Use of Neighbourhood Open Spaces by Older Adults in Disadvantaged Communities - A Mixed Methods Study

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Odense 2019
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Submitted August 2019

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Acknowledgement:
The research presented in this thesis was funded by The Danish Foundation for Culture and Sports Facilities, The Velux Foundations, TrygFonden and the University of Southern Denmark

Front cover graphic: Tanja Bettina Schmidt
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Any fool can know. The point is to understand

~Albert Einstein
Preface and acknowledgements

The work presented in this thesis represents an independent research study carried out between September 2016 and August 2019 at the research unit for Active Living, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, and made possible by funding from The Danish Foundation for Culture and Sports Facilities, The Velux Foundations, TrygFonden and the University of Southern Denmark. A thank to the APEN/Move the Neighbourhood research team that have collaborated on the overall research setup and provided insight and expertise that greatly assisted the project: Rene Kural, Kamilla Nørtoft & Sidse Carroll, The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, Bettina Lamm, Anne Wagner & Laura Winge, University of Copenhagen and Jens Troeslen & Charlotte Skau Pawlowski, University of Southern Denmark.

Working on this project throughout the last three years has truly been an interesting and challenging process which unquestionably has made me a better researcher. The driving force throughout this journey has been my constant hunger towards learning new methods, theories and methodologies that could broaden my skills, insights and knowledge of older adults, the built environment and behaviour change. The quote by Albert Einstein highlights this journey from being a young pre-graduate student who loved to be in control, being systematic and organised about everything, focusing on quantitative research to know more and more. To finally become a researcher accepting that I can’t control everything, that changes will occur, and acknowledging the value of qualitative research to better understand people and their behaviour. Although moving into the field of mixed-methods research has truly broadened my insights into the value of knowing and understanding, I still have to learn a lot and will continue to do so by mixing qualitative and quantitative research.

There are several people I would like to thank for being part of this journey and my process of becoming a researcher. I wish to thank my team of supervisors Jasper, Lars and Jacqueline for providing support and guidance when needed throughout the last three years. A special thanks to Jasper for believing in me when you met me as a young master student, giving me the opportunity to become a pre-graduate research student, followed by research assistant and finally a PhD student. The last six years at the research unit for Active Living wouldn’t have been possible without you. Thank you for all the trips across the world.
which you made possible, introducing me to researchers and research networks, as well as for all the hours of guidance, feedback and discussions. Thank you Lars, for being the ‘bad guy’ providing thorough and critical comments when needed – especially during the last 3 months – and all the hours of discussions and feedback on one silly paper! Thank you Jacqueline, for inviting me to stay in San Diego and work together with your research unit. I learnt a lot from being part of your team at UCSD and helping you with your data collections. A special thanks for taking the time to have one-on-one sessions with me while I was in San Diego, and all the hours you’ve spent providing feedback on papers and the thesis. Your insight and knowledge of research in older adults and the built environment was indispensable. I would also like to thank Ester Cerin, for allowing me to visit you at ACU in Melbourne, and all the hours you have spent on teaching me statistics and helping me with a paper – even though you did not have the time for it.

I would also like to thank my colleagues at the research unit for Active Living for all the great hours of dancing, cake, and making it fun and enjoyable to go to work every day. Thank you Charlotte, for working with me on this challenging project and taking your time to guide me through qualitative research. I am so grateful for having you with me on this journey and for the many hours of working with you. Also, a special thanks to Henriette for asking the right questions at the right time, and for the many hours of port vine and G&T you’ve shared with me. You made this journey much more enjoyable.

Finally, thanks to family and friends for being interested in my research, and for accepting my work priorities during the last months. Thank you Kristian for enduring my complaints and frustrations about the project and writing of the thesis, and for making me smile two seconds after – your support has been irreplaceable.

Tanja Schmidt

Odense, August 2019
List of Papers

Paper I


Paper II


Paper III

Schmidt T, Pawlowski C, Kerr J, Schipperijn J. Investigating the WHAT and WHY on Older Adults’ Use of Neighborhood Open Spaces Following an Environmental Intervention. Submitted to Translational Behavioral Medicine. Currently undergoing review
List of papers not included in the thesis

The ‘Move the Neighbourhood’ study design paper:

Evaluation of the ‘Move the Neighbourhood’ study – with children:
Pawlowski CS, Schmidt T, Nielsen JV, Troelsen J, Schipperijn J. Will the children use it? - A RE-AIM evaluation of a local public open space intervention involving children from a deprived neighbourhood. Submitted to the journal of Evaluation and Program Planning. Accepted for publication

The Survey of Health Ageing and Retirement in Europe:
Schmidt T, Christiansen LB, Schipperijn J, Cerin E. Social Network Characteristics as Correlates and Moderators of Older Adults’ Quality of Life and Functional Capacity: Results from The Longitudinal Survey of Health, Ageing and Retirement in Europe. Submitted to Journal of Aging and Health. Currently undergoing review
Abbreviations

CPAT Community Park Audit Tool
GPS Global Positioning System
NOS Neighbourhood Open Space
PA Physical Activity
SES Socioeconomic Status
SI Social Interaction
SOPARC System for Observing Play and Recreation in Communities
VERITAS Visualization and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces
List of appendices

Appendix I: Maps of Sydhavnen, the two neighbourhoods and the 13 Neighbourhood Open Spaces

Appendix II: SOPARC protocol manual

Appendix III: SHARE study paper

Schmidt T, Christiansen LB, Schipperijn J, Cerin E. Social Network Characteristics as Correlates and Moderators of Older Adults’ Quality of Life and Functional Capacity: Results from The Longitudinal Survey of Health, Ageing and Retirement in Europe.
English summary

BACKGROUND: Older adults (60+ years old) are a growing population expected to increase to 22% of the worldwide population by 2050, resulting in more older adults than children. This increase will lead to major financial burdens on governments, as health care costs usually increase with age due to greater health problems and physical impairments. Hence the importance of promoting healthy ageing. One way of promoting healthy ageing is by supporting social interaction (SI) and walking in older adults. Neighbourhood open spaces (NOS) may act as a place for walking and SI for older adults. These spaces close to home may be especially important for older adults as they typically are less mobile and have smaller social networks than other age groups. Disadvantaged neighbourhoods often provide fewer activity friendly open spaces than other neighbourhoods. This lack of appropriate space contributes to the social inequality in healthy ageing and highlights the importance of focusing on the built environment in disadvantaged communities. Although numerous studies have been conducted on walking and SI in parks or open spaces, little is known about NOS in disadvantaged neighbourhoods. Understanding reasons for using NOS may be essential for promoting healthy ageing for older adults living in disadvantaged communities. The aim of this thesis was to investigate older adults’ use of NOS in a disadvantaged community in Denmark.

METHODOLOGY: A convergent mixed methods approach using quantitative and qualitative methods was employed. The overall theoretical framework behind the research was a socio-ecological model which captured the multiple influences on older adults’ use of NOS. The empirical data used for the investigation were derived from the intervention study ‘Move the Neighbourhood’. Two senior housing associations within the disadvantaged neighbourhood Sydhavnen, Copenhagen, Denmark participated in the study. Data were collected by systematic observations of older adults age 60+ years (paper II: N = 353, paper III: N = 209 at baseline, N = 329 at follow up) within 13 NOS during 2016 and 2017 using SOPARC, and systematic auditing of facilities and features within NOS in 2017 using CPAT. GPS and VERITAS were used to collect data on older adults’ mobility in 2016. Structured (n =34) and semi-structured (n = 10) interviews were conducted with older adults during Fall 2016 and Spring 2018 to assess perceived factors promoting or inhibiting use of NOS. Binomial logistic regression analysis of SOPARC and CPAT data were used to assess factors associated with walking in NOS. Descriptive
statistics of baseline and follow-up SOPARC data assessed changes in walking and SI after the intervention. A deductive thematic analysis of interviews was used to identify reasons for using NOS.

**RESULTS:** Thirteen factors at all levels of the socio-ecological model were identified to influence older adults’ use of NOS: 1) age, 2) sense of ownership, 3) SI, 4) organisation of activities, 5) shelter, 6) shade along paths, 7) condition of paths, 8) seating, 9) landscaping, 10) distance to NOS, 11) economical support for social caretakers, 12) housing allocation, and 13) weather. Paper II identified five built environment factors and SI to be important for older adults’ walking behaviour in NOS. Paper III identified seven factors important for older adults’ use of NOS. SI was identified in both papers to be important for older adults’ use of NOS and was found to be connected to several other factors at different levels of the socio-ecological model (individual, socio/cultural, built environment, political, and natural). An applied framework was developed, combining the assessment of a measurement’s ‘recruitment and compliance’, ‘practicalities’ and ‘data applicability’, for use in future by researchers to identify the most appropriate method for their data collection. A combination of direct observations using SOPARC and interviews was found the most appropriate methods to use in measuring older adults’ use of NOS – considering the socio-ecological approach and the specific study population.

**CONCLUSIONS:** The results support the need for addressing a combination of factors from different levels in the socio-ecological model to increase older adults’ use of NOS. The findings suggest that SI in NOS is a key reason for older adults to use NOS. NOS may support SI and walking, by ensuring a supportive built environment, including seating for SI and resting while walking, shelter from wind and rain, and well-maintained paths. Further, NOS in close proximity may act as public front yards but rely on the support from social caretakers and local janitors to promote a sense of ownership, allowing the residents to create their own green space. NOS placed further away need additional support from social caretakers and volunteers to organise social activities, which requires the municipality to provide social care takers and the allocation of resourceful older adults. To account for the complexity of the behaviours, setting and study population, the investigation of older adults’ use of NOS required a mix of methods. To identify the most appropriate (mix of methods) for a specific purpose, several factors should be considered. The thesis advises considering ‘recruitment and compliance’, ‘practicalities’ and ‘data applicability’, which are presented in a new framework.
Dansk resumé

BAGRUND: Ældre mennesker (60+ år) er en hurtigt voksende befolkning og forventes at stige til 22% af verdensbefolkningen i 2050, hvilket resulterer i flere ældre end børn. Denne stigning vil føre til store økonomiske udfordringer, da udgifter til sundhedsvæsen typisk stiger med alderen, på grund af større sundhedsmæssige problemer og fysiske begrænsninger. Dette understreger vigtigheden af at fremme sund aldring. En måde at fremme sund aldring på, er ved at støtte social interaction (SI) og gåture blandt ældre. Offentlige rum i nabolaget (NOS) er potentielle steder for gåture of SI for ældre. Disse områder tæt på hjemmet kan være speciel vigtige for ældre, da de typisk er mindre mobile og har mindre sociale netværk end andre aldersgrupper. Udsatte boligområder kan have færre aktivitetsvenlige offentlige områder end andre områder, hvilket bidrager til den sociale ulighed i sund aldring og fremhæver vigtigheden af at fokusere mere på udsatte boligområder. Selvom der er foretaget adskillige undersøgelser af det at gå og SI i parker eller offentlige rum, har få studier fokuseret på NOS i belastede områder. At forstå grunde for brug af NOS kan være afgørende for fremme af sund aldring for ældre der bor i belastede områder. Formålet med denne afhandling var at undersøge ældres brug af NOS i et belastede område i Danmark.

METODE: Der blev anvendt et konvergent mixed methods design ved hjælp af kvantitative og kvalitative metoder. Den overordnede teoretiske ramme bag forskningen var en social-økologisk model, der beskriver de mange påvirkninger på ældres brug af NOS. De empiriske data, der blev brugt til undersøgelsen, stammer fra interventionsstudiet 'Move the Neighbourhood'. To seniorboligområder i det belastede område kaldet Sydhavnen, København, Danmark deltog i undersøgelsen. Data blev indsamlet ved systematiske observationer af ældre i alderen 60+ (artikel II: N = 353, artikel III: N = 209 ved baseline, N = 329 ved opfølgning) i 13 NOS i løbet af 2016 og 2017, ved anvendelse af SOPARC og systematiske registreringer af faciliteter og funktioner i NOS i 2017 ved hjælp af CPAT. GPS og VERITAS blev brugt til at indsamle data om ældres mobilitet i 2016. Strukturerede (n = 34) og semistrukturere (n = 10) interviews blev gennemført med ældre i efteråret 2016 og foråret 2018 for at undersøge subjektive faktorer, der fremmer eller hæmmer brugen af NOS. Binomial logistisk regressionsanalyse af SOPARC of CPAT data blev anvendt til at undersøge faktorer associeret med gå-adfærd i NOS. Deskriptiv statistik af baseline og follow-up SOPARC data undersøgte ændringer i gå-
adfærd og SI efter en intervention. En deduktiv tematisk analyse af interviews blev anvendt for at identificere grunde til brugen af NOS.

RESULTATER: Tretten faktorer på alle niveauer af den social-økologiske model blev fundet at påvirke ældres brug af NOS. Disse var: 1) alder, 2) ejerskabsfølelse, 3) SI, 4) organisering af aktiviteter, 5) ly, 6) skygge langs stier, 7) stiernes tilstand, 8) siddepladser, 9) landskabet, 10) afstand til NOS, 11) økonomisk støtte til sociale viceværter, 12) tildeling af boliger og 13) vejr. Artikel II identificerede fem faktorer i det bebyggede miljø samt SI for at være vigtige for ældres gå-adfærd i NOS. Artikel III identificerede syv faktorer, der er vigtige for ældres brug af NOS. SI blev identificeret i begge artikler at være vigtige for ældres brug af NOS og viste sig at være forbundet med flere andre faktorer på forskellige niveauer af den social-økologiske model (individuelt, socialt/kulturelt, bebygget miljø, politisk og natur). Der blev udviklet et praktisk framework, der kombinerer vurderingen af målingens 'rekruttering og overensstemmelse', 'praktiske forhold' og 'dataanvendelighed', som skal bruges af forskere til at identificere den bedste metode til deres dataindsamling. En kombination af direkte observationer ved hjælp af SOPARC og interviews var fundet de mest passende metoder til at måle ældres brug af NOS - i forhold til den social-økologiske tilgang og den specifikke studiepopulation.

KONKLUSION: Resultaterne understøtter behovet for at adressere en kombination af faktorer fra forskellige niveauer i den social-økologiske model, for at øge ældres brug af NOS. Resultaterne antyder at SI i NOS er en vigtig årsag til, at ældre bruger NOS. NOS er også et værktøj til at fremme gang. NOS kan fremme SI og gang ved at sikre et understøttende bebygget miljø, herunder siddepladser til SI og hvile, ly mod vind og regn, samt velholdte stier. Desuden kan NOS i umiddelbar nærhed fungere som offentlige forhaver, men kræver støtte fra sociale viceværter og lokale pedeller til at fremme følelsen af ejerskab, ved at beboerne kan skabe deres eget grønne rum. NOS længere væk skal understøttes fra sociale viceværter og frivillige, der kan organisere sociale aktiviteter. Det kræver, at kommunen sørger for sociale viceværter såvel som allokeringen a ressourcestærke ældre. For at kunne redegøre for kompleksiteten af adfærd, område og undersøgelsespopulation ved ældres brug af NOS, er det nødvendigt at kombinere flere metoder. Afhandlingen anbefaler at tage stilling til 'rekruttering og overholdelse', 'praktiske forhold' og 'dataanvendelighed', der er præsenteret i et nyudviklet framework.
1. Introduction

1.1 The ageing population

Ageing is emerging as a key policy issue in most high-income countries due to the increase in proportion and absolute numbers of older adults, resulting in more older adults (+60 years old) than children worldwide by the year 2050 [1]. This would not be an issue if the additional years were lived in good health where older adults are still able to contribute to society by for example, retiring from their job later in life. However, if ageing is accompanied by declines in physical, cognitive and social health, leading to loss of independence, this will contribute to major economic costs for the society [2]. Loss in independence is not only an economic concern for the society but may also be an individual concern, by affecting older adults’ ability to live happy and satisfying lives, ensuring well-being in old age [3, 4]. Unfortunately, based on the newest ‘World Report on Ageing and Health’ by the World Health Organisation (WHO) [5], the evidence is quite unclear and inconsistent on whether older adults live healthier longer lives or not [6-8]. The inconsistent results may be because studies have used different methods investigating different aspects of health in older adults, which makes the results difficult to compare. It may also be because older adults are a quite heterogeneous population group with great disparities in health. Especially older adults with lower socio-economic backgrounds are characterized to have poorer health [9]. Consequently, those who are most in need of health-related changes, are the ones with the fewest resources to address it.

1.2 Healthy ageing

The heterogeneity in older population groups means that a 70-year-old person may require support to meet their basic needs, whereas another 70-year old may be in good mental and physical shape. Health in old age is thus a complex system affected by physiological and cognitive changes, as well as increased risks of chronic diseases and physical limitations [5]. However, a person’s health condition does not necessarily define their well-being in life [10], and health during old age may depend on a range of factors which need to be addressed to ensure healthy ageing, well-being for the individual person, and decrease the economic burden. The term ‘healthy ageing’ is a concept used by WHO to describe; “... the process of developing and maintaining the functional ability that enables well-being in older age” [5]. This approach is based on a holistic view on the complex system of health in old age, which considers healthy ageing to be a person’s ability to be and to do what they value, based on their intrinsic capacity and
environmental characteristics. WHO uses an ecological approach to healthy ageing, influenced by physical and mental capacities (intrinsic), as well as interactions with the environment defined by our home, the community we live in and broader cultural norms (environment). Several ecological models of ageing, have been discussed over the years [11-13] and the approach is increasingly recognized as the most effective way to promote long-term health-related changes in older adults.

One way of promoting intrinsic capacity is by sustaining or improving physical functioning and hereby mobility in old age [4]. Regular physical activity (PA) is known to be an effective mean to promote physical functioning as well as well-being in older adults [14-16], and walking within the community may be a safe and easy PA behaviour for older adults. PA may also be dependent on the physical functioning of older adults, as some level of physical abilities are needed to participate in PA [17, 18]. Still, in Denmark over a third of older adults do not meet the recommended PA guidelines [19], and similar trends are observed globally [20]. Being able to build and maintain relationships is another factor identified by WHO to be important for healthy ageing, which may be especially important for older adults living alone in disadvantaged communities. The prevalence of social isolation (lack of social integration [21]) in community dwelling older adults range, from 7-17 %, whereas approximately 40% of older adults report feeling lonely [22]. In Denmark, 62% live alone and 22% are either sometimes or often lonely [23]. Loneliness is associated with decreases in health and well-being [24]. Promoting social relationships is thus an important element of healthy ageing, as social interaction (SI) can increase well-being, protect against functional decline, enhance longevity and promote resilience [25-33]. Hence, SI as well as PA is a means to an end, as well as an outcome. Maintaining relationships is central for older adults’ well-being and its priority seem to increase with age [34]. However, social networks often shrink with age, as declines in physical functioning and resources makes it harder to maintain relationships [28, 29, 31]. Consequently, promoting SI in older adults living alone is crucial to ensure healthy ageing – especially in disadvantaged communities where older adults have poorer health.

1.3 Neighbourhood open spaces
Creating supportive built environments – as suggested by WHO – can support older adults’ physical functioning and social health [35, 36], by providing safe, walkable and aesthetically pleasing neighbourhoods, with access to green and social spaces, as well as different services [37-41]. However,
emerging evidence suggests that older adults are living in neighbourhoods that do not support healthy ageing [42] and especially older adults with lower socioeconomic status (SES) live in less walkable and activity-friendly environments [43-47]. Public parks or green spaces may provide a space for older adults to engage in walking and SI [48-50]. However, disadvantaged neighbourhoods are often characterised by higher safety concerns, poorer accessibility, and poorer perceived distance to parks, resulting in less frequent use [47, 51]. Further, older adults living alone in apartment buildings do not have access to a private garden, front yard or porch, known to foster social contact with neighbours [52, 53]. This suggests that green spaces or public spaces in closer proximity such as neighbourhood open spaces (NOS), may be a more suitable setting to promote SI and walking in older adults living in disadvantaged communities.

NOS are in this thesis defined as; outdoor spaces such as village greens, local parks or small public open spaces within the neighbourhood, which are in close proximity to the residents’ housings (< 400 meters walking distance), are accessible by the residents of the neighbourhood, and large enough for people to use (small grassy spots are not included) [54].

These spaces may be especially important for older adults living in disadvantaged communities. Older adults are typically less mobile due to increased physical or cognitive limitations with age [55], experience smaller activity spaces due to reduced mobility, and have smaller social networks than other age groups [56, 57]. Due to their limited activity space and physical limitations, the proximity of NOS and its characteristic of being a social meeting place [58, 59], make NOS a crucial outdoor space for older adults to foster social relations and PA behaviours. Especially NOS acting as public front yards (spaces directly outside apartment buildings) may help promote SI between neighbours living in apartment buildings [52, 53]. However, little research exists that has investigated features of NOS and its promotion of walking or SI in older adults [54, 60-62]. The heterogeneity within this age group suggests that research within one setting and sub group of older adults, may not be transferable to other settings and sub groups. This leaves the question how NOS in other settings such as senior housing apartments in disadvantaged neighbourhoods are used by older adults, and what characteristics within these NOS may support healthy behaviours.
A key issue which should concern health promoters and urban planners, is how to design and promote use of NOS for SI and walking within disadvantaged communities. What features of NOS promote healthy ageing in older adults living in apartment buildings within disadvantaged communities, is not well established. The characteristics of NOS as small and often green spaces scattered around the neighbourhood, makes them perfect venues for small-scale renovations. These small-scale changes are typically less costly than large neighbourhood improvements, which makes them particularly relevant for disadvantaged neighbourhoods. To improve the designs of NOS, it is necessary to increase the limited knowledge on what specific factors may promote SI and walking in NOS for older adults living in disadvantaged communities. Multilevel ecological approaches considering several environmental and intrinsic factors important for healthy ageing as proposed by WHO, may be the preferred approach to capture the impact of the different factors on older adults’ use of NOS. SI and walking in NOS may promote healthy ageing by supporting older adults’ intrinsic capacities through walking, and create supportive environments such as NOS, for social interaction. Investigating the interactions between these intrinsic and environmental concepts, may require intervention studies and several methods, to address the multilevel approach suggested by WHO. However, the limited research on NOS makes it uncertain which methods are most suitable to use. This thesis investigates this approach using a case of older adults living in a disadvantaged community in Denmark, applying several methods.
2. Aim and research objectives

The overall aim of the thesis is to investigate use of NOS by older adults living in disadvantaged communities. The term ‘use’ can comprise of many things but will in this thesis focus on walking and social interaction, based on the above identified advantages of these behaviours for healthy ageing. The aim is explored through three research objectives – each representing an individual paper with their own perspective and objectives, which combined contribute to answering the overall aim. The research objectives are:

**Paper I:** To assess the feasibility and practicality of using the map-based questionnaire system VERITAS and GPS devices to measure daily mobility in older adults living in a deprived neighbourhood.

**Paper II:** To investigate the association between built environment features, social interaction and walking within NOS, among older adults living in a deprived neighbourhood.

**Paper III:** To assess how older adults used NOS before and after a participatory research intervention, and factors promoting or inhibiting their use, focusing on social interaction and walking.

The three papers, each with its own research objective, address different aspects of older adults’ use of NOS. The first paper addresses different measurement methods which can be applied to measure older adults’ use of specific spaces. The second paper focuses on built environment features within NOS important for walking. And the third paper investigates several intrinsic and environmental factors important for walking and social interaction in NOS after small-scale renovations of NOS. Across the three papers, a synthesis is conducted focusing on the emerging factors influencing older adults’ walking and SI in NOS, and the methodological aspects of measuring older adults’ use of NOS. The conceptualisation of the PhD thesis and how each of the three papers contributes to the overall aim is depicted in figure 1.
Figure 1: Conceptualization of the PhD thesis.

