the neighbourhoods.	2
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	Open Access.	2

	15	Yes	Acknowledged in the Acknowledgements section	2
	16	No	None reported.	0
Total Score = 24 (Medium-High)				
Chui et al. (2020)	1	Yes	This study examined the effects of using photo-voice as an alternative method in facilitating older adults' civic participation in Hong Kong; In this study, we aimed to explore how the process of participating in a photo-voice project facilitated participants' civic participation and propose an empowerment-based participatory photo-voice training model.	2
	2	Yes	This study uses focus groups to evaluate citizens scientist's experiences who previously took part in an empowerment-based participatory photo-voice training, take home assignment and exhibitions. In this study, older adults took part in group interviews and were asked questions and discuss their feelings and opinions about the photovoice experience they were previously involved in and trained in.	2
	3	Unclear	Citizens shared their feelings and opinions in the group interviews about their experience and were actively involved in the photo voice stage (but this was a previous study and not the aim of this study) but were not involved in the focus group preparation or data analysis/dissemination.	1
	4	Yes	Citizens were re-invited back to discuss their experiences in group interviews.	2
	5	Unclear	Citizens were actively engaged in sharing their feelings and opinions in the group interviews about their experience (as well as actively engaged in the previous study) but they were not engaged in the analysis or dissemination of outcomes.	1
	6	Yes	Limitations are addressed in this study, including 'findings may not be directly transferable to other older adults' and 'second, because participation in this photo-voice project was entirely voluntary, older adults who are willing to participate may already have been the more "active" group, thus creating a self- selection effect'	2

	7	Yes	The views and opinions of citizens and their experiences of using photovoice and being empowered are clearly described by the study.	2
	8	No	Citizens were not fully engaged and empowered in this study but were instead invited back to discuss their previous experiences.	0
	9	Unclear	The outcomes demonstrate the value of photo-voice in this context and engaging older adults in research to provide a relevant pathway for decision making, but the outcomes relate more to the use of photovoice for developing further studies/research and engagement with older adults.	1
	10	No	None reported.	0
	11	Yes	Citizens were evaluated in this study on their training and use oh photo-voice and how it can convey older adults' views, broaden perspectives, and enables knowledge acquisition and dissemination. It evaluated their knowledge and attitudes towards photovoice.	2
	12	No	None reported.	0
	13	No	None reported.	0
	14	No	Not Open Access.	0
	15	No	None reported.	0
	16	Yes	The study does critically evaluate the use of photo-voice as an empowerment approach for older adults and received feedback from citizens about the use of this method	2
Total Score = 17 (Medium)				
Fang et al. (2016)	1	Yes	(1)This paper illustrates how applications of community-based participatory research methods, in particular, participatory community mapping workshops (PCMWs),can be used to access experiences of place, identify facilitators and barriers to accessing the built environment and co-create place-based solutions among older people and service providers in a new affordable housing development in Western Canada;	2
	2	Yes	Participatory Community Mapping Workshops were run where citizens directed group walks and mapping workshops for generating ideas and solutions (with each workshop building on the previous). Citizens	2

			directed the mapping process and were co-owners of the maps produced, as well as building relationships with service providers and researchers in the workshops to develop achievable goals and actions. The approach used is described as a community-based participatory research method (participatory mapping research). Citizens are described as those who direct the workshop processes, outcomes, and solutions as a way to further understanding sense-of-place and experiences among older adults.	
	3	Yes	Citizens are engaged in the CBPR methods through walks and co-owning the mapping processes. They were also engaged in earlier research where strong relationships and community ties were developed prior to the PCMWs. It is clear that citizens are actively engaged in the four workshops and co-conducted the data analysis for workshops 2 and 3.	2
	4	Yes	The aims of the workshops identify the clear focus of each workshop and how citizens can direct and co-own the stages. Citizens were also engaged as co-owners of maps and co-conductors of data analysis.	2
	5	Yes	Citizens are engaged as generators, co-owners and co-conductors of the data and data analysis as well as building actions and solutions with other workshop members/stakeholders.	2
	6	Unclear	Limitations of the study are considered in the form of (1) Not video recording the workshops to understand how maps are drawn; (2) the resource intensive and time-consuming factors or participatory methods and the study faces a challenge of maintaining long term impact and outcomes. However, there is no consideration of data quality or bias that may have been impacted by the methods.	1
	7	Yes	The key findings from the workshops are described clearly and separated into different categories.	2
	8	Yes	Citizens are active collaborators and drive the workshops as well as the action points and solutions that are generated	2
	9	Yes	The outcomes highlight the experiences of older adults and their needs including the services, activities and solutions that are wanted	2

			by older adults in their community which could provide a pathway to real-world decision making.	
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	No	None reported.	0
	15	Yes	Acknowledged in the acknowledgements section.	2
	16	Yes	The study was evaluated by participants in the fourth workshop and provided an overview of positive aspects and challenges of the workshops.	2
Total Score = 21 (Medium-High)				
Garvin et al. (2012)	1	Yes	Objectives of the study were (1) delineate characteristics of built environment that are meaningfully different between summer and winter from the perspective of older adults; (2)ascertain which of the elements of the WHO age-friendly cities checklist are relevant to Edmonton seniors and how; (3) identify and critically evaluate additional characteristics seniors identify as particularly helpful to consider in low-density, northern winter cities.	2
	2	Unclear	Citizens are described as 'participants' but are engaged in photo-elicited focus group methods where they took photos of their environment a discussed these photos, which formed the data to be analysed and topics that are important to older adults. However, participants were reminded of project goal and purpose of research rather than being the drivers of this. The activities do engage participants in the methods, and they direct their photos and identify topics that are important to them. However, the project goals, purpose and data analysis and themes are all directed by the researchers so is a mix of citizen science and traditional.	1
	3	Yes	Citizens are clearly engaged in the photo-elicited methods in which they take their own photos, and inform discussions based on what is	2

			important to them. So citizens are engaged in the data collection stages but no other stages.	
	4	Yes	The roles for participants are made clear in the focus groups, as well as through the photo-elicited approach	2
	5	Yes	It is clear that citizens are actively engaged in the photo-elicited approach and in the focus group discussions.	2
	6	No	None reported.	0
	7	Yes	The findings highlight the experiences and concerns of older adults in the summer and winter and provide pathways to real-world decision making in terms of the barriers and facilitators highlighted with photos.	2
	8	Unclear	Citizens were engaged as data collectors as well as identifying the key themes that are important. However, it is unclear how much the data-driven strategies and solutions were directed by citizens and how much were directed by researchers.	1
	9	Yes	The findings provide a pathway for designing and adapting urban environments based on the needs and experiences of older adults living in these spaces.	2
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	No	None reported.	0
	15	No	None reported.	0
	16	No	None reported.	0
Total Score = 14 (Medium)				
Glover et al. (2020	1	Yes	This paper firstly provides a description of a theoretically in- formed co-creation study to investigate what it means to maintain health and wellbeing in older age and how to support this in a local context. Objectives were to: (a) develop a shared understanding of the meaning of healthy ageing, (b) identify barriers and facilitators to adopting behaviours that would support the identified essential components of healthy ageing, (c) make recommendations for	2

			adapting local ser- vices or developing new ones that are feasible, acceptable, and sustainable and (d) evaluate and make recommendations for authentic co-creation with older people.	
	2	Yes	A co-creation approach was used in which citizens are actively involved in four group discussion meetings, with the theme of each meeting determined at the previous meeting (1st meeting theme decided by researchers). The study identifies itself as a 'co-create' study in which older adults are actively engaged.	2
	3	Yes	Citizens are clearly actively engaged in the discussion meetings as well as in evaluating the co-creation method. The group shared written and verbal information about the aims of the project and agreed both ground rules and levels of involvement	2
	4	Yes	Citizens are engaged and debate or share their views in each of the discussion group meetings as well as evaluating the project, so their roles are identified. The group shared written and verbal information about the aims of the project and agreed both ground rules and levels of involvement	2
	5	Yes	The extent to which citizens are engaged in clear in that they are steering the discussion group meetings and producing the recommendations.	2
	6	Unclear	The study does consider its limitation in terms of the location of the study, but it does not address data quality, bias, or limitations	1
	7	Yes	The findings of the study are clearly described and separated into relevant categories to address the objectives of the study.	2
	8	Unclear	The study argues that co-creation took place at every stage of the project from design to dissemination. However, it only reports that the data collection and recommendations are produced by older adults but do not report their engagement in driving the research focus, data analysis or the dissemination. Older adults were asked about the next steps in a questionnaire but the dissemination of this was not reported. The research question was already defined but it was	1

			argued that how it was addressed was shaped by older adults involved.	
	9	Yes	The study presents outcomes and recommendations that could provide a pathway to real-world decision making, with feasible acceptable and sustainable recommendations for healthy ageing, as well as for recommendations for co-creation with older adults.	2
	10	No	None reported.	0
	11	Unclear	Citizens were asked after in a questionnaire about the key things that were discussed, what stood out and what should happen next. However, the outcomes of this were not clearly reported.	1
	12	No	Although the study says that co-creation was part of the study from data collection to dissemination, the dissemination part is not clearly reported at any stage.	0
	13	No	None reported.	0
	14	No	None reported.	0
	15	Yes	Acknowledged in the acknowledgements	2
	16	Yes	A process evaluation was completed based on group reflections through the co-creation experience and how this can be used/improved/ evaluated further as well as providing recommendations	2
Total Score = 21 (Medium-High)				
Gustafsson et al. 2018	1	Yes	the aim of this paper was to describe Life filming as a means of participatory approach among older community-dwelling persons regarding their local environment	2
	2	Yes	The study describes participatory methods and approaches, as well as empowerment of older adults through the participatory approach. This is through life filming which is a participatory approach and is used to collect data and capture older adults' experiences in which older adults describe their local environment and highlight areas in need of improvement using this approach. From planning to completion, the study describes continuous discussions of the purpose of the assignment, which strengthened groups awareness and commitment.	2

	3	Yes	Citizens were part of a group there were given a goal to produce one film each about their local environment and attended information sessions and workshops to guide this (training of taking photographs and movies, homework assignments, filming of their environment and group discussions) which had a focus of learning and helping each other. Citizens also reflected on the process at each workshop to address their needs and perspectives. Representatives of the older persons who participated in the group activity also were involved in validating the findings collected by researchers. They were also part of guiding the dissemination of the videos they produced by demonstrating the need for them to be share with relevant municipal departments.	2
	4	Yes	It is clear that researchers are undertaking a descriptive single case study of the participatory methods, setting the community assignment and collect data through observations and memos. However, citizens are actively engaged in the different stages (see Q3), so the relationship is clearly reported.	2
	5	Yes	It is clear to what extent the citizens are actively engaged in the data collection through life filming and workshops (see Q3), alongside the authors collecting data from observations, conversations, and experiences from the group activity, and are part validating the data analysis. They are also part of the dissemination by demonstrating the need for them to be shared with relevant municipal departments and shared their videos with the city's website. This is a 'with the people' approach as there is a mixture of direction from the authors and citizens.	2
	6	Yes	The authors consider the study design limitations and how the findings are based on a small number of participants and personal experiences which may limit transferability. They also highlight that the older adults were a group of 'healthy older people' with good socio-economic conditions which may have also affected the findings. They offer a solution for using a mixed-method approach or additional data	2

			sources to strengthen the study and to include a broader heterogenous group of older persons.	
	7	Yes	The findings highlight Anchoring the concept of participation, Practical application of Life filming, The film as a product, Making a real difference, and An identity as a capable older person as the findings are clearly separated out.	2
	8	Unclear	Although the findings/solutions are based on outcomes from the active engagement of older adult citizens (in terms of the film as a product, the workshops which were based on learning and helping each other, and the dissemination of the films), part of this was directed by the researchers through the assignment given to the community centre, as well as from the data the authors collected through observations and field notes taken of older adults taking part in the group activity. It is unclear if the study outcomes area direct result of data-driven strategies generated by citizen scientists as instead, it is a mix of strategies driven by both citizens and researchers.	1
	9	Yes	The findings described a pathway to real world change in which the videos have been shared with the municipal government, shared at a national conference on city planning, and have been used for education purposes at Gothenburg University. The study also says ‘ any improvements in the local environment due to the action plan will also be reported’ showing that the videos are contributing and providing a pathway to real world change.	2
	10	Yes	The study intends to track the action plan for ‘age-friendly Gothenburg project’ when it is adopted and shared the outcomes from the videos that may contribute to local improvements with the citizens. Ripple effects were also highlighted in which older adults want to continue on after to teach others about how to produce films using tablets.	2
	11	Yes	Throughout the workshop, the study evaluated the citizens in terms of life filming to address their needs and perspectives and to include a reflective learning process throughout. The outcomes of this were highlighted in the findings through ‘an identify as a capable older	2

			person' in which citizens wanted to learn about new technology and have continued on after to teach others about how to produce films using tablets.	
	12	Yes	The study reports that it will continue to track and share the action plan for 'age-friendly Gothenburg project' when it is adopted and shared the outcomes from the videos that may contribute to local improvements with the citizens.	2
	13	No	Citizens are not mentioned in the publication process or asked to review the publication at any point	0
	14	No	The study is not in an open access format.	0
	15	Yes	Thanked in the acknowledgements	2
	16	Unclear	The citizens do take part in a reflective learning process throughout and highlight the positive aspects of life filming as an experience. However, there is no other critical evaluation of the study or its limitations	1
Total Score = 26 (Medium-High)				
Hand et al. (2018)	1	Yes	As such, this article describes an approach that draws on qualitative and geospatial methods aimed at understanding transactions between older adults and their neighbourhoods, illustrating its development and reflecting on its potential. The objectives are: To describe a combined qualitative-geospatial approach for studying of older adults in neighbourhoods; To investigate the qualitative-geospatial approach developed, including its utility and feasibility in exploring person–place transactions in neighbourhoods.	2
	2	Unclear	The study describes using CBPR approach and combining participatory geospatial and qualitative methods. The methods are described to capture in-depth story of older adults' experiences in their neighbourhoods, are grounded in their local environment and an advisory panel of older adult community members and other stakeholders were formed to contribute to decision making and collaboratively implementing the research approach. However, citizens are called 'participants' and took part in researcher directed	1

			combined methods of a narrative interview, a go-along interview and GPS tracking, completing an activity/travel diary and follow-up interview.	
	3	Yes	The methods chosen to do have active engagement of citizens in choosing the local destination and are engaged in informal interviews to discuss their walks, as well as discussing their maps after and to highlight their stories and provide meaningful data. However, they are part of semi-structured interviews with prompts, are tracked for 4 days using GPS and complete an activity diary and are not part of the data analysis of dissemination. This is a mixture of 'with' and 'for' the people with less active engagement.	2
	4	Unclear	The methods are set out clearly and the contribution of citizens is clear in that they are involved in each stage of the data collection which is directed by researchers. However, it is unclear if there is a partnership, or a shift from participant to active researcher.	1
	5	Unclear	Citizens participate in narrative interviews, go-along interview walks, tracked via GPS and discuss their maps. However, they are not engaged in the data analysis, and it is unclear if they are engaged in the dissemination of findings and results. Although citizens are provided with the opportunity to discuss their stories, It is unclear how much researchers directed the methods (i.e. study describes participants being 'observed' during their walks') and how actively engaged citizens are throughout these processes.	1
	6	No	The study does not discuss limitations or bias.	0
	7	Yes	The findings are clearly described and show the understandings gained through each stage of the combined methods used as well as highlighting reflections on the combined methods.	2
	8	Unclear	Although the methods provide an opportunity for citizens to engage and provide their stories, it is unclear if the findings and solutions are a direct result of data- driven strategies generated by the citizens or if they are driven by researchers.	1