**AIM:**
OLDER ADULTS’ USE OF NEIGHBOURHOOD OPEN SPACES (NOS)

**PAPER I**
Objective: Feasibility and practicality of two measures of mobility
Methodology: Quantitative
Methods: GPS, VERITAS

**PAPER II**
Objective: Association of built environment and social interaction with walking in NOS
Methodology: Sequential Mixed Methods Design (qual → Quant → Qual → Quant)
Methods: Structured + Semi-structured Interviews, SOPARC Observations, CPAT Audits

**PAPER III**
Objective: Factors affecting use of NOS before/after an intervention
Methodology: Convergent Mixed Methods Design (Quant + Qual)
Methods: Semi-structured Interviews, SOPARC Observations

**Synthesis of results across papers**

**How to measure use of NOS**

**What influences use of NOS**

Discussions and conclusions based on findings of the synthesis

Note: Quant = quantitative, Qual = qualitative. Uppercase letters indicate primary priority (Qual), lowercase letters indicate secondary priority (qual)
3. Scientific theoretical approach

My scientific approach used as an underlying foundation of my thesis is described in the following sections based on the research process elaborated by Crotty [63] and described in figure 2; epistemological position, theoretical perspectives, methodology, and methods. These elements have guided my research process and informed my choice of methods. The following sections describe the first three elements used in my thesis (pragmatism worldview, socio-ecological model as a framework, convergent mixed methods design) and how they form my scientific theoretical approach, following a methods section guided by the three elements.

Figure 2: My scientific approach, adapted from Crotty 1998

3.1 Research Paradigm
This PhD project was guided by a pragmatic worldview. This philosophy focuses on a problem to be researched in its social and historical context, where the meaning of actions can be found in the consequences of the research [64, 65]. Rather than focusing on one specific method used to investigate a problem, multiple methods are applied which are deemed relevant to answer the specific research question. Which is why pragmatism is commonly used and the leading foundation in mixed methods research [65]. In my PhD thesis, I focus on specific problems to research – the three research questions
– and rely on a range of different measurement tools, using a mixed methods approach, to help answering the specific questions. This problem centred pragmatic approach, helped design a mixed methods study where qualitative data could support quantitative measures and help understand quantitative results.

The abduction approach – an essential part of pragmatic thinking – moves back and forth between inductive and deductive reasoning, as well as subjective versus objective thinking [65]. This approach came especially into action with the back and forth between analysing quantitative and qualitative data. This abductive approach is driven by empirical observations of the specific problem being investigated and as such, no theoretical stand is taken beforehand, but are used afterwards to explain the results of the empirical observations. Consequently, in this thesis, I did not rely on a theory as my foundation for my research guiding me through the different studies. Instead, based on my abductive approach, I relied on a theoretically founded framework to structure and guide me through the analysis of the thesis. A framework as such is not a theory, as it does not provide explanations for the problem being investigated, but merely guides me in the direction of where to look and what to look for. The following section will present the framework used in this thesis and how it is used as a guide throughout the thesis.

3.1.1 The socio-ecological model as a framework
The thesis is guided by a framework called the socio-ecological model of health behaviour. In public health research, this model is based on the ecological paradigm providing a framework for understanding people’s interactions with their physical and sociocultural environments [66]. Ecological models are distinguished from other models by providing greater attention to the social, institutional and cultural context expected to influence people’s behaviour [66, 67]. The model suggests that a specific health behaviour is not influenced by merely a narrow range of psychosocial variables, but by a combination of a wide range of influences at multiple levels [13, 68]. These levels are typically intrapersonal (e.g. demographics), interpersonal (e.g. social), physical environment (e.g. facilities within NOS) and political (e.g. regulations) influences [67]. Sallis et al. suggests another dimension of the model by including behavioural settings as the physical and social context in which a behaviour occurs (e.g. NOS) [67]. These settings are; school domain, home domain, recreational domain and transport domain.
In line with this model, older adults’ use of NOS is not influenced, and cannot be assessed merely, by one individual level of influence, but needs to be studied at multiple levels found influencing older adult’s use of NOS. Figure 3 depicts a adapted version of the socio-ecological model of health behaviour by Sallis et al. [67], used as the underlying framework in this thesis. Although the model by Sallis et al. is created for specifically PA behaviour, it’s concept can be used to assess other types of healthy behaviours such as SI. The model in figure 3, focuses only on those domains relevant for my thesis, the recreational setting and the home setting (red circle), as these two settings relate to NOS. Each level described in the model refers back to how they influence older adults’ use of NOS. The framework has guided me on different levels through the investigation of the overall aim of the thesis. The framework was used as an underlying guide in the discussion of the use of different measurement tools to collect data at different levels of the socio-ecological model. As such, some tools may collect data on individual factors, whereas others collect data on built environment factors. To investigate different factors influencing older adults’ use of NOS, the framework was used as a tool for analysing the data and present factors related to use of NOS at the different levels.

Figure 3: The socio-ecological model of health behaviour. Adapted from Sallis et al. 2006
3.2 Methodology
This thesis overall employed a convergent mixed methods design. Several definitions of mixed methods exist, with different terminology within different fields. This thesis adopts the definition used by Johnson et al [69], which was based on a composite understanding of 19 different definitions, discussed by 21 mixed methods researchers. The final composite definition was:

“Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purpose of breadth and depth of understanding and corroboration”. (p. 123)

Based on the definition of mixed methods, using this approach in the thesis aligns well with the scientific theoretical stand of pragmatism, arguing that a combination of various methods can be a useful way of investigating the problems or research questions at hand [64]. The purpose of the convergent mixed methods design is complementarity, to gain broader, deeper and more comprehensive knowledge of older adults’ use of NOS and how to measure it, by applying various methods which tap into the same phenomenon [70]. This approach is in the thesis applied by combining the three papers in answering the overall aim of the thesis. Figure 4 depicts and explains the convergent mixed methods design of the thesis. First, the different quantitative and qualitative methods used in the three papers, were implemented concurrently for each of the two themes (i.e. measuring use of NOS and factors influencing use of NOS). Second, the results of each strand are synthesized into a meta-inference by merging the quantitative and qualitative results for the individual themes. For instance, systematic observations represent a quantitative strand used in paper III to determine older adults’ use of NOS, whereas semi-structured interviews represent the qualitative strand used to get in-depth knowledge of why older adults’ use some NOS and not others. Finally, the results were integrated and interpreted in the overall discussions and conclusions of the thesis. Although a convergent mixed methods design was used to explore the overall aim of the thesis, this does not imply that each individual paper used convergent mixed methods design. Each paper had their own specific study aim, which was assessed using different methodologies.
Figure 4: Convergent Mixed Methods Study Design.

Note: QUAN = quantitative, QUAL = qualitative. Uppercase letters indicate primary priority (Qual), lowercase letters indicate secondary priority (qual).
4. Methods

4.1 Research Setting and Study Population

4.1.2 The ‘Move the Neighbourhood’ study

This study is part of the quasi-experimental community-based intervention study called ‘Move the Neighbourhood’. The primary objective of the intervention was to promote active living among children (10-13 years old) and older adults (60+) living in a deprived neighbourhood in Copenhagen, by making small-scale renovations in NOS in collaboration with the local citizens [71]. Apart from my PhD project assessing older adults’ walking and SI in the NOS, I was also responsible for conducting the quantitative effect evaluation for both children and older adults. In this thesis, I will only present the design and methods used for my PhD project, and direct to the study design protocol for the ‘Move the Neighbourhood’ for further details on the Move the Neighbourhood study [71].

Older adults from two senior housing associations living in the deprived neighbourhood called Sydhavnen [South Harbour] in Copenhagen, were the study population used in the present thesis. Sydhavnen is one of the most disadvantaged neighbourhoods in Copenhagen, with a life expectancy of 73.0 years (average in DK is 80.6 years) and 40.2% being on a low income (30.6% on average in DK) [72]. The neighbourhood is characterized by apartment blocks, high-traffic streets and a few shops and pubs. Two out of the three existing senior housing associations within the neighbourhood agreed to participate in the study – Tranehavegård (senior housing area I) and Engholmen Nord (senior housing area II). Detailed information on neighbourhood characteristics of the two senior housing associations were described in paper II. Participants were recruited using a convenience sampling strategy [73] with help from the social staff of the residence, by participating in social activities for the residents, and through word of mouth. Participants were given information about the project verbally and in writing and were able to sign up for the project on the spot or contact me by e-mail or phone for more information. Participants could choose whether they wanted to be visited at home, meet in a local office, or in another place defined by them. This flexible approach was chosen to make it as easy as possible for the respondents to participate, offering familiar and comfortable surroundings. One respondent chose a green space for the interview, another their local men’s club, and a third chose her local office (she was a member of the residents’ board), whereas the reminder chose their home. Anyone from the two senior
housing associations aged 60 years and above could participate in the study, no matter their physical abilities or impairments. Descriptive of the 39 participants are presented in table 1.

Table 1: Description of the participants from the two senior housing associations (N = 34)

<table>
<thead>
<tr>
<th></th>
<th>Senior housing area I</th>
<th>Senior housing area II</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>75</td>
<td>73</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>87.5%</td>
<td>61.1%</td>
</tr>
<tr>
<td>Living alone</td>
<td>56.3%</td>
<td>83.3%</td>
</tr>
<tr>
<td>Self-perceived health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>12.5%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Very good</td>
<td>12.5%</td>
<td>22.2%</td>
</tr>
<tr>
<td>Good</td>
<td>31.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Less good</td>
<td>31.3%</td>
<td>22.2%</td>
</tr>
<tr>
<td>Bad</td>
<td>0%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Mobility limitations</td>
<td>12.5%</td>
<td>44.4%</td>
</tr>
<tr>
<td>Limitations due to health</td>
<td>58.3%</td>
<td>61.1%</td>
</tr>
<tr>
<td>Home care</td>
<td>81.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Use of assistive device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheelchair, scooter</td>
<td>43.8%</td>
<td>16.6%</td>
</tr>
<tr>
<td>Cane, walker</td>
<td>93.8%</td>
<td>38.8%</td>
</tr>
</tbody>
</table>

4.1.2.1 Neighbourhood Open Spaces

The two senior housing associations were surrounded by several NOS which were the main setting in this thesis. Thirteen specific NOS within the neighbourhood of Sydhavnen were chosen to be included in the study, based on the definition of NOS presented in the introduction and applied in this thesis [54]. The first senior housing area included seven NOS and the second included five NOS. The NOS were chosen based on their proximity to the apartment buildings, their size and amenities. Areas that were further away from the entrances to the apartment buildings (> 400 meters), were too small to do any activities in small grassy spots), or had no facilities, were excluded. The 13 included NOS within Sydhavnen are depicted in figure 5. Most of the NOS were green spaces, whereas a few of them were mainly paved with some landscaping like trees, bushes and flowerbeds. Detailed maps of the NOS are found in Appendix I.
Figure 5: Map of Copenhagen (top left), Sydhavnen (bottom left), the two senior housings (marked in black), and the 13 neighbourhood open spaces (marked in white)
4.2 Data collection
Several different qualitative and quantitative methods were used in the thesis. In this section, the methods are described in overall terms focusing on why and how they were used. A more detailed description of the individual data collection methods can be found in papers I-III. The following table (table 2) defines all data sources used in the thesis, time of data collection and which data sources were used in which of the three papers. Data sources not used in the thesis are not described here. This includes SOPARC data collection in Fall 2017 (follow up), CPAT data collection in Spring 2018 (follow up), and structured questions in Fall 2016 during GPS data collections. These data sources were not included in the thesis, as they were not used in the individual papers or found relevant to assess the overall aim of the thesis.

Table 2: Description of data sources applied in the thesis.

<table>
<thead>
<tr>
<th>Measurement tools</th>
<th>Volume</th>
<th>Data collection period</th>
<th>Paper I</th>
<th>Paper II</th>
<th>Paper III</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>23 participants</td>
<td>Fall 2016</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERITAS</td>
<td>34 interviews</td>
<td>Fall 2016</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPAT</td>
<td>13 audited NOS</td>
<td>Spring 2017 (Baseline)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>SOPARC</td>
<td>13 observed NOS</td>
<td>Fall 2016 (Baseline)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring 2017 (Baseline)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring 2018 (Follow up)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Structured interviews</td>
<td>34 interviews</td>
<td>Fall 2016</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-structured interviews</td>
<td>10 interviews</td>
<td>Spring 2018</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: SOPARC: System for Observing Play and Recreation in Communities, CPAT: Community Park Audit Tool, VERITAS: Visualization and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces, GPS: Global Positioning System
4.2.1 Global Positioning System
Global Positioning System (GPS) devices were used to assess daily mobility in older adults, as well as its feasibility to measure daily mobility in older adults. Using GPS to measure mobility such as walking within the neighbourhood, has become more prevalent in recent years as it provides reliable objective 24-hour data on individuals [74-77]. Older adults’ locations, time spent in locations and routes travelled to locations were measured in paper I, using the QStarz BT-Q1000xt GPS tracker. The GPS device uses satellites to calculate time and location of the participant wearing the device and was set to log data every 15 seconds. The software program BT747 (www.bt747.org) was used to prepare the GPS device and download the data from the device after participants had worn it. Participants were asked to wear the device for 7 consecutive days and only to take it off during night time and when at risk of getting in contact with water. Participants were further given the option of wearing the device on a belt, ankle holder, key hanger, in their pocket or bag to increase compliance with study protocol. Additional procedures to increase compliance included posting reminder flyers in their home and sending them text messages every morning and evening, reminding them of how to put on the device, how to charge the device, to charge the device when going to bed and taking it with them when leaving their home.

4.2.2 VERITAS
The Visualization and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces (VERITAS) was in paper I used to assess older adults’ daily mobility compared with GPS measured mobility. VERITAS is a map-based retrospective online questionnaire system which can be performed either as an interview or online by self-administration, providing contextual information about daily mobility. The questionnaire used in paper I was adapted to fit the specific purpose of the study, but is based on the questionnaire developed for the CHURA study [78]. The questionnaire consisted of 32 categories with up to five questions in each category, depending on previous answers. Participants were asked to draw routes and point out destinations they visited (at least once a month) on a google maps. After each drawing or point participants were asked additional questions about how they transported themselves to this destination and with whom. The interview version of the questionnaire was employed in this thesis, as some research implies this method to be more reliable for older adults [79]. Data were downloaded and processed in QGIS version 2.18.3.
4.2.3 The Community Park Audit Tool
The Community Park Audit Tool (CPAT) was used to audit facilities and built environment features within all 13 NOS in paper II. CPAT was developed by Kaczynski and colleagues to provide quickly, reliable and user-friendly means of auditing community parks for their potential to promote PA [80]. CPAT was initially chosen because of its good content validity and reliability in mapping community parks similar to NOS [80]. Detailed information about the CPAT instrument can be found on the Active Living Research website (https://activelivingresearch.org/community-park-audit-tool-cpat). In paper II, the aim was to assess specific features within NOS associated with older adults’ walking behaviour within the NOS and its association with SI. Since CPAT is not specifically developed for older adults, I decided to adapt the tool to comply with the specific needs and barriers expressed by the study population. To do this, structured interviews with local older adults were preliminary conducted. This procedure is further explained in section 4.2.5 in this thesis. The results of these interviews were used to adapt CPAT by excluding themes from the tool that were deemed not relevant for the study population and the setting (e.g. presence of sports equipment, basket courts etc.), and by including themes that were deemed relevant (e.g. wheelchair friendliness). The auditing of each NOS was conducted by going around within the NOS and filling out a printed version of the CPAT tool. The recorded information was afterwards typed into a Microsoft excel sheet and uploaded into the statistical software program IBM SPSS statistics 24 when data collection was finished.

4.2.4 The System for Observing Play and Recreation in Communities
System for Observing Play and Recreation in Communities (SOPARC) observations were carried out in paper II and paper III to systematically observe older adults’ use of the NOS. SOPARC is a validated and reliable systematic observation tool used to investigate PA and associated variables in community environments [81]. SOPARC can be used in different settings like NOS, but has been mainly used in studies on parks and urban green spaces [82]. The original version of SOPARC can be found on the Active Living Research website [83].

To accommodate the specific focus of this thesis on older adults’ use of NOS, I decided to modify the original version of SOPARC to include additional information on SI not present in the original version. The SOPARC observation scheme was used in printed paper version and contained information on age
(to distinguish between older adults and other age groups), gender, activity level (sedentary, walking, vigorous), SI (i.e. two or more persons talking, walking, running, biking, sitting together) and primary activity (e.g. dog walking, sitting inside the pavilion, having a picnic), as well as information on time and day of observations, lighting and weather conditions. The systematic observations were based on momentary time sampling, meaning that every NOS was observed during a short time frame in which all people entering the NOS were registered. Based on a previous study by Cohen and colleagues [84], four days of observations (3 weekdays and 1 weekend day) with four observations each day (morning, lunch, afternoon, evening), over a period of 1½ months in each of the 13 NOS were conducted. This sampling timeframe was considered sufficient for capturing both walking and SI behaviour, although the study by Cohen et al. was only conducted for PA. The same NOS was never observed twice on the same day, to ensure high variability in observations.

Observations were carried out by a team of trained observers, including myself. Bachelor and master students studying at the Department for Sports Sciences and Clinical Biomechanics were recruited and trained by me to become observers. The students participated in a 1-day workshop – the same procedure used by McKenzie and colleagues in their validation study [81]. The workshop consisted of three steps. Step one was an overall introduction to the study and SOPARC. In step two, the students had to study a manual which I created, to ensure thorough knowledge of the procedures and consistency in observations. We afterwards went through the manual to confirm that everyone understood the procedure. The specific manual can be found in Appendix II. In the third and last step, on-site training and tests were conducted with me and the students within the NOS. First, all students and I performed the same observations, and were afterwards given feedback on their coding. Lastly, all performed new observations to improve and were given new feedback. There was especially focus on coding age, activity level and SI correct, as these may be challenging to assess, as well as identifying the specific boundaries of the NOS to ensure that students did not observe any activity happening outside of the NOS. Included in the manual were three maps of the neighbourhood including the specifically defined NOS, to ensure that the observers would observe each NOS correctly.

Observations registered in the printed paper version were after each observation entered into a shared Microsoft excel sheet and at the end uploaded to IBM SPSS Statistics 24, to prepare for statistical
analyses. Printed paper versions used during observations were collected by me and used to perform several tests to identify any mistakes in entering the data.

### 4.2.5 Structured interviews

Structured interviews were conducted to gain knowledge about local older adults’ perceived barriers and motivators for using their neighbourhood built environment. These interviews were used in paper II to adapt the CPAT tool to the specific study population as described above in section 4.2.3. The structured interview method is characterized by using pre-established questions which only allows a limited number of response categories. Every respondent is asked the same questions and in the same order to produce brief answers which should increase generalizability of the findings [85]. The advantage of using structured interviews is its ability to study larger samples due to its less time-consuming data collection and analyses. Additionally, the purpose was not to gain in-depth knowledge. But to adapt an existing auditing tool by confirming or rejecting specific built environment features identified in the literature to be important for respondents’ use of their local neighbourhood. It was therefore found more suitable to conduct many short and structured interviews, than few long and in-depth interviews.

The structured interviews were mainly conducted by me, with additional help from two master students to reach a total of 34 conducted interviews (18 interviews conducted in senior housing I and 16 in senior housing II). An interview guide including instructions was created, to ensure that each interview would be conducted the same way by all interviewers. This guide contained details about what information the respondents should receive before the interview started, how the interviewer should ask the questions during the interview, and how the interviewer should record the answers using the survey tool called SurveyXact [86]. Before data collection, the two master students were guided in how to navigate in SurveyXact and conduct the interview.

### 4.2.6 Semi-structured interviews

Semi-structured interview was the method used to gain more comprehensive knowledge on local older adults’ use of NOS, reasons for using or not using NOS, and perceived qualities and challenges of the NOS. The semi-structured interviews were used in both paper II and paper III of this thesis. The semi-structured interview is the most commonly used of all qualitative research methods, probably because it
is highly flexible and at the same time permitting a certain degree of standardization [85]. This interview method generally includes a range of prepared questions guided by a set of themes or topics explored in some depth. Further, the guide includes probes and follow-up questions designed to produce more in-depth responses, but at the same allowing new questions to develop during the interview [87]. Using the semi-structured interview method gave me the possibility of asking specific open-ended questions about respondents’ use of NOS, but also allowed the respondent to identify important themes not covered by the interview guide. The role of the interview guide was to ensure that I used the same thematic approach during every interview and directed the conversations towards the themes of interest [87]. Since I was new to qualitative research, using an interview guide helped me focus on the themes during the interviews. Especially when the respondents talked about irrelevant things – which I quickly came to experience was the norm – the interview guide helped me stay on track.

Ten semi-structured interviews were conducted, five in each senior housing area. The ten respondents came from the same sample used for the structured interviews. The themes in the interview guide were respondents’ use and none-use of NOS, reasons for use or none-use and perceived qualities and challenges for using NOS. In *paper II*, the interview guide was used to gain knowledge on older adults’ perceived qualities and challenges which could explain the results of the quantitative analysis. In *paper III*, the interview guide was used to gain deeper knowledge on older adults use of different NOS after a built environment intervention and how to promote use of NOS. A mobile phone was used to audio record the interviews, after attaining respondents’ permission to do so. Backup recordings of interviews is highlighted by research as important for effective conducting of the interviews and producing good quality data [87]. Using audio recordings to back up my interviews enabled me to focus on the interview situation and the respondent’s answers, creating a natural conversation between two people rather than focusing on note taking and risking missing out on important information.
4.3 Data Analysis
The following section will shortly describe the analyses used for each of the three papers. Further details on specific analyses can be found in papers I-III.

A common approach in paper II and III, was using the software called NVIVO [88] to transcribe the interviews and using a deductive thematic analysis [89] to code the semi-structured interviews. All interviews were transcribed verbatim and coded afterwards using NVIVO, to ensure consistency. A deductive thematic approach was employed to code the transcripts in both papers. Deductive thematic analysis was found the most appropriate approach to use, as the qualitative data was used to underpin and understand the quantitative results. Specific themes of interest were therefore used when coding the transcripts based on the socio-ecological framework. The thematic analysis was used to identify those themes or factors in the data material. Whereas inductive thematic analysis is a common approach used in qualitative research, the deductive approach is less common [89, 90]. Although the deductive approach tends to provide a less rich description of the overall data, this approach was chosen because its strength is to provide a more detailed analysis of some aspects of the data [89].

The thematic analyses were conducted using the six phases described by Braun & Clarke [89] as a guide. The six phases in the following order were: 1) familiarizing myself with the data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, and 6) producing the two papers. Braun and Clarke highlights that these phases are not a linear process where researchers move from phase one to phase two and so on, but dynamical moving back and forth as needed, with fluent and overlapping transitions between the phases. The order in which the phases are represented here are not representative for the deductive approach used to analyse the data. As described by Braun and Clarke these phases should be used flexible to fit the specific research questions. I started by familiarizing myself with the data, as described in the guide. Next, as the deductive approach was employed, specific themes had already been generated based on the specific research question of the paper. Using these themes as a guide, codes were generated by going through every transcribed interview. Some codes did not fit into the pre-identified themes which is why new themes were created when necessary. Finally, quotes from the different themes were chosen when reporting the results in the two papers which highlighted the importance of the identified themes.
4.3.1 Paper I
The web-based application called Personal Activity and Location Measurement System (PALMS) was used to process the GPS data [91]. PALMS identifies different variables like trips, time spent outdoors and mode of transportation, based on user-defined settings. The processed data were visualized afterwards in QGIS version 2.18.3 to assess transportation mode, routes and destinations like NOS. QGIS can create, edit, visualize and analyse geospatial information [92]. QGIS was also used to visualize the geographical coordinates stored in VERITAS on a google maps, including information destinations and routes. The visualized geospatial information of GPS and VERITAS data were afterwards compared to assess their compatibility. Contextual information about how and with whom they visited each destination was descriptively assessed using the statistical software IBM SPSS Statistics 24.

4.3.2 Paper II
4.3.2.1 Structured interviews
The structured interviews used to adapt the CPAT audit tool in paper II, were not audio recorded and therefore, did not have to be transcribed afterwards. Using the survey tool SurveyXact, the answers of the respondents were typed directly into the computer and afterwards transformed and downloaded into a Microsoft excel file. This file was afterwards uploaded to IBM SPSS Statistics 24. Descriptive statistics was performed in SPSS, identifying how many respondents perceived experiencing each of the 17 variables in their neighbourhood. Additionally, an open-ended category was added to the survey, where people could mention other perceived factors important for them, as I wasn’t sure to capture all relevant factors important for this study population based on the structured questions. Quotes from the respondents were analysed using the deductive thematic approach [89], by coding the quotes into categories of different built environmental features. The descriptive results of the 17 variables and the results of the deductive thematic analyses of the open-ended questions were combined in a matrix to identify overlaps and level of importance. The results of this analysis were then used to adapt the CPAT tool by including factors from the matrix not present in the audit tool and excluding irrelevant factors.

4.3.2.2 Semi-structured interviews
The semi-structured interviews were used in paper II to further understand the quantitative results by either confirming or contradicting findings. The deductive thematic approach used to analyse the qualitative data and described above, allowed for the specific CPAT categories used in the quantitative
analysis to direct the thematic analysis. Identifying the different CPAT categories as themes, the interview transcripts were then coded using these themes. An additional theme was created, namely SI, as the coding phase identified this factor to be very important and mentioned by all the respondents. The themes including quotes were matched with the quantitative CPAT variables in a matrix to identify which variables should be included in the quantitative analysis. The quantitative analysis was guided by the qualitative results, as I wanted it to be case specific focusing on the specific study population, which was characterized by being a quite heterogeneous group. Finally, quotes from the thematic analysis were used in the discussion of the paper, to discuss and try to explain the quantitative results.

4.3.2.3 SOPARC and CPAT
The purpose of the quantitative analysis was to assess if walking within 11 NOS – retracted from SOPARC observations – was associated with a range of built environmental features, identified using the CPAT tool, and SI, retracted from SOPARC observations. To do this, the two datasets, created from the SOPARC observations and CPAT audits, were combined in a single dataset using IBM SPSS Statistics 24. Variables included and extracted from SOPARC were age group (child, teen, adult, senior), gender (male, female), SI (yes, no), and the outcome variable walking (yes, no). All CPAT variables were initially included in the dataset. However, choosing to use binomial logistic regression for the analysis, it was not possible to include all variables, due to the relatively small sample size (n = 353). The variables included were those identified in the qualitative analysis to be important for most of the respondents. These variables were: benches (the number of benches within a NOS), picnic tables (the number of picnic tables within a NOS), landscaping (flower beds, pruned bushes), green space shade (whether there is shade within a green space), path shade (whether there is shade on a walking path), path wheelchair friendly (is a wheelchair able to pass, get on/off the path, wide enough path), and path conditions (whether the path conditions are good or bad based on the presence of holes and uneven surface). Lastly, an additional variable called NOS size was initially included in the analysis, as the NOS were quite different in size. I hypothesized that it would affect the number of people visiting the NOS, as well as the availability of amenities within the NOS. The variable was created using the Geographical Information System QGIS version 3.6.3, by uploading a map of the neighbourhood and drawing boundaries around each NOS. QGIS than calculated the size of each drawn NOS. Initial analysis did not identify NOS size to affect the results, which is why it was excluded from the final model used in the analysis.
4.3.3 Paper III

4.3.3.1 Semi-structured interviews
Using the same deductive thematic approach as in paper II, the analysis in paper III differs from the analysis in paper II, by using a theoretical framework to guide the thematic analysis, and by inviting a second researcher to perform the same deductive thematic analysis. I decided to use a second researcher highly skilled in qualitative research to perform the same analysis, to enhance the reliability of the results presented in the paper. Qualitative research results are often dismissed as being not as reliable and generalizable as quantitative results. Having two researchers independently conducting the same analysis, and afterwards discuss similarities and discrepancies in the coded data, can therefore increase the credibility of the qualitative results [93]. The second researcher was a qualitative researcher experienced in conducting and analysing different types of interviews. This person was chosen – especially because I was a novice at that time – to confirm or contradict my findings and help me understand the results. The second researcher did not use NVIVO for the thematic analysis, as she was not familiar with the software, but instead chose to code the transcripts manually.

The theoretical framework used to code the transcripts was the socio-ecological model presented earlier [67]. The five levels in the model (natural, policy, built environment, social/cultural and individual) were used as the themes which guided the coding process. Under each theme, several different codes were identified and grouped into similar sub-themes. Lastly, in-depth descriptions of each theme were produced to identify factors important for the respondents in using NOS and reasons for their use or non-use. These results were used to gain a more in-depth knowledge on older adults’ use of NOS.

4.3.3.2 SOPARC
SOPARC data were used in paper III to assess the use of 13 NOS by older adults before and after an intervention conducted in the ‘Move the Neighbourhood’ study. To do this, IBM SPSS statistics 24 was used to descriptively analyse the observational data. The initial idea was to perform a general linear mixed model analysis to test the differences between older adults’ use of the intervention sites and all other NOS before and after the intervention. However, due to small sample sizes in the observational data, it did not seem feasible to perform any statistical tests, which is why descriptive analysis was chosen. The descriptive results were presented by creating different graphs in SPSS, highlighting the use of the different NOS in total by age and gender, as well as the specific use of each NOS focusing on
walking and SI. Additionally, notes taken at each observed NOS indicating where specifically the older adults were observed within the NOS, were assessed, as the overall SOPARC observations did not identify specifically the use of the intervention-built installations but only an overall use of the NOS. By analysing these notes, it was possible to distinguish between activity occurring at the new-built installations and activity occurring elsewhere inside the NOS. These results were presented in the text to support the descriptive graphs.

4.4 Ethical considerations
Ethical considerations ought to be highly prioritised to protect human subjects participating in research. The ‘Move the Neighbourhood’ study and its data-management procedures were registered and approved by the Danish Data Protection Agency (2015–57-0008).

All participants signed a consent form agreeing to take part in the study. Alt-White points out that the essential parts of an informed consent in the study of older adults, is the decision-making capacity, the freedom to decide about participation, and clarity of information about the study they are asked to participate in [94]. The consent form included information on the study and purpose of the interview, that participants could withdraw from the study at any time, and that all information on the participants would be treated confidentially. Special consideration may be taken when working with older adults. It was thus important to ensure that respondents understood the consent before signing it. In line with this, it is necessary to consider the respondents’ ability to understand questions and to provide meaningful answers, as older adults’ cognitive abilities or memory capacity may limit this. For that reason, social caretakers familiar with the respondents, were prior to the interview contacted and asked whether they thought that each respondent was capable of answering the questions.

Further, Cowles also argues that a confidential relationship between the informant and researcher should be established, by taking a non-judgemental stance as well as the ability to establish trust during the interview [95]. One way of achieving this may be by meeting the respondent in a familiar and safe environment [96]. I thus decided to let the respondents choose the place of the interview, of which most of them chose their home. I was further focused on establishing trust during the interviews, as several respondents feared that their negative attitudes towards the intervention would dissatisfy me or be
brought forward to the designers who were in charge of the intervention. I therefore ensured them of their anonymity and that my interest lied in their thoughts and perceptions, no matter if they were negative or positive. Respondents names were anonymized to ensure the participants’ anonymity during analysis and presentation of results. In the papers, names where never listed, but only information on age, gender and housing association, assuring no specific identification of respondents. Data were stored on a secure server.

Public observations of NOS using SOPARC and audits using CPAT, did not require consent as no identifiable information was collected on participants. Pictures taken of NOS before or after observations did not include people with identifiable faces, and mostly included no people at all.
5. Summary of results

The purpose of this section is to present the main findings of each of the three papers that form the empirical basis of this thesis. The results section is divided into four sections. The first three sections each represent one of the papers, and the last section presents the results of the synthesis across all papers. A more detailed description of the results of the individual papers can be found in papers I-III.

5.1 Paper I – Feasibility of using GPS and VERITAS to measure daily mobility

The feasibility of using GPS and VERITAS to measure daily mobility in older adults living in a disadvantaged community, was assessed based on the method’s ‘recruitment and compliance’, ‘practicalities’, and ‘mobility variables’.

Recruitment, compliance and practicalities

Recruitment was challenging and time-consuming. Only 10% out of 340 older adults agreed to complete the VERITAS interview and 6.8% agreed to wear the GPS device. Two persons had difficulties completing the VERITAS interview and 11 had difficulties remembering to charge the GPS or to carry it, and only 52% had valid GPS data for at least one day (> 8 hr of wear time). The practicalities of both methods are presented in table 3. The two methods vary greatly in relation to costs, time spent on preparation and data collection, as well as the scalability, related to the specific case of older adults living in the disadvantaged community of Sydhavnen.

<table>
<thead>
<tr>
<th>Factors</th>
<th>VERITAS</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment costs $</td>
<td>At least $1500 (one-time payment)</td>
<td>Around $100 (per device + key hanger)</td>
</tr>
<tr>
<td>Time: equipment preparation</td>
<td>1 min (registration of 1 participant by name and login information on computer before visit)</td>
<td>10 min (preparing 1 GPS in software on computer, nametag on GPS device, tape on ‘On’ button, attach to key hanger)</td>
</tr>
<tr>
<td>Time: data collection</td>
<td>30 min – 1 hour (per interview)</td>
<td>25 min/7days (explaining the GPS, how to wear, how to charge, hanging reminder poster on wall, collecting phone number for reminder text, 7 days wear time)</td>
</tr>
<tr>
<td>Time: home visits</td>
<td>1 home visit</td>
<td>2 home visits (delivering and explaining the GPS and collecting it 7 days later)</td>
</tr>
<tr>
<td>Scalability (can this be done on a larger study population?)</td>
<td>Yes (if done online instead of interview)</td>
<td>Yes (but need many devices which is expensive)</td>
</tr>
</tbody>
</table>
Mobility variables

An overview of the two methods’ capability of measuring different aspects of daily mobility is presented in table 4. VERITAS was able to measure most aspects of daily mobility based on self-report, except specific routes taken from home to destinations, time spent in different modes of transportsations, and distance travelled by mode. SI was a substantial and integrated part of the VERITAS interview, as each question about specific destinations was followed by a question of whether they went by themselves or with someone, and how often they visited specific friends and family. GPS was also able to measure most of the aspects of daily mobility based on 24-hour objective data, except type of destination, use of assistive devices during trips, and SI.

Table 4: Overview of variables explaining daily mobility through VERITAS and GPS data (copy of table 3, paper I)

<table>
<thead>
<tr>
<th>Variables</th>
<th>VERITAS</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of destinations visited</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Type of destination</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Routes from home to destinations</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Frequency of destinations visited</td>
<td>Yes (total)</td>
<td>Yes (for 7 days)</td>
</tr>
<tr>
<td>Distance to destinations</td>
<td>Yes</td>
<td>Yes (high temporal precision)</td>
</tr>
<tr>
<td>Time spent at a location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode of transportation</td>
<td>Yes (specific mode)</td>
<td>Yes (walk, bike, vehicle)</td>
</tr>
<tr>
<td>Frequency of transportation mode</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time spent in different transportation modes</td>
<td>No</td>
<td>Yes (high temporal precision)</td>
</tr>
<tr>
<td>Use of assistive devices during trips</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Distance travelled by mode</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time spent outdoors</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Social interaction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.2 Paper II - Association between NOS features, social interaction and walking

Structured interviews were conducted with 39 older adults, mean age was 74 years old and 73.5% were female. The interviews revealed weather conditions, lack of seating, condition of paths and safety concerns, to be important categories for the older adults in relation to their use of NOS. The semi-structured interviews were led with 10 older adults (five from each senior housing), mean age was 79 years old and 67% were female. Categories identified in the thematic analysis were; SI, seating, landscaping, wheelchair friendliness, shade and shelter. SOPARC observations revealed a total of 353 older adults observed within the 11 NOS. Mean age was 66.7, 48.2% were female, 72% were observed
walking within NOS and 30% engaged in SI. The results of the regression analysis presented in table 5, demonstrated that older adults were 1.05 times more likely to walk in NOS for each additional year, 1.57 times more likely to walk for each additional picnic table present within the NOS, and 9.70 times more likely to walk if the condition of paths within NOS were good. Whereas, older adults were 0.30 times less likely to walk if there was bushes and flower beds present within the NOS, 0.02 times less likely to walk if the paths within the NOS were shady, and 0.22 times less likely to walk if they engaged in SI. The crude rate identified that 80.2% of older adults walked when they were alone, whereas only 52.8% walked while engaged in SI.

Table 5. Binomial Logistic Regression analysis on walking (dependent variable). (copy of table 3, paper II)

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Crude % or Mean</th>
<th>OR</th>
<th>95% CI for OR</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (count)</td>
<td>353</td>
<td>67</td>
<td>1.05</td>
<td>1.000, 1.095</td>
<td>0.046</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>170</td>
<td>72.9%</td>
<td>1.35</td>
<td>0.799, 2.290</td>
<td>0.261</td>
</tr>
<tr>
<td>Male</td>
<td>183</td>
<td>71.0%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOS size (square meters)</td>
<td>353</td>
<td>10574.36</td>
<td>1.00</td>
<td>1.000, 1.000</td>
<td>0.987</td>
</tr>
<tr>
<td>Landscape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bushes, flower beds</td>
<td>159</td>
<td>68.6%</td>
<td>0.30</td>
<td>0.104, 0.882</td>
<td>0.029</td>
</tr>
<tr>
<td>None</td>
<td>194</td>
<td>74.7%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bench (count)</td>
<td>353</td>
<td>5</td>
<td>0.89</td>
<td>0.760, 1.045</td>
<td>0.157</td>
</tr>
<tr>
<td>Picnic table (count)</td>
<td>353</td>
<td>1</td>
<td>1.57</td>
<td>1.092, 2.255</td>
<td>0.015</td>
</tr>
<tr>
<td>Green space shade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shade</td>
<td>164</td>
<td>78.0%</td>
<td>0.77</td>
<td>0.146, 4.054</td>
<td>0.756</td>
</tr>
<tr>
<td>None</td>
<td>189</td>
<td>66.7%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path shade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shade</td>
<td>229</td>
<td>71.2%</td>
<td>0.02</td>
<td>0.002, 0.218</td>
<td>0.001</td>
</tr>
<tr>
<td>None</td>
<td>124</td>
<td>73.4%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>231</td>
<td>73.6%</td>
<td>9.695</td>
<td>1.261, 74.550</td>
<td>0.029</td>
</tr>
<tr>
<td>Bad</td>
<td>122</td>
<td>68.9%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path wheelchair friendly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>202</td>
<td>72.8%</td>
<td>1.788</td>
<td>0.502, 6.366</td>
<td>0.370</td>
</tr>
<tr>
<td>No</td>
<td>151</td>
<td>70.9%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social interaction</td>
<td>106</td>
<td>52.8%</td>
<td>0.223</td>
<td>0.129, 0.384</td>
<td>0.000</td>
</tr>
<tr>
<td>None</td>
<td>247</td>
<td>80.2%</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: N: population, Mean: mean for participants walking (continuous), Crude%: crude rate for participants walking (categorical), Sig.: significance< 0.05, 95% CI: Confidence intervals, OR: Odds Ratio, NOS: Neighbourhood open spaces.
5.3 Paper III - Factors promoting or inhibiting use of NOS after intervention

Within senior housing I, the intervention resulted in the building of a pavilion in a green space (area 2B), as well as the renovation of existing benches and the building of raised flower beds in an area right outside residents’ homes (area 2D) (see figure 2 in paper III). In senior housing II, another pavilion within a green space was built (area 3DEF) (see figure 2 in paper III). A total of 209 at baseline and 329 older adults at follow up were observed in the 13 NOS. At baseline, 54.5% females were observed and 31.1% engaged in SI, whereas 50.2% females were observed at follow up and 53.8% engaged in SI. Walking was observed for 65.6% at baseline and 45.6% at follow up. In area 2D, 29 older adults were observed at baseline, of which four where sitting on benches and 11 engaged in SI. At follow up, 52 older adults were observed, of which 22 were sitting on the renovated benches and 33 engaged in SI. In area 2B, four and one persons were observed at baseline and follow up, respectively. In area 3DEF, two older adults were observed at baseline and 12 at follow up – all engaging in SI, but they did not use the newly built pavilion. Evaluating the use of the intervention areas including other NOS by older adults using interviews, resulted in a range of reasons older adults would or would not use the NOS. Based on the analysis of the semi-structured interviews using the socio-ecological model as a framework, six factors – presented in the following – were identified to be important for respondents’ use of NOS.

Natural environment – Weather

Aspects of the natural environment were identified to be important for older adults use of NOS. Especially windy and too hot places were mentioned as a barrier for using NOS as one woman expressed:

“…It depends on the weather where you can find shelter” (female, 75 years old, housing area 2, paper III)

More older adults were observed using area 2D which provided shade through trees along the paths as well as shelter from the wind, by having raised flower beds built. The pavilions built in area 3DEF and 2B were not observed being used more, although they were meant to provide shade and shelter. Due to the hot summer that year, the older adults experienced the pavilions to be too hot.
**Policy environment - Support**

A lack of resourceful older adults was raised in both senior housings as an issue which affected community engagement. The respondents expressed that the municipality has 100% housing allocation rights, meaning that they decide who gets to live in the senior housings. In the last years, the residents perceived the municipality to have allocated more mentally ill, sick and frail older people, resulting in fewer residents who have the energy to help with daily chores like gardening work, or help organise activities within NOS or just participate in them. As one respondent says:

> “The municipality has 100% housing allocation rights. When they do not know where to put them, they just toss them in here, and we don’t want that anymore. If they keep on allocating weak people, we do not have the people needed. We are too few at the moment who have the strength to participate and help out.” (female, 69 years old, housing area 1, paper III)

Another lack of support from the municipality argued by the residents as an issue, was economic support to hire social caretakers who can organise activities in the NOS and visit the residents, to prevent loneliness. The respondents argued that the two pavilions built in area 2B and 3DEF were not being used by older adults, as the residents relied on social caretakers or volunteers to organise gatherings.

**Socio/cultural environment - Social interaction**

SI was found important for older adults’ use of NOS and was connected to most of the other levels in the socio-ecological model. Loneliness was raised as an issue by some of the respondents, and NOS were identified to be used for SI important for especially those living alone, as one woman expressed:

> “There are many who are alone right, it’s always like that right. But then they meet down there [NOS outside their apartment entrance] and talk, they get out” (female, 83 years old age, housing area 1, paper III)

Several interviewees talked about these places just outside their apartments as a place they cherished for SI, having someone to sit and talk to or meet along the way. Respondents argued that they did not use the new-built pavilion partly because residents were sitting somewhere else within the NOS and no one wanted to sit alone in the pavilion. Not wanting to be alone was by several mentioned as a barrier for
visiting NOS that were further away. Respondents were aware of the importance of SI and cherished those NOS right outside their apartment as they were able to casually meet and greet neighbours:

“\textit{I think it is nice to go down there in the morning and walk past with my little stroller, and then they sit there and drink coffee and talk, with the flowers surrounding them. I greet them all because I know them, right. They wave back when I am on my way to something. So, I know them and say ‘hello’, and exchange a few words, but to sit with them… unless they one day ask me to sit down and have a cup of coffee, I might do it}” (female, 74 years old, housing area 1, paper III)

Area 2D was identified in the qualitative findings to be cherished by many respondents. This NOS was talked a lot about, as a place with lots of neighbours to meet and a nice place.

\textbf{Socio/cultural environment - Organisation}

Social caretakers were responsible for organising activities with help from resourceful residents but were not perceived as very supportive towards using the NOS. Support from the social caretakers and volunteers was found to be important for the use of new facilities and places, by older adults. Small activities like making coffee and having to carry that all the way to a NOS seemed too strenuous and was identified by several respondents to be a barrier. This is highlighted by one man:

“\textit{There needs to be coffee, if there should be a gathering. If something could be organised there, a group making coffee once a week. I don’t know if you can get people to do that here. It takes some manpower. I think it would be used a lot if something would be organised}” (male, 82 years old, housing area 1, paper III)

\textbf{Individual factors – sense of ownership}

Sense of ownership may have affected their use of those NOS being part of the intervention. Older adults who took part in the intervention were concerned about its maintenance as one woman mentioned:

“\textit{They take good care of them this year [raised flower beds]. Last year they hadn’t really found the rhythm of watering them and so on, right!... But now I see that some people have taken it upon themselves to water them}” (female, 74 years old, housing area 1, paper III)
5.4 Synthesis of findings across papers
This section presents the results of the synthesis across the three papers addressing factors influencing older adults’ use of NOS and how to measure it (see figure 1). Papers II and III were used to assess factors influencing older adults’ use of NOS. Paper I was not included, as this paper did not assess predictors but compared methods. All three papers were used to assess how to measure use of NOS.

5.4.1 Factors influencing use of NOS
Thirteen factors influencing older adults’ use of NOS for SI and walking were identified at all levels of the socio-ecological model in paper II and paper III. Figure 6 presents an overview of each quantitatively and qualitatively assessed factor for both papers and which level in the socio-ecological model it represents. Some of the same factors were identified in both papers, as well as in both the qualitative and quantitative results. Several of the factors at different levels in the model were also found to be linked across papers and methods. For example, the built environment factor ‘seating’ found in both papers, was closely linked to SI. The quantitative analysis in paper II found SI to negatively affect walking as it mostly happened during sedentary behaviours, and the qualitative analysis in paper III, highlighted how the respondents cherished meeting outside their apartment door, sitting on the benches and talking. While the SOPARC observations identified a large amount of SI and sedentary behaviour in this area. Other factors found to be linked across levels, papers and analysis were SI and organisation at the socio/cultural environment level, distance to NOS at the built environment level, and social caretakers and housing allocation at the policy environment level. The perceived lack of support from the municipality to hire social caretakers willing to organise activities for the residents, is identified as a reason for older adults to not use NOS. NOS further away seemed to be dependent on the organisation of social activities to attract users, as older adults would not visit a NOS alone. If social caretakers were not present, older adults were more dependent on other resourceful older adults to organise social activities. But the municipality’s 100% housing allocation rights was perceived by the residents to be an issue, as only frail and less abled older adults were assigned an apartment in their neighbourhood, resulting in less resourceful older adults, able to contribute to the community and engage in social activities.
5.4.2 Measures of older adults’ use of NOS
Table 6 presents an overview of all six methods used in the three papers and the differences and commonalities in measuring older adults’ walking behaviour and SI in the neighbourhood. I acknowledge that not all six methods have been used to measure older adults’ use of NOS, as GPS and VERITAS were used to measure daily mobility within the neighbourhood. The six methods capture behaviour in different defined areas depending on the purpose of measurement, which is presented in the first column. The table features the categories ‘recruitment and compliance’ and ‘practicalities’, which were used in paper I, and ‘data applicability’, which originate from a framework by Kelly et al. [97]. Strength and weaknesses are lined up based on the application in the three papers.
Table 6: Results of the synthesis describing the six measurement tools used in the thesis

<table>
<thead>
<tr>
<th>Method</th>
<th>Information Description</th>
<th>Data applicability</th>
<th>Recruitment and compliance</th>
<th>Practicalities</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Correlates &amp; Determinant</td>
<td>Dimensions</td>
<td>Data collection</td>
<td>Time: data collection</td>
<td></td>
</tr>
<tr>
<td>Qstarz BT- Q1000xt GPS</td>
<td>Objective 24 hr data on where the participant has been, for how long and distance travelled</td>
<td>Where</td>
<td>When</td>
<td>Duration</td>
<td>Frequency</td>
<td>Device placed on the body of participant or in a pocket, for 7 consecutive days</td>
</tr>
<tr>
<td>VERITAS</td>
<td>Subjective online map-based information on mobility, routes, places, how and with whom</td>
<td>Where</td>
<td>With whom</td>
<td>Frequency</td>
<td>Intensity</td>
<td>Face-to-face interviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Why</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPAT</td>
<td>Quantitative audits of built environment within a NOS</td>
<td>Where</td>
<td></td>
<td></td>
<td></td>
<td>Standing within the NOS, registering everything, based on the audit sheet</td>
</tr>
<tr>
<td>SOPARC</td>
<td>Quantitative observations on specific use of NOS</td>
<td>Where</td>
<td>When</td>
<td>With whom</td>
<td>Intensity</td>
<td>Type</td>
</tr>
<tr>
<td>Structured interviews</td>
<td>Subjective data on specific barriers and facilitators for using NOS</td>
<td>Where</td>
<td>When</td>
<td>With whom</td>
<td>Why</td>
<td>Duration</td>
</tr>
<tr>
<td>Semi-structured interviews</td>
<td>Subjective in-depth data on reasons for (not) using NOS</td>
<td>Where</td>
<td>When</td>
<td>With whom</td>
<td>Why</td>
<td>Duration</td>
</tr>
</tbody>
</table>
The strength of the GPS device is that it provides 24-hour objective person-specific data on older adults’ time spent in and out of the neighbourhood. It also captures which NOS they used during a week and which routes they take to travel to them. GPS does not provide information about what the participant did within the NOS, nor with whom. Recruitment was found challenging and time-consuming. Device preparation and data collection can be time-consuming when handling large study populations, and strenuous especially for the study participant, having to wear the device for seven consecutive days.