	9	Unclear	The outcomes have impact for studies to further use combined methods to highlight how participants interact with their neighbourhood, highlights their experience and how they navigate their environments. It is unclear whether the findings have real world impact or could be taken to real-world decision making but instead would provide impact for further research on this topic that aim to use these methods.	1
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	Open Access format	2
	15	No	None reported.	0
	16	Unclear	The study does provide a detailed overview of 'reflections on the combined methods' which highlights a positive evaluation only of the outcomes of the methods, however, does not provide an overview of its limitations or involve citizens in the evaluations.	1
Total Score = 14 (Medium)				
Novek et al. (2014	1	Yes	The purpose of this study was to use a participatory methodology to explore older adults' perceptions of age-friendliness and to identify priorities and barriers to making communities more age-friendly.	2
	2	Yes	The study used a photovoice technique, described as a participatory research methodology) to address older adult's experiences within their social and physical environment. Older adults took photos to illustrate age-friendly features or barriers and recorded journal entries described each photograph, as well as taking part in interviews and discussions. Participants took photos and used a journal to describe the photos, were engaged in interviews after to elaborate further, and then attended group discussions to highlight priorities, give feedback on the themes. That had been generated and to identify how they wanted the findings to be used. An information session was held to explain the project and digital cameras, as well as info and instructions	2

			on how to use the camera. Participants were also given a journal to describe and interpret each photo they took. Participants were asked to select three priority photos which were used to compile a list of key issues for each community. Interviews were also undertaken after structured around the photos taken to elaborate on the photos. Participants also attended a focus group discussion to determine age-friendly priorities, which was based on the photos taken, and to give feedback on preliminary themes generated based on the photographs, journals & Interviews. At the end of the focus group, participants were asked how they wanted their findings to be used.	
	3	Yes	Participants are actively engaged in taking their own photos and describing them, elaborating further in interviews based on their photos, taking part in discussion groups to highlight priorities and give feedback on themes that had been produced, and highlighting how they want the findings to be used	2
	4	Yes	It is clear that participants are actively engaged in the data collection, and parts of the analysis and dissemination and are provided with an information session at the start to discuss the study.	2
	5	Yes	The study clearly highlights citizens are engaged throughout the data collection, in validating the themes produced and by identifying where and how they want their findings used.	2
	6	Yes	The limitation of the homogeneity of participants is considered and selection bias is discussed, with the suggestion of addressing perspectives of older adults from ethnic minorities in future research.	2
	7	Yes	Three categories of themes are presented clearly and show age-friendly features, contextual factors, and cross-cutting themes.	2
	8	Unclear	Although citizens are active data collectors, involved in the first stage of analysis, highlighting priorities within their data and identify where they want their information disseminated, it is unclear if they are active collaborators in terms of steering the project from start to finish. The study describes an information session which was used to ‘explain the project’ rather than to discuss the project and steer it. The majority of	1

			data analysis is completed by the researchers and a summary report was sent to participants and community members (service providers etc), but it is unclear if participants were involved in the development of the report aside from their photos and discussions.	
	9	Yes	The study highlights key themes for 'age-friendliness', including physical environments, housing, business and services, activities, volunteering, social environment, affordability etc that could provide a pathway to real-world decision making for developing the urban environment for this group of older adults	2
	10	No	None reported.	0
	11	No	None reported.	0
	12	Yes	The study reports provide a summary report of age-friendly issues and recommendations which was shared with participants as well as service providers and community members.	2
	13	No	None reported.	0
	14	No	None reported.	0
	15	No	None reported.	0
	16	No	None reported.	0
Total Score = 19 (Medium)				
Parekh et al. 2018	1	Yes	The purpose of this study is to explore the role of social capital (e.g., social support through indirect ties) and social cohesion (e.g., interdependent support among neighbours) to unravel pathways for building age-friendly communities.	2
	2	Unclear	The study used a CBPR approach where three community liaisons assist in all phases of the study (planning, recruitment, data collection, translation & data analysis). Input from the community liaisons were integrated into the interview protocol and older adults were involved in member checking the final themes produced. However, the researchers collected data via face-to-face in-depth interviews with homebound older adults and focus groups for other older adults. A semi-structured interview guide used open-ended questions to address the experience of older adults. Aside from the community	1

			liaisons and member checking of themes, it is unclear if older adults were actively involved or collaborated in this study.	
	3	Unclear	The methods chosen were used to understand 'aging well' from the 'lens of older adult participants', with the questions asked in interview elicit further responses and engaging individuals in conversations about what community means to them. The protocols also had input from community liaisons in older adult services. However, the degree of active engagement is unclear, as apart from member checking the final themes and engaging in conversations in interviews, they did not actively engage in other stages of the research.	1
	4	Unclear	The roles and responsibilities are clear for the community liaisons, but it is unclear what the roles and responsibilities were for older adults apart from engaging in the interview/conversations and member checking the data analysis.	1
	5	Unclear	Citizens participate in the data collection stage by engaging in conversations and answering questions (although this is not active collaboration) and are also engaged in member checking the final stages of data analysis only but it is unclear if they are actively engaged any further or in the dissemination or use of data.	1
	6	Yes	The study considers the limitations in terms of the older adults recruited through community organisations, meaning those that do not interact with their community were not represented in the sample, as well as LGBTQ and other minority groups.	2
	7	Yes	The findings are clearly separated in clear sections for each theme and included quotes	2
	8	No	The study's outcomes are not a direct result of data-driven strategies, although the strategies did have input from community liaisons, as the strategies and outcomes/solutions were guided by the researchers through interviews and data analysis.	0
	9	Yes	The findings provide pathway to real-world decision making for African American, Hispanic, and Vietnamese older adults in terms of the impact of their local community for participating in social cohesion &	2

			Civic Engagement, social inclusion barriers and the impacts of ageism.	
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	Open Access	2
	15	No	None reported.	0
	16	No	None reported.	0
Total Score = 14 (Medium)				
Ronzi et al. (2016	1	Yes	The photovoice study reported in this paper was part of a wider study (doctoral) looking at approaches to evaluation of respect and social inclusion in older people in the context of an aspiring AFC. This study aimed to stimulate collective action and advocacy to affect policy and empowerment by (i) encouraging dialogue between older people and city stakeholders at the exhibition; and (ii) by ensuring that older people's views were brought to the attention of city stakeholders so that they could include their concerns in decision making and planning processes for an AF	2
	2	Yes	A CBPR method was used through photovoice and is described by the study to focus on co-creation knowledge, community empowerment and combines research with action. Participants participate in group discussion focus groups (which introduced the project and photography, received digital cameras, given a broad pre-identified problem and were asked to photograph this broadly as to limit the researcher influence over problems identified), took photos over a week (telling stories to highlight issues that are important to them), semi-structured interviews based on the photographs to select the most meaningful photos and the related stories (as well as a discussion on any photos that weren't taken), a second focus group where photographs were discussed, and researchers and participants agreed on the photos and descriptions for the exhibition. The findings	2

			are disseminated through a photo-exhibition to promote community discussions, policy and social change with participants, city stakeholders and members of the community.	
	3	Yes	It is clear that citizens are actively engaged in each stage of the data collection (including taking the photos, telling the stories about the photos, discussing this with others and deciding on meaningful photos for the exhibition) and dissemination stage (taking part in the exhibit)	2
	4	Yes	An introductory focus group was undertaken to explain the project and to introduce citizens to the photography experience. It is clear that citizens are active researchers in the photos they take, described, and disseminated.	2
	5	Yes	Citizens are actively engaged in the data collection, and dissemination but are not engaged in the data analysis stage.	2
	6	Yes	The limitations of the citizen gender imbalance are considered as well as the limited time to take photos.	2
	7	Yes	The findings describe the opportunities, challenges, and solutions of using the photovoice methods and are separated into sections for the process to raise participants consciousness, factors influencing ability to take photos, negative aspects of photography, negative social concepts, time period for taking photos ,training, social expectations, and comfort using the camera, ethical aspects	2
	8	Unclear	Although citizens were engaged and empowered take photos on highlighting issues that are important to them as well as disseminating results at an art exhibition, and researchers tried to avoid influencing the photos taken, it is unclear in terms of citizen involvement in the structure and focus of the overall study, the interviews were semi-structured and data analysis were completed by researchers with no/unclear involvements of citizens.	1
	9	Unclear	Although the project provided pathway to real world decision making at the exhibition and with the report they provided, the findings reported in the study relate to the use of photovoice and the opportunities, challenges, and solutions for this. This would provide a	1

			good pathway for future research to use this method but unclear in terms of real-world decision making.	
	10	No	None reported.	0
	11	Yes	In the findings, the study provided an overview of the photovoice methods experienced by participants including raising the participants consciousness (related to their city and awareness of respect/social inclusion etc) and thinking about what they want from the city.	2
	12	Unclear	The study reported a dissemination plan of providing a report with the findings to share with city stakeholders and follow-up this report and its impact, but it is unclear if citizens will be involved in this stage or if this report will be shared with them.	1
	13	No	None reported.	0
	14	Yes	Open Access.	2
	15	Yes	Thanked in acknowledgements	2
	16	Yes	At the end of the focus group, participants were asked how they experienced the photovoice project and how it could be improved in the future. The exhibition event was also assessed with a short evaluation survey.	2
Total Score = 25 (Medium-High)				
Tuckett et al. (2018)	1	Yes	1)What are the features that help or hinder access to a seniors' centre? 2)What are the features of the physical environment surrounding a seniors' centre that help or hinder physical activity (walking)?; 3)In what ways can older adults acting as citizen scientists bring about changes to their local environment?	2
	2	Yes	A Citizen Science framework was used (*our voice*) for collaborative research where citizens undertook a walk using a digital tool to take photos, audio narratives and GPS track the walks. Citizens were also engaged in the data analysis and the dissemination of the findings through activate sessions through public presentations.	2
	3	Yes	Yes it is clear that citizens are actively engaged in data collection (the walk to take digital photos, audio narratives and GPS track the walks and individually designated a feature as helpful or hindrance), Photos	2

			were printed and preliminary content coded elements were derived from the walks (by researchers) for the discussion group, data analysis(Citizens took part in a further discussion group phases where they coded their own data (facilitated by researchers) by assigning photos graphs with paired audio transcripts under the code element headings to validate the codes. Once this was completed, the citizens reached a consensus on the data and two citizens were nominated to advocate the groups findings and solutions at an 'activate' session. A collective brainstorming of solutions and priorities also took place with citizens which were recorded on a photograph board) and disseminating the outcomes (two activate sessions were completed by the two citizen scientists (driven by citizens, with the second session co-delivered with researcher through public presentations to municipal council members and to the public to discuss group needs.)	
	4	Yes	A community partnership process is undertaken where citizens are actively engaged as co-researchers in the research and the roles/expectations are clear to citizens. and are involved in steering the data collection, data analysis and dissemination of data, which is clear.	2
	5	Yes	Yes, this is a by the people approach in which citizen scientists are co-research and are involved in steering the data collection, data analysis and dissemination of data	2
	6	Yes	Research limitations were considered in terms of small sample size in which the outcomes need to be weighed carefully against sample size (Outcomes need to be weighed carefully against sample size/ caution must be taken about extrapolating outcomes), predominantly female sample, and reasonably short time frames in which impacts of the intervention have been evaluated.	2
	7	Yes	The findings are broken down into examples of the coded elements with relevant photos taken (i.e. footpaths, playgrounds)	2

	8	Yes	Citizens were actively engaged in steering the data collection, and actively collaborating in the discussion groups, highlighting action points and solutions, and advocating and disseminating the results.	2
	9	Yes	The findings provide coded elements of the physical environment with photos that could provide a pathway to real world decision making through adapting and changing the physical element. The advocating of the results also led to 'the Councillor committed to making the citizen scientists' proposed changes.	2
	10	Unclear	The study does report ripple effects from the project in terms of the work that is being planned or has taken place (line marking road works, footpath repairs), approval for construction of a new toilet block. However it does not report long term impacts or changes (or intention to track) for citizens.	1
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	Yes	Open Access	2
	15	Yes	None reported.	2
	16	No	None reported.	0
Total Score = 24 (Medium-High)				
Verma & Huttunen (2015)	1	Yes	The aim of this case study was to gain understanding of the user experience of the living environment integral to further local development.	2
	2	Unclear	Participatory user study methods are described (workshops and walk-throughs, together with an internet-based online questionnaire were used) with workshops focused on daily paths and current/need for services were the focus and pictures of the local environment and a map were used to facilitate the workshop where older adults shared their experiences and impressions of the living environment/ services they would like/dislike in their neighbourhood. Three walk-through assessments were completed to evaluate users personal experience through discussion and observation, as well as routes, walking speeds	1

			and resting spots collecting on a mobile map application. The findings from this walk-through helped to formulate the online questionnaire about individual's local environment. It is unclear if this is a citizen science approach as although they are described as participatory user study methods, citizens are not involved in the planning or focus of the study, the analysis, dissemination and during the data collection they only provide data in terms of their experience and insights, but the photos/routes are already chosen.	
	3	Unclear	The methods chosen provide active engagement in terms of older adults providing individual and collective experiences, discussing things they want or dislike in their neighbourhood and reporting their experiences through the tour. However, the active engagement is unclear as the workshops were guided by the researchers (they chose the route from homes to the library, provided the photos, and it is unclear how the discussion was facilitated) and the walks were organised by organisations or the researchers and called a 'tour' where older adults provided their observations during the walk. Older adults were also not engaged in the planning of the study and data analysis is not mentioned.	1
	4	Unclear	The roles and responsibilities are clear between citizens and researchers, but it is unclear if citizens are more participants who provide data rather than active researchers (i.e. they were provided pictures, walks were organised by association or researchers rather than citizen, they were not involved in the data analysis or the planning of the research) and it is unclear if there is a clear partnership between researchers and citizens.	1
	5	Unclear	Citizens are actively engaged in the data collection to share their in-depth knowledge, experiences, and impressions but they are not actively engaged in the data analysis or dissemination. The active engagement in data collection is unclear as the workshops were guided by the researchers (they chose the route from homes to the library, provided the photos, and it is unclear how the discussion was	1

			facilitated) and the walks were organised by organisations or the researchers and called a 'tour' where older adults provided their observations during the walk. Older adults were also not engaged in the planning of the study and data analysis is not mentioned.	
	6	Unclear	The study does consider its limitations briefly - 'This study has limitations, as this research was conducted in a particular place over a certain period of time. The participants represented 2% of the elderly living in the area.' but does not discuss data limitations or biases further or how these limitations could be addressed.	1
	7	Yes	The main findings are separated into features of the environment and the experience or impressions from older adults about these features.	2
	8	No	Citizens are engaged in the data collection to provide their insights and experiences but are not active collaborators in terms of the data-driven strategies and solutions produced.	0
	9	Yes	The findings provide a pathway to real world decision making in terms of identifying the local services and features (green spaces, transportation etc) that are important to older adults in this area and can be adapted, changed, or promoted.	2
	10	No	None reported.	0
	11	No	None reported.	0
	12	No	None reported.	0
	13	No	None reported.	0
	14	No	Not Open Access.	0
	15	No	None reported.	0
	16	No	None reported.	0
Total Score = 11 (Medium)				
Von Faber et al. (2020)	1	Yes	The main aim of this paper is to describe how participatory video design can add knowledge about the preferences and needs of older people about the improvement and preservation of their local environment.	2

	2	Yes	We focus on participation in research, enabling older people to seek their own solutions according to their priorities. A participatory video method is used as co-creative approach.	2
	3	Yes	Representatives and a regional advisory board of older people helped shape the focus of the study, the neighbourhoods where participants were recruited and took part alongside other older adults in the data collection. Citizens (both the representatives and the older adults recruited) actively engaged in a 5-day workshop to produce a film and disseminate it to family and friends based on a topic.	2
	4	Yes	It is clear that there is a partnership between researchers and the regional advisory board who are there to provide insight and steering to the project focus. Citizens also take part in the study to develop, film and disseminate a film on a specific topic.	2
	5	Yes	Citizens are engaged in developing, filming and disseminating the film on a specific topic. They write the script, chose the aspects to film, edit their films and disseminated it to family members	2
	6	Yes	The study considers a potential limitation of visual methods in that it could exclude persons with impairments related to vision, hearing, or mobility. This could introduce a selection bias and under-representation of vulnerable groups.	2
	7	Yes	The findings are broken down based on the topics of the films and clearly identify the barriers and facilitators of cities that influence older adults. The process of participation and ways to improve the film making process are also documented in the results.	2
	8	Yes	The findings are those that are directly produced by older adults who developed their own subtopics of the films, such as outdoor spaces, social participation and characteristics of the neighbourhoods. Citizens were actively engaged in writing their own scripts and going out and filming their own films which produced the topics for the findings.	2
	9	Yes	The findings demonstrated the preferences and needs of the older adults in these locations and demonstrated features and characteristics that could be used to develop age-friendly spaces. This	2

			produces a pathway to making real-world decision-making based on these characteristics.	
	10	No	Although the study did provide the opportunity for a follow-up activity by participating in a focus group to discuss the final results and further suggestions for improvements and reported the neighbourhood association was also reported to take responsibility of improving mobility and safety, there was no intention to track these changes and their impacts further, alongside any further participatory activities of citizens. The study also reported that no arrangements were made to evaluate and discuss the results of the video research.	0
	11	No	None reported	0
	12	Unclear	The study reports sharing the film with citizens who wanted to receive their film. However, no other dissemination is reported.	1
	13	No	None reported.	0
	14	Yes	Open access article.	2
	15	Yes	Acknowledged in the acknowledged sections	2
	16	Yes	An evaluation was completed by participant experience during the film making processes and provided an overview of the experience, and suggestions for improvement such as more time to complete filming.	2
Total Score = 25 (Medium-High)				
Ronzi et al. (2020)	1	Yes	We employed a Photovoice methodology within a Community-Based Participatory Research approach to: (i) explore the extent to which respect and social inclusion were promoted as the city sought to become more age-friendly/an AFC, and (ii) actively involve older adults in the research process and to allow them to directly communicate issues with stakeholders involved in AFC policy.	2
	2	Yes	A photovoice methodology within a CBPR approach was employed to involve older adults in identifying priorities for action and in decision0making processes. It was used to provide a unique perspective on the issue of respect and social inclusion in the urban context whilst creatively involvement participants in the research process.	2