The strength of VERITAS is that it provides GIS based contextual subjective data (with whom and why) but lacks information about specific routes taken to destinations and time spent within the NOS. The method relies on respondents recall abilities, risking recall bias or social desirability bias. Compliance rate was satisfying. The questionnaire takes time to prepare to fit the specific study population and aim the study. When using self-administration, VERITAS may be used in larger studies, but this was found less feasible for this study population.

CPAT in combination with SOPARC provides contextual and area-specific information about older adults’ use of NOS and NOS characteristics. These methods provide place-specific information rather than person-specific information, and cannot be linked to GPS, VERITAS or other person-specific data. The methods do not require active involvement of participants or their consent. The methods take time to prepare, as researchers have to choose which NOS to observe and audit, as well as conducting training of observes. When used to assess SI and use of specific facilities in NOS, the methods must be adapted. Data-collection can be time-consuming depending on the number of NOS and the size of NOS to observe and audit.

The structured and semi-structured interviews provide information on respondents’ self-reported use of NOS, contextual information about their use, why and with who, and barriers and facilitators of using NOS. Especially the semi-structured interview method has the advantage of providing in-depth information about older adults’ perception of NOS which is valuable when trying to understand why a certain phenomenon occurs. Compliance was not found to be an issue. The methods rely on respondents recall abilities, risking recall bias or social desirability bias. Interview guides take time to prepare and data-collection can be time-consuming making it less feasible for larger data-collections.
6. Discussion

This thesis contributed to new knowledge on specific individual and environmental factors influencing older adults’ walking behaviour and SI in NOS, living in a disadvantaged neighbourhood. The unique part of this thesis is its focus on older adults living in disadvantaged communities and how to promote use of NOS by providing specific built environmental features, organisational support and social spaces. The thesis provides insights into the impact of an intervention changing NOS for older adults’ walking behaviour and SI, which has not been assessed previously. Lastly, the thesis contributed to the research field by being the first study to assess the applicability of different types of methods for measuring older adults’ use of NOS, resulting in a practical framework used to identify the most appropriate measurement tool in a given research study.

In the following sections, results from the synthesis of the three papers are interpreted, discussed and compared to previous research in the field. Overall methodological considerations of the thesis will be discussed, highlighting strengths and limitations.

6.1 Factors influencing use of NOS

Thirteen factors, at all five levels of the socio-ecological model, were identified to be important for older adults’ use of NOS, by either negatively or positively influencing SI and walking in NOS. These factors were: age, sense of ownership, SI, organisation of activities, shelter, shade along paths, condition of paths, seating, landscaping, distance to NOS, economical support for social caretakers, housing allocation, and weather. The factors will be discussed in the following section.

6.1.1 Built environment – NOS features

Shelter, shade along paths, the condition of paths, picnic tables, and landscaping were found to be important built environment factors influencing older adults’ use of NOS by walking, either negatively or positively. Unlike other studies [60, 98-100], paper II found landscaping such as flower beds and pruned bushes as well as shade along paths to be negatively associated with older adults’ walking. The negative association found with landscaping indicates that this is not important for walking but may be important for other types of use of NOS, such as relaxing and enjoying the landscape. Landscaping may
thus promote more sedentary activities and SI for this study population. The studies by Finlay et al. [99] and Strath et al. [100] both found landscaping to be important for PA in older adults using interview data. Although they identified the importance of landscaping for PA, Strath et al. highlighted that it was more important for leisure and relaxation and Finlay et al. mentioned respondents’ views related to QoL rather than PA. This implies that landscaping may be more important for sedentary activities and SI, which may explain the negative results for walking behaviour found in paper II.

High temperatures with sunny days are quite rare in Denmark. As such, people typically want to enjoy the sun when it is possible, which may explain why shade was found to negatively affect walking. Paper III also identified issues with the sun as respondents mentioned shade as an important factor during a rare heat wave in 2018. Reasons for the contradicting results may lie in the methods and variables used in the different studies. The studies by Sugiyama et al. [60] and Giles-Corti et al. [98] did also audit NOS or public open spaces (using a different auditing tool), but instead of observing older adults’ walking behaviour, they asked users to give an estimate of how much they walked during a week. Additionally, they created a weighted mean score of 9 attributes, one of which was shade, meaning that it is unclear which of the attributes affected their walking behaviour. Lack of shelter from wind was mentioned by several respondents as a reason for not using some facilities within different NOS, as mentioned earlier, bad weather was identified as a barrier for using NOS.

The possibility of seating and well-maintained walking paths was identified to be important features for older adults’ use of NOS. Other studies have also identified the availability of paths and its condition to be important for older adults walking behaviour [100, 101]. Older adults typically lose some of their mobility as they age, resulting in increased risk of falling [102] and the need for assistive devices for active transportation [103]. Uneven surfaces or poorly maintained paths may consequently pose a risk for older adults of low mobility and act as a barrier for walking within NOS. Age related decreases in mobility, may also explain the importance of seating for older adults, as seating provides the possibility of taking a rest while walking [54, 104], as a place for enjoying the NOS [99], or as a natural meeting point for SI within NOS, as this is less strenuous than having to walk and socialise at the same time, which may be challenging for some groups of older adults [105-107]. Built environment features promoting sedentary activities rather than walking may thus not be a negative factor, as these features
promote other health enhancing behaviours within NOS such as SI and relaxation. Some features may promote one behaviour but inhibit the other. Being aware of this distinction when building NOS is necessary, to ensure the support of several healthy behaviours, rather than inhibiting it. It also highlights the importance of being explicit about the specific type of behaviour being promoted.

Distance to the NOS seemed also to be a factor influencing older adults use of different NOS. Although distance travelled to the NOS was not specifically assessed in this study, respondents talked about the burden of having to transport things such as coffee or food to the NOS placed further away, and not wanting to use the NOS because of that. Whereas the distance to the NOS right outside their apartments, was not perceived as a burden for the respondents to walk and carry things like, coffee or food. Distance to parks or other outdoor spaces are found in several studies to influence use of the specific setting [108-110]. For example, the study by Mowen et al [108], found perceived park proximity to affect park visitation, but at the same time found social support to outweigh the influence of park proximity. This suggests that distance is important, but that older adults are willing to travel further for social activities. However, studies investigating distance to parks often use a 400-meter cut point to define short versus long distances. This thesis only looked at the short distance of less than 400 meters and identified variations in behaviour within different distances of these 400 meters (see Appendix I for maps of NOS) as well as an increased use of NOS for the oldest older adults. This highlights the difference between typical public parks and NOS, as NOS may attract less mobile older adults, and suggests that NOS are a mix between private front yards and public space next to housings. These spaces in close proximity serve as a kind of public front yard, provide opportunities for staying outdoors, observing things happening and talking to neighbours, but at the same time provide the intimacy and closeness of a private front yard [52]. These in-between spaces are argued by Jan Gehl to be important for supporting SI – maybe especially in areas characterized by apartment buildings, were people usually do not have front yards. This suggests that the close proximity of NOS may be especially important for older adults living in apartments in disadvantaged neighbourhoods.

6.1.2 Natural environment
Weather conditions may affect the importance of specific built environment features within NOS. Weather – especially too much wind and high temperatures – was found to influence older adults’
decisions on whether to visit a NOS. Seventy-five % of the 34 interviewed people identified weather as an issue, and weather was mentioned by several during the semi-structured interviews as a barrier for using specific features within a NOS. Bad weather may pose a risk of falls for mobility impaired older adults, or a risk of getting unwell due to the heat, which may have greater health-related consequences for older adults than other age groups [111, 112]. Weather was identified in other studies to be important for older adults’ outdoor walking and use of outdoor spaces [113-116]. The study by Klenk et al. supports the results that wind is a barrier, whereas the study by Prins et al. contradicted these results and furthermore found that higher temperatures were positively associates with older adults walking behaviour. These differences in results may be explained by the different methods used and outcomes investigated, i.e. walking behaviour, overall PA behaviour, SI or general use of NOS. Although weather has been identified in this study and in other studies to play a role in older adults’ use of outdoor spaces, weather is not something that can be changed, but built environment solutions for shelter may be considered as discussed in section 6.1.1.

6.1.3 Policy environment - support
Lack of support from the municipality was found to influence older adults’ use of NOS. Economic support for hiring resourceful social caretakers seemed to be important for organising activities, but their lack of engagement was mentioned as a reason for not using some of the NOS (paper III). Other studies have identified the presence of organised activities and caretakers to be important for living in community housings [117-119] and expressed the importance of engaging in organised activities [119]. Social caretakers are thus a relevant source of support within communities to engage community members in activities within NOS, but older adults also rely on resourceful older adults to organise and implement activities. However, several respondents mentioned issues with the municipality’s 100% housing allocation rights. Older adults who do not have the money to stay in their homes any more or are too sick or too frail to take 100% care of themselves, are being offered a senior housing apartment by the municipality. Based on several respondents, the municipality has in recent years only allocated very sick and frail older adults, and less resourceful older adults to these apartments. Having resourceful older adults who want to participate and support the community has been highlighted in other studies to be important, but in decline [120, 121]. Consequently, support for organising activities seems to be an important factor for older adults to participate in activities within NOS and may explain the limited use
of some of the NOS observed in paper III. Several different types of age-specific housings exists, such as retirement villages [122], senior co-housing communities [121, 123, 124], and continuing care retirement communities [125], which all share the common aim of providing support for older adults’ individual life and autonomy, support for residents’ ability to contribute and participate in the community, as well as supportive social contacts. To achieve this, may require great investment by municipalities to allocate fund for supportive social caretakers who may especially help the less resourceful older adults, as well as the municipalities allocation of resourceful older adults who can contribute to the community.

6.1.4 Socio/cultural environment – Organisation and social interaction
The allocation of certain types of older adults to the senior housings mentioned at the policy environment level, was also connected to the need for organisational resources at the socio/cultural level, as well as to the importance of SI within NOS. NOS that were not placed immediately outside of residents’ apartment doors were not being used, and were mentioned by several respondents to be due to the lack of activities organised by either themselves or the social caretakers. Whereas areas right outside their apartment doors were highly used and did not require help from social caretakers. This difference was supported by the identified importance of distance to NOS discussed in section 6.1.1.

The type of SI varied across the different NOS, as the interviews suggests that areas right outside their apartment buildings were used for chance social encounters while walking through, as well as spontaneous coffee drinking. Whereas NOS further away relied on more organised social encounters, where people had agreed to meet, suggesting that these NOS need organisational support from more resourceful older adults or social caretakers to promote use. The high use of areas close to participants’ homes, may be explained by respondents mentioning how much they cherish randomly meeting and talking to people within these NOS on an everyday basis, whereas social encounters within NOS that are further away, happened more seldom. This suggests that frequent social encounters in these NOS characterized as public front yards – although short – may be more valued by older adults, than rare organised social encounters in NOS further away. Several studies identify the importance of SI for older adults’ use of green spaces and public open spaces in general [48, 49, 99, 126, 127], and especially to combat loneliness in older adults due to loss of family members and friends, or having to move to a
different community. However, it is unknown if NOS in other communities or countries have the same influence on SI, as none of the studies identified earlier on specifically NOS and older adults, included SI in their assessment [54, 60-62].

Some respondents mentioned, that they would not visit a NOS if they risked being alone or would choose to sit where other people were sitting, even though they rather wanted to sit somewhere else due to shelter. This is somewhat supported by a study from Yung et al [128] highlighting that older adults consider SI to be more important than walkable and safe public open spaces. SI may thus promote well-being, which seem to be the most important factor for this specific study population, supporting the need to focus more on creating and promoting social spaces within NOS [129]. Although, it is unsure if the high focus on SI is because the built environment already is walkable and safe enough for older adults. Even though this study and the study by Yung et al. suggests that social spaces are more important than built environment features, the results do not imply that safe and walkable NOS should not be prioritised and promoted. A supportive built environment may be a prerequisite for older adults to be able to use NOS for SI [130]. As paper II indicates, well-maintained paths and seating are important features for older adults to walk within NOS, and though mostly sedentary activities were observed to occur within NOS, older adults still need to get from their home to the NOS, which may generate some level of PA by walking. This suggests that SI may be a means to promote walking, as well as being the goal. Especially those NOS placed further away may promote more PA as people have to walk to the NOS to participate in the organised activities. Whereas the NOS in close proximity may promote more SI and less walking. Although social activities were happening mostly sedentary, it is still a vital part of healthy ageing and should therefore be the focus of health promoters as much as PA is.

Although NOS seem to be important for SI and may provide a supportive social space, this does not imply that other facilities may not be important for SI or be able to promote it. Both senior housing areas within the neighbourhood of Sydhavnen provided other types of organised social activities for the residents within common. Common meals prepared by the social caretakers and volunteer residents, as well as bingo were the most common activities. These activities may also promote SI and well-being for some residents. After participating in these activities during recruitment of study participants, it however became clear that these activities attracted the same few people every time, rather than a large diverse
group of residents. NOS may thus provide an alternative space for older adults to engage in social activities, who are not interested in playing bingo. Being outside in green spaces may also have additional health benefits for older adults compared to being inside [131] and can be used to promote PA e.g. through garden activities [132]. Finally, NOS acting as public front yards may provide opportunities for SI on a daily basis, whereas organised activities in common areas usually happen once or twice a week.

6.1.5 Individual factors
The individual level factors age and sense of ownership were somewhat related to older adults’ use of NOS. Older people were more likely to walk within NOS, than younger people. This is an essential finding which highlights the importance of providing supportive NOS for older adults living in disadvantaged communities, dealing with mobility limitations and less resources [47]. As the NOS are in closer proximity to the residents’ homes, they may be easier to reach for less mobile older adults [58, 59]. Whereas public parks are typically further away and may attract younger and more socio-economically strong older adults who have the mobility to travel to parks.

Sense of ownership was found to occur for some of the respondents who also participated in the intervention study. Being part of creating something and afterwards taking care of it, seemed to promote some form of use of the NOS, as participants had to water the raised flowerbeds and felt the need to keep an eye on the facilities. This suggest that older adults value the ability to take care of something such as small gardens or front yards. A study in a Finnish senior co-housing community also highlights that having responsibilities such as maintaining the premises or organising activities was important for the residents [133]. And a study by Glass found that older adults living in co-housing communities where they had responsibilities gave them a sense of empowerment [124]. This suggests that supporting older adults in gaining a sense of ownership and empowerment by letting them take care of shared facilities and organise activities, is an important factor for the healthy ageing of older adults living in senior co-housing communities, such as the two communities in Sydhavnen. Providing older adults with the right opportunities may contribute to their well-being and physical ability, as they cherish this activity, are able to bond with neighbours and are physically active at the same time [134, 135]. Other research suggests that older adults need to feel that they contribute to others in some way by for example volunteering within their community, which supports their well-being [136, 137]. This is further
connected to the socio/cultural environment level presented in section 6.1.4, finding organisation of activities either by social caretakers or volunteers to be important. During data collection, I encountered several residents mentioning that they have tried to establish small front yards but were forced to remove them on order from the janitors. Residents were not allowed to personalise the green space in front of the apartment buildings, because – as presumed by the residents – the janitors did not like the extra work. This suggests that to promote sense of ownership towards the close NOS, senior housing officials have the responsibility to empower the residents by making rules allowing residents to create public front yards or other initiatives that supports well-being – connected to the policy environment level presented in section 6.1.3. This also supports the need to involve older adults more in interventions targeted at themselves, to support empowerment and a sense of ownership towards the community they live in.

Finding only age and sense of ownership to affect older adults’ use of NOS, does not imply that other individual factors were not at stake, but may be because these factors were not covered during the interviews. Other individual level factors may have been related to older adults’ use of NOS but were not assessed in this study. Physical disabilities, issues with hearing or sight, or chronic conditions could have affected older adults’ ability to visit NOS and their perception of NOS [54, 61].

In summary, the discussion of factors influencing older adults’ use of NOS at all levels of the socio-ecological model highlights the reciprocal relationship between these factors and across the levels. Use of NOS by walking or SI is argued to be influenced by all levels in the socio-ecological model. As such, all levels should be considered, to comprehensively asses what influences the behaviours. In this thesis, some factors seemed more important than others. For older adults to use NOS for walking, NOS placed further away from homes, providing well-maintained walking paths and seating, and organisational support from social caretakers, seem to be important. For older adults to use NOS for SI, NOS right outside their homes acting as semi-public front yards, providing social spaces and a sense of ownership seem more important. NOS further away may promote SI but need additional help from social caretakers or resourceful older adults to organise activities, relying on support from the municipality. How to create supportive NOS for SI and walking, seem to depend on the distance to NOS and may also work in different directions, as promoting SI seems to inhibit walking. These findings stress the importance of specifying the type of NOS and use within the NOS, when assessing factors influencing use of NOS.
6.2 Measuring older adults’ use of NOS
Kelly et al. [97] argue that the choice of methods to measure PA, should depend on the purpose of the measurement. In the ‘Move the Neighbourhood’ study, objective measurements with GPS was planned as method. But based on the baseline measurement and gained experience with the participants, interviews and SOPARC observations replaced them. The following section discusses the strengths and weaknesses of different methods and proposes a new practical guiding framework for method selection.

The lack of consensus about the best ways to define, utilize and assess different concepts of behaviours such as walking or SI, has led to misinterpretations of strengths and weaknesses of methods for measuring specific concepts such as frequency, versus duration [97]. This creates a one-sided measurement hierarchy where objective measures of PA are considered the ‘gold standard’, failing to consider the complexity of the behaviour and which method is best at measuring a specific concept of PA. Based on Kelly et al. [97], there are different ‘gold standards’ depending on which concept of older adults’ use of NOS is of interest, and as such, which method is most suitable depends on the purpose of the measurement, e.g. energy expenditure, mobility or SI. GPS measurements may be sufficient to use to capture PA or mobility in NOS, but it would disregard the social behaviour. As SI is identified in numerous studies to be important for healthy ageing [25-34], as well as a tool for the promotion of PA in older adults [138-140], this suggests that measures of SI should always be included when studying active living behaviour. Identifying the method or methods most suitable for assessing both SI and PA can be challenging and should be defined based on a specific set of aspects.

6.2.1 Framework for choosing a measurement method
Kelly et al. proposed a framework which considers the complexity of PA and sedentary behaviour and can be used to identify the most appropriate measurement method for a specific purpose [97]. The framework considers three aspects that help characterize a given behaviour by assessing the domains, dimensions, and correlates and determinants of the behaviour. These considerations are argued to be assessed before choosing the most appropriate measurement method for the specific purpose. I argue that the framework by Kelly et al. is missing key aspects and propose that researchers should also consider the suitability of the measure in relation to its recruitment, compliance and practicalities. This is not only the case for PA assessed by Kelly et al., but also for SI and other types of use of NOS. Choosing the right
method should not only dependent on the method’s data applicability, since aspects such as the study population, time frame and resources, may influence which method is most suitable for the specific study.

The six methods used in this thesis vary greatly in terms of practicalities, recruitment and participants’ compliance with data collection, which may make a suitable method in terms of data applicability, less suitable. Suggesting the importance of considering these factors when choosing a method. For example, using interview methods pose a risk of recall bias or social desirability bias, as respondents must remember feelings and behaviours, and may try to answer falsely to please the interviewer [141]. Recruitment and compliance were very difficult for the GPS data collection in low-SES older adults, as reported previously [142]. Whereas SOPARC does not require any recruitment of participants and does not risk recall bias but can be burdensome from a practical perspective as researchers need to be trained in using the method. Although other studies succeeded in using GPS devices for data collection in older adults [143-145], these were studies involving resourceful older adults, which may not be comparable to the study population used in this study. GPS is also not able to assess SI, suggesting that other objective measures might be more suitable. Some have tried to assess joint PA behaviour between children and their parents using GPS and accelerometers, by defining a linear separation distance of less than 50 meters between the two people [146]. However, less than 50 meters between a parent and a child, does not suggest SI between them. Further, this approach can only be applied to people wearing the devices and is not able to assess for example, behaviour between children wearing the device and children who do not wear it. SOPARC or VERITAS may thus be an alternative to GPS, when interested in SI.

Some measures may be feasible for large study populations, whereas others for smaller samples, judged by time spent on preparing and collecting the data. For example, online surveys are not time consuming for the researcher, whereas VERITAS was very time consuming when conducted as face-to-face. Making it less feasible to use on a large study population. Other studies have succeeded in using a self-administered online version of VERITAS on a large study population [78, 147, 148], highlighting the differences in feasibility of a method for different study populations. Thus, researchers cannot rely on the validity or reliability results of a method tested on a different study population than the one of interest. In line with the socio-ecological thinking, it is important to consider that using only one method may not be sufficient to explore a multifaceted concept such as walking or SI [97, 149, 150]. Another way of
applying better measurements may also be to adapt existing methods, by including the additional measures needed to assess a specific concept (e.g. SOPARC was adapted to include SI).

Measuring older adults’ use of NOS can be done in many ways, depending on how ‘use’ is defined. If only one type of behaviour and one type of dimension or correlate was of interest, one method rather than several may be sufficient to use. To identify the most suitable method for a specific measurement, it is imperative to be specific about what type of use or what type of behaviour is the focus of the investigation. The type of use most relevant to investigate may also depend on the study population. High-intensity PA may be appropriate to measure in a study population of younger adults, as their mobility and physical health allows them to perform such physical activities. Whereas measuring high-intensity PA in disadvantaged older adults with low mobility, seem less appropriate. In this study population, getting out of their apartment and walking to a NOS to socialize with a neighbour, may be a much more appropriate health behaviour to assess. The identification of the most suitable method for a specific type of behaviour, also depends on if interested in a specific context or setting. Some methods such as SOPARC, may be more suitable to use when interested in specific contexts, for example how changes in the built environment within NOS affects SI and walking by older adults. However, SOPARC provides area-specific information rather than person-specific, requires the selection of NOS to observe during specific hours and days, and risk observation bias [84]. Whereas other methods such as GPS, may be better if interested in person-specific total time spent in high-intensity PA during a week. The sensitivity of a method to measure a possible change in a behaviour is also of interest for intervention studies and should thus be considered when assessing methods to use. The GPS device may thus be the preferred method to use for measuring change in use of NOS before and after an intervention, due to its high sensitivity and accuracy [151]. Although, if GPS is not feasible to use for the specific study population, other methods such as questionnaires found to be sensitive to change, may be an alternative [152]. Consequently, use of NOS may be measured in different ways, and researchers must be specific about which behaviour to measure for which study design and population, using which method(s).

In summary, a combined assessment of a measurement’s ‘recruitment and compliance’, ‘practicalities’ and ‘data applicability’ is the preferred approach used when researchers have to choose the most appropriate methods to measure a specific behaviour. Based on the discussion of Kelly et al.’s framework and the assessment of the six methods, I have developed an applied framework, researchers can use to
identify the most appropriate method for their data collection, presented in figure 7. The approach starts by addressing what setting (place, age-group, SES), which domains and what correlates and determinants the researcher is interested in. When these are defined, a list of potential methods addressing these questions can be developed. Next, the researcher assesses all methods’ ‘recruitment and compliance’ and ‘practicalities’ based on their study, previous research and their experiences with the methods. Finally, based on this assessment, some methods will be more suitable than others for the specific study.

**Figure 7**: Framework for choosing the most suitable measurement method
6.3 Methodological considerations
This thesis was grounded in a pragmatic worldview, applying a convergent mixed method design to produce comprehensive knowledge on factors influencing older adults’ use of NOS in disadvantaged communities, and how to measure it. This section presents and discusses the strengths and limitations of the study design, as well as the methods used.

6.3.1 Key strengths
A key strength of this thesis is that it combines different methodological approaches in a mixed methods design, as it gives a more nuanced picture of the use of NOS in Sydhavnen. The combination of quantitative and qualitative methods contributes with different perspectives, which could not have been captured using one approach. The pragmatic background and the intervention design of the ‘Move the Neighbourhood’ study led to a strong focus on the specific problems and the pragmatic use of the methods most appropriate for assessing these problems. Focusing on older adults living in disadvantaged communities is another strength of this thesis, as this study population is relatively understudied. Gaining insights into a study population which is especially vulnerable and in need for support, is imperative to combat inequality in healthy ageing.

A key strength of using the socio-ecological model as a framework for my analyses, is its focus on several factors of influences at multiple levels from intrapersonal to environmental, broadening the investigation of health promotion approaches and interventions [13]. Determining important factors within the levels and their complex interplay for a specific study population is challenging. Some studies have tried to assess the different levels in the model and its influence on PA [153-155], and found all levels to be significantly related to PA, with people having higher scores for supportive individual and physical environment factors were more likely to walk. Whereas studies assessing SI seem to be less common. It is not possible to comprehensively assess all factors within all level of the model. Therefore, other factors not investigated here might be important. However, including qualitative interviews, made it possible to identify factors that seemed most important for the specific study population, which strengthened the analysis and interpretation of quantitative results, rather than including all possible factors at all levels.
The pragmatic worldview suggests that a researcher cannot be completely subjective or objective [64]. By adopting this view, it was necessary to limit potential bias caused by subjective views. The use of the socio-ecological model as a framework to guide the qualitative analyses and appointing a second qualitative researcher to perform the same analysis, was another strength and limited the potential bias. Furthermore, combining qualitative results with quantitative results on different factors influencing older adults’ use of NOS, may potentially have limited bias in the interpretation of the results and strengthened the credibility of the qualitative results, by confirming the results using the quantitative results.

Another strength of this thesis was the adaption of the quantitative method CPAT using qualitative methods, to fit the specific study population of older adults from disadvantaged communities, which may have specific needs or barriers not relevant for a high-income population. The adaption and development of SOPARC to include SI is another key strength which may further develop the field of SI in active living research, suggesting the use of methods which combine PA and SI behaviour.

6.3.2 Key limitations
There are several limitations that needs to be considered. Being part of an intervention study involving human participants, several collaborators, and a construction phase, was from a pragmatic point of view a strength, but did create challenges with the data collection. Delays with constructions of the NOS forced me to adjust the study design, having to conduct additional SOPARC observations, as construction sites were not finished on time. This may have biased some of the results. For example, construction barely finished in area 2B, when SOPARC observations were conducted, which may explain the low number of older adults observed in this area, as new built spaces may take time to become places used by people.

Although adapted to fit the specific purpose, CPAT and SOPARC are not tools developed for auditing NOS or observing older adults living in senior housings. As such, other tools may have been more appropriate to use as the foundation for the adaption [156-158]. Second, SOPARC is based on observations of PA behaviour assessed by trained researchers. Although the tool is validated, has been used in numerous studies [82], and guidelines for training observers in performing the observations are available [159], it still poses some challenges, when researchers have to assess age, gender and activity level, often from a distance and within a short time frame. Thus, it is uncertain if and how many older
adults observed were not over the age 60, which may have biased the results in paper II and paper III. Third, even though the two methods have been validated previously [80, 81], the adapted versions of the methods used in this thesis were not.

Discarding the use of objective and person specific GPS data made it difficult to assess person-specific changes in use of NOS by comparing pre- and post-intervention measures. Applying only the SOPARC method instead of combining it with GPS, limited my abilities to assess real use of NOS, as SOPARC observations only provided area-specific snapshots of the actual events occurring within a given NOS. The geographically outlined area, difficulties with recruitment and compliance and time constraints due to the intervention design, led to a quantitatively limited number of included older adults. Assessing more types of deprived neighbourhoods, increasing number of participants in the quantitative analyses and prolonging the observation time using SOPARC would have strengthened the study.

The selection of specific NOS as the setting for the SOPARC observations and CPAT audits poses another potential limitation. NOS is not a common term used to describe a specific well-defined setting. NOS have only been assessed in few other studies [54, 60-62], mainly by the same research team and no well-established definition exists. How NOS was defined in this study, may therefore not be the same as the NOS investigated by other researchers and study results may not be comparable. For example, I decided to exclude some green spaces which to me did not seem like NOS, either because they were small grassy spots, or on the backside of a building with no physical features other than some grass. I may potentially have missed out on valuable observations of older adults using these areas, which a GPS device would have captured. Additionally, identifying the boundaries of each NOS was sometimes challenging. Questions such as, whether to include paths that did not run through but next to the NOS, or if a large NOS divided into several smaller areas, should be considered as one or three individual NOS, were challenging to decide upon. Lastly, use of NOS can be measured in different ways as discussed, but was in this thesis defined as walking and SI. Other behaviours could have been relevant to assess in combination with SI and walking, to get a more comprehensive assessment of different factors affecting different types of use, and how the same factors may promote some behaviours and inhibit others.

The different interview methods (VERITAS, structured interview, semi-structured interview) applied in this thesis all pose the risk of social desirability bias, social approval bias and recall bias. It is well known
that participants overreport PA behaviour [141, 160], and may also overreport or underreport other behaviours thought to be desirable. Recall bias my especially pose a risk in this study population, as older adults may have greater difficulties remembering specific behaviours, thoughts or feelings [161]. The VERITAS method tries to address this issue by asking participants about their usual behaviour, rather than having to remember the last week or month. In my structured and semi-structured interviews, I tried to address this issue by asking participants about current barriers, facilitators and behaviours.

Finally, in line with the pragmatic stand of this thesis, transferability is set to be the main quality criteria, focusing on the applicability of the produced knowledge and its’ ability to translate findings to other similar cases or practices [162, 163]. As such, the transferability of this study may be restricted due to the investigation of only one neighbourhood including two senior housing areas within a small area of Copenhagen, Denmark. The transferability may also be limited by potential selection bias, as recruitment was challenging, and interviewed participants may represent a better functioning group of older adults from this neighbourhood. Therefore, caution must be taken if the findings from this study are applied to other contexts. The description of participants presented in table 1, show that the study population is a vulnerable population living in a disadvantaged community. It also shows some variation in recruited participants such as self-perceived health, although there is an overweight of females. As more females than males in general live in this neighbourhood the older they get [164], this suggests that selection bias may not have occurred. The table also shows some variation between the two housing areas, suggesting that not one specific group of older adults had been recruited e.g. the most resourceful older adults. This suggests that the findings from the current study may be transferable to other similar disadvantaged neighbourhoods in Denmark or Europe. This is investigated further in my latest paper, where we assess the importance of social networks for healthy ageing, for older adults living in different neighbourhoods and with different socio-economic status, across 16 European countries (see appendix III). The paper found social networks to be especially important for disadvantaged older adults, and thus supports the finding in this thesis, that SI is important for older adults. Further, the mixed-methods design may have strengthened the transferability of the results, by including multiple data sources which complimented as well as confirmed each other’s results. Using a theoretical framework to guide my qualitative analysis, and applying a systematic analysis approach using the six phases described by Braun & Clarke [89], further supported the transferability of the results and their applicability to be used in other similar cases.
7. Conclusion

This thesis provided empirical knowledge on older adults’ use of NOS living in disadvantaged communities. The aim was realized through three research objectives assessing factors influencing older adults’ use of NOS by walking and SI and how to measure it. This was assessed using a convergent mixed method design, based on three independent papers. The mixed methods approach provided comprehensive knowledge about two behaviours – SI and walking – and combined different methods using the socio-ecological model to comprehensively assess older adults’ use of NOS. This was the first study on NOS specifically, assessing both walking and SI by older adults living in a disadvantaged community, providing new knowledge to further the field of active living research and NOS. A thematic synthesis and discussion of the three papers was conducted, resulting in the following conclusions.

The assessment of factors influencing older adults’ use of NOS was based on quantitative objective observations and audits of NOS, as well qualitative interviews of local older adults, to investigate potential influences at all levels of the socio-ecological model. Thirteen factors were identified to influence older adults’ use of NOS: age, sense of ownership, SI, organisation of activities, shelter, shade along paths, condition of paths, seating, landscaping, distance to NOS, economical support for social caretakers, housing allocation, and weather. These factors were present at all five levels of the socio-ecological model and were interdependent, stressing the importance of considering all levels within the model to affectively promote sustainable behaviour change. Especially SI was found to be an important reason for older adults to use NOS, as well as being a tool to promote walking.

For this specific case of older adults living in a disadvantaged community, creating NOS in close proximity acting as public front yards, may provide a space for older adults without private front yards, to engage in the life on the streets and interact with neighbours, as well as engage in PA. Creating these supportive public front yards requires support from the municipality and social caretakers to allow for older adults to create and take care of front yards to support a sense of ownership, as well as a built environment supportive of both SI and walking behaviour. Especially disadvantaged older adults living alone in apartment buildings, will benefit from having access to supportive NOS acting as their front yard, enabling them to interact with neighbours daily and engage in PA. NOS further away may be used
more by resourceful older adults organising gatherings for SI and promoting PA by having to walk further to reach the NOS. These NOS do also require a supportive built environment and additional organisational support from social caretakers and volunteers to organise activities.

Investigating older adults’ use of NOS in disadvantaged communities required a range of methods, to account for the complexity of the specific behaviour (walking or SI), setting and study population. This thesis applied both quantitative and qualitative methods to assess older adults’ use of NOS. Not all methods were found equally suitable to use, and only SOPARC and CPAT, combined with structured and semi-structured interviews were found appropriate to use in this specific case.

A new applied framework was created helping researchers to choose the most suitable measurement method for their specific study. Using this framework by considering the suitability of different methods before applying them, based on a combined assessment of ‘recruitment and compliance’, ‘practicalities’ and ‘data applicability’ is advisable, to ensure using the most appropriate methods for a specific purpose.

7.1 Implications for practice
The translation of research results into practice is an issue within health research often forgotten or not spending resources on [165], even though it is recognized to be important to promote health [166] and the focus of the pragmatic researcher [64]. This section will aim at suggesting specific practical implications targeted at researchers as well as practitioners such as landscape designers and health promoters, promoting use of NOS by older adults to improve healthy ageing.

Health promoters need to focus more on creating supportive social NOS as well as NOS supportive of PA such as walking, as a strategy to promote healthy ageing. This requires a multi-disciplinary approach involving different disciplines – policy, social caretakers, landscape designers, health promoters – in working together to achieve context specific programs and behaviour change.

To promote use of NOS by older adults living in disadvantaged communities, using NOS in close proximity as well as further away, requires a supportive built environment. Health promoters should therefore work together with landscape designers or architects to create features within NOS supportive
of SI and walking. These NOS require seating for social encounters and to take a rest while on a walk, shelter from different weather conditions, some type of aesthetically pleasing landscaping, such as green space, flower beds and trees, as well as well-maintained paths for walking. For NOS further away, a supportive built environment is not enough, as promoting use of NOS still requires organisational support from social caretakers and volunteers. For NOS in close proximity, health promoters should promote the use of NOS as public front yards by older adults, by working together with landscape designers to create the foundation for public front yards, and to ensure that the senior housing officials allow residents to hold these gardens. Janitors employed by the senior housing officials need to support the residents in maintaining the front yards, such as planting, watering and cutting flowerbeds. This will support social contact with neighbours, PA through garden work and a sense of ownership which may promote feeling useful and contributing to the community.

For older adults living in disadvantaged communities, health promoters should work together with the local municipality to change and even out the distribution of resourceful versus limited older adults living in the senior housings, to provide the opportunity for volunteerism by resourceful older adults, able to engage in and organise social activities. This may also be done by supporting varied housing with different groups of people (e.g. educational or economical differences and different age groups), to promote intergenerational activities and contact between social classes, already being implemented in several countries and communities. This should be further supported by hiring resourceful and willing social caretakers, provided by the senior housing officials. These social caretakers need to be trained in how to organise and support activities within NOS which considers the different needs, limitations and wishes of the residents, enabling all residents to participate in social activities or PA – especially for those living alone. The support from social caretakers is especially important when NOS are situated further away from the residents’ apartment buildings, whereas NOS in close proximity, such as public front yards, may not rely on social caretakers to organise activities.

Finally, social caretakers usually do not have the skills or the knowledge to promote healthy behaviours such as SI and physical activities. Health promoters should therefore work with local social caretakers to educate them in how NOS can be used to engage older adults in healthy behaviours, tailored to their specific needs, limitations and interests.
As these recommendations may not be relevant in other settings such as high-income neighbourhoods, I suggest that health promoters should start by investigating which levels of the socio-ecological model need being supported in the specific setting and population of interest, by applying the methods presented in this thesis. In one case, political and organisational support may be in place, but lacks supportive built environment to promote the desired behaviour. Whereas in other cases, it might be the other way around. Applying this approach helps concentrating resources on those aspects which are in real need of improvements, rather than wasting scarce resources on less important areas.

7.2 Implications for research
NOS are a relevant setting to target in future health promotion research, as their close proximity to older adults’ homes and their physical features, pose special benefits for older adults who are less mobile and live in more disadvantaged neighbourhoods. This research showed that NOS right outside apartment doors act as public front yards, whereas those further away are used for organised activities. The observed difference in behaviours within NOS with different proximities to the residents, suggests that feature research should consider investigating the influence of different proximities to NOS, on older adults’ use of NOS and how they are used. This should be assessed using different study populations than only disadvantaged older adults, such as resourceful older adults, as their needs may differ. This may help understand what type of NOS can promote different health behaviours, and to construct better interventions targeting different settings and health behaviours for different population groups. Future research should also investigate which health benefits public front yards may promote and support the evidence for building NOS or public front yards in all senior housing areas where residents do not have their own garden. A recent paper by me (Appendix III) suggests that SI is associated with different health benefits (quality of life and functional capacity) in a European sample of older adults, and especially disadvantaged older adults may benefit from supportive social networks. Feature research should thus assess how NOS supportive of SI may affect healthy ageing in different countries and settings.

Creating and validating specific tools measuring different types of use of NOS and their physical features for older adults but also other age groups is warranted, to be able to make comparisons across studies using the same tools. Researchers should consider different concepts defining use of NOS by applying
the framework presented in this thesis when assessing which methods to use in future data collections. Based on this framework, future studies could benefit from using an adapted version of SOPARC if the goal is to measure context-specific frequency or intensity of SI. Whereas GPS is advisable to use if person-specific 24-hour walking behaviour is of interest, although not if the study population is older adults from disadvantaged communities. GPS could therefore be used to measure walking occurring to/from NOS, which was not possible in this thesis using SOPARC. Different types of interview methods such as a combination of VERITAS and in-depth interviews are preferred to be used in future research on older adults if investigating why walking or SI may or may not occur within NOS. A combination of SOPARC and CPAT with structured and semi-structured interviews might be preferable, if interested in assessing and understanding SI or walking behaviour in NOS by older adults living in disadvantaged communities. However, the presented framework is new, and needs to be tested in different study designs to assess its usability for identifying the most suitable methods for different outcomes.

Although comprehensive research of older adults’ use of NOS across all levels of the socio-ecological model is warranted, as this holistic approach may be more sustainable in long term, the complexity of conducting and evaluating such large study designs may appear overwhelming and cost-prohibitive. It would however, be interesting to investigate specific behaviours within NOS – based on all levels of the socio-ecological model – and how the same factor may promote one behaviour but inhibit another. For example, SI is an important health outcome, but may also inhibit walking which is important too. Feature research should therefore consider measuring both health behaviours using SOPARC or better GPS analyses software able to identify social connections. By being specific about the relationship between different factors and behaviours within NOS, future research will be able to more comprehensively investigate what influences use of NOS.

Lastly, I want to stress the need for qualitative and quantitative researchers to work more closely together and for researchers to gain skills in both fields, applying the best of both worlds to comprehensively assess, explore and understand complex health behaviours and how to promote them. Researchers like me, could potentially broaden their insights and impacts of their research in the field of health promotion by obtaining a more comprehensive knowledge of complementary fields and disciplines.
In future, I will continue to conduct mixed methods research, adapting methods to the specific context and involving the study population in decision making, as well as other disciplines and fields, to avoid creating interventions based on uni-dimensional conceptualisations of complex phenomena. Being fortunate to have applied for and received a post.doc. grant from the VELUX Foundation, I will in the near future be able to apply some of the new knowledge and experiences gained from this PhD project in a different setting. Having to work with institutionalised older adults, I will explore how to create green spaces tailored to their special needs, by involving the residents, relatives, caretakers, physiotherapists and landscape designers in developing and conducting an intervention promoting PA and cognitive health. I look forward to applying mixed methods to assess the effect of the intervention on older adults’ physical and cognitive health, and to better understand the process of participatory research involving multiple disciplines and practitioners in successful implementation of a health promotion program in the care setting.
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Appendices I-III
Appendix I

Maps of Sydhavnen, the two neighbourhoods and the 13 Neighbourhood Open Space
SOPARC
System for Observing Play and Recreation in Communities

Manual for using SOPARC as a tool in community observations

by Tanja Schmidt
August 2016
**Preparations before observations**

Before heading out to the observation area, remember the following:

- Make sure you have writing material and the folder with all the observation sheets you need.
- Make sure you have 1 observation sheet per sub area. That is, if you have 6 sub areas in 1 target area, you must have 6 observation sheets for the 1 hour you must observe.
- Make sure you have at least 3 extra observation sheets in case there are more than 30 people to observe at once.
- Make sure you have a watch so you can keep an eye on time and not exceed it.
- Make sure you have an umbrella in case it starts to rain, so you can still fill in your observation sheets.
- Make sure you have a map of the area where all your locations in the observation areas are marked so you always are placed in the same spot.
- Make sure you have a bike so that you can quickly move on to the next observation area and be there in time before it starts.
- Arrived a few minutes before the start of observation for each observation area, so you can complete the background information before the observation starts.
- Be sure to take a picture of each NOS, each time observing. Avoid faces!

**Background information**

Date: \[\text{Day/month}\]

Target area: Number of the overall area being observed (e.g. Engholmen Nord is target area 3)

Sub area: The specific area within the target area being observed (e.g. area 1A)

Lighting: Is the lighting sufficient, bad or none present?

Weather: Is it sunny, cloudy, windy or rainy? (or a combination of several)

Start time: Start of the 5 min scan/observation

End time: End of the 5 min scan/observation

Period: Morning, midday, afternoon, evening observation

Week day: Day of the week

**Description of target areas and sub areas**

**Target area 1**

A: Stand on the road along the fence and look into the green area. Use the buildings as a natural boundary for your observation. Do not observe the road.
B: Stand on the road and look into the area, observe for approx. 1 minute. Then walk through the path for approx. 1 minute and observe new things along the path. Turn around at the end of the path and observe again for approx. 1 minute. Finally go through the path again for approx. 1 minute and observe again.

C: Stand next to the box. Observe people on the green space, the path and along the street, all the way up to the red sign.

D: Stand next to the box. Observe all the way to the kiosk (but not after the kiosk). Observe the green space, the path and street all the way to where sub area C ended.

E: Same approach as in sub area B.

Target area 2

A: Stand next to the box. Observe everything in your sight. Observe the path all the way to the second turn on the right.

B: Stand inside the fence. Observe everything within the fence. Do not observe the street.

C: Stand next to the tree at the end of the green area. Use the buildings as natural boundaries for the observation. Do not observe the street.

D: Same approach as in target area 1, sub area B.

Target area 3

A: Stand next to the bushes on the street. Observe everything within the green area. Do not observe street.

B: Stand next to the shed in front of the bike racks. Observe the space on the left and in front of you all the way to the second shed.

C: Stand against the wall. Observe to your right all the way to the shed. Observe to your left all the way to the end of the space.

D: Stand outside the fence and observe along the building all the way to the flower beds

E: Same as target area 1, sub area B.

F: Stand next to the three and observe in front of you, the terrace on your right and the bench area to your left.

Target area 4

A: Stand next to the tree between building 26 and 28. Observe the whole green area. Include the street in front of you. Include the dog area.
B: Sit on the bench furthest away and observe the whole playground.
C: Stand next to the tree and observe the paths to your left and right, and the green space in front of you, all the way to the culture house and pavilion.
D: Stand in front of the pavilion and observe to your left and right. Only observe the green space.
E: Stand next to the largest rock and observe the whole green area. Do not observe streets.

**Procedure for observations**

We need 4 observations per day (morning, midday, afternoon, evening) for 1 weekend day and 3 week days. Observations of each of the 4 target areas takes 1 hour, of which each sub area takes 5 minutes. This is a total of 64 hours of observation material.

If more than 30 persons are observed, a new sheet is used (extra).

The order of which each sub area is observed, must be the same every time.

Include only people in your observation who are within the area you observe. If a person leaves the area before you start the observation, the person is not being counted for in the observation sheet.

If the same person is observed in two different sub areas, this counts as two persons.

**Filling out the observation sheet**

Each row in the sheet represents 1 person observed. This means, that 1 person is observed at a time, and the sheet is filled out for each person at a time. There is space for 30 persons on each sheet.

Scan the sub area for 5 minutes and fill out the sheet for every person you observe. After 5 minutes, the observation is finish. Walk to the next sub area and start the new observation.

**Codes**

Gender: Select if the person is male or female
Age group: Write the expected age in the box for the different age categories (child, teen, adult, senior)
Activity level: Select the expected activity level (sedentary, walk, vigorous)
Social interaction: Select ’none’ if the person is alone. If the person interacts with another person, write the ID number of that person
Primary activity: Write the primary activity of the person. Write if they use any physical features (e.g. sitting on a bench).
After observations

After each target area is observed, the sheet is transferred to the shared Excel sheet.
Mark in the shared google sheets calendar if you have successfully completed an observation or not. Mark the observation with red if not completed and write a reason for not completing it.