	3	Yes	The active engagement of citizens is presented in six phases were completed which included: 1) Discussion group providing an overview of the project aims, a focus group discussion to explore perceptions of research and social inclusion, photographical and ethical trained, and were asked to photograph aspects of their environment that enabled or prevented feeling valued and part of the community and to identify potential solutions; 2) Participants spent a week taking photos; 3) Each participant selected six photographs they wanted to discuss during an in-depth semi-structured interview and focus group; 4) A second focus group discussion took place where photographs were collectively interpreted and key themes emerged from the discussions. Participants also discussed how they wanted to communicate their findings to policy makers and relevant stakeholders; 5) Captions were developed for participant chosen photos by researchers and reviewed by participants for the photo-exhibition; 6) Photos were shown at a public and stakeholder event where participants presented their photos and communicate directly to stakeholders. Data analysis was completed by the researchers without member checking.	2
	4	Yes	It is clear that citizens are engaged to actively collect data through photovoice, identify key photos and solutions, and disseminate them with community stakeholders. Researchers are present to facilitate the process (i.e. providing an overview of the project aims, facilitating ethical training and complete data analysis).	2
	5	Yes	Citizens are engaged in actively collecting and disseminating the data. However, they are not engaged in the data analysis stage where researchers completed thematic analysis.	2
	6	Yes	The limitation related to the gender imbalance in the sample was considered (males: 7; females: 19). The guiding principle for recruiting participants was to have a mix of included and less included participants, rather than focusing on gender differences. Moreover, we realised that (i) our strategy to recruit participants from grassroots organisations in order to include a mix of more or less socially	2

			included older adults and (ii) our requirement for participants to physically attend the sessions and being able to walk (even if for short distances only) to take photographs, meant that we did not reach some of the most excluded older people.	
	7	Yes	The outcomes are presented in relation to the urban context that fostered or hindered respect and inclusion, which included the physical environment, transportation, public facilities, disrespectful environmental attitudes, social environment, places to cultivate informal and formal relationships and negative age perceptions, disrespectful attitudes and neighbourhood fragmentation.	2
	8	Yes	The outcomes are based on the photos taken from the active data collection completed by citizens through the photovoice and focus group discussions. Citizens were also engaged to advocate their photos with community stakeholders.	2
	9	Yes	The outcomes provide an overview of the contexts and features that hinder or facilitate respect and social inclusion for older adults in Liverpool, and these are aspects that can provide a pathway for being developed or altered to facilitate this further	2
	10	No	None reported	0
	11	No	None reported	0
	12	No	None reported	0
	13	No	None reported	0
	14	Yes	Open Access	2
	15	Yes	Citizens acknowledged in the acknowledgements	2
	16	No	None reported	0
Total Score = 22 (Medium-High)				
Salma et al. (2020)	1	Yes	This study elicits perceptions of aging and related needs of immigrant Muslim communities in an urban centre in Alberta by answering two questions: What are immigrant Muslim older adults' experiences of growing old in their communities? ; What are the stakeholders' perceptions of the needs for aging well in immigrant Muslim communities?	2

	2	Yes	The study discusses community-based participatory principles that are used for ‘power-equalizing’ and follows principles of shared leadership, collaborative decision-making and researcher-community trust-building	2
	3	Yes	. A community advisory group of stakeholders and older adults participated in all stages of the research process via monthly meetings and drafting the interview guide, identifying stakeholders, recruiting older adults and informing data analysis. Older adults themselves were only actively engaged in the interview or focus group process. This demonstrates a ‘by the people’ due to the advisory group but a ‘with the people’ due to the only active engagement of other older citizens in the interview/focus group process.	2
	4	Yes	A relationship has been built with the lead research and the advisory group/ older adults engaging in the study and the roles are clear about their level of engagement and expectations.	2
	5	Yes	Older citizens are actively engaged in the data collection stage only, and the advisory group are engaged in informing the last step of data analysis. No involvement of older adults or advisory group is discussed for dissemination.	2
	6	Yes	The study considers their limitations through the following: 1)The majority of participants were low-income women belonging to Arab, South Asian, or African immigrant communities. The findings of this study are not necessarily transferable to other immigrant Muslim groups; 2) The study took place in only one province and city in Canada. The traditional immigrant-receiving locales of Vancouver, Montreal, and Toronto have higher percentages of immigrant older adults, which might interpret into more resources available to this population and different aging experiences.	2
	7	Yes	The findings are reported in three clear categories: 1) Aging while living across place; 2) Negotiating access to aging-supportive resources in a time of scarcity; 3) Re-envisioning Islamic approaches to eldercare.	2

	8	Unclear	Although an advisory group were engaged in the planning of the interview guide, the recruitment, and the data analysis, and older adults were actively engaged in focus groups, the researchers directed the choice of methods, the data collection and it is unclear if citizens were fully engaged as active collaborators.	1
	9	Yes	The outcomes identify the needs of older adult Muslim's residing in Canada and can be used as a pathway to real-world decision making i.e. the need for religious, cultural and spiritual considerations to be incorporated into eldercare.	2
	10	No	None reported	0
	11	No	None reported	0
	12	No	None reported	0
	13	No	None reported	0
	14	No	Not open access	0
	15	Yes	The community members are thanked in the acknowledgements section	2
	16	No	None reported	0
Total Score = 19 (Medium)				

Urban Environment Barrier and Facilitator Themes to Active and Healthy Ageing

Table 15. Urban environment barriers to active ageing

Theme	Sub-themes	First order themes	No of Articles	Reference
Accessibility	Physical access to amenities and facilities	1. Physical and disability-friendly accessibility to local buildings 2. Health Services 3. Community services 4. Shopping facilities 5. Senior centres 6. Activities & social gatherings	11	(71,304, 551-553,558,560,563,565,567)
	Technological barriers	Development of modern technology negatively impacts availability and accessibility of online information and availability of physical information	5	(551,555,556,559,567)
	Information about services	Services and organisations offering activities do not communicate or signpost information	4	(556,559,563,567)
	Housing	Lack of accessible housing	4	(554,560,563,567)
Affordability	Health Services	Costs of health services too high and causing financial hardship and	6	(71,556,559,562,563)

		concern, especially for those ageing-in-place		
	Housing	Lack of affordable housing creates a financial barrier, particularly for ageing-in-place	3	(554,556,560,563)
	Public Transportation	High costs of public transport	4	(555,556,559,563)
Community support	Community respect and inclusion	Community unsupportive, disrespectful and devalue older adult contributions	5	(71,553,555,556,565)
Barriers for migrants & cross-cultural communities	Engagement in activities	Ethnicity or differences in cultural norms prevents or negatively impacts engagement in activities outside of home	3	(560-562)
	Social Isolation	Cultural differences and language barriers increase social isolation	3	(560,562,565)
	Access to resources	Poor access to transport, social platforms for civic engagement, suitable care facilities, or support from government amongst ethnic, culturally and linguistically diverse minorities.	3	(71,562,565)
Physical environment barriers	Unmaintained or unsuitable infrastructure	Poorly maintained infrastructure, pavements and presence of obstacles, particularly during winter	8	(117,304,552,558,563,564,566,567)
	Absence of signage and crossing facilities	Lack of crossing facilities and signage for wayfinding and traffic related safety, particularly a danger for those with visual and physical impairments	8	(304,551,552,556,558,564,566,567)
	Negative aesthetics in outdoor spaces	Unclean, disorderly, and displeasing physical environment	6	(304,555,564,566,567)

	Unavailable facilities	Lack of suitable toilets, facilities for drinks, benches & suitable seating, particularly in summer	8	(117,304,553,555,558,559,564,567)
	Unsuitable routes & outdoor spaces	Poor walkability, unsafe and inaccessible routes or outdoor spaces	3	(556,558,567)
Safety & security	Crime & Vandalism	Reduces feeling of safety and time spent outdoors in urban areas	4	(555,558,563,566)
Social isolation & exclusion	Social Isolation in local community	Lack of connections & activities with neighbours or local community contributes to social isolation	3	(559,560,567)
	Developments & alterations to neighbourhoods	Physical alterations, new builds, & rotation of neighbours negatively impact social connections, community cohesion & 'locality'	3	(554,555,566)
Transportation	Unsuitable public transport infrastructure, system & scheduling	Lack of public transport, physical accessibility to transportation and unsuitable infrastructure a barrier to accessing services, facilities & social activities	9	(71,551,555, 556,558,563-565,567)
	Reliance on driving and social networks	Lack of public transportation creates pressure for driving and reliance on social networks	2	(71,556)
	Increased flow of traffic	Producing unsafe spaces and hazards difficult to navigate	4	(551,556,558,566)

Table 16. Urban environment facilitators to active ageing

Theme	Subtheme	First order themes	No of Articles	Reference
Community Support	Availability of services & facilities	Availability of shops, cafes & 'third places' such as libraries, particularly useful during winter and for social links	9	(552,554,555,558,562-564,566,567)
	Community-based programmes, neighbourhood associations and religious institutions	Encourages and provides support to older adults	5	(554,558,561,563,565)
	Intragenerational programmes and communities	Senior-specific programmes & community of people the same age promotes health, wellbeing & independence	3	(556,560,563)
	Local community, neighbours, and Intergenerational neighbourhoods	Provide support for older adults, particularly for ageing-in-place, and encourage social activities with others	7	(552,554,556,558,561,563,567)
	Technological Opportunities	Availability of computers helpful for accessing support & information	2	(555,556,559)
Housing	Close geographic proximity to community places & services	proximity to services, facilities and transportation services provides opportunities for community engagement, accessibility & reduces isolation	3	(552,560,563)
	Suitable housing and services	Age-friendly homes, assisted living and home care services are beneficial and promote wellbeing	3	(552,554,563)

Physical Environment Facilitators	Positive Aesthetics	Aesthetics, cleanliness & positive living environments	6	(117,558,560,563,564,567)
	Availability of facilities	Availability of toilets, drinking facilities and sufficient seating & benches for places to rest and socialise, especially during summer	8	(117,304, 550,555,558,563,564,567)
	Well-maintained infrastructure	Well-maintained paths enable walking and mobility, both in summer and winter	7	(304,550,552,555,558,564,567)
	Green & blue recreational spaces	Parks, public green spaces, gardens, and seashore are valued recreational spaces	6	(117,552,555,558,566,567)
	Ramps & Railings	Enable mobility in outdoor spaces	3	(558,563,564)
Social activities and participation	Accessible, convenient & frequent social activities	Encourage contribution, meaningful involvement, social connections, & reduces isolation, particularly volunteering activities	9	(552,556,558-561,563,565,566)
	Intergenerational social activities	Availability of intergenerational activities encourage connection with others	3	(556,558,566)
	Cross-cultural activities	Availability of cross-cultural social activities beneficial for migrant communities	4	(552,560-562)
Transportation	Convenient, affordable and accessible public transport and infrastructure	Availability of public and community transport vital for independence, transportation mobility and ageing-in-place	6	(71,553,555,556,558,564)
	Living Central	Living central to transportation services beneficial for accessibility	2	(71,553)

	Accessible parking	Low cost and accessible parking enables transport mobility and time spent in recreational spaces	2	(558,563)

Comparison of the 13 themes with the WHO's 8 features and descriptors presented on the essential features of age-friendly cities checklist

Table 17. Urban environment themes from the 20 included studies that map or add to the WHO Essential Features Checklist of Age-friendly Cities. *Note: (1)Green = Facilitator themes; (2) Red = Barrier themes; (3) The columns greyed out did not have any themes present in the 20 studies that matched the WHO features or description.*

WHO Essential Features of Age-Friendly Cities	WHO Description of age-friendly features Description (WHO, 2007)	Theme	Subtheme	First order theme	Refs
Outdoor spaces and buildings	***Barriers***				
	Clean & pleasant public areas	*Physical environment barriers*	Negative aesthetics in outdoor spaces	Unclean, disorderly, and displeasing physical environment	(304,564,566,567)
	Seating is well-maintained, safe & sufficient		Unavailable facilities	Lack of suitable toilets, facilities for drinks, benches & suitable seating, particularly in summer	(117,304,553,555,558,559,564,567)
	Public toilets are sufficient in number, clean, accessible & well-maintained				
	Pavements are well-maintained, free of obstructions, reserved for		Unmaintained or unsuitable infrastructure	Poorly maintained infrastructure, pavements and presence of obstacles,	(117,304,558,563,564,566,567)

	pedestrians, non-slip, wide enough for wheelchairs, dropped curbs at road level.			particularly during winter	
			Unsuitable routes & outdoor spaces	Poor walkability, unsafe and inaccessible routes or outdoor spaces	(556,558,567)
	Pedestrian crossings are sufficient in number, safe, non-slip, visual & audio cues, adequate crossing times		Absence of signage and crossing facilities	Lack of crossing facilities and signage for wayfinding and traffic related safety, particularly a danger for those with visual and physical impairments	(304,551,556,558,564,566,567)
	Drivers give way to pedestrians.				
		Transportation	Increased flow of traffic	Producing unsafe spaces and hazards difficult to navigate	(551,556,558)
	Outdoor safety promoted through lighting, police patrols & community education.	*Safety & Security*	Crime & Vandalism	Reduces feeling of safety and time spent outdoors in urban areas	(558,563,566)
	Services are accessible & situated together	*Accessibility*	Physical access to amenities and facilities	1. Physical and disability-friendly	(71,304,551,553,558,560,563,565,567)

	Special customer service arrangements for older adults			accessibility to local buildings 2. Health Services 3. Community services 4. Shopping facilities 5. Senior centres 6. Activities & social gatherings	
	Facilitators				
	Clean & pleasant public areas	*Physical environment facilitators*	Positive Aesthetics	Aesthetics, cleanliness & positive living environments	(117,558,560,563,564,567)
			Green & blue recreational spaces	Parks, public green spaces, gardens, and seashore are valued recreational spaces	(117,558,567)
	Seating is well-maintained, safe & sufficient		Availability of facilities	Availability of toilets, drinking facilities and sufficient seating & benches for places to rest and socialise, especially during summer	(117,304,550,555,558,563,564,567)

	Pavements are well-maintained, free of obstructions, reserved for pedestrians, non-slip, wide enough for wheelchairs, dropped curbs at road level.		Well-maintained infrastructure	Well-maintained paths enable walking and mobility, both in summer and winter	(304,550,558,564,567)
			Ramps & Railings	Enable mobility in outdoor spaces	(558,563,564)
	Public toilets are sufficient in number, clean, accessible & well-maintained		Availability of facilities	Availability of toilets, drinking facilities and sufficient seating & benches for places to rest and socialise, especially during summer	(117,304,550,555,558,563,564,567)
	Services are accessible & situated together.		Ramps & Railings	Enable mobility in outdoor spaces	(558,563,564)
	Unmatched				
	Cycle paths separate from pavements & walkways				
Transportation	***Barriers***				
	Public transport costs are consistent, clear & affordable.	*Affordability*	Public Transportation	High costs of public transport	(556,559,563)

	Public transport is reliable & frequent.	*Transportation*	Unsuitable public transport infrastructure, system & scheduling	Lack of public transport, physical accessibility to transportation and unsuitable infrastructure a barrier to accessing services, facilities & social activities	(71,551,556,558,563-565,567)
	City areas & services are accessible by public transport, with good connections, well-marked routes.	*Transportation*	Unsuitable public transport infrastructure, system & scheduling	Lack of public transport, physical accessibility to transportation and unsuitable infrastructure a barrier to accessing services, facilities & social activities	(71,551,556,558,563-565,567)
	Transport stops & stations are convenient, accessible, safe, clean, well-lit, well-marked, adequate seating & sheltered.		Unsuitable public transport infrastructure, system & scheduling	Lack of public transport, physical accessibility to transportation and unsuitable infrastructure a barrier to accessing services, facilities & social activities	(71,551,556,558,563-565,567)

	Voluntary transport is available when public transport is limited.		Reliance on driving and social networks	Lack of public transportation creates pressure for driving and reliance on social networks	(71,556)
	Traffic signs & intersections are visible.	*Physical environment barriers*	Absence of signage and crossing facilities	Lack of crossing facilities and signage for wayfinding and traffic related safety, particularly a danger for those with visual and physical impairments	(304,551,556,558,564,566,567)
	Facilitators				
	Public transport is reliable & frequent.	*Transportation*	Convenient and accessible public transport and infrastructure	Availability of public and community transport vital for independence, transportation mobility and ageing-in-place	(71,553,555,556,558,564)
	Specialised transportation available for disabled people				
	Voluntary transport is available when public transport is limited.				
	Parking & drop-off areas are sufficient, safe & convenient, with		Accessible parking	Low cost and accessible parking enables transport mobility and time	(558,563)

	priority for people with special needs.			spent in recreational spaces	
	Unmatched				
	Vehicles are clean, well-maintained & not overcrowded.				
	Drivers stop at designated areas to facilitate boarding				
	Accessible information is provided about transport.				
	Taxis are accessible & affordable.				
	Roads are well-maintained, free of obstructions.				
Housing	Barriers				
	Housing is sufficient, available, in safe areas & close to services & the community	*Accessibility*	Housing	Lack of accessible housing	(554,560,563,567)
	Sufficient & affordable home maintenance and	*Affordability*	Housing	Lack of affordable housing creates a financial barrier,	(554,556,560,563)

	support is available.			particularly for ageing-in-place	
	Sufficient & affordable housing for frail & disabled older people is provided with appropriate services.				
	Facilitators				
	Housing is sufficient, available, in safe areas & close to services & the community	*Housing*	Close geographic proximity to community places & services	Close proximity to services, facilities and transportation services provides opportunities for community engagement, accessibility & reduces isolation	(71,553,560,563)
	Sufficient & affordable housing for frail & disabled older people is provided with appropriate services.	*Housing*	Suitable housing and home services	Age-friendly homes, assisted living and home care services are beneficial and promote wellbeing	(554,563)
	Unmatched				
	Housing is well-constructed & provides safe & comfortable shelter.				

	Public & commercial rental housing is clean, well-maintained & safe.				
Social participation	***Barriers***				
	Good information is provided about activities & events.	*Accessibility*	Information about services	Services and organisations offering activities do not communicate or signpost information	(556,559,563,567)
	There is a consistent outreach to include people at risk of social isolation.	*Social isolation & exclusion*	Social Isolation in local community	Lack of connections & activities with neighbours or local community contributes to social isolation	(559,560,567)
	Facilitators				
	Venues for activities/events are convenient, accessible, well-lit & easily reachable by public transport.	*Social activities, participation & network*	Accessible, convenient & frequent social activities	Encourage contribution, meaningful involvement, social connections, & reduces isolation, particularly volunteering activities	(556,558-561,563,565,566)

	Wide variety of activities are offered that appeal to a diverse population of older people.	*Social activities, participation & network*	Intergenerational social activities	Availability of intergenerational activities encourage connection with others	(556,558,566)
			Cross-cultural activities	Availability of cross-cultural social activities beneficial for migrant communities	(560,561)
	Gatherings including older people are held in various local community spots.	*Community Support*	Availability of services & facilities	Availability of shops, cafes & 'third places' such as libraries, particularly useful during winter and for social links	(554,558,563,564,567)
	Unmatched				
	Activities/events can be attended alone or with companions.				
	Activities are affordable with no additional costs.				
	Barriers				
Respect and inclusion	Older people are recognised by the community for their contributions.	*Community Support*	Community respect and inclusion	Community unsupportive, disrespectful and	(71,553,556,565)

				devalue older adult contributions	
	Older people who are less well-off have access to public, voluntary & private services.	*Affordability*	Health Services	Costs of health services too high and causing financial hardship and concern, especially for those ageing-in-place	(71,556,559,563)
			Housing	Lack of affordable housing creates a financial barrier, particularly for ageing-in-place	(554,556,560,563)
			Public Transportation	High costs of public transport	(556,559,563)
	Unmatched				
	Older people are regularly consulted by public, voluntary & commercial services.				
	Service staff are helpful.				
	Older people are visible in the media & are depicted positively without stereo-typing.				

	Older people are included in community activities for 'families'.				
	Community-wide settings, activities & events attract all generations by accommodation age-specific needs.				
	Services & products suit varying needs & preferences provided by public & commercial services.				
	Schools provide learning about ageing & older people.				
Civic participation & employment	***Facilitator***				
	A range of flexible options for older volunteers are available.	*Social activities, participation & network*	Accessible, convenient & frequent social activities	Encourage contribution, meaningful involvement, social connections, & reduces isolation, particularly	(556,558-561,563,565,566)

				volunteering activities	
	Unmatched				
	Qualities of older employees are well-promoted.				
	Decision-making bodies in public, private & voluntary sectors encourage & facilitate memberships of older people.				
	A range of flexible & paid opportunities for older people to work are promoted.				
	Discrimination on the basis of age is forbidden in hiring, retention, promotion & training of employees.				
	Workplaces are adapted to the needs of disabled people				
	Self-employment options are				

	promoted & supported for older people				
	Training in post-retirement options are provided for older workers.				
	Barriers				
Communication & information	Basic, effective communication system reaches residents of all ages.	*Accessibility*	Technological	Development of modern technology negatively impacts availability and accessibility of online information and availability of physical information	(551,556,559,567)
			Information about services	Services and organisations offering activities do not communicate or signpost information	(556,559,563,567)
	Regular & widespread distribution of information is assured, coordinated &		Technological	Development of modern technology negatively impacts availability and accessibility of	(551,556,559,567)

	central access is provided.			online information and availability of physical information	
	Regular information of interest to older people is offered.		Information about services Information about services	Services and organisations offering activities do not communicate or signpost information Services and organisations offering activities do not communicate or signpost information	(556,559,563,567)
	Oral communication accessible to older people is promoted.		Technological	Development of modern technology negatively impacts availability and accessibility of online information and availability of physical information	(551,556,559,567)
	People at risk of social isolation get one-to-one		Information about services	Services and organisations offering activities do not	(556,559,563,567)

	information from trusted individuals.			communicate or signpost information	
	Printed information is accessible to all individuals.		Technological	Development of modern technology negatively impacts availability and accessibility of online information and availability of physical information	(551,556,559,567)
	Electronic equipment has large buttons & big lettering				
	Wide public access to computers, internet at no minimal charge in public places.				
	Facilitators				
	Wide public access to computers, internet at no minimal charge in public places.	*Community Support*	Technological	Availability of computers helpful for accessing support & information	(556,559)
	Unmatched				
	Public & commercial services provide friendly, person-to-person service on request.				
	Print & spoken communication uses simple & familiar words &				

	straight-forward sentences.				
	Telephone services are accessible to all individuals.				
Community & Health services	***Barriers***				
	An adequate range of health & community support services are offered for promoting, maintaining & restoring health.	*Affordability*	Health Services	Costs of health services too high and causing financial hardship and concern, especially for those ageing-in-place	(71,556,559,563)
	Health & Social services are conveniently located and accessible by means of transport	*Accessibility*	Physical access to amenities and facilities	1. Physical and disability-friendly accessibility to local buildings 2. Health Services 3. Community services 4. Shopping facilities 5. Senior centres 6. Activities & social gatherings	(71,304,551,553,558,560,563,565,567)
		Transportation	Unsuitable public transport infrastructure, system & scheduling	Lack of public transport, physical accessibility to transportation and unsuitable	(71,551,556,558,563-565,567)

				infrastructure a barrier to accessing services, facilities & social activities	
	Clear & accessible information is provide about health & social services to older adults.	*Accessibility*	Information about services	Services and organisations offering activities do not communicate or signpost information	(556,559,563,567)
	Economic barriers impeding access to health & community services are minimised.	*Affordability*	Health Services	Costs of health services too high and causing financial hardship and concern, especially for those ageing-in-place	(71,556,559,563)
	Facilitator				
	An adequate range of health & community support services are offered for promoting, maintaining & restoring health.	*Community Support*	Availability of services & facilities	Availability of shops, cafes & 'third places' such as libraries, particularly useful during winter and for social links	(554,558,563,564,567)
			Community-based programmes, neighbourhood	Encourages and provides support to older adults	(554,558,561,563,565)

			associations and religious institutions		
			Intragenerational programmes and communities	Senior-specific programmes & community of people the same age promotes health, wellbeing & independence	(556,560,563)
	Home care services include health & personal care & housekeeping.	*Housing*	Suitable housing and home services	Age-friendly homes, assisted living and home care services are beneficial and promote wellbeing	(554,563)
	Residential care facilitates and older people's housing are located close to services & the community.	*Housing*	Close geographic proximity to community places & services	Close proximity to services, facilities and transportation services provides opportunities for community engagement, accessibility & reduces isolation	(71,553,560,563)
	Voluntary services by people of all ages are encouraged & supported.	*Social activities, participation & network*	Accessible, convenient & frequent social activities	Encourage contribution, meaningful involvement, social	(556,558-561,563,565,566)

				connections, & reduces isolation, particularly volunteering activities	
	Unmatched				
	Delivery of services is coordinated & simple.				
	Staff are respectful, helpful & trained to serve older people.				
	Sufficient & accessible burial sites are available.				
	Community emergency planning takes into account the vulnerabilities & capacities of older people.				

Appendix 3

Urban Barrier and Facilitator Themes Diagram

(1) Discussion Group

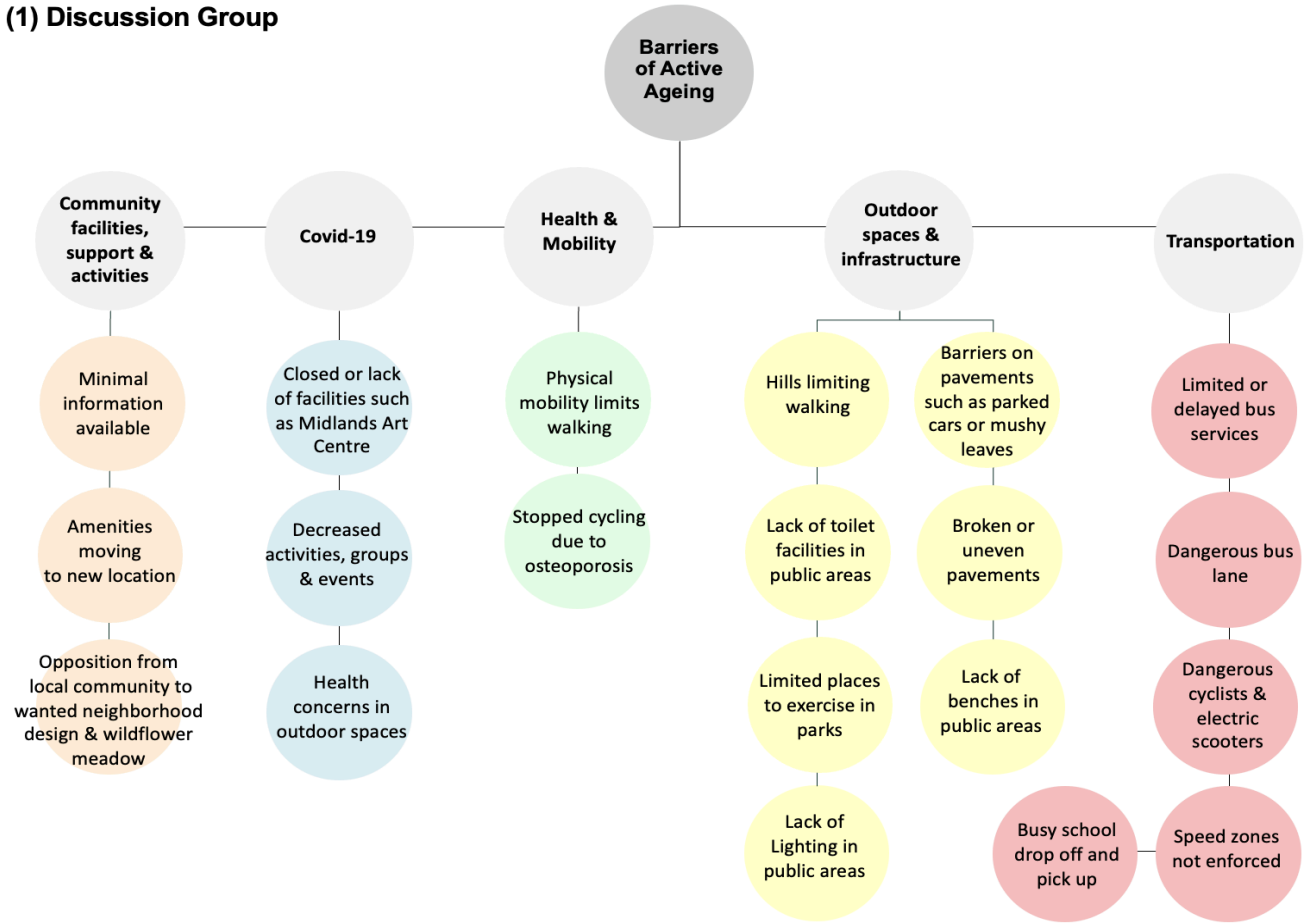


Figure 30. Example of barrier themes diagram shared with citizen scientists

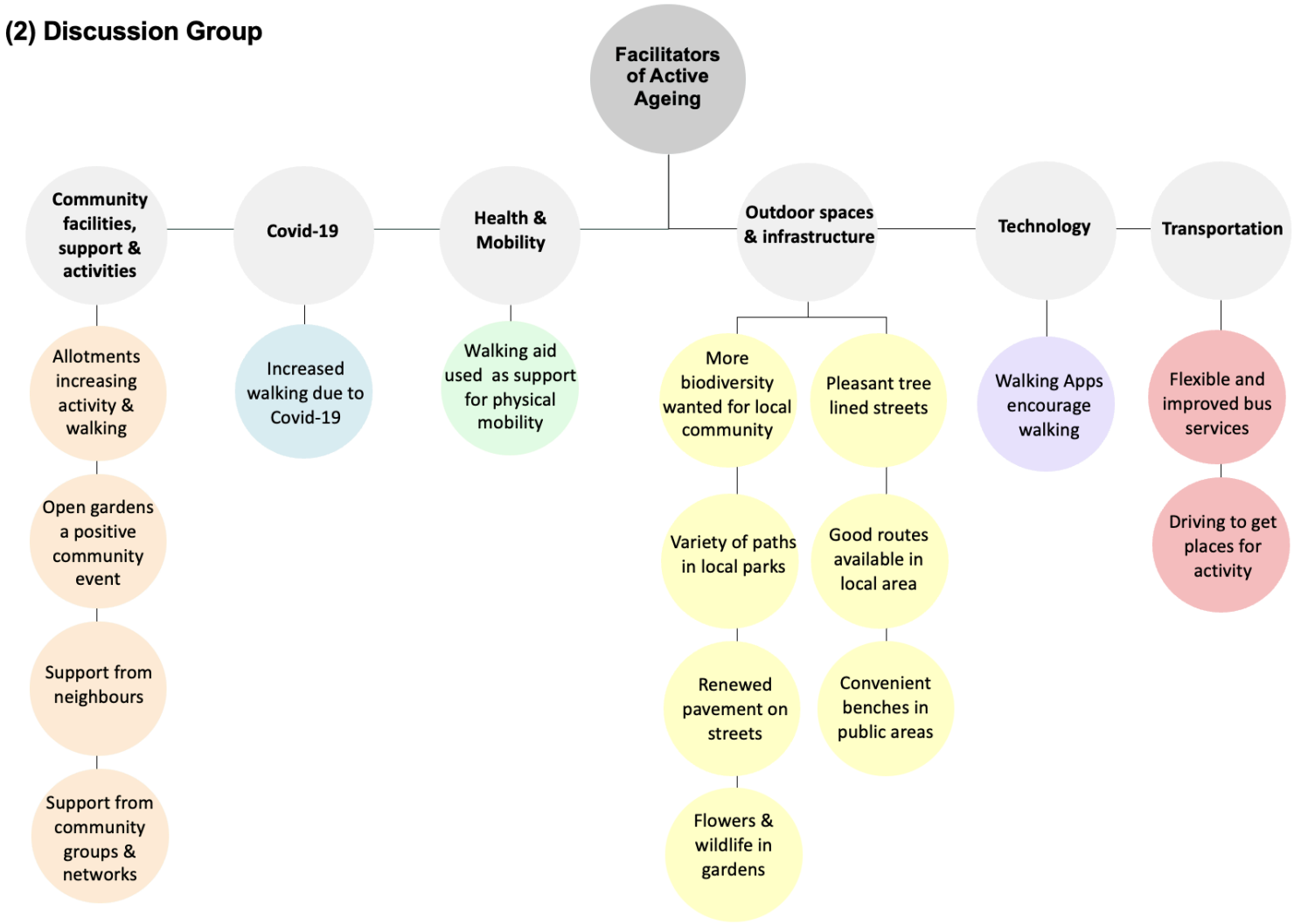


Figure 31. Example of facilitator themes diagram shared with citizen scientists

Common thematic trees of older adult and community stakeholder discussion groups

Table 18. Common thematic trees of older adult discussion groups.