<table>
<thead>
<tr>
<th>Date</th>
<th>Target area:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observation sheet

<table>
<thead>
<tr>
<th>Person Gender</th>
<th>Age group</th>
<th>Activity Level</th>
<th>Social Interaction ID number</th>
<th>Primary Activity(note)</th>
<th>Note</th>
<th>Date</th>
<th>Target area:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Female</td>
<td>Child</td>
<td>Adult Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult Male</td>
<td>Child</td>
<td>Adult Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult Female</td>
<td>Adult Male</td>
<td>Adult Female</td>
<td></td>
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</tr>
<tr>
<td>Adult Male</td>
<td>Adult Male</td>
<td>Adult Male</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note: Write a note that may provide additional information about the situation. Write if the person uses the sub area, or just walks through it (a-b). Write if an older person uses any assistive devices.
Map of target areas and sub areas

TARGET AREA 1 + 2 // TRANEHAVEGÅRD + KIRKEGÅRD

TARGET AREA 3 // ENGHOLMEN NORD + SKOLEN
Note: Areas B, D, E and F were only part of the the Move the Neighbourhood - child study
Appendix III

SHARE study paper
Social Network Characteristics as Correlates and Moderators of Older Adults’ Quality of Life and Functional Ability: Results from The Longitudinal Survey of Health, Ageing and Retirement in Europe

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Abstract
Objectives: To examine the associations of socio-economic status (SES) and neighborhood type (NT) with quality of life (QoL) and functional ability (FA) among older adults, and how social networks (SN) moderates these associations.

Methods: Wave four and six from the longitudinal Survey of Health, Ageing and Retirement in Europe were analyzed using multilevel regression. 34,792 participants from 16 countries were included in the analysis, with a mean age of 66.45 years.

Results: SES was positively associated with QoL and FA. NT was a correlate of QoL and FA. The effect of education on FA increased with higher SN satisfaction, while those on QoL decreased with larger SN size. The effects of not living in a rural area on QoL and FA were enhanced by a larger SN size.

Discussion: To increase QoL and FA in low SES older adults, health promoters and city planners should create more sociable neighborhoods.

Keywords
SHARE, Multilevel analyses, Cross-country
INTRODUCTION

The ability to ‘age in place’ – remaining in one’s community living independently or with some help – is important to most people because it enables them to stay connected to friends and family, and experience independence, social participation, and thus, healthy aging (Rantz et al., 2005). Moreover, helping older adults to stay healthy throughout life might not only benefit the person in terms of quality of life (QoL), but is also seen as a more cost effective option (Tinker et al., 1999). Research indicates that healthy aging requires a range of physical, mental and social functions, as one needs to be able to do everyday chores, receive help from family and friends and be happy and satisfied with one’s life. Thus, healthy aging may be determined by one’s functional capacities (FC) and QoL, which again may be affected by several factors.

To be able to take care of one self requires a certain level of physical functioning, as limited mobility can result in lack of access to health services and other resources, as well as isolation from friends, neighbors and family (Glass TA, 2003; Lampinen & Heikkinen, 2003). Activities of daily living, instrumental activities of daily living and general mobility limitations are concepts that are widely used to assess older adults’ disabilities and functional limitations in their daily lives and are associated with health-related intrapersonal, interpersonal and environmental risk factors (Yeom, Fleury, & Keller, 2008). FC may be affected by the type and quality of the neighborhood a person lives in, as, for example, the accessibility to daily destinations, such as supermarkets, varies across neighborhoods. Where a person lives can be an indication of the person’s ability to age healthy as those with low mobility and functional limitations are likely to have difficulties performing daily activities, such as grocery shopping, if they live in a rural area with large distances to retail facilities. Conversely, living in lower-quality environments has been found to correlate with a loss of physical function (Balfour & Kaplan, 2002; Rosso, Auchincloss, & Michael,
2011). This suggests that where older people live can affect their functional capacity. Similarly, one’s place of residence (neighborhood type, NT) is often determined by socio-economic status (SES), which has also been found to be associated with FC (Berkman & Gurland, 1998; Rautio, Heikkinen, & Heikkinen, 2001).

QoL is important for healthy aging (Peel, Bartlett, & McClure, 2004; Stewart AL, 1994). Numerous studies have investigated different correlates of QoL, and found self-reported health complaints such as pain, fatigue and mobility impairment (Borglin, Jakobsson, Edberg, & Hallberg, 2005), as well as self-reported physical activity and sedentary behavior (Balboa-Castillo, León-Muñoz, Graciani, Rodriguez-Artalejo, & Guallar-Castillón, 2011) to be associated with QoL. Similarly to FC, older adults’ QoL may also be affected by NT and their SES, as several studies indicate (Breeze et al., 2005; Gilroy, 2008; Huguet, Kaplan, & Feeny, 2008; Netuveli, Wiggins, Hildon, Montgomery, & Blane, 2006). Living in a rural area with large distance to daily amenities, low walkability and few neighbors may adversely impact on QoL and increase the risk of loneliness and depression (Berke, Gottlieb, Moudon, & Larson, 2007; van den Berg, Kemperman, de Kleijn, & Borgers, 2016; Yu, Cheung, Lau, & Woo, 2017).

Having a strong social network (SN) is recognized to be important for aging well. Numerous studies identify the benefits of having a large SN on different physical health outcomes, such as cardiovascular disease and mortality (Cohen & Janicki-Deverts, 2009; Olofsson, Padyab, & Malmberg, 2018). The size and quality of one’s SN are also found to be associated with QoL and FC in older adults. A study found that low frequency of relationships with friends was associated with a decline in QoL among older adults living in Spain (García, Banegas, Pérez-Regadera, Cabrera, & Rodríguez-Artalejo, 2005). Another study found that lower levels of social support was associated with decrease in life satisfaction and an increase in depressive symptoms (Newsom & Schulz, 1996). Lastly, SN quality and frequency of social contacts
were found to be associated with an increase in QoL for older adults living in England (Netuveli et al., 2006). These studies highlight the various ways of investigating SN and its influence on QoL, and pinpoint the need to investigate various aspects of SN to understand its influence on QoL. However, most studies have focused on social support or frequency. Other factors, such as SN satisfaction, may be considered to be associated with QoL as stressed by other researchers (Olofsson et al., 2018). Similar results have been found in studies on SN and FC (Ali, Nilsson, Weuve, Rajan, & Mendes De Leon, 2018; Avlund, Lund, Holstein, & Due, 2004), indicating that various aspects of SN are of great importance for older adults’ healthy aging.

The above studies highlight the importance of QoL and FC for healthy aging, and indicate how older adults’ SES, NT and SN may be associated with QoL and FC. However, studies on the independent and interactive effects of these factors on QoL or FC are lacking. Understanding the relationships of these factors on QoL and FC are crucial to be able to comprehend what independent and combined factors may promote healthy aging. It is especially important to examine the potential effect of SN on older adults’ QoL and FC, as it may be easier to promote social interaction among older adults, whereas changing someone’s SES or where they live is less feasible. However, the different results presented above for different concepts of SN suggest, that some aspects of SN may promote one health indicator, whereas other aspects promote another health indicator. Assessing different concepts of social network is thus necessary, to identify which specific factors may promote or inhibit QoL and FC.

The current study contributes to filling this gap in the literature by using data from a large European multi-country and longitudinal survey on people aged 50 and above, to investigate if QoL and FC are associated with older adults’ NT, SES, and SN.
Specifically, we:

- Examined the extent to which social network, socio-economic status, and neighborhood type are associated with quality of life and functional capacity in people aged 50+ in 16 European countries over a four-year period.
- Examined if social network moderates the associations of socio-economic status or neighborhood type on quality of life and functional capacity across the 16 European countries.

RESEARCH DESIGN AND METHODS

Design and sample

This study is based on longitudinal data from the Survey on Health, Aging and Retirement in Europe (SHARE), representing 27 European countries and Israel. The study was initiated in 2004 and collects bi-annual cross-national data on health, economic and social issues of individuals aged 50 years and over (Börsch-Supan et al., 2013). Data are available free of charge on the SHARE homepage (http://wwwSHARE.org/). Data from the 4th (year 2011) (Börsch-Supan, 2018a) (DOIs: 10.6103/SHARE.w4.700) and 6th (year 2015) (Börsch-Supan, 2018b) (DOIs: 10.6103/SHARE.w6.700) wave of SHARE were used in this study, as these waves provide extensive data on social networks. Computer-assisted personal face-to-face interviews were carried out in each wave, and only participants with data on all baseline variables were included in this study. 18,499 participants were excluded as they were younger than 50 years of age and 29,966 participants were excluded due to missing data on key variables. The final sample used for the QoL analysis was a total of 102,126 (34,792 at wave 4 and 67,334 at wave 6). Additional 57 participants were removed from the dataset for the FC analysis as they had no
baseline information on FC. The participants provided written informed consent. Detailed information on ethics can be found on the SHARE homepage (http://www.share-project.org/data-access/share-conditions-of-use.html).

**Study variables**

The dependent variables used as outcome measures in this study are FC and QoL. FC is a combined score of three different mobility scores – Activity of Daily Living (ADL), Instrumental Activity of Daily Living (IADL) and mobility limitations – which indicates the difficulties a respondent reported having experienced in each of 23 functions, such as getting up from a chair, taking medicine or managing money. These three scores were combined to assess the full scale of limitations a person might experience, rather than just focusing on one part and leaving out the rest. As suggested by other researchers (LaPlante, 2010), we employed a cumulative score of FC by combining the three mobility scores into a continuous scale, ranging from 0 to 23, where 23 indicates great functional disability. FC scores were reverse coded (i.e., changed 0 to high functional disability and 23 to high FC, to match the coding of QoL. QoL was measured using the 12-item version (CASP-12) (Borrat-Besson C, 2015) of the original 19-items CASP scale (Hyde, Wiggins, Higgs, & Blane, 2003), which measures four domains; Control, Autonomy, Self-realization, and Pleasure. The domains are explored through a range of statements about how often the respondent experienced certain feelings and thoughts which are answered on a 4-point frequency scale. The overall QoL score was based on reverse-coding ranging from 12 to 48 (high QoL).

The independent variables included in the analysis were NT (housing type and area type), SN characteristics (size and satisfaction) and SES (education and making ends meet). Respondents were
asked to indicate the type of house they were living in. Options were: a farmhouse; a free standing one- or two-family house; a one or two family house within a row of houses or a duplex; a building with 3 to 8 flats; a building with 9 or more flats but no more than 8 floors; a high-rise building with 9 or more floors; a housing complex with services for elderly, or special housing for the elderly (24-hour care). The three housing options consisting of flats were combined into one variable called apartment building. Housing complexes with services for elderly and special housing for elderly were not included in the analyses, as we were only interested in the general population of older community dwellers. The area a person lived in was classified as: a rural area or village; a small town; a large town; the suburbs or outskirts of a big city; or a big city. Both housing type and area type were chosen to assess if living in a specific place may affect older adults’ QoL or FC and how the social network may alter the possible negative influences of living in a farm house in a rural area versus living in an apartment in a big city.

To assess the moderating role of older adults’ SN, variables from the survey assessing the size of - and satisfaction with each respondent’s SN were employed. The size of the SN was defined as the number of people (e.g. family, friends or neighbors) being part of the respondent’s network and ranged from 0 to 7 closest persons. The SN satisfaction variable was derived from a question asking about respondents’ overall satisfaction with their relationship with SN members, ranging from 0 – completely dissatisfied, to 10 – completely satisfied. The variables were chosen as the literature indicates different effects of size and satisfaction on different health outcomes, suggesting that older adults’ satisfaction with their social network may be more important for their health than the size (Huxhold, Fiori, & Windsor, 2013; Pinquart & Sörensen, 2000).

The SES variable education was based on the International Standard Classification of Education from 1997 (ISCED-97). The variable making ends meet, was based on a question from the survey asking
whether the household was able to make ends meet. The following answers were used: with great
difficulty; with some difficulty; fairly easily; and easily. The variable making ends meet was included as
an SES variable, as educational attainment may not depict a true picture of an older person’s SES, since
higher educational attainment may not have been common when they were younger. Being able to make
ends meet on a daily basis may thus be a better representation of a person’s QoL and FC. Lastly,
covariates were employed in the analysis consisting of age, gender and living situation (living alone or
with someone).

STATISTICAL ANALYSIS

Descriptive statistics of all included variables were computed on baseline data using IBM SPSS Statistics
24. Before any regression analysis was performed, all continuous variables were centered around their
mean value to avoid multicollinearity issues. Making ends meet and education were coded to represent
variables on a continuum from 0 to 6 and 1 to 4, respectively, given that regression analyses indicated
better model fit indices (e.g. smaller Akaike Information Criterion) when these variables were defined as
continuous rather than categorical predictors. SN size and satisfaction were treated as continuous
variables.

Multilevel analyses were performed to estimate the associations between the dependent and independent
variables, and the moderating effects of SN on the associations of SES and NT with older adults’ QoL
and FC. Using the statistical software MLwiN (Charlton, 2019), the first step was to create two empty
(i.e., with no covariates) models for QoL and FC including the 3 levels of variability - namely, country
level, person level, and time level (longitudinal differences). The aim of this first step was to examine
the extent to which FC and QoL might be determined by intra-individual factors, inter-individual factors or country-level differences. Secondly, we regressed QoL and FC scores on the respective independent variables and co-variates (Model 1). These models provide information on the effects of co-variates on the outcomes at different time points (as outcomes and co-variates were time varying) across individuals and, as such, represent a mixture of between- and within-individual effects. In the third step, we entered the interactions terms of SN by SES variables, and of SN by NT variables to assess the moderating effect of SN on the associations of SES and NT with QoL and FC. This step was data driven by testing the significance of all possible 2-way interactions using the likelihood-ratio test (LRT). This resulted in the final model (Model 2) including only significant interaction effects.

RESULTS

Descriptive statistics of wave 4 participants are presented in table 1. The participants’ mean age at wave 4 was 66.45 years, 58.3% were females, and 70.1% lived with one or more persons in their home. Most participants lived in rural areas or villages (34.3%) and in a free standing one- or two-family house (42.3%) or in an apartment building (36.3%). Participants were quite satisfied with their SN (average score: 8.82), even though they had few people in it (2.53 persons). Participants’ mean QoL was higher at wave 6 (37.06) than at wave 4 (36.91), whereas their FC was worse at wave 6 (20.50 at wave 6 compared to 20.70 at wave 4).

[Insert Table 1 here]
QoL analyses

Results from the 3-level empty model of QoL indicated that 17.46% of QoL variance was due to differences between countries, 44.96% to differences between individuals, and 37.61% to changes within individuals. The summary findings of regression models of QoL and FC including SES, NT, SN predictors and a range of covariates are displayed in tables 2 and 4.

Model 1 (table 2) which included all covariates and independent variables showed a significantly better fit to the data than the empty model ($\chi^2 (15) = 179998; p<0.001$). The results for model 1 indicate significant correlates of QoL. Being older was associated with lower QoL ($b = -0.093; p<0.001$), and women tended to report lower QoL than men ($b = -0.574; p<0.001$). Both SES indicators were positively associated with QoL. This was also the case for both aspects of SN examined in this study. For example, an increase of one close relationship in a person’s SN was associated with an increase of 0.133 points on the QoL scale ($p<0.001$). Regarding NT, people living in the suburbs/outskirts of a big city had lower QoL ($b = -0.145; p = 0.053$) compared to those living in rural areas. People living in a farm house had lower QoL than people living in some other building types.

[Insert Table 2 here]

In the final model (model 2, table 2), we included all significant interactions with the two SN variables. The model had significantly better fit than the previous model 1 ($\chi^2 (5) = 27.3; p<0.001$).

SN size was found to significantly interact with education and area type, whereas SN satisfaction did not interact with any other variables on QoL. This suggests that SN satisfaction was a strong independent correlate of QoL but did not modify the relationship between QoL and SES or residential area type. To examine further the significant interaction effects, we estimated the associations of education and
residential area type with QoL at the mean value and mean +/- 1SD values of the moderator (SN size) (Table 3). While all associations between education and QoL were positive at all three investigated values of SN size, the positive effect of education on QoL was stronger for people who had a smaller SN size ($b = 0.445; p<0.001$) than for those with a larger SN size ($b = 0.348; p<0.001$).

Regarding area type, SN size moderated the difference in QoL between people living in rural areas and those living in small towns ($b = 0.099; p = 0.001$) and big cities ($b = 0.130; p<0.001$). People living in small towns with larger SN size had a significantly higher QoL ($b = 0.232; p = 0.008$) than their rural counterparts, while this difference was not significant for people living in the same types of area but with smaller SN sizes. The same pattern of findings was observed for people with larger SN sizes living in big cities vs. rural areas (Table 3).

[Insert Table 3 here]

**Functional capacity analyses**

Model 1 including all main effects fitted the data significantly better than the empty model ($\chi^2 (15) = 83471; p<0.001$). Results from the 3-level empty model of FC indicated that 3.50% of FC variance was due to differences between countries, 56.82% to differences between individuals, and 39.67% to changes within individuals. Similarly to QoL, older people and females reported lower FC (Table 4). People living with one or more persons reported higher FC than people living alone. Both SES variables were positively associated with FC. The neighborhood area type was also found to be associated with FC. People living in rural areas had lower FC than people living elsewhere, and people living in a big city had the highest FC. People living in free standing family houses had higher FC ($b = 0.175; p = 0.002$)
compared to people living in farm houses, whereas living in a row of houses or duplex, or living in an apartment building was not significantly different from living in a farm house. People who had a large SN size reported lower FC, whereas people who had a higher SN satisfaction report higher FC.

[Insert Table 4 here]

In Model 2, all significant interactions were included, and the model had a significant better fit than Model 1 ($\chi^2 (5) = 14.3; p = 0.014$) (Table 4). SN satisfaction significantly interacted with education on FC, while SN size interacted with area type on FC only with respect to people living in small towns ($b = 0.053; p = 0.012$). The interaction effects of SN satisfaction with education and of SN size with area type on FC are explained in Table 5, where associations of education and area type with FC at different values of the moderators can be found.

The estimated associations of education and FC at values of SN satisfaction were positive, indicating that higher education is associated with higher FC. However, the positive effects of education on FC increased with increases in SN satisfaction. Specifically, people who had a higher SN satisfaction had a stronger association between education and FC ($b = 0.299; p<0.001$) than people with a lower SN satisfaction (mean -1 SD) ($b = 0.261; p<0.001$).

Model 2 also showed an interaction between SN size and area type on FC. More specifically, the difference in FC between people living in small towns vs. rural areas was larger among those with a larger SN size ($b = 0.184; p<0.001$), then those with a smaller SN size ($b = 0.016; p = 0.731$). Similar findings were observed for people living in large towns (Table 5). People living in big cities had the highest FC.

[Insert Table 5 here]
DISCUSSION

The aim of this study was to examine how SN, SES and the NT were associated with QoL and FC in European older adults; and to which extent SN moderate the influence of SES and NT on QoL and FC. This was explored using multilevel analysis based on data from two waves of the European SHARE project. The results are discussed in detail below.

Social network

SN satisfaction had a positive influence on participants QoL and FC, while SN size was positively associated with QoL and negatively associated with FC. Previous research indicates that SN are important for older adults’ QoL, as having friends to talk to and ask for help prevents loneliness and supports wellbeing (García et al., 2005; Shankar, Rafnsson, & Steptoe, 2015). Research on FC suggests that having a SN of people that can help with daily chores is important especially for older adults with physical limitations as they are more reliant on help (Yeom et al., 2008). This might explain the negative relationship between SN size and FC, as people with less FC are more reliant on their SN and need more regular help. Having a supportive SN may promote and sustain FC, as those people may more often visit friends and family, participate in community activities, and assist others with their daily chores (Ali et al., 2018; Avlund et al., 2004). The direction of the causal effect could also be opposite – feeling more satisfied with one’s SN could be dependent on having higher levels of FC.

Previous studies suggest that older adults tend to have smaller SN with age, as they let go of less close relationships and rather focus on fostering relationships with their closest social companions (Huxhold
et al., 2013). This is supported by our results, as the mean value for SN size was quite low compared to the high SN satisfaction rate, and by the importance of SN satisfaction on QoL. This is further confirmed by previous research (Pinquart & Sörensen, 2000), indicating that SN satisfaction is more important for QoL in older adults than SN size.

Socioeconomic status and interaction with social network

As expected, both SES variables were found to be significantly associated with participants’ QoL and FC. That is, the higher their educational level and the better they were at making ends meet, the higher their QoL and FC. These results are not surprisingly and are in line with previous studies that linked SES to QoL (Huguet et al., 2008; Robert et al., 2009) and FC (Acciai, 2018; Yeom et al., 2008).

Education significantly interacted with SN for both outcomes. SN size buffered the relationship between education and QoL, as the effect of education on QoL was greater for people with smaller SN sizes. This suggests that for lower educated older adults, having a larger social network may be more important for their QoL. Several reasons for this may emerge. SN size may be associated with less educated individuals because they may have larger families than the highly educated – indicating reverse causality. Lower educated older adults may also be more reliant on social and emotional support from friends and family, to cope with a less advantaged life (Campbell, Marsden, & Hurlbert, 1986; Van Groenou & Van Tilburg, 2003). Other studies have found that the effect of SN size on QoL may depend on personal characteristics (Veenstra, 2000; Wiggins, Higgs, Hyde, & Blane, 2004), as relationships can lead to conflicts and stress for some older adults. These studies suggest that the quality rather than the quantity of the SN is important for older adults’ QoL. This highlights the importance of specifying which construct of social network is
being investigated and suggests that different approaches are needed to promote social network satisfaction rather than just increasing the size of the social network.

Turning to the results of SN’s moderating role on FC, the positive association of education with FC was found to be augmented by SN satisfaction. This means that on top of positive additive effect of education and SN satisfaction, people scoring higher on both variables have even greater FC. Or in other words, people with lower education are particularly vulnerable towards lower FC if they also have low SN satisfaction. This is in line with previous research, finding SN satisfaction to be especially important for older adults from low SES communities (Nilsson, Avlund, & Lund, 2011), maybe because they are more reliant on help from neighbors, friends and family than resourceful older adults. The interaction effect was, however, small and the effect of education on FC was found to be strong despite the moderation by SN satisfaction, highlighting the importance of educational attainment alone, as found in previous research (Berkman & Gurland, 1998; Rautio et al., 2001).

**Neighborhood and interaction with social network**

The neighborhood variables *area type* and *building type* were also found to be significantly associated with FC and QoL. People living in rural areas had significantly lower FC compared to people living anywhere else. Rural areas are typically characterized by less walkable neighborhoods, fewer public transportation options and greater distances between family and friends (De Sa & Ardern, 2014; Saelens & Handy, 2008). This may decrease older adults’ life-space (Parker, Baker, & Allman, 2002) and thus limit their ability to stay active – both mentally and physically – leading to decreases in FC. More disadvantaged older adults may also be forced to move to or stay in rural areas, as they do not have the
resources needed to live in more expensive areas such as a big city. People living in the suburbs or outskirts of a big city had lower QoL than people living elsewhere. This is somewhat surprising as people living in rural areas were expected to have the lowest QoL. A study by Lee and Lassey (Lee & Lassey, 1980) suggests that older adults living in rural areas have higher QoL because they are more involved in social and community activities, are more satisfied with their neighborliness, and felt more support from neighbors, than people living in urban areas. However, several studies reported that older adults’ place of residence is associated with their QoL and FC, as older adults living in rural areas were in general less healthy, had poorer QoL and poorer FC than people living in urban areas (Baernholdt, Yan, Hinton, Rose, & Mattos, 2012; Fogelholm et al., 2006; Song et al., 2007; Weeks et al., 2004; Zhou et al., 2011). Even though we found similar results, the effects of the neighborhood variables on both QoL and FC were quite small compared to SES.

People living in a farm house had lower QoL compared to those living in other building types, and people living in free standing family houses had the highest QoL and FC. The low QoL and FC for people living in farm houses is difficult to explain as living in a farm house usually entails greater FC to manage a farm. This is similar for the people living in free standing houses, as they would be expected to be quite physically and mentally healthy, as they need to be able to take care of the house (Baernholdt et al., 2012; Weeks et al., 2004). Older adults who can afford living in a free standing house may also have higher SES, which was found to be positively associated with both QoL and FC. However, the effects of the building type on both QoL and FC were also quite small compared to those of SES.