Main Thread	Main Themes	Subthemes	Codes
Barriers of active ageing	Community facilities, support & activities	Lack of information	Minimal information available
			Information unavailable
			Information not communicated
			Feeling cut off
			Physical information unavailable
			No vehicle for providing Information
			Privatised services reducing Information
			No advertisement of information
			Minimal information for public toilets location
			Information out of date
		Lack of suitable and accessible facilities, venues & services	Doctors surgery moving to new location
			Pelican crossing wanted to reduce traffic
			Council services lacking
			Council services only completed if there is a danger
			Local access & provision to health care services needed
			Health care services not good enough
			Venues too expensive
			No age-friendly access
			Access not a priority to council
			Handyman needed for support at home
			Improvements too expensive
			Waiting list to access allotment

		Few vegetarian Indian restaurants
	Opposition from local community to neighbourhood design	Opposition to neighbourhood design
		Opposition to uncut verges
		Opposition to wildflower meadow
		Opposition against trees
		Opposition to public art
	Lack of age inclusive activities and adult educations	Limited age profile for activities
		Difficult to engage with younger people
		Need more age inclusive projects
		Limiting social and physical activity
		No funding available
		No common place to meet up
	Lack of funding and individuals for community groups	Not easy to find funding
		Running out of funding
		Small base of individuals running groups
	Costs of activities	Costs are too high
	No social support for activities	No one to do activities with
Covid-19	Closed or lack of facilities	Closed art centre
		Closed cafes, restaurants & shops
		Unavailable facilities for drinks or rest breaks
		Takeaway only
		LGBT centre closed
		Concern for groups not re-opening
		Unavailable information for toilets
		Leisure centre not running activities
		Cleaning of facilities
	Decreased activity, groups & events	Cancelled events
		Limited locations for walking

		Reduced cycling due to closed destinations
		Boring zoom events
		Not going anywhere
		Not going out due to isolation
		Reduced walking
		Can’t attend community groups
		Can’t meet friends
		Reduced travelling
		Missing in-person activities
		Reduced exercise
		Community groups stopped
		Reduced time outdoors due to increase of people
		Reduced activity due to health risk
		Less active due to covid
	Health concerns	Concern for safety on transport
		Reduced visibility due to face masks
		Concern for being close to school children
	Reduced community & social support	Can’t attend hospital appointments
		Haven’t got enough social friends
		Can’t help neighbours
		No face-to-face support with digital technology
	Safety & Crime	Increase of crime due to Covid-19
		Covid-19 rules not followed
	Second lockdown	Negative impact on health and wellbeing
	Bad weather	Decreasing exercise
Health & mobility	Activity limitations due to health	Walking limitations
		Osteoporosis stopped cycling
		Inactive due to health condition

			Personal limitations stopping exercise
	Outdoor spaces & infrastructure	Barriers on pavements	Blocked by cars
			Blocked by businesses
			Broken and uneven pavements
			Curbs causing injury
			Curbs not suitable for wheelchair users
			Hazardous leaves
			Muddy pathways slippy
		Commonwealth games impacting outdoor spaces	Closed off footpaths
			Making park muddy
			Moving and rebuilding infrastructure
		Limited facilities, activities & paths in parks	Empty park
			Unavailable facilities for food or sitting
			More lighting needed
			Events needed
			Lack of variety of paths & places to exercise
		Cleanliness of outdoor spaces	Cleaning of streets needed
			Spaces not aesthetically pleasing
			Dirty environment due to litter
			Fly tipping
		Lack of suitable lighting	More lighting needed
			More street lighting needed
			Current street lighting unsuitable
			Lighting needed to feel safe
			Unsuitable lighting for health and mobility impairments
		Lack of suitable benches & toilets	More benches needed
			Unsuitable Benches
			Areas poorly supplied with benches

			Availability of Toilets
			Toilets used for other purposes
			Lack of toilet facilities in parks
			Fear of no toilets
			Journey planned for available toilets
			Using supermarket or shopping centre toilets
			Unsuitable and low standard toilets
		Lack of care & responsibility for green spaces	No responsibility taken
			Pockets not adopted
			Green spaces vandalised and littered
		Safety in outdoor & green spaces	Crime in parks
			Need to feel safe
			Not safe for children
			Unsafe to walk alone
		Unsuitable design of built environment	Discourages older people from going out
			Design disabling older adults
			Narrow steps take time
			Design unsuitable and claustrophobic
			Road design reducing feeling of community
			Pelican crossing wanted to reduce traffic
			Hills limiting active transport
			Road construction not improving roads
		City centre	Dislike for town
			Feeling unsafe
			Lack of things to do
			Lack of Parking
	Transportation	Public transportation	Dangerous bus lane
			Limited or delayed bus services
			Underused bus service

		Not good for connecting between areas
		No information for times or routes
		No technology on buses
		No access to public transport
		Removing guards from train
		Unreliable services
	Traffic & private transportation	Dangerous cyclists
		Hazardous electric scooters
		Unsafe to cycle on roads
		Busy school drop off and pick up
		Speed zones not enforced
		Drivers not following rules
		Too many cars
		More traffic and parking restrictions needed
		Parking causing traffic
		Traffic calming measures making traffic worse
		Parking on pavements and Verges
		Cars speeding
		Dangerous electric and mobility scooters
		Not enough parking
		Cyclists are annoying
	Air quality due to traffic	Air quality a health hazard
	Cost of Driving	Driving too expensive
Technology	Digital Exclusion	Digital literacy important
		Ability to use technology needed
		Difficult for older people to use
		Not coping with digital technology
		Need to re-train

		Development of technology excluding older people
		Not Natural to Use
		Lacking confidence with digital technology
		Lack of access to technology & wi-fi
		Costs add up
	Negative multimedia	Reducing perception of safety
Crime & Safety	Feeling of crime and feeling unsafe outside	Cautious when outside
		Feeling unsafe due to closed facilities
		Staying home to feel safe
		Young boys intimidating and aggressive
		Carrying walking pole for safety
		Neighbour almost got mugged
		Fear of crime more destructive
		Fear of teenagers
	Dog walkers a danger	Dogs not on leads a risk
		Dog walkers not controlling dogs
Winter	Darker evenings	Reduced walking
		Feeling unbalanced
Ageing	Resources for older adults	Need to consider available resources
	Becoming isolated	Reduced social connections
		World becoming smaller
	Intergenerational challenges	Divide with younger people
		Difficult to engage with younger people
		More distanced from younger people
	Lack of support for retirement	Support focuses on pensions
		No awareness for going out
	Different abilities & confidence	Losing self-confidence due to frailty
		Older adults varied in abilities & confidence

	Ageism	Age inclusivity issues	Society needs to be more age inclusive
			Need to break down age barriers
		Negative perception & treatment of older people	Patronised due to age
			Viewed negatively
			Society tries to dictate older adults
Facilitators of active ageing	Community facilities, support & activities	Allotments increasing activity	Reason for walking & activity
			Reason for social and physical activity
		Aesthetics of allotments & facilities	Aesthetically pleasing allotments
			Local facilities look nice
		Support from surrounding community	Neighbours Help with gardening
			Neighbours helping and talking to neighbours
			Churches providing Christmas decorations
			Churches providing food and seating
			Enforcing car parking regulations
		Available local facilities & services	Cafes increasing walking
			Cafes providing toilets and seating
			Socialising at pubs and restaurants
			Health services available
			Shops & library available
			Walking to shops
			Good quality toilets in shops
			Supermarket toilets are useful
			Good access to health services and shops
			Free art centre
		Available & inclusive activities	Many arts events available
			Content with available activities
			Activities that are not ability led a positive
			Age inclusive groups

		Positive holiday events
	Positive community groups and events	Bournville magazine
		Community club member
		Litter picking
		Open garden events
		Increased socialising and walking
		Making a positive difference in local area
		Online community network
		Providing digital schemes for older people
		Building community cohesion
Covid-19	Increased outdoor activity during Covid-19	Exploring local area more
		Easy to walk in the summer
		Increased cycling and walking
		More inventive walks
		Increased walking
		Exercising outdoors
	Improved community facilities & support	Facilities providing toilets
		Changes to facilities imaginative and lively
		Shops more comfortable with distancing
		Improved health care system
		Increased community cohesion
		Socially distanced activities increasing community cohesion
		Love and care from local community
		Community Groups focused on re-engaging
	Connecting through Digital Technology	Keeping connected through Zoom
		Activities continued online
		WhatsApp increasing social support
Health & mobility	Support for walking	Walking aid a positive for activities
	More biodiversity wanted	Leaving uncut grass for biodiversity

	Outdoor spaces & infrastructure	Positive aesthetics and design of outdoor and green spaces	Aesthetically pleasing gardens
			Variety of design wanted
			Flowers & wildlife
			Private space to spend time
			Aesthetically pleasing tree lined streets
			Great asset to the environment
			Aesthetically pleasing area
			Beautiful green spaces
			Single track road more pleasant
			Dropped curbs are good
			Improving off road cycle routes wanted
			Beautiful houses & grounds
			Lovely green spaces
		Good routes, paths & pavements available	Grass paths encourage walking
			Pathways encourage walking
			Good variety of alleyways and snickets
			Renewed pavement chosen for walking
		Activity in outdoor spaces	Music events wanted
			Walking to link up spaces
			Activities available in local parks
			Increased cycling and walking
			Walking in parks
			Walking along the river
			Walking for wildlife
			Easy to cycle and walk
			Many places to go
			Outdoor spaces feel like countryside
		Safe outdoor spaces	Feeling safe in local area
			Lights increasing safety in parks
			Private estate very safe

		Feeling safe to walk
	Features & facilities convenient and improving spaces	Facilities available for all ages
		Public art brightens up places
		Seating outside is pleasant & lively
		Benches convenient for resting
		Flowers making a difference
	Positive infrastructure design	Single track road more pleasant
		Dropped curbs are good
		Improving off road cycle routes wanted
	Accessible green spaces	Green space within walking distance
		Local green Space available
Technology	Walking apps encourage activity	Encourage walking
	Digital technology providing information	Information available on google maps
	Increased connection, support & online activity	Connecting online and through WhatsApp
		Supporting neighbours through WhatsApp
		Online activities increasing exercise
Transportation	Driving	Get to places for activity
		Not driving encourages walking
		Only driving when necessary
	Public transportation	Flexible bus services
		Works well for travel
		Increasing walking
		Can manage without a car
		Easy to access
		Travel pass a positive
		Used for travelling to cities
		Accessible public transport
		Free pass increasing travel

			Used for physical & social activities
		Enforcing road regulations	Speed cameras slowing traffic
			Enforcing parking slowing traffic
	Diversity of city	Diversity of experiences and facilities	Variety of people and experiences
			Variety of cultural facilities and art activities

Table 19. Common thematic trees of two expert discussion groups.

Main Thread	Main Themes	Subthemes	Codes
	Lack of community facilities, support & activities	Lack of information	No Information for activities
			No information for available facilities
			Reducing community capacity & shared spaces
		Lack of support for activities	Individuals think they are forgotten
	Covid-19	Closed or lack of facilities and services	Low attendance reduces money for venues
			Closed churches
			Support & services vanished
			Fear of services spreading Covid-19
			Closed shops
			Facilities not re-opening due to economic impact
			Decreased physical & social activity
		Deskilled individuals	Individuals deskilled due to Shielding
		Reduced activity	Couldn't buy a bike
			Decreased socialising
			Older adults not leaving home

		Issues with digital technology	Lack of access to technology & wi-fi
			Not a priority to older adults
			No face-to-face support available
			Digital exclusion
			Priority issue due to pandemic
		Re-engaging in activities post Covid-19	Anxiety for re-engaging
			Need to re-skill & re-enable people
			Need to feel safe indoors
			Worsening performance due to no training
			Less outdoor activities
			Not comfortable or confident leaving home
		Reduced use of public transport	Afraid to use public transport
			Limited availability of and capacity on buses
			Risk of covid-19
			Reliance on social network for transport
	Demographics	Gender differences impacts engagement & movement	Women take part more than men
			Gender difference for moving around
			Need comfortable places for older men
		Race & ethnicity impact active ageing	Different enabling factors for active ageing
	Deprivation & Poverty	Economic deprivation and poverty limiting older adults	Economic situation limits access to resources
			Cost of transport limiting travel
			Poverty a huge issue
		Level of deprivation a key barrier in Birmingham	Deprivation key barrier to tackle
			IMD greatest predictor of physical inactivity
	Technology	Digital exclusion	Limited or no access to technology
			Costs of wi-fi & devices
			Reactive digital policies
		Long term conditions impact activity	Predictor of physical activity uptake

	Health, mobility & person-specific barriers	Individual capacity & capability	Confidence & belief in capacity and capability
		Individual perception of barriers	Perception of risk
	Outdoor spaces & infrastructure	Need for inclusive spaces	Lack of wheelchair accessibility
		Perception of safety in outdoor spaces	Canals perceived as unsafe
			Green spaces have a bad narrative
		Lack of public seating	More public seating needed
		Lack of toilet facilities	Can't go far without a toilet
			Public toilets not available anymore
			People nervous when toilets are not available
		Barriers on pavements	Blocked by cars
			Unsuitable pavements for crossing
			Quality of footpaths impacts walking
		Different location experiences	Experiences based on location
			Inner and outer city have different experiences
		Lack of wayfinding in outdoor spaces	No signage for wayfinding
			Need to consider wayfinding for dementia
		Bubbled communities not mixing	Fear of visiting other communities
			Not mixing with other communities
		Varied accessibility to activities & green spaces	Varied access to green spaces
			Varied access to activities & opportunity to participate
		Size of Birmingham	Takes time & money to navigate
		Unsuitable infrastructure design	Infrastructure reduces safety
			Unsuitable crossing facilities
			Infrastructure designed for cars instead of people

			Reaching local amenities difficult due to lack of crossing facilities
			Road design splitting up communities
	Ageism	Negative perception & attitudes of older adults	Negative attitude towards older people
			Not respected or treated well
			Not viewed as valid contributors
		View of ‘older adults’ as a homogeneous group	Different needs & circumstances for different age groups
			Different travel & mobility Needs
			Heterogeneity and intersectionality
			Term ‘Older Adult’ needs more understanding
	Transport	Traffic & Private transportation	Transport is a wicked issue
			Speed of traffic
		Public Transportation	Transport is a wicked issue
			Unsuitable bus stops
			Perceived as awful & not good
			Perceived as unsafe & dangerous
			Not good at connecting across neighbourhoods
			Cost of public transportation
			Lack of use from older adults
			Shuttle bus cut due to funding
			Not connected radially
	Winter	Bad weather	Fear of slipping on snow
			Reduced activity in bad weather
	Planning & design of Birmingham	Planning & design issues	Planning lacks specificity & direction
			Gap between policy & what’s delivered
			Caveat for council to do what they want