SN size was found in this study to moderate the effect of residential area type on QoL. People living in small towns or big cities had higher QoL than people living in rural areas if they had a large SN size. In other words, there was an additional effect of living in small towns / big cities and having a large SN size
at the same time, meaning that SN size was more important for the city dwellers. Previous research highlights the importance of living in a place with good access to social networks, and living in cities could entail easy access to family and friends, whereas people living in small towns usually have closer relationships with neighbors because the communities are small (Breeze et al., 2005; Gilroy, 2008). Living in a small or large town seemed to enhance FC as compared to living in rural areas especially for older adults with a large SN size. However, the interaction effect was small, and older non-rural dwellers had greater FC than people living in rural areas regardless of their SN size. Older adults living in rural areas more often experience isolation due to the infrastructure and limited public transportation (Cleary & Howell, 2006; Findholt & practice, 2006; Winters, 2013). Older adults who are unable to drive may thus feel homebound and isolated from friends and family, affecting their FC as well as QoL (Baernholdt et al., 2012; MacKenzie, 2001).

Methodological considerations

We acknowledge that there are several limitations in the current study. Firstly, the two main outcomes, QoL and FC, as well as the two SN variables, were based on self-reports rather than objective data, which might bias the results. Secondly, the measures of QoL and SN satisfaction had quite high mean values, suggesting less variability in the sample distribution, which may bias some of the results (i.e., yield attenuated associations). The exclusion of 29,966 participants in the analysis due to missing data on key variables might have caused bias by reducing the representativeness of the sample. However, the exclusion of participants came mainly from countries which did not have the social network variables in their dataset, and not from specific people within the countries. Lastly, the results may be biased by
reverse causality. Associations between social network and health can be in both directions, as less FC may inhibit older adults’ ability to travel to meet family and friends or participate in community activities.

The use of standardized questionnaires and a large cross-country European dataset is a major strength of this study. Further, we included several measures of the neighborhood type, socio-economic position and social network to demonstrate the diversity in outcomes when using different operationalizations. This highlights the need for investigating different aspects of SN, SES, and the neighborhood. Lastly, investigating a combination of different possible correlates of QoL and FC rather than assessing them individually and including a multilevel structure is also a major study strength.

**CONCLUSION AND IMPLICATIONS**

The aim of the current study was to investigate if and how QoL and FC were associated with older adults’ SES, SN and NT, and to assess if SN attributes moderate these associations. We found that education was a strong predictor of QoL and FC irrespective of the size of, or satisfaction with, one’s SN, but that SN does moderate the association between education and QoL or FC either negatively or positively. The effect of where people lived on QoL and FC was found to be moderated by SN size. Social network satisfaction was found to be an important independent and positive factor on QoL regardless of older adults’ SES and neighborhood type. The results suggest the need for health promoters to focus more on creating supportive sociable environments to promote QoL and FC in older adults, to support the process of healthy aging. Especially older adults with low SES may benefit from intervention programs focusing on improving different aspects of their SN. However, SN quality may be more important than quantity in some cases, and, as such, health promoters should not entirely rely on social programs to increase the
SN size, but rather focus on creating strong relationships with great social support. Future research should continue to identify correlates and determinants of healthy aging to further improve the knowledge on how to promote healthy aging especially in low socio-economic groups.

REFERENCES


Campbell, K. E., Marsden, P. V., & Hurlbert, J. S. (1986). Social resources and socioeconomic status. Social Networks, 8(1), 97-117. doi:https://doi.org/10.1016/S0378-8733(86)80017-X


Table 1: Descriptive statistics of wave 4 participants for QoL (N = 34792) and FC (N = 34735).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC (wave 4)</td>
<td>20.70 (3.50)</td>
<td>0-23</td>
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<tr>
<td>FC (wave 6)</td>
<td>20.50 (3.90)</td>
<td>0-23</td>
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<tr>
<td>QoL (wave 4)</td>
<td>36.91 (6.48)</td>
<td>12-48</td>
<td></td>
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<tr>
<td>QoL (wave 6)</td>
<td>37.06 (6.34)</td>
<td>12-48</td>
<td></td>
</tr>
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<td></td>
</tr>
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<td>Spain</td>
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<td>Poland</td>
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<tr>
<td>Germany</td>
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<tr>
<td>Age</td>
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<td>Gender (Female)</td>
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<td>58.3</td>
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<tr>
<td>Living situation (Living alone)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
SES

Education 2.81 (Upper secondary education) (1.44) 0-6
Making ends meet 2.74 (Fairly easily) (0.98) 1-4

Neighborhood

Area type

A rural area or village 34.3
A small town 23.9
A large town 16.4
Suburb/outskirts of a big city 10.4
A big city 15.1

Housing type

A farm house 6.5
A free standing one or two family house 42.3
A one- or two-family house within a row 14.8
of houses or a duplex
Apartment building 36.3

Social Network

Size (number of people) 2.53 (1.58) 0-7
Satisfaction (high: 10) 8.82 (1.48) 0-10

Note: The characteristics of the samples with non-missing QoL and FC data were equal, except for Gender (QoL: 58.3, FC: 58.2), Country (QoL: Slovenia = 5.3, Denmark = 4.0; FC; Slovenia = 5.4, Denmark = 4.1) and the age range (QoL: 50-106, FC 50-103)
Table 2: Multilevel regression models of quality of life (QoL): main effects and interactions of social network (SN) with neighborhood type and socio-economic status (SES).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
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<td></td>
<td>b</td>
<td>95% CI</td>
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<tr>
<td><strong>Time</strong> (ref: wave 4)</td>
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</tr>
<tr>
<td>Wave 6</td>
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</tr>
<tr>
<td>Age</td>
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<td><strong>Gender</strong> (ref: male)</td>
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<td><strong>Living situation</strong> (ref: living alone)</td>
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<td>Living with one or more</td>
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<td>-0.096, 0.096</td>
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<td><strong>SES</strong></td>
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<tr>
<td>Education</td>
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<td>0.376, 0.442</td>
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<td>Making ends meet</td>
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<td>2.100, 2.200</td>
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<td><strong>Neighborhood type</strong></td>
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<td>A big city</td>
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<td>Building type (ref. farm house)</td>
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<tr>
<td>Free standing family house</td>
<td>0.477***</td>
<td>0.310, 0.644</td>
</tr>
<tr>
<td>Row of houses or duplex</td>
<td>0.285**</td>
<td>0.087, 0.483</td>
</tr>
<tr>
<td>Apartment building</td>
<td>0.175</td>
<td>-0.011, 0.361</td>
</tr>
<tr>
<td><strong>Social Network</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>0.133***</td>
<td>0.107, 0.158</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.649***</td>
<td>0.622, 0.676</td>
</tr>
</tbody>
</table>
### Interactions

<table>
<thead>
<tr>
<th>SN size x Education</th>
<th>(-0.031^{***})</th>
<th>(-0.047, -0.015)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>SN Size x Area type (ref: rural)</th>
<th>(0.099^{**})</th>
<th>(0.034, 0.164)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A small town</td>
<td>0.055</td>
<td>-0.019, 0.129</td>
</tr>
<tr>
<td>A large town</td>
<td>0.030</td>
<td>-0.054, 0.114</td>
</tr>
<tr>
<td>Suburb/outskirts of a big city</td>
<td>0.130^{***}</td>
<td>0.057, 0.202</td>
</tr>
<tr>
<td>A big city</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Log-likelihood

<table>
<thead>
<tr>
<th></th>
<th>435961.199</th>
<th>435933.850</th>
</tr>
</thead>
</table>

Note: Model 1: main effect model including all variables. Model 2: model including significant interaction terms. N: 34792. Continuous variables are centered around their mean. 95% CI: confidence interval, b: regression coefficient. Ref.: reference category. Significance levels: *\(p<0.05\); **\(p<0.01\); ***\(p<0.001\)
Table 3: Associations of socio-economic status and residential area indicators with QoL at different values of social network size (moderator).

<table>
<thead>
<tr>
<th>Significant interaction effects of SN size by exposure variables on QoL</th>
<th>QoL</th>
<th>Statistics</th>
<th>$b$ (95% CIs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education</strong></td>
<td>Interaction term</td>
<td>-0.031***</td>
<td></td>
</tr>
<tr>
<td>Association at mean -1 SD of moderator: -1.568 SN size</td>
<td>0.445 (0.407, 0.483)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean value of moderator: 0 SN size</td>
<td>0.397 (0.364, 0.430)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean +1 SD of moderator: 1.568 SN size</td>
<td>0.348 (0.302, 0.394)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Area type (Small town)</strong></td>
<td>Interaction term</td>
<td>0.099**</td>
<td></td>
</tr>
<tr>
<td>Association at mean -1 SD of moderator: -1.568 SN size</td>
<td>-0.078 (-0.212, 0.056)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean value of moderator: 0 SN size</td>
<td>0.077 (-0.039, 0.193)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean +1 SD of moderator: 1.568 SN size</td>
<td>0.232 (0.062, 0.402)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Area type (Large town)</strong></td>
<td>Interaction term</td>
<td>0.055</td>
<td></td>
</tr>
<tr>
<td>Association at mean -1 SD of moderator: -1.568 SN size</td>
<td>0.003 (-0.155, 0.161)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean value of moderator: 0 SN size</td>
<td>0.090 (-0.049, 0.229)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean +1 SD of moderator: 1.568 SN size</td>
<td>0.176 (-0.027, 0.379)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Area type (Suburb/outskirts of a big city)</strong></td>
<td>Interaction term</td>
<td>0.030</td>
<td></td>
</tr>
<tr>
<td>Association at mean -1 SD of moderator: -1.568 SN size</td>
<td>-0.169 (-0.348, 0.010)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean value of moderator: 0 SN size</td>
<td>-0.122 (-0.272, 0.028)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean +1 SD of moderator: 1.568 SN size</td>
<td>-0.076 (-0.293, 0.141)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Area type (Big city)</strong></td>
<td>Interaction term</td>
<td>0.130***</td>
<td></td>
</tr>
<tr>
<td>Association at mean -1 SD of moderator: -1.568 SN size</td>
<td>-0.122 (-0.291, 0.047)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean value of moderator: 0 SN size</td>
<td>0.082 (-0.066, 0.230)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association at mean +1 SD of moderator: 1.568 SN size</td>
<td>0.286 (0.081, 0.491)**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: SD: Standard Deviation. $b$: regression coefficient. CIs: confidence intervals. SN = social network *$p < .05$; **$p < .01$; ***$p < .001$. 


Table 4: Multilevel regression models of functional capacity: main effects and interactions of social network with neighborhood type and socio-economic status.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>95% CI</td>
<td>b</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Time (ref: wave 4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave 6</td>
<td>0.055*</td>
<td>0.012, 0.098</td>
<td>0.056*</td>
<td>0.013, 0.099</td>
</tr>
<tr>
<td>Age</td>
<td>-0.111***</td>
<td>-0.115, -0.107</td>
<td>-0.111***</td>
<td>-0.115, -0.107</td>
</tr>
<tr>
<td><strong>Gender (ref: male)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>-0.822***</td>
<td>-0.885, -0.759</td>
<td>-0.822***</td>
<td>-0.885, -0.759</td>
</tr>
<tr>
<td><strong>Living situation (ref: living alone)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with one or more</td>
<td>0.084*</td>
<td>0.019, 0.149</td>
<td>0.083*</td>
<td>0.018, 0.148</td>
</tr>
<tr>
<td><strong>Socioeconomic status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>0.278***</td>
<td>0.254, 0.301</td>
<td>0.280***</td>
<td>0.256, 0.303</td>
</tr>
<tr>
<td>Making ends meet</td>
<td>0.546***</td>
<td>0.517, 0.575</td>
<td>0.545***</td>
<td>0.516, 0.574</td>
</tr>
<tr>
<td><strong>Neighborhood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area type (ref: rural)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A small town</td>
<td>0.078*</td>
<td>0.003, 0.152</td>
<td>0.100**</td>
<td>0.024, 0.176</td>
</tr>
<tr>
<td>A large town</td>
<td>0.152**</td>
<td>0.060, 0.244</td>
<td>0.170***</td>
<td>0.076, 0.264</td>
</tr>
<tr>
<td>Suburb/outskirts of a big city</td>
<td>0.107*</td>
<td>0.009, 0.205</td>
<td>0.107*</td>
<td>0.007, 0.207</td>
</tr>
<tr>
<td>A big city</td>
<td>0.258***</td>
<td>0.156, 0.360</td>
<td>0.266***</td>
<td>0.162, 0.370</td>
</tr>
<tr>
<td>Building type (ref: farm house)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free standing family house</td>
<td>0.175**</td>
<td>0.063, 0.287</td>
<td>0.179**</td>
<td>0.067, 0.291</td>
</tr>
<tr>
<td>Row of houses or duplex</td>
<td>-0.014</td>
<td>-0.143, 0.115</td>
<td>-0.009</td>
<td>-0.138, 0.120</td>
</tr>
<tr>
<td>Apartment building</td>
<td>0.010</td>
<td>-0.113, 0.133</td>
<td>0.015</td>
<td>-0.108, 0.138</td>
</tr>
<tr>
<td><strong>Social Network</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>-0.033***</td>
<td>-0.049, -0.017</td>
<td>-0.054***</td>
<td>-0.081, -0.027</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.047***</td>
<td>0.029, 0.065</td>
<td>0.052***</td>
<td>0.034, 0.070</td>
</tr>
</tbody>
</table>
### Interactions

Social network satisfaction x Education

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.013*</td>
<td>0.001, 0.025</td>
</tr>
</tbody>
</table>

Social network size x Area type (ref: rural)

<table>
<thead>
<tr>
<th>Area Type</th>
<th>Coefficient</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>A small town</td>
<td>0.053*</td>
<td>0.012, 0.094</td>
</tr>
<tr>
<td>A large town</td>
<td>0.043</td>
<td>-0.004, 0.090</td>
</tr>
<tr>
<td>Suburb/outskirt of a big city</td>
<td>-0.011</td>
<td>-0.064, 0.042</td>
</tr>
<tr>
<td>A big city</td>
<td>0.020</td>
<td>-0.027, 0.067</td>
</tr>
</tbody>
</table>

### Log-likelihood

|                                |             |                 |
|                                | Model 1     | Model 2         |
|                                | 282108.637  | 282094.373      |

Note: Model 1: including all variables. Model 2: including interactions. N = 34735. Continuous variables are centered around their mean. 95% CI: confidence interval, b: regression coefficient. Ref.: reference category. Significance levels: 0.05*, 0.01**, or 0.001***
Table 5: Associations of socio-economic status and residential area indicators with functional capacity at different values of social network variables ( moderators).

<table>
<thead>
<tr>
<th>Significant interaction effects</th>
<th>Functional Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>of SN size and satisfaction by exposure variables on FC</td>
<td>Statistics</td>
</tr>
<tr>
<td>Education</td>
<td>Interaction term</td>
</tr>
<tr>
<td></td>
<td>Association at mean -1 SD of moderator: -1.420 SN satisfaction</td>
</tr>
<tr>
<td></td>
<td>Association at mean value of moderator: 0 SN satisfaction</td>
</tr>
<tr>
<td></td>
<td>Association at mean +1 SD of moderator: 1.420 SN satisfaction</td>
</tr>
<tr>
<td>Area type (Small town)</td>
<td>Interaction term</td>
</tr>
<tr>
<td></td>
<td>Association at mean -1 SD of moderator: -1.583 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean value of moderator: 0 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean +1 SD of moderator: 1.583 SN size</td>
</tr>
<tr>
<td>Area type (Large town)</td>
<td>Interaction term</td>
</tr>
<tr>
<td></td>
<td>Association at mean -1 SD of moderator: -1.583 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean value of moderator: 0 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean +1 SD of moderator: 1.583 SN size</td>
</tr>
<tr>
<td>Area type (Suburb/outskirts of a big city)</td>
<td>Interaction term</td>
</tr>
<tr>
<td></td>
<td>Association at mean -1 SD of moderator: -1.583 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean value of moderator: 0 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean +1 SD of moderator: 1.583 SN size</td>
</tr>
<tr>
<td>Area type (Big city)</td>
<td>Interaction term</td>
</tr>
<tr>
<td></td>
<td>Association at mean -1 SD of moderator: -1.583 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean value of moderator: 0 SN size</td>
</tr>
<tr>
<td></td>
<td>Association at mean +1 SD of moderator: 1.583 SN size</td>
</tr>
</tbody>
</table>

Note: SD: Standard Deviation. $b$: regression coefficient. CIs: confidence intervals. FC: functional capacity. SN: social network *p < .05; **p < .01; ***p < .001
Papers I-III
Challenges in using wearable GPS devices in low-income older adults: Can map-based interviews help with assessments of mobility?

Tanja Schmidt,1 Jacqueline Kerr,2 Yan Kestens,3 Jasper Schipperijn1

Abstract
Daily mobility, defined as the ability to move oneself within one’s neighborhood and regions beyond, is an important construct, which affects people as they age. Having a feasible and valid measure of daily mobility is essential to understand how it affects older adults’ everyday life. Given the limitations of existing measures, new tools may be needed. The purpose of the study is to assess the feasibility and practicality of using the map-based questionnaire system VERITAS and GPS devices to measure daily mobility in older adults living in a deprived neighborhood in Denmark. Older adults were recruited from two senior housing areas, completed an interview using VERITAS and wore a GPS for 7 days. Feasibility of both methods was assessed by looking at practicalities, recruitment and compliance, and ability to measure daily mobility. Thirty-four older adults completed the VERITAS questionnaire, of which 23 wore the GPS device. Remembering to wear and charge the GPS was difficult for 48% participants, whereas remembering street names and drawing routes in VERITAS was difficult for two. Both the GPS and VERITAS were able to measure 10 out of the 13 identified components of mobility; however, VERITAS seemed more qualified at measuring daily mobility for this target population. The feasibility of assessing mobility may vary by specific context and study population being investigated. Wearable technology like a GPS may not be acceptable to low socioeconomic older adults, whereas interview-led self-reported measurements like VERITAS might be more suitable for a low socioeconomic elderly population.

Keywords
VERITAS, GPS, Older adults, Low-income community, Feasibility

BACKGROUND
The worldwide population of older adults (60+) is expected to double from 11% in 2006 to 22% by 2050 [1]. By this time, in Western countries, there will be more older adults than children and local governments may struggle to deliver appropriate services to this large population. With the increase in older adults worldwide, there has also been an increased interest in enabling people to age-in-place. The World Health Organization has supported a program of age-friendly communities to increase capacity for aging in place [2]. Aging-in-place is a term typically defined as “remaining living in the community, with some level of independence, rather than in residential care” [3]. The majority of older Americans state that they want to age-in-place as long as possible [4], and several factors seem to affect one’s ability to do so.

The ability to conduct everyday activities is an important predictor of aging in place, and limitations in daily mobility may represent an important barrier. Although there are several accepted definitions of mobility [5, 6] in this study, mobility is a concept that describes “the ability to move oneself (e.g., by walking, using assistive devices, or by using transportation) within community environments that expand from one’s home, to the neighborhood, and to regions beyond” [7]. It describes people’s ability to move around in their homes as well as inside and outside of their neighborhood, to do daily activities such as going to the grocery store, accessing health care services, meeting friends, and performing recreational activities. In the present study, we used the following components to describe daily mobility: destination type, number of and distance to destinations; routes used from home to destinations;
number of times visiting destinations (frequency) and amount of time spent at destinations; mode of transportation (vehicle, public transportation, walk, bike) as well as distance traveled, frequency of use and time spent in these modes; use of assistive devices during trips (cane, walker, wheelchair); total time spent outdoors; and social interactions during trips and at destinations [8–10].

Mobility is fundamentally important for being able to maintain physical and psychological health and is especially important for elderly people because their mobility usually declines with age. In particular, socioeconomically disadvantaged older adults are at greater risk for declines in mobility and, consequently, institutionalization [11]. Studies indicate that elderly people travel shorter distances and less often than younger adults and have identified changes in activity patterns, health constraints, and traffic safety as potential contributors to their decreased mobility [12–14]. Features of the built environment have also been linked to mobility among older adults, underlining the fact that some types of environments offer greater opportunities to be mobile than others. Additionally, mobility is strongly related to social interaction (i.e., going somewhere to meet with a peer) and, consequently, loss in mobility might translate into reduced social participation [15, 16]. Even passive mobility, for example in vehicle versus walking, seems to have some mental and social health benefits [17]. Furthermore, mobility represents the translation of people’s need to access various resources like health services and grocery stores. That is, a certain level of mobility is important to be able to access these various resources. Thus, investigating how well older adults can conduct their everyday activities, how it affects their health, and how the built environment and the social environment affect their mobility is important to support aging-in-place.

The complex concept of daily mobility has led to a range of different methods to measure mobility in older adults, like physical functioning tests [18, 19] or the self-reported Life-Space Questionnaire (LSQ) [20]. Even though these methods capture some of the elements of daily mobility, they do neglect some other important components, such as different modes of transportation and the social components of daily mobility. Consequently, there is a need to explore other measurement tools that might better capture daily mobility in older adults.

One method that is increasingly being used to assess daily mobility and exposure to multiple environments is Global Positioning System (GPS) devices. GPS devices are an objective tool used to capture location and, in combination with data from a Geographic Information System [21], they can reveal movement through different environments in all age groups. Typically, GPS studies have collected data for 1 week although this is changing with increased use of smartphones and embedded GPS trackers. In the last few years, GPS has also been used in studies investigating daily mobility in older adults [22–25] by assessing a persons’ time spend in different spaces, different destinations visited, or mode of transportation. GPS may be a better tool to assess daily mobility than LSQ as it can capture many of the different components of daily mobility described earlier objectively. A relatively new method to assess daily mobility is spatial interviews or questionnaires like the Visualization and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces (VERITAS). VERITAS is a web-based application that combines interactive mapping (using Google Maps) with activity and travel questions [26, 27]. VERITAS facilitates the collection of self-reported data about participants’ destinations, routes, modes of transportation, and on related social dimensions (i.e., whom is generally met at these destinations), and provides a more general picture of daily mobility [26]. Please visit the SPHERELAB website (http://www.spherelab.org/tools) to see a demonstration of VERITAS. To our knowledge, VERITAS has only been used in a few studies, for respondents with different socioeconomic statuses [28] and ages. One study focusing on older adults (65+ years old) was conducted in Canada [27] and another which to some degree included an older study population (range: 33–84, mean age 51 years) was conducted in France [29]. However, none of these studies specifically looked at the feasibility of using VERITAS to assess daily mobility.

Identifying a suitable method for measuring daily mobility, especially among older adults and deprived populations, is important to fully understand what affects daily mobility. Measurement tools need to be adaptable to different population groups (age and socioeconomic status (SES)) and measurements need to be sensitive toward change because they might have to measure relatively small behavioral changes in older adults. Both VERITAS and GPS devices seem promising and their strengths and weaknesses need to be assessed to improve the next generation of built environment studies focusing on aging-in-place.

Aim

This paper is looking at two methods to collect daily mobility data in older adults: one that is self-reported and focuses on regular destinations and the other one that is objective and uses passive tracking capabilities providing acute measurement of daily mobility. More specifically, the aim of this study was to assess the feasibility and practicality of using the map-based questionnaire system VERITAS and wearable GPS devices to measure daily mobility in a sample of older adults living in senior housing in a socially deprived neighborhood of Copenhagen, Denmark. This includes assessing tool acceptability, adherence to protocol, barriers to their use (cost, time, etc.), and ability to provide measures of daily mobility in low-income older adults.
METHODS

Case study sample and recruitment procedures
This study is part of a multicomponent intervention study (Move the Neighborhood) focusing on using co-creation, in collaboration with local seniors, design and build installations that have the potential to increase physical activity and decrease sedentary behavior among older adults living in a deprived neighborhood (Sydhavnen) of Copenhagen [30]. With only 73.0 years, Sydhavnen has one of the lowest life expectancies in Denmark (the average in Denmark is 80.6 years) [31], 32% of the population only attended primary school and 40.2% have a low income [32].