			Planning documents are generic & open to interpretation
			No communication & cohesion between ward plans
			Lack of support & engagement for ward plans
	Safety	Barrier for mobility	Safety a mobility barrier for older adults
Facilitators of active ageing	Approaches to increasing engagement and participation	Gamification for increasing engagement and participation	Competitive element for greater uptake
			Fun games for increasing activity
			Extrinsic value & rewards
		Age inclusive activities	Not identifying as 'older adults'
			Self-worth from joining and contributing
		Local neighbourhood approach	Keeping individuals connected & active
			Cheaper than other activities
			Using local assets for activities
			Keeping it local
		Participant lead	Doing something for others
			Leading & running activities
			More meaningful to the Individual
	Community facilities, support & activities	Comfortable & safe facilities	More comfortable in churches & community facilities
			Feeling safe in pubs
		Facilities encourage activity	Brand new leisure centre
			Opportunities to take part
			Facilities offering drinks
		Community assets and activities available	1400 assets & activities available
			Self-sustaining community activities
			Music activity encourages physical activity

			Activities happening across the city
		Support from community schemes	Online classes increasing confidence
			Working with digital technology
			Improving infrastructure for active travel
			Improving local parks
			Supporting community assets & needs
			Improving engagement and accessibility in open spaces
			Removing barriers in open spaces
			Older adult focused schemes
			Providing bikes for cycling initiative
		Social & companionship support	Social element bringing people together
			Building social connections through activities
			Sociability just as important as physical activity
			Engaging in activities for companionship
		Community & stealth activities available	Self-sustaining community activities
			Music activity encourages physical activity
			Activities happening across the city
	Covid-19	Digital technology providing support	Community support through technology
			Individuals becoming more digitally active
			Online activities increasing confidence & support
			Support & services moved online
			Making digital technology accessible
		Increased outdoor activity due to Covid-19	Exploring neighbourhoods
			Increased gardening
			Increased walking and cycling

			Staying active through online fitness and dance
		Increased local community & social support	Deepened friendships through Covid-19
			Increased community cohesion & support
			Support from neighbours with transport
			Support from volunteers to keep connected
			Individuals with mental health conditions reconnecting
			Positive re-connections with others
		Adapting services post covid-19 instead of restarting	Adapt current services instead of starting again
		Re-engaging face-to-face activities, support & services post-covid-19	Picking up Services, volunteering & support again
			Making activities safe
			Need for more cooking classes
			Enabling local neighbourhood activities to continue
		Keeping people connected post-covid-19	Findings ways to keep people connected
			Using socially distanced activities
	Outdoor spaces & infrastructure	Activities in outdoor spaces	Available parks & open spaces
			Community assets running activities
		Positive aesthetics and well-kept outdoor spaces	Nice green space
			Well-kept canal tow paths encourages activity & feeling Safe
		Inclusive changes to design & infrastructure	Design changes interesting & engaging
			Making facilities such as toilets and seating accessible positive for all age groups
		Narrative of outdoor spaces	Need to change narrative of green spaces

		Wayfinding & signs	Improving signage increases exploration & wayfinding
	Transportation	Low traffic neighbourhood	Encourages physical activity
		Public transportation	Perceived as good
			Perceived as safe
			Frequent bus service
			Good for going to town
		Social network & private transport	Driving or social network used for journeys

Appendix 4

Citizen Scientist and Stakeholder Demographics

Table 20. Citizen scientist and stakeholder demographics and the stages in which they engaged

Citizen scientists and stakeholder demographics					Project Stages			
Citizen Scientist	**Sex**	**Age**	**Ethnicity**	**Educational Level**	**1**	**2**	**3**	**Member Checking**
1	M	68	White British	University	X	X	X	X
2	M	65	White British	Postgraduate	X	X	X	X
3	F	77	White British	Postgraduate	X	X	X	X
4	F	63	Asian British	College	X	X	X	X
5	F	78	Mixed White American	Postgraduate	X	X	-	X
6	F	84	White European	Postgraduate	X	X	X	X
7	M	88	White European	Postgraduate	X	X	X	X
8	F	70	White British	High School	X	X	X	X
9	M	70	White European	Postgraduate	X	X	X	X
10	F	62	White British	Postgraduate	X	X	X	X
11	F	67	White British	High school	X	X	X	X
12	F	71	White European	Postgraduate	X	X	X	X
13	M	73	White British	University	X	X	X	X
14	F	75	White British	High school	X	X	X	X
Stakeholder	**Sex**	**Age**	**Ethnicity**	**Organisation**				
1	F	-	-	Joint Venture Charity	-	-	X	X
2	F	-	-	Birmingham City Council	-	-	X	X

3	M	-	-	Constituency based network	-	-	X	X
4	F	-	-	Constituency based network	-	-	X	X
5	F	-	-	Voluntary Service Council	-	-	X	X
6	F	-	-	Lesbian, Gay, Bisexual and Trans Communities Charity	-	-	X	X
7	F	-	-	Housing Association	-	-	X	X
8	M	-	-	Housing Association	-	-	X	-
9	M	-	-	Local Councillor	-	-	X	X
10	F	-	-	Community Benefit Society	-	-	X	-
11	M	-	-	Town Centre Manager	-	-	X	X
12	F	-	-	Local Councillor	-	-	X	X
13	M	-	-	Birmingham City Council	-	-	X	X
14	F	-	-	Birmingham City Council	-	-	X	X
15	M	-	-	Private Company for housing and social inclusion	-	-	X	X

City-wide recommendations and their similarities to the area-based recommendations

Table 21. City-wide recommendations and their similarities to the area-based recommendations

City-wide recommendations	Area-based recommendations	Similarities between city-wide and area-based recommendations
1. Provide funding for maintenance, services, and care for local spaces, green spaces in particular	1. Clear public pedestrian areas and footpaths of fallen leaves, bushy areas and cut back trees	The recommendations relate to the maintenance of local and green spaces and their features, such as cutting back trees, mending pavements and providing services to clean and develop these spaces further.
	4b. Maintain the development of beautiful green spaces across Birmingham	
	5a. Make walking areas in open and green spaces clean, pleasant, and well-maintained	
	6a. Mend and maintain pavements, and 6b.use tarmac rather than paving with slabs	
2. Provide toilets in public spaces, green spaces, and other local areas	2. Put in a café, toilets, and community hub for a community space at the local park	The recommendations relate to providing public toilets in local and green spaces
	3. Make public toilet facilities available in public and green spaces	
	4a. Provide greater access to public conveniences	
3. Enforce and regulate parking in local areas	7b. Provide stronger enforcement of drivers who park their cars in local areas	The recommendations relate to enforcing parking in local residential areas
	8. Stop drivers who park their cars in local areas for school pick-up and drop-off in resident cul-de-sac	
	9. Provide stricter enforcement of speeding cars and a 20mph speed limit in residential areas	
	10a. Stop drivers who park their cars on pavements	
4. Provide access to local information, resources, including digital and non-digital collective information points	N/A	N/A
5. Improve green spaces and communication from council services	1. Clear public pedestrian areas and footpaths of fallen leaves, bushy areas and cut back trees	The recommendations relate to a need for improved services in green spaces that can be provided by the city council, such as cleaning, development and maintenance
	4b. maintain the development of beautiful green spaces across Birmingham	
	12. Provide a plan for integrating communities that can support older and younger groups, employment services and provide maintenance of green spaces	

6. Improve and enhance community cohesion	11. Encourage local communities to be proud of their green spaces and how important they are to the environment	The recommendations relate to enhancing community cohesion, which include engaging local communities to care for their green spaces, be supported and have employment opportunities
	12. Provide a plan for integrating communities that can support older and younger groups, employment services and provide maintenance of green spaces	

Comparison of Implementation Framework Pathways (from *Our Voice* study) to WHO Age-friendly Cities Guide

Table 22. Comparison of the implementation framework, encompassing the six city-wide recommendations, and the eight topics identified by the World Health Organization Age-Friendly Cities Guide and Checklist (WHO, 2007a; 2007b).

City-Wide Recommendation	Implementation Framework Domain	Implementation Framework Action	WHO Domain	Differences
1) Provide funding for maintenance, services, and care for local spaces, and in particular green spaces	Local communities	- Develop a localism agenda - Volunteer - Actively Guide Councils	***Outdoor spaces and buildings*** - Pleasant and clean environment - Importance of green spaces that are well-maintained and safe - Age-friendly pavements including well-maintained, smooth, wide and non-slip pavements ***Civic participation and employment*** - Volunteering options for older people ***Respect and social inclusion*** - Listening to the voices of older adults	Although there are similarities to the domains listed and their guidance for maintaining outdoor and green spaces, they do not provide: - Specific types of maintenance i.e. cutting back trees, bin emptying etc. that have been identified by older adults in Birmingham - Actions across the multiple pathways at the local and city level - Individuals who can provide resources i.e. private sector volunteers - Pathways for funding
	Public health and planning	- Enable local groups to maintain spaces - Embed services into council programs - Use 'Match Funding'		

	Business and private sector	- Engage with private sector volunteers - Impose levy for green spaces events	- Trust and using capacities and life experience of older adults in decision-making.	- Pathways of achieving this maintenance i.e. developing a localism agenda, enable local groups to maintain services, engaging with private sector volunteers There is also the "community support and health services" domain but the community support listed by the WHO does not encompass the need for maintenance services in public and green spaces.
2) Provide toilets in public spaces, green spaces, and local areas	Local communities	- Fundraise as local groups - Fundraise to maintain public toilets	***Outdoor spaces and buildings*** - Adequate public toilets ***Respect and social inclusion*** - Intergenerational interactions and public education such as facilitating and educating awareness of ageing, including community education and primary schools - Listening to the voices of older adults - Trust and using capacities and life experience of older adults in decision-making.	Similarly as recommendation 1, there are universal matches between the recommendations and the domain for adequate public toilets. However, the WHO cities guide does not provide: - Actions to implement this in local communities and across a city, such as the community toilet scheme listed, or providing funding through local dynamic fundraising from local residents. - Individuals or organisations that can provide the resources for this.
	Public health and planning/ Business and private sector	- Community toilet scheme - Engage community assets - Provide good PR - Demonstrate shop incentives		

		- Reduce business rates - -Identify risks and resources		- Ways to elevate this recommendation further to public health policy There is also the domain of "community support and health services", but this does not encompass the support of public toilets in this section.
	Public health policy	- Re-educate younger people on public toilets - Marry-up issues of vandalism, young age groups and toilets		
3) More enforcement and regulation of parking in local areas	Local communities	- Report parked cars - Take part in school drop off pilot schemes - Take personal responsibilities	***Outdoor spaces and buildings*** - Traffic (Enforcement of traffic rules) ***Transportation*** - Transport drivers – drivers should be educated to the needs of older adults - Parking – inadequate and costly parking facilities are identified as barriers for older people	Transport drivers – although this discusses that drivers should be educated to be sensitive of the needs of older adults, this is not in-relation to parking on pavements and blocking accessibility. Similarly, parking discusses a need for suitable parking facilities but this in relation to parking space sizes, respect for parking bays required by older adults and proximity of spaces to buildings.
	Public health and planning/ Business and private sector	- Increase parking enforcement - Provide city care share scheme		

		- Generate developments that reduce car ownership - Tarmac pavements - Develop shared spaces	***Respect and social inclusion*** - Listening to the voices of older adults - Trust and using capacities and life experience of older adults in decision-making. -	This recommendation shows specificity to individuals across Birmingham, and actions to work on this further to implementing stronger parking enforcement. The recommendation and actions elevate the universal guidance further to provide actionable solutions across the different levels of a city.
	Public health policy	- Increase road tax - Charge households with more than one car - Reduce public transport cost		
4) Provide access to local information and resources, including digital and non-digital	Local communities	- Identify local information - Enhance what is already in place - Share information via word-of-mouth	***Social participation*** - Awareness of activities and events – older adults need to know about opportunities in order to participate. Events need to be communicated well.	The universal recommendations still need tailoring to specific local information required, understanding what is already in place, and the locations where information is valued by older adults i.e. providing libraries as a location for non-digital word of mouth, and

collective information point	Public health and planning/ Business and private sector	- Develop an active community infrastructure - Needs to be bottom-up - Use community assets - Provide local point of contact - Community notice boards - Engage local groups - Prioritise libraries for non-digital	***Respect and Social Inclusion*** - Trust and using capacities and life experience of older adults in decision-making. - Listening to the voices of older adults ***Communication and Information*** - Widespread distribution of information that reaches older people in their daily lives and activities through personal delivery, telephone and distribution in key locations. - The right information at the right time that is relevant and timely. - Will someone speak to me? Word-of-mouth is a principal and preferred means of communication for older adults and needs to be employed to provide info where older people gather together. - Information technology (boon and bane) where internet and computers are appreciated whereas excludes others.	ways to provide points of contact for sharing information. Developing an active community infrastructure is represented by the communication and information domain but in a universal way. The actions demonstrate a way to further elevate the recommendation and guidance to provide actionable solutions across the city level.

			- Printed information, oral communication and an offer of information are required.	
5) Green spaces and communication from council services needs to be addressed and improved	Local communities	- Devolve services to local-level - Engage with younger age groups/schools - Pro-actively lobby priorities	***Outdoor spaces and buildings*** - Pleasant and clean environment - Importance of green spaces that are well-maintained and safe - Age-friendly pavements including well-maintained, smooth, wide and non-slip pavements. ***Civic participation and employment*** - Volunteering options for older people ***Communication and information*** - Widespread distribution of information that reaches older people in their daily lives and activities through personal delivery, telephone and distribution in key locations. - The right information at the right time – relevant and timely information	- Similarities to the domains and their guidance for maintain outdoor and green spaces, but do not provide pathways of how to achieve this i.e. developing a localism agenda, enable local groups to maintain services, engaging with private sector volunteers. - Communication and information domain covers the widespread distribution of information, but the actions localise this to the need for councils to provide this communication. The universal guidelines could provide a pathway to do achieving this recommendation. - Although there is the domain of "community support and health services", this does not encompass the need for maintenance services in public and green spaces.
	Public health and planning	- Reduce volunteer risk adversity - Communicate baseline of services - Maintain non-digital services - Research cost gaps		

			- Information technology (boon and bane) – internet and computers are appreciated whereas excludes others - Printed information, oral communication and an offer of information are required. ***Respect and Social Inclusion*** - Listening to the voices of older adults - Trust and using capacities and life experience of older adults in decision-making.	
6) Improving and enhancing community integration	Local communities	- Build on what is already working - Encourage younger age groups/schools - Focus on localise solutions	***Outdoor spaces and buildings*** - Pleasant and clean environment - Outdoor safety is promoted - Services are situated together and are accessible ***Respect and social inclusion*** - Place within the community – having a voice in society and play a role.	Respect and social inclusion and social participation domain represents this recommendation at a universal level. The actions presented by older adults and stakeholders identify clearer pathways to achieving the respect and social inclusion, focusing on localised solutions, engaging younger age groups, and ways to foster community integration through city-wide projects, local streams of funding, bumping places etc.
	Public health and planning/ Business and private sector	- Connect with local assets - Develop city-wide projects to		

		encourage connections - Develop community shared spaces - Create 'bumping' places - Provide local streams of funding - Invest in community development	- Helpfulness of the community -helpfulness of people towards older adults and reasons why communities are more or less inclusive. - Listening to the voices of older adults - Trust and using capacities and life experience of older adults in decision-making. ***Social participation*** - Integrating generations, cultures and communities – opportunities to socialise and integrate with other age groups and cultures in their communities, activities and families. Intergenerational activities are desired. - Fostering community integration – facilities promote shared and multipurpose use by people of different ages/ local gathering places and activities promote familiarity and exchange among neighbourhood residents. ***Community support and health*** - Older people everywhere voice a clear desire for basic health and income support.	
	Public health policy	- Consider community integration a policy issue for a flourishing city - Remove bureaucracy for community events		

			- Public decision-makers and the private and voluntary sector at the city level do have an influence on the number, range and location of services and on other aspects of accessibility of facilities and services - Providing a network of local community services such as community centres.	

Appendix 5

CSAT Evaluation of the manuscript Employing citizen science to enhance active and healthy ageing in urban environments

Table 23. Detailed Overview of the Critical appraisal Outcomes of the Improving Your Local Area study

Author, Year	Question	Answer	Reason	Point
Wood et al. (2022)	1	Yes	The manuscript presents an overview of the aims as: 1) identifying urban barriers and facilitators that influence older adults' active and healthy ageing in the city of Birmingham; and 2) co-producing a set of relevant and actionable recommendations for improving local urban areas that can promote age-friendliness.	2
	2	Yes	The "*Our Voice* CS framework" was employed to engage older adults and community stakeholders as citizen scientists and co-produce the research.	2
	3	Yes	Citizen scientists were engaged in four stages, with the manuscript presenting three of the four stages. Their engagement included Discovery Tool Walks, Discuss Together Groups, and Discuss together Workshops, utilising a co-production CS.	2
	4	Yes	It is clear that the citizen scientists are engaged in the four stages to co-produce a set of recommendations for their local areas and identify their priorities, as well as who the recommendations should be shared with.	2
	5	Unclear	Although citizen scientists collect the data and are involved in member checking of the analysis and materials produced, they are not involved in the data analysis. Citizen scientists are also involved in disseminating the outcomes to chosen stakeholders at the workshop stage, but the dissemination of the end findings (the framework) is unclear and not reported.	1
	6	Yes	The manuscript reports a need to be representative of the population, as there was a small group of citizen scientists engaged who were mainly female and from a white English ethnic background, not being fully representative of the population of the superdiverse city of Birmingham. The manuscript reports that the recommendations are at the local and city- level, but it is unclear whether the health inequalities identified will be similar same across different communities.	2
	7	Yes	The findings highlight 12 area-specific recommendations, 6 city-wide recommendations, and an implementation framework for actioning the recommendations at the city-level.	2
	8	Yes	Although guided by the OV framework, the data collected at each stage and the recommendations identified were co-produced by citizen scientists as a collective group. Citizen scientists also identified their priority	2

			recommendations through the 6 city-wide recommendations and identified who they should be shared with to be actioned.	
	9	Yes	The recommendations are identified by citizen scientists for their local areas, and collectively for areas across the city, and can be implemented by stakeholders across the city. The implementation framework also identifies actions that can be undertaken across local communities, public health and planning, businesses, and public health policy, identifying the actors and the actions that could scale and undertaken these recommendations across the city.	2
	10	Unclear	Although the study does not report intention to track, it does highlight that "there was insufficient time and resources to fully engage citizen scientists and the multiple participating stakeholders in the final "action" stage". It also reports that this action stage would provide a "systematic evaluation of the cascade of impacts and outcomes that can occur over time as community members, stakeholders, and researchers together build efficacy as agents of change in their own communities". The method of ripple effect mapping is also identified as a way to continue to evaluate ripple effects, so avenues for doing this are identified. However, it is unclear whether this will be undertaken.	1
	11	Yes	An evaluation has been undertaken to explore the process, outcomes, successes and future improvements, which included an evaluation through an online survey and online interview with those engaged in the study. This evaluation was undertaken separately to this study and the PhD thesis and is currently in the process of being submitted as a manuscript outcome. The CS was undertaken within a time limit of PhD thesis, which created logistics in terms of completing the proposed steps and a realistic plan of evaluating.	2
	12	Yes	Supplementary material booklet – user-friendly version which was disseminated with older adults.	2
	13	No	There is no report of citizen scientists to review or participate in the study's publication processes	0
	14	Yes	The manuscript is currently under review for open access at Health & Place	2
	15	Yes	Citizen scientists are acknowledged in both the authorship and the acknowledgement sections of the manuscript	2
	16	Yes	The study provides a section called "strengths, limitations and future research" in which limitations are identified on the representativeness of the citizen scientists engaged, issues within the method relating to the Discovery Tool and its use by older adults, a consideration to "the extent to which health inequalities in different communities are driven locally", and the studies lack of resources and time to undertake the last step of the citizen method, which is change and long-term tracking and evaluation. The study also provides avenues to address and strengthen these limitations further.	2
Total Score = 28 (Medium-High)				

User-Friendly Age-Friendly Booklet

UNIVERSITY OF BIRMINGHAM | CENTRE FOR URBAN WELLBEING

Improving Your Local Area

Working together to make Birmingham more age-friendly



Produced by Grace Wood, Professor Afroditi Stathi and Dr Jessica Pykett in collaboration with Citizen Scientists and Community Stakeholders

Foreward

Improving Your Local Area



Improving your local area is an innovative public engagement project, conducted at the University of Birmingham, that explores urban influences directly impacting older adults' lives across Birmingham. With a focus on healthy and active ageing, we have collaborated with older adult citizen scientists and a range of community stakeholders in Birmingham to co-produce recommendations for improving local urban areas.

Acknowledgements

We would like to thank:

- the 17 citizen scientists who guided the project and co-produced its outcomes for their time, effort and input.
- the 22 stakeholders who engaged throughout the project for their time, effort and input.
- the University of Birmingham Public Engagement team who provided funding and support.
- the Stanford Our Voice initiative, Professor Abby King and Ann Banchoff for their support.

We acknowledge that the views presented are not representative of all older adults and community stakeholders across Birmingham.

About us

Grace Wood is a doctoral researcher from the West Midlands, researching the interactions between urban environments and active and healthy ageing through citizen science methods.

Professor Afroditi Stathi is an expert in the field of physical activity and community health with research expertise in the design and implementation of community-based, active ageing programmes.

Dr Jessica Pykett is a social and political geographer with research interests in governance, knowledge practices, policy innovation and political subjectivities.

Engagement

We would like to extend our thanks to the people listed below, as well as all other people who were engaged throughout the project.

Citizen Scientists

Ann Beattie	Ian Ellis	Harriet Martin	Sue Silk
Douglas Beattie	Aart Heesterman	Julia Morris	Nicholas Tulley
Robert Cummins	Wiebina Heesterman	Jean Phillips	
Valerie Edkins	Sharda Lavingia	Richard Phillips	
Jean Elledge	Viren Lavingia	Lucy Sobrero	

Community Stakeholders

Jessica Allan – Bournville Village Trust

Jo Bagby – Thrive Together Birmingham

Karen Bennett– Selly Oak Constituency Neighbourhood Network Scheme

Paul Campbell – Birmingham City Council

Karen Cheney – Selly Oak Constituency Neighbourhood Network Scheme

Councillor Liz Clements – Labour for Bournville and Cotteridge

Lauren Deere – University of Birmingham

David Elliot – Office for Health Improvement and Disparities

Ian Ellis – Selly Oak Constituency Neighbourhood Network Scheme

Theresa Gordon – Bournville Village Trust

Councillor Fred Grindrod – Labour for Bournville and Cotteridge

Harry Guildford – Bournville Village Trust

Maria Hughes – Birmingham LGBT

Helen Jenkins – Birmingham City Council

Ridhi Kalaria - Sustrans

Councillor Mary Locke – Labour for Stirchley Ward

Dr Carlo Luiu – University of Birmingham

Amy Parker – Birmingham City Council

Matt Powell - Kings Heath BID

George Unsworth - Mortar

Benita Wishart – Birmingham Voluntary Service Council

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Improving Your Local Area

Introduction



Improving your local area is a public engagement project that employed a citizen science co-creation approach to identify urban influences that impact active and healthy ageing across Birmingham. Citizen scientists aged 60 and above, alongside community stakeholders, were engaged to collaborate with researchers, direct the project, and co-produce outcomes for improving local urban areas.

Why Birmingham?

Although Birmingham is identified as having a younger population than the national average[1], by 2038 there will be an additional 43,700 individuals aged 65 and above in Birmingham. This is a 29.5% rise in those aged 65+ compared to a 6.5% for those aged 16 to 64[2]. In Birmingham, the healthy life expectancy for those aged 65 and above is also lower compared to the national average, with older men living only 8 years in good health and women living only 9[3]. To address these current trends, tackling the wider determinants of health, wellbeing and improving older adult lifestyles is key for healthy ageing[4].

It is well-understood that urban environments influence an individuals ability to be active and healthy as they age[4]. Birmingham Policy Commission's 2014 '*Healthy Ageing in the 21st Century*'[6] report identified the significance of physical and social environments for older adults health and wellbeing. What is still required though is a need for older adults to have a "louder voice"[6] in relation to their local environments and communities. In doing so, the local level pathways between urban features and healthy ageing can be identified and effectively shape the opportunity to live and age well.

Why 'Citizen Science'?



To incorporate the voices of older adults into initiatives for their local urban areas, approaches are required that can engage directly with these individuals. In doing so, local knowledge and experiences can be shared with decision-makers and community stakeholders to enable relevant and wanted initiatives to be developed.

Citizen science can engage local residents in all stages of a project to co-produce its processes and outcomes[7]. It enables residents to direct the focus of a project, collect their own data, and take part in participatory discussion processes to co-create outcomes and solutions. Citizen science has been effectively applied in health and urban domains, with local expertise of older residents directing relevant outcomes for altering local urban spaces to promote health and wellbeing[8].

Citizen Scientists and Location

Citizen Scientists

A total of 17 older adult citizen scientists were recruited via emails to community organisations and groups. Citizen scientists were engaged in the project from November 2020 to January 2022. The demographics of these individuals were:

- **Age Range** – 62 to 88 years (Mean age = 72, (7.5 SD))
- **Sex** – 11 Women and 6 Men
- **Ethnicity** – White British = 10, Asian British (Indian) = 2, White European = 4, and Mixed White American = 1
- **Work Status** – Retired = 14 and part time = 3

Location

Citizen scientists resided across 11 wards of Birmingham including:

- Shard End = 1
- Kings Heath = 2
- Sutton Four Oaks = 2
- Moseley = 1
- Selly Oak = 2
- Bournville & Cotteridge = 5
- Harborne = 1
- Acocks Green = 1
- Edgbaston = 1
- Perry Bar = 1

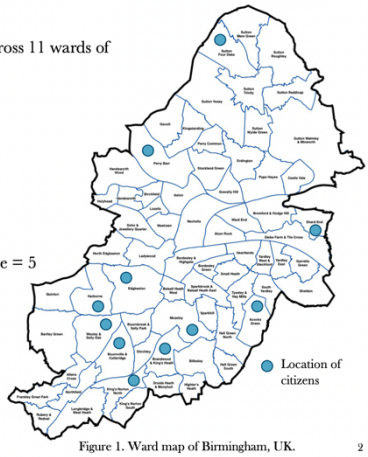


Figure 1. Ward map of Birmingham, UK.

Project Steps

The Improving Your Local Area project was based on the principles of the Stanford University *Our Voice Citizen Science Framework for Health Equity*[5] and followed four stages:

Stage 1
Discover Together
- Six online discussion groups to identify important urban features that influence healthy and active ageing
- Citizen scientists = 16
- Community stakeholders = 11

Stage 2
Discovery Tool Walks
- Twelve walks around local areas using the Stanford Discovery Tool mobile application on a tablet for citizen scientists to collect data
- Citizen scientists = 14

Stage 3
Discuss Together
- Three discussion groups to review walks, collective data and co-produce recommendations for improving local areas
- Citizen scientists = 14

Stage 4
Improving Your Local Area Workshop
- Two workshops to discuss and advocate recommendations with community stakeholders
- Citizen scientists = 14
- Community Stakeholders = 15







Stage 1- Discover Together Groups

Six Discover Together groups were held with 16 of the 17 citizen scientists and 11 community stakeholders, aiming to discuss the barriers and facilitators of active and healthy ageing in Birmingham. Due to Covid-19, the discussion groups were shifted from in-person to digital via Zoom online video calls.

Barriers and Facilitators to Active and Healthy Ageing

A total of 13 barrier themes and 8 facilitator themes were identified by citizen scientists and community stakeholders. The themes highlighted a range of interconnected and multi-level barrier and facilitator themes across urban spaces. Some themes matched between citizen scientists and stakeholders whilst others differed.

The themes covered different elements of **personal** (e.g. *health and mobility, ageism*), **environmental** (e.g. *outdoor spaces and infrastructure, transportation,*), **socio-cultural** (e.g. *lack or presence of community support and activities*), **economic** and **policy** (e.g. *transportation, technology*) domains of urban environments in Birmingham.



Figure 2. Urban barrier and facilitator themes influencing active and healthy ageing. Themes in green matched between older adults and stakeholders, whilst themes in purple and blue differed.

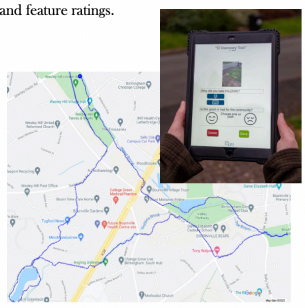
Some themes presented both a barrier and facilitator, such as *Covid-19*. This theme was highlighted to increase physical activity and time outdoors for some citizen scientists whilst reducing it for others due to health risks.

Stage 2 - Discovery Tool Walks

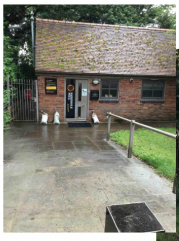
Twelve Discovery Tool walks took place with 14 of the 17 citizen scientists across 11 wards of Birmingham. The *Our Voice* Discovery Tool facilitated citizen scientists to identify and collect data about their local areas through geotagged photos, audio and text comments, and feature ratings.

Discover Together Walks

Citizen scientists were asked to choose the walks based on meaningful and everyday locations they use in their local areas. Elements of local urban environments were identified as barriers or facilitators by citizen scientists along the walk. These were photographed, provided with text or audio comments, and rated good or bad for their local community.



Facilitators of Active Ageing





Barriers of Active Ageing



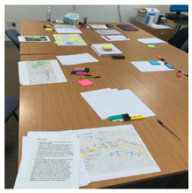


Examples include the presence of facilities and well-managed green spaces as facilitators, whilst poor air quality and broken pavements from parked cars were barriers.

Stage 3 & 4 - Discuss Together Groups and Improving Your Local Area Workshop

Stage 3 – Discuss Together Groups

Three in-person discussion groups were held with 12 of the 17 citizen scientists to discuss the data collected at stages 1 and 2. Two zoom online video discussions were also held with 2 citizen scientists. Each citizen scientist was invited to propose their own recommendation for their local area, which appear in appendix 1, and co-produce collective recommendations for improving urban areas of Birmingham.





Stage 4 – Improving Your Local Area Workshops



Two public engagement workshops with 14 of the 17 citizen scientists and 15 community stakeholders were held at The Exchange in Birmingham city centre. The 6 co-produced collective recommendations were discussed with stakeholders to develop ideas and feasible recommendations that can be actioned.



The following pages present the 6 co-produced recommendations and an ideas guide discussed with citizen scientists and community stakeholders for implementing recommendations through; 1) Local communities; 2) Public health and planning; 3) Businesses and private sectors; and 4) Public health policy.

Co-Produced Recommendations



1. "Provide funding for maintenance, services, and care for local spaces, and in particular green spaces"

What? To provide accessible and clean spaces.

Why? Increase or improve services including street cleaning, emptying bins more regularly, and incorporate care from local people and 'friends of parks' groups.

How? Cutting back trees and bushes from paths which prevents walking and cycling, and ensuring pavements are in good condition and curbs are easily visible.

When? All year round but with some maintenance services, such as street cleaning, particularly in winter.

Who? Active citizens, local community assets and groups, Birmingham City Council, local businesses and the private sector.

Ideas Guide

Citizen Scientist and Stakeholder Ideas	Guidance
Local communities	
"Prioritise important local services and spaces"	• Empower citizens to develop a localism agenda and resident associations
"Set up a small group of like-minded people to pull things together"	• Be active citizens to guide councils and MPs
"Suggestions of Brownie groups and schools, and social media galvanising a different kind of energy"	• Engage local volunteers and the community to provide maintenance and services
Public health and planning	
"The city council has got to let go and enable groups to do stuff ... if you want community activity, let communities get on with it."	• Work with and enable local groups to maintain spaces • Consult Friends of Parks groups with budgets • Connect with local assets and schools for maintenance services • Embed maintenance services into current council programmes • Engage with councils 'match funding' for projects • Provide equal distribution of funding to local groups • Develop more joined-up services
"There is an educational piece here for young people who can contribute to this"	
"There is a programme of leaf cleaning after the main leaf fall, if you get this into the programme, at least it will get a once over"	
Businesses and private sectors	
"Look at the volunteer resources that come from the private sector"	• Engage with private sector volunteers and services • Impose private sector levy for green space events
"A levy for private events ... that would create a pot of money that can be directly put back"	

Co-Produced Recommendations

2. "Provide toilets in public spaces, green spaces and local areas"

What? Provide greater access to public toilets in public spaces, high streets and green spaces.

Why? Older individuals can go to open spaces and drink water when they go out.

How? Provide accessible toilets and implement Community Toilet Schemes for access to toilets in shops and cafes.

When? All year round.

Who? Local groups, community stakeholders, younger age groups, local businesses and the private sector.



Ideas Guide

Citizen Scientist and Stakeholder Ideas	Guidance
Local communities	
"There is a group like friends of Cotteridge park ... and they have a really dynamic fundraising programme"	• Dynamic fundraising from local groups • Develop funding to maintain public toilets
"If you have community toilets you have to pay for, most people don't mind paying 20p ... it's a way of providing funding to keep them clean "	
Public health and planning and Businesses and private sectors	

"look at the wider benefits of bringing more people to the high street and developing relationships with local traders"	• Implement a **Community Toilet Scheme:**
	  • More effective for providing public toilets
	  • Engage community assets and high streets
	  • Provide good PR, signage and information
	  • Get feedback from areas already implementing the scheme
	  • Reduce business rates
	  • Demonstrate incentives for shops
	  • Identify the risks and available resources
	• Provide port-a-loos in green spaces

"Community toilet scheme is far more likely to be effective than expecting the council to put up public toilets"	
"shop keepers found they benefited from it, so people who were coming to the toilet or have a seat became customers"	
"one of our members of staff whose expert by experience and did some fantastic training around what to do for risks"	
Public health policy	
"If young people are doing this then there is a piece that goes back into education to show young people the knock-on effect of vandalism on toilets"	• Re-educate younger people on the importance of public toilets • Marry up issues of vandalism, younger age groups and public toilets

Co-Produced Recommendations



3. "More enforcement and regulation of parking in local areas"

What? Stop cars parking on pavements.

Why? Prevents pavements from being damaged and becoming a trip hazard and increases accessibility for walking and emergency services.

How? Stronger enforcement of cars parking on pavements, including in school zones, and use tarmac rather than slabs where pavement parking is required.

When? All year round.

Who? Active citizens, community stakeholders, schools, businesses and the private sector, Birmingham City Council and central government.

Citizen Scientist and Stakeholder Ideas — **Ideas Guide** — **Guidance**

"Do the reporting, you have got to do your bit"

"The primary school has a walking bus, there are 25 kids and parents drop them off in a local car park"

"It's a journey that we are all on and actually people have to start taking some personal responsibility"

Local communities

- Report drivers parking on pavements
- Introduce pilot schemes for school drop-off and pick-up
- Drivers taking personal responsibility

"Generating developments where owning a car is not essential"

"If we are going to reduce the number of cars then car share schemes have to be part of it"

"make it a genuine shared space... if it was just one surface level and bricked then people might feel more inclined to see it as a shared space"

"Tarmac one section and leave slab for the other so people can pull off without smashing pavement slabs"

Public health and planning and Businesses and private sectors

- Increase parking enforcement
- Introduce local parking campaigns
- Provide a city car share scheme
- Increase confidence in public transportation
- Generate developments that reduce car ownership
- Tarmac or use resin on small sections of pavements where there are no other parking possibilities
- Adding more double yellow lines
- Develop shared spaces between pedestrians and drivers
- Manage available parking better

"Impose a tax on households with more than one car"

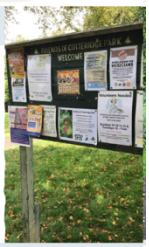
"Making public transport free and frequent might persuade people to not have a car"

Public health policy

- Increase road tax
- Charge households with more than one car
- Decrease public transportation costs

Co-Produced Recommendations

4. Provide access to local information and resources, including a digital and non-digital collective information point



What? Provide access to up-to-date information for relevant local resources, services and groups in Birmingham.

Why? Older individuals will feel connected and have access to much needed local information and support.

How? Develop one central collective point that provides up-to-date and accessible information for local groups and services. Libraries should be prioritised for non-digital access.

When? All year round.

Who? Local groups, community stakeholders, local businesses and the private sector, Birmingham city council and central government.

Citizen Scientist and Stakeholder Ideas — **Ideas Guide** — **Guidance**

"What do we mean by information...I think unpicking it [*the recommendation*] and thinking in terms of local community-based activity... thinking about things that are already in place and how to keep these up to date"

"Word of mouth is definitely still the best way people find out about good stuff ... conversation is much more important"

Local communities

- Identifying what relevant information is needed in local areas and enhancing what is already in place
- Word-of-mouth important for sharing information

"Having a wide active community infrastructure, that's libraries, community facilities, assets where people can go"

"Local places that become known as a source of up to date and current information become very valuable .. they are much better at connecting people"

"Projects older adults are involved in are super important, they share information out locally and people will chat to each other"

"if you have one central point that linked out to other places, it is going back to joined up thinking"

"It's got to be bottom-up, too much top-down and people don't pay attention"

Public health and planning and Businesses and private sectors

- Develop an active community infrastructure:
  - Needs to be bottom-up
  - Use community assets for information points
  - Provide local groups and points of contact
  - Use community notice boards
  - Link with GP services
  - Engage local groups and neighbourhood schemes
  - Prioritise libraries for non-digital information
- Facilitate a 'joined-up' thinking and sharing of local information

Co-Produced Recommendations



5. "Green spaces and communication from council services need to be addressed and improved"

What? Park ranger and park services have been reduced, and individuals are unable to contact correct departments or receive a response.

Why? Increase the maintenance, cleaning and accessibility of valued green spaces, and provide more proactive and connected council services.

How? More management and care of green spaces, including clearing footpaths and emptying bins, and provide an effective communication system between services and individuals.

When? All year round.

Who? Active citizens, local groups, Birmingham City Council and universities.

Citizen Scientist and Stakeholder Ideas — **Ideas Guide** — **Guidance**

"Some maintenance jobs volunteers are happy to do"

"Devolve it locally but it has to be funded somehow"

"make proactive use of councillors ... that is one way of engaging, and councillors get service contact links for services"

"a really active friends of parks group ... they are constantly lobbying to have the footways resurfaced"

Local communities

- Devolve some services to the local level
- Engage with younger age groups, schools and local groups for services
- Residents need to proactively engage with counsellors
- Local groups need to lobby priorities

"sometimes the council needs to be less risk adverse"

"the schools, the brownies and the guides, if you are getting children to maintain green spaces, they are more likely to use them"

"The best way to do this is in a planned maintenance way and not in a reactive way because reactive isn't going to cut it"

"If you get an answer to say we don't have a budget but it's on the list, that is all you want as it means you feel acknowledged"

"People in the 80+ bracket, it's not unusual to find they have no computer ... we have to maintain a way to engage with them"

Public health and planning

- Reduce council risk adversity to devolving services to volunteers
- Provide accessible and proactive services:
  - Maintain non-digital services
  - Make services more accessible and proactive
  - Provide a proactive communication system with responses
  - Communicate baseline of council services to set expectations
- Engage universities to research the cost gaps between resident needs and current services

Co-Produced Recommendations

6. "Improving and enhancing community integration"



What? Finding ways to integrate communities better across different age groups and ethnicities.

Why? Provide more connected communities that care for local areas and engage younger generations to continue the work older adults are currently doing in local spaces.

How? Develop a plan that has joined-up and long-term thinking for local services, supports all age groups and open spaces, and focuses on integrating younger people.

When? All year round.

Who? Active citizens, local communities and assets, businesses and the private sector, Birmingham City Council and central government.

Citizen Scientist and Stakeholder Ideas — **Ideas Guide** — **Guidance**

"Birmingham is a good city to be in...how do we hold up the stuff that is working and connect it better"

"Start from schools and young ages to teach about volunteering and getting involved in their community, it becomes a much more joined up community"

Local communities

- Build on what is already working in communities
- Encourage younger age groups and schools to engage and volunteer
- Focus on localised solutions

"encourage movement in communities, cross-community links and conversations"

"It's important for people to have these casual conversations...the concept of 'bumping places', a community centre, school gate, post office"

"creating spaces in which different parts of the community feel comfortable"

"community developer workers can help groups form but they can also be connectors"

"invest in community development to encourage people to form local groups"

Public health and planning and Businesses and private sectors

- Connect with local assets such as GPs
- Develop city-wide projects to encourage connections across communities
- Develop local community spaces:
  - Create community shared spaces
  - Creating 'bumping' places
  - Consider how people connect in spaces
- Invest in local communities:
  - Provide local streams of funding
  - Invest in community development and community development officers

"We need to include this in polices so that there are funding streams available and support"

"it's about removing bureaucracy, if people think there is too much red tape to organise an event, they won't bother"

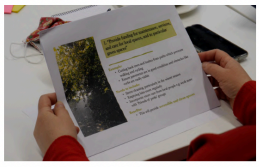
Public health Policy

- Consider community integration as a strategic policy issue for a flourishing city
- Remove bureaucracy to encourage local community events

Project Future Steps

Providing supportive local urban spaces is key for enabling individuals to be healthy as they age. The co-produced recommendations captured the voices of older adults and identified a range of interconnected urban elements that influence active and healthy ageing across Birmingham. The recommendations require consideration and alteration across the environmental, social, cultural, economic and political domains of urban areas as a way of promoting age-friendly spaces. The co-produced recommendations also fit well within the city's agenda for future actions, including 'Route to Zero' for tackling climate change, 'Our Future City Plan' for greener and inclusive growth, and as we continue to evolve from the impacts of Covid-19.

It is our aim that these recommendations are shared and implemented across local urban areas by community members, stakeholders and organisations as a way of promoting active and healthy ageing.



The project processes and resulting recommendations provide a strong foundation to further build on and engage the voices of a wider group of older adults across Birmingham. This is crucial for continuing to co-produce recommendations and initiatives that encompass a diverse range of voices, experiences and needs in urban spaces of Birmingham.

Measuring Impact

We would like to capture and measure the impact, dissemination and implementation of the co-produced recommendations. Please could you contact us if the recommendations are incorporated into literature, plans or actionable changes via the details below.

Contact Details

UNIVERSITY OF BIRMINGHAM

If you have any questions or would like to discuss the project or its outcomes further, please contact us via email: **urbanwellbeing@contacts.bham.ac.uk**

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Appendices 1

Co-produced recommendations for local areas



Local Co-Produced Recommendations

Each citizen scientist was invited to propose their own recommendation for their local area. The following section presents the recommendations proposed and represents the views of citizens scientists only.

Acocks Green — **Provide a plan for integrating communities that can support older and younger groups, employment services and provide park maintenance.**

- There needs to be consideration for a 'joined up' thinking about local services.
- The local authority and council, through central government funding, needs to make these changes for the greatest impact.
- This needs to be considered through long-term thinking.
- Local and non-political groups need to help make this change happen in local communities.

Kings Heath — **1)Re-think the setting of Low Traffic Neighbourhoods so that Kings Heath high street and other major routes move more freely, and 2) Stronger enforcement of parking areas.**

- This will 1) improve the air quality of local areas and produce less particulates, and 2) will make pavements accessible for wheelchair users, and prams/pushchairs.
- These changes need to be made on Kings Heath high street and surrounding streets.
- The changes need to be made urgently and have the involvement of local councillors and 'altruists' in the community.
- Possible solution: Putting in a one way system round Kings Heath.



Parked cars blocking pavement

Perry Barr

To encourage local communities to be proud of their green spaces and how important they are to the environment.

- If green spaces aren't used, the land will be sold for building. However, future families need to be able to access open green spaces.
- This change needs to happen with the council, parish councils and local communities, who need to come together to make a plan for green spaces.
- This needs to be done as soon as possible and everyone in the local community and neighbourhood needs to be involved.



Horse Chestnut Avenue in Perry Barr Park

Shard End

Clear pedestrian areas and footpaths (owned by the council) of fallen leaves, bushy areas and cut back trees.

- This will enable easy access and reduce falls, as well as reducing conflict between people and wheeled transportation e.g. prams, bikes, scooters.
- This change needs to be made along the 'country' park areas and side streets.
- This needs to happen in autumn and winter to clear the end of the year leaves and needs to be done by the parks department and road sweeping.



Route needs to be better managed, and bushes need to be cut back.

Bournville

Stop parking for school pick-up and drop-off in residential cul-de-sac

- This will make children 'more active' and reduce the congestion and pollution from cars.
- This change needs to be made by lots of schools to make the greatest impact and needs to be made as soon as possible.
- The local councillor, Bournville Village Trust and the school need to help make this change happen.



Narrow road to cul-de-sac where white lines have been put over drives, but this hasn't solved the problem.

Shenley Green

Put in a café, toilets and community hub for a community meeting space at Manor Farm Park.

- This would attract a wider range of users as other parks such as Rowheath park.
- This change needs to be made in the Manor Farm park car park area.
- Bournville Village Trust, Friends of Manor Farm Park, the city council, and the Cadbury Barn Trust all need to be involved to help make this change happen.

Positive Action

The Cadbury Barn Trust in partner with Birmingham School of Bell Ringing are currently in the process of providing a café and toilet facilities for Manor Farm Park[9]. More information available here

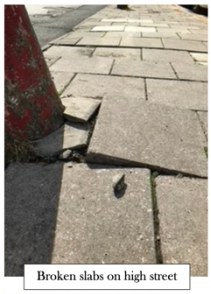


Area of car park which could be established to provide toilets and café facilities.

Cotteridge High Street

Pavements need to be mended and maintained.

- This is a health and safety issue, with 3 accidents occurring in one month due to the unsuitable pavement.
- This change needs to be made on the high street and is urgently needed to stop more accidents.
- The council, Kier, and shops who own the paving outside their shops need to help make this change happen.



Broken slabs on high street

Weoley Hill

There needs to be publicly available toilet facilities.

- Many people can't go to open spaces as toilets are frequently needed.
- This change needs to happen in green spaces and shopping areas.
- It needs to be budgeted for and have council involvement.
- Local community groups, campaigns and the council need to help make this change happen.



Green space in Weoley Hill that has no access to toilets

Kings Heath

1) Greater access for public conveniences, which is vital for older residents, and 2) Continued and maintained development of the beautiful green spaces across Birmingham.

- 1) Older residents need greater access to loos, and 2) The resources (including people) to maintain green spaces are dwindling – this must stop.
- Access to toilets is a general and ongoing issue.
- Birmingham City Council need to be involved to make these changes happen, but there could be solutions in local centres to encourage trade to allow people to use toilet facilities.



Unsuitable public toilet in Kings Heath

Bournville

1) Stop cars parking on pavements in areas where they don't need to park on pavements, and 2) The pavements should be tarmacked and not paved with slabs.

- This has been a recurring problem for over 40 years.
- Pavements should be tarmacked if cars and vans persistently drive over and park on them. Inevitably this means dangerous and broken paving slabs.
- Tarmacked strips between the slabs and the roads could also be used. If the strips are wide enough, this can stop slabs being broken up.
- This change needs to be done around many of the residential areas of Bournville.
- Local Councillors may be able to help communicate this issue to the local council.



Paving slabs loose and broken on a corner between Newant Road and a drive. The only solution here is tarmacking.

Moseley and Sparkhill

1) There is a need for clean and pleasant walking areas that are maintained, and 2) A bicycle pathway is needed in the Moseley and Sparkhill area

Recommendation 1)

- Areas are needed for walking, especially during and after the lockdown that have pleasant surroundings and are clean.
- When spaces are dirty, such as parks, individuals don't feel like walking there. This is important for those who can't do any other sort of exercise and rely on walking.
- The spaces need to be well-maintained by Birmingham City Council.

Recommendation 2)

- There needs to be a safe and well-connected cycling pathway to connect areas for those who want to cycle and be safe.
- Need to provide areas by pathways that allow individuals to cycle with enough room. For example, shop keepers need to remove their items and groceries for sale off the footpath outside their shops so that there is enough room.
- Individuals are not going to the gym as much due to Covid-19, so individuals want a safe space to cycle.

Bournville

Stricter enforcement of speeding cars and a 20mph speed limit in residential areas

- This is a recommendation for across Birmingham as well as local residential areas in Bournville and Weoley Hill.
- Solutions include 20mph zones, enforced with speed cameras, signs and more gradual speed bumps.
- This would need to include the police, as this requires the enforcement of law, and the city council to enforce this change.



20mph speed enforcement zone in a residential area of Bournville