The study population was recruited within the neighborhood from two housing areas (350 tenants, age 50+) for the elderly that accommodate seniors who have a low socioeconomic status. Many tenants cannot pay the usual rent for an apartment in Copenhagen and might need extra help with cleaning, grocery shopping, and/or personal care. Older adults were recruited from the two housing areas through letters, local stakeholders, and existing social activities. Information about the intervention study, this substudy, and its purpose of providing valuable knowledge to this study and future studies targeting open spaces for older adults was provided during each recruitment procedure. Participants were introduced to both methods GPS and VERITAS and were encouraged to “use” both of them. However, they were given the option to refuse to participate in one or both of the measurements. Those who agreed on participating in both measurements completed the VERITAS interview and were afterwards given a GPS to wear for the following 7 days. We collected information on participants’ reasons for refusal. Participants were offered to be interviewed at their home or at our offices; all of them chose at home interviews. The study was registered in the ISRCTN registry (ISRCTN50036837). Furthermore, the study and its data-management procedures were approved by the Danish Data Protection Agency (2015-57-0008).

GPS
Those participants who agreed to wear a GPS wore a Qstarz BT-Q1000xt GPS device and were given several choices on how to wear the device (belt, ankle holder, key hanger, in their pocket or bag). Participants were asked to wear the device for seven consecutive days and to take the GPS off only when there was a risk of contact with water and at night while charging. Participants received short reminder text messages on their mobile phones—one in the morning and one in the evening—to increase compliance and remind them to charge their GPS device. Additionally, reminder flyers were posted next to their apartment door and next to their nightstand with information on how to charge and wear the GPS device because some participants did not use their phone a lot or were not used to text messages. GPS devices were collected after 7 days and GPS data were processed using a web-based application called the Personal Activity and Location Measurement System (PALMS) [33]. PALMS uses a range of user-defined settings to identify different variables like trips, mode of transportation and time spent outdoors, to assess mobility. In this study, trips were categorized as continuous movement of at least 3 min, with stationary periods of maximum 5 min. Mode of transportation during each trip was calculated using speed and included three modes: walking (≥1 km/h, <10 km/h), biking (≥10 km/h, <25 km/h), and in a vehicle (≥25 km/h) [34]. Data were afterwards visualized in QGIS version 2.18.3. QGIS is a free and open source GIS used to create, edit, visualize, and analyze geospatial information [21].

VERITAS
VERITAS is a map-based retrospective questionnaire that allows for identification of locations (points), routes between locations (lines) or areas (polygons) such as perceived neighborhoods, on a map. Google Map search functionalities can be used to facilitate the identification of specific locations. Participants were first asked to confirm the location of their home address (point), which served as a basis for all other identified locations to determine distance. The specific VERITAS questions used in this study were based on the CURHA study conducted in Canada by Yan Kestens et al. [27] focusing on older adults with a mix of socioeconomic statuses. The questionnaire was originally in French and English. We translated it into high-school level Danish and made some adjustments to account for the Danish context. The questionnaire consisted of 32 categories each including one to five questions. Depending on whether the participant answered “yes” or “no,” the participant was asked to specify each of the 32 categories by drawing destinations or routes on the digital map, and identify how often, how (mode and use of assistive devices) and with whom they go there (social interaction). For example, “Do you shop for groceries at a supermarket at least once per month?”, if they answered “yes,” we asked them to locate the supermarket on the map. Questions considering specific places (e.g., supermarket, doctor, bank) all use the phrase, “...at least once per month,” that is VERITAS does not ask questions about the last 7 days or other specific period, but provides a more general picture of activities and destinations. We decided to deliver the questionnaire as an interview instead of a self-administered questionnaire because interviewing has shown to be a more reliable method for older adults [35]. Questions in the VERITAS interview encouraged participants to identify the following regular destinations: recreational destinations, different...
types of destinations for grocery shopping (supermarket, butcher, etc.) and services (bank, doctor, post office). Participants were asked to identify their perceived neighborhood by “drawing” a polygon picturing the perceived boundaries of their neighborhood. Participants reported destinations visited at least once a month to account for several different destinations, for example the post office, which may not be frequently visited. After completion of data collection, VERITAS data were downloaded as csv files and processed in QGIS version 2.18.3.

Feasibility
To fully evaluate the feasibility of the GPS device and VERITAS in measuring daily mobility in low socioeconomic older adults, three criteria were used: practicalities, recruitment and compliance, and mobility variables. Each of these three criteria had several subcriteria that were assessed and compared. The three criteria are described in the following section.

Practicalities
First, we evaluated several practical barriers to using the two methods, which included costs and time spent on equipment preparations, data collection, and data processing. Second, we assessed the practicalities of method acceptability qualitatively by interviewing participants before and after data collection. Seniors who did not want to be part of the study were asked, “What are your reasons for not wanting to participate in this study?” If participants only wanted to participate in one part of the data collection (e.g., only VERITAS interview) they were asked, “What are your reasons for not wanting to participate in the other part of the data collection?” Seniors who wore the GPS device were asked two questions after the 7 days of wear time: (a) “Have you had any difficulties or other experiences with the device while wearing it?” (b) “Did you at any time during the last 7 days forget to wear your device during all waking hours?” Three researchers were responsible for the home visits and interviewing the participants and non-participants. Responses of all three researchers were combined and assessed after completion of the data collection. After all practicalities were assessed, the scalability of the two methods was evaluated.

Recruitment and compliance
Second, we assessed recruitment difficulties and recruitment rates for both methods, that is how easy or difficult is recruitment and how many agree to participate in the VERITAS interview versus the GPS data collection. We further assessed compliance with the data collection procedure and data quality, that is difficulties answering the VERITAS questionnaire or wearing the GPS device, and the quality of the data when downloaded.

Mobility variables
Lastly, to fully evaluate the feasibility of the two methods, we assessed their ability to measure daily mobility. In this study, the concept of daily mobility is defined by several components listed in the Background section. These components are conceptualized through 13 variables, divided into three themes: Destination, Transportation, and Other.

Destinations: number of destinations visited; type of destination; routes from home to destinations; time spent at a location; frequency of destinations visited; and distance to destinations. Transportation: mode of transportation; frequency of transportation mode; time spent in different transportation modes; use of assistive devices during trips; and distance traveled by mode. Other: time spent outdoors and social interaction.

The 13 variables were evaluated by assessing GPS’s and VERITAS’s technical capability to measure the variables using PALMS (GPS) and QGIS (VERITAS).

Finally, we present an example map of a participant’s GPS mobility data (for walking) and VERITAS mobility data (recreational walking), which was used for a visual assessment of the spatial data. The map was generated using QGIS. We recognize that caution should be taken when mapping two different types of data for the same person because they might not be fully comparable as VERITAS data and GPS data are not necessarily representing the same time points during data collection. GPS data were captured for seven specific days, whereas VERITAS data show a general picture of destinations visited during a usual month. But even though the two methods represent different ways of measuring daily mobility, they have a similar goal, providing a description of daily mobility which can be used in health research.

Analyses
On completion of the fieldwork, qualitative data from three researchers including field notes and notes from the unstructured interviews with participants were combined and coded to assess the feasibility of using VERITAS or GPS. During the first step of the thematic analysis, the combined data were analyzed and three themes emerged based on the participants’ feedback on the measurement procedure: GPS difficulties, VERITAS experiences, and no participation. VERITAS difficulties were not reported.

To assess the two methods’ ability to measure the different aspects of the concept of mobility, we used a descriptive approach looking at a range of different variables identified in the methods section. These variables were assessed by visualizing VERITAS data in QGIS using the available geographical coordinates that allowed us to locate destinations and areas, as well as look at questions about
the use of assistive devices, transportation mode, and social activities. GPS data were processed in PALMS and afterwards visualized in QGIS, allowing us to visually assess GPS processed data about transportation mode, routes, and time spent outside. To compare the spatial information collected using the two methods, we created a map for each participant using QGIS and visually assessed the percentage of agreement between GPS and VERITAS measurements, by first, counting the number of times were VERITAS identified destinations and recreational walking routes were visually on or next to GPS calculated trips using the QGIS illustrated map. Second, the percentage of agreement was calculated by dividing the total number of matches by the total number of VERITAS identified destinations and recreational walking routes and multiply by 100.

RESULTS

Recruitment and compliance
Recruitment was challenging and time-consuming. No one responded to flyers in their mail (180 out of 350 households received flyers)—normally, the method used by local stakeholders to communicate with residents—which meant that we had to recruit them on the spot by participating in their social activities. Out of 340 older adults asked (including the 180 households), 34 (10%) agreed to complete the VERITAS questionnaire. Ages ranged from 51 to 90 years, of which 26.5% were men (see Table 1). During the VERITAS interview, two participants had difficulty remembering street names and drawing specific routes in the VERITAS map. Of the 34 older adults completing the VERITAS interview, 23 (6.8% out of 340 asked) agreed to wear the GPS device. Ages ranged from 53 to 86 years, and 24% were men (see Table 1). Of the 23 agreeing to wear the GPS device, only 12 participants (52%) had valid GPS data for at least 1 day (>8 hr of wear time), and only five participants had 7 days of GPS data. The 12 participants with GPS data had on average worn the GPS for 9 h/day for 5.6 days. Eleven participants had difficulties remembering to charge the device and to carry it on them at all time. Participants who did not want to wear the GPS said they did not want to be responsible for remembering to charge the device and to take it with them wherever they went (10 participants). Those who did not want to participate in the study at all stated that they did not have anything interesting to say (64 persons) or that they almost never left their apartment (6 persons) and thus, wearing the device did not make sense for them. Fifty-six older adults did not give any reason for not wanting to participate.

Practicalities
Table 2 shows an overview of the practicalities related to using GPS and VERITAS in the study. Setting up a VERITAS questionnaire costs a one-time payment of at least $1500 regardless of the size of your study population, whereas a GPS device+key hanger costs roughly $100 per person and consequently will get more expensive the more devices are needed for a study. When there is no need for simultaneous GPS tracking, one GPS device can typically be used for two consecutive participants per month. Time spent on equipment preparation, data collection, and data processing varied a lot for the two methods. VERITAS took approximately 1 min to prepare per participant; however, it took around 45 min to do the interview. In contrast, each GPS took about 10 min to prepare beforehand, around 20 min to explain and attach to the participant, and additionally 5 min to pick up after the 7 days. VERITAS only required transport time for one home visit, whereas the GPS required two home visits. Moreover, the participant needed to wear the device for 7 days and charge it every night, which might be considered as an extra burden for the participant.

Because this study was a pilot study with a relatively low number of participants, we considered whether the methods were applicable in larger studies investigating mobility in older adults, based on results displayed in Table 2. Both methods seem to be applicable to larger studies. However, the costs for each GPS device and the specific target population must be considered because this study population had low participation rates and difficulty complying with the protocol. The interview version of VERITAS was applicable in the small sample used in this study, but might be difficult to implement on a larger scale, because interviewing takes a long time. An online version of VERITAS might be more applicable if the study population were more acquainted with using computers and the internet.

Mobility variables
Table 3 provides an overview of the two methods’ capability to measure the variables we identified to be important for daily mobility in older adults. Both methods seem to be able to measure most of the daily mobility variables. However, the quality of the measurement varies between the two tools. VERITAS was able to record the specific mode of transportation, for example whether the person used a bus or a car and whether the person was driving himself or someone else was driving him.

| Table 1 | Overview of descriptive, recruitment, and compliance |
|---|---|---|
| Descriptive | VERITAS | GPS |
| Recruitment (n) | 34 | 23 |
| Age (mean) | 74 (SD 9.6) | 73 (SD 8.9) |
| Sex (female) | 73.50% | 76% |
| Compliance issues (n) | 2 | 11 |
On the other hand, VERITAS was not able to capture the actual distance traveled in different modes of transportation or the specific time spent in different modes of transportation. Whereas GPS data processed in PALMS were able to measure the specific distance traveled in different modes. However, PALMS was not able to capture the difference between car driving or taking the bus, nor was it able to assess the use of assistive devices (e.g., cane or walker), which VERITAS was able to do.

Other components that explain daily mobility in older adults are the type and frequency of destinations visited, distance, and specific routes taken from home to destinations. VERITAS provides measures of type, frequency, and number of destination visited, as well as the distance to destinations. Each destination drawn on Google Maps is followed by a question asking to specify the type of destination, at what frequency they visit that place, and how they generally go there. Participants were able to choose several options for the same trip, which means that VERITAS captured the use of different assistive devices and modes of transportation (e.g., walking with a cane to a bus stop and taking the bus). However, this version of VERITAS was not able to measure the specific routes taken from home to destinations and only poorly measures time spent at destinations (by asking participants to give an estimate of time), whereas GPS was able to measure all types of time with high temporal precision, as well as routes from a to b. Social interaction is another variable of daily mobility which is captured by VERITAS, as participants were asked whether they traveled by themselves or with someone else to each specific destination, and whether they regularly visited friends or family in their homes, or friends and family visited the participant in their home. If they answered “yes,” they were asked to elaborate on how well they knew this person, how often they met and how they communicated (mail, phone, in person). Combined, this information can give an in-depth knowledge about participants’ social relationships. GPS data on the other hand, is not able to detect social interactions; however, identification tagging on different GPS devices may allow assessment of social interaction in the future.

### Table 2 | Overview of practicalities relevant to the use of VERITAS and GPS

<table>
<thead>
<tr>
<th>Factors</th>
<th>VERITAS</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment costs $</td>
<td>At least $1500 (one-time payment)</td>
<td>Around $100 (per device + key hanger)</td>
</tr>
<tr>
<td>Time: equipment preparation</td>
<td>1 min (registration of 1 participant by name and login information on a computer before visit)</td>
<td>10 min (preparing 1 GPS software on a computer, nametag on GPS device, tap on “On” button, attach to key hanger)</td>
</tr>
<tr>
<td>Time: data collection</td>
<td>30 min–1 hr (per interview)</td>
<td>25 min/7 days (explaining the GPS, how to wear, how to charge, hanging reminder poster on wall, collecting phone number for reminder text, 7-day wear time)</td>
</tr>
<tr>
<td>Time: home visits</td>
<td>1 home visit</td>
<td>2 home visits (delivering and explaining the GPS and collecting it 7 days later)</td>
</tr>
<tr>
<td>Scalability (can this be done on a larger study population?)</td>
<td>Yes (if done online instead of interview)</td>
<td>Yes (but need many devices which are expensive)</td>
</tr>
</tbody>
</table>

### Table 3 | Overview of variables explaining daily mobility through VERITAS and GPS data

<table>
<thead>
<tr>
<th>Variables</th>
<th>VERITAS</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of destinations visited</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Type of destination</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Routes from home to destinations</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Frequency of destinations visited</td>
<td>Yes (total)</td>
<td>Yes (for 7 days)</td>
</tr>
<tr>
<td>Distance to destinations</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time spent at a location</td>
<td>Yes</td>
<td>Yes (high temporal precision)</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode of transportation</td>
<td>Yes (specific mode)</td>
<td>Yes (walk, bike, vehicle)</td>
</tr>
<tr>
<td>Frequency of transportation mode</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time spent in different transportation modes</td>
<td>No</td>
<td>Yes (high temporal precision)</td>
</tr>
<tr>
<td>Use of assistive devices during trips</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Distance traveled by mode</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time spent outdoors</td>
<td>Yes (not precisely)</td>
<td>Yes (high temporal precision)</td>
</tr>
<tr>
<td>Social interaction</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Finally, we created a map for each participant using QGIS for illustrative purposes and visual assessment of the spatial information collected using the two different methods. The map in Fig. 1 displays one participant’s identified destinations (yellow dots) and recreational walking route (yellow line) in VERITAS and GPS measured walking using PALMS (orange lines). As can be seen, the two types of visualizations are very different, providing different information. For the example person, the GPS identified walking represents 25 different trips, which may be recreational walking or walking for transportation to specific destinations. The VERITAS data for the same person revealed 21 different destinations and 3 routes for recreational walking. Due to many GPS tracks starting and ending inside buildings, determining the exact start and end points of trips is difficult. GPS accuracy is lower inside buildings which causes trip start and end data to contain noise, that is incorrect GPS points. The advantage of the GPS data, however, is that it is certain that the person actually walked the specific routes seen in Fig. 1, as he or she was wearing the GPS device. From these data, detailed information can be retrieved about the specific trips taken, for example the actual distance traveled, and specific duration and time of day when the trip was made. Looking more closely at the VERITAS data, we see that most of the destinations (yellow dots) are on or close to GPS routes, which indicates that these destinations were most likely also visited during the days of GPS monitoring. In fact, comparing all participants’ data by visually matching each participant’s GPS trips with VERITAS destinations, we see that 58.4% of VERITAS identified destinations are on or next to GPS measured trips. However, the mismatch between VERITAS identified recreational walking trip (yellow line in Fig. 1) and GPS trips may indicate that the recreational trip was not taken during the 7 days of GPS monitoring. For each destination in VERITAS, detailed information about the context and purpose of the trip can be retrieved. Furthermore, we can retrieve information about mode of transportation and use of assistive devices (i.e., bus, train, walking without any assistance), and how often the participant visits each destination, ranging from several times per week to a couple of times per month or year. This information depicts a more general picture of the participant’s life space, but does not provide detailed information about specific time points or routes taken to these destinations.

DISCUSSION
This pilot study aimed to assess the challenges and benefits of two different spatial measurement methods by descriptively investigating the feasibility of using an interview version of the map-based VERITAS questionnaire compared to GPS devices to assess daily mobility in low-income older adults.
We investigated feasibility by assessing three main criteria: practicalities; recruitment and compliance; and mobility variables, using both qualitative fieldwork data during data collection and objective quantitative data from the two methods.

Practicalities

Using a GPS device on low-income older adults imposed numerous practical issues. First, one GPS device costs $100, which might be considered prohibitive for a larger study. However, often researchers are able to get bulk discounts, borrow devices, or rotate a smaller pool of devices among a larger group since each person only wears the device for 7 days. Second, even though 10 min to prepare one GPS device does not seem burdensome, the amount of time and staff needed to do this at scale mount up. Third, the actual data collection, in this case, was done through home visits, explaining the device, how to wear and charge it, and setting up for reminder texts and reminder posters. This procedure was very time-consuming. However, because this study population was disadvantaged in several ways (low-income, physical disabilities, disadvantages neighborhood), it was not considered feasible to mail the device to their homes. Fourth, participants had to wear the device for 7 days and remember to charge it daily, which was found to be a challenge, and might explain the low participation rate (6.8%). However, other studies did succeed in using the GPS device on older adults [36–38], although study participants in these studies were mainly Caucasians with high levels of physical functioning and education. Lastly, one might consider the specific context (low income and socially disadvantaged community) to be the reason for the several identified limitations and not the GPS device itself. One study by Paz-Soldan et al. [39] found several limitations in the use of GPS on adults in a low SES city in the Amazon Basin of Peru. Consequently, it might be the specific age group in combination with its vulnerability by being a disadvantaged population group, which might make the GPS device less feasible to use in studies focusing on disadvantaged older population groups.

The map-based interview version of VERITAS used in this study seemed to have both benefits and some practical limitations when used on a disadvantaged population of older adults. The benefits of using VERITAS were as follows: first, the lower burden of participation (one interview of around 45 min vs. 7 days of wear) consequently, higher participation rates. Second, it took a relatively short time to prepare the VERITAS procedure before visiting the participant in their home, which saved time. Third, VERITAS was completed during one guided home visit instead of seven consecutive days of wear time (GPS), which avoids the challenges of incomplete data over multiple days. On the other hand, we might have incomplete VERITAS data which we might not be aware of because there is no actual “golden standard” to compare VERITAS data to. Assessing the practical limitations of VERITAS, a 1-hr home-based interview with a stranger (researcher) may be more burdensome for the participant than a 20-min visit followed by 7 days of wear time proposed for the GPS. However, results from this study did not confirm one or the other method to be better. Additionally, costs for the VERITAS software are relatively high and data processing takes time. Lastly, this was only a small pilot study with a sample of 34 participants. If VERITAS had to be used on a larger scale, it might not be feasible using the same approach as in our study because home visits are time-consuming and require several trained researchers and travel costs. Even though VERITAS can be self-administered, it implies that participants have sufficient internet and map literacy, which might not be the case among older adults in general and older adults of lower socioeconomic status. First, low-income older adults may not have the money to own a computer and thus be able to learn to use one. Second, lower educational level older adults may not have had a job where they worked on a computer and, thus, have never been able to learn to use one. Third, older adults in general grew up in a time without computers and, thus, have difficulties to learn to use it in such late age. However, because more and more seniors are getting used to different technological devices as well as the internet, an online version of VERITAS might be possible in a few years. A report from Pew Research Center showed an increase in internet use by American older adults (65+) from 14% in 2000 to 58% in 2015 [40]. Because this increase is exponential, we might expect that this number has increased further since 2015 and will keep increasing in the coming years. However, an online process might not elicit the quality of data leveraged in an interview and does not include the human contact with the researcher which may be very valuable to older adults.

Recruitment and compliance

More participants wanted to participate in the VERITAS interview and experienced the interview to be pleasant, compared to wearing the GPS device, although recruitment was difficult and time-consuming for both methods. Only a few participants had difficulties with the VERITAS interview, whereas most of the participants wearing the GPS reported difficulties remembering to wear the device and charging it, which might be due to the old age and less experience with technology. Additionally, only 52% of the 23 participants had GPS data for at least 1 day and only 5 participants had 7 days with at least 8 hr of wear time, which poses another limitation to the GPS approach. As mentioned in the Results section, participants reported that they did not want to...
take the responsibility of remembering to charge the device and to take it with them when leaving their apartment. However, our communication strategy when introducing the project and the GPS device to this specific target population might not have been the most suitable or sufficient in this case. That is, a more targeted communication strategy considering the specific context and population in the development of the communication strategy might have increased participation.

**Measurement of daily mobility**

Daily mobility can be measured in several different ways, depending on the specific context, the population being investigated, and the concept of mobility of interest. Our interpretation of daily mobility goes beyond the commonly considered “ability to move oneself within community environments that expand from one’s home, to the neighborhood, and to regions beyond” [7]. We are identifying several additional components as important variables in explaining mobility, which will allow researchers and health promoters to better target individual or environmental interventions to support increased mobility and consequently, aging in place. For example, the use of different modes of transportation—both active and passive—the use of assistive devices, and social interaction as being important to maintain mobility, by having family or friends who can help you with transportation or who you can visit and socially interact with. Using this definition, we found VERITAS and the Qstarz BT-Q1000xt GPS device to be useful in measuring mobility to some extent.

GPS is able to objectively measure the traditional main components of mobility, as it can measure movement from home, in the neighborhood and further afield. The benefit of using an objective measurement tool like the GPS is its ability to capture a persons’ actual movement with great temporal precision throughout an entire week, without being affected by recall bias or other biases, which self-reported measurements typically involve [41, 42]. However, when digging deeper into mobility, it becomes clear that GPS has some limitations. First, the GPS device itself is potentially capable of providing some of the daily mobility components, but limitations in data processing and data transformation (algorithms), diminish our possibilities (i.e., transportation mode detection). However, complementary sensors like the accelerometer might enhance the algorithm performance. Second, the GPS device itself has some limitations, which cannot be improved by creating better algorithms, and, consequently, is not able to measure some daily mobility variables like use of assistive devices and social interaction. Although recent studies have used complementary diaries or wearable data streams (e.g., smartphones), that can serve to complement the GPS derived data with the missing information.

VERITAS, on the other hand, is a self-reported map-based measurement tool that allows researchers to comprehensively assess spatial behavior along daily mobility. In contrast to GPS that provides objective information on seven specific days, VERITAS provides a general picture of the participants’ behavior, by asking questions about predefined activities which the respondent has to map and specify in terms of how often they visit this destination, how they generally reach this destination, and whether they go there by themselves or meet with someone. Although we were able to measure almost all components of mobility using VERITAS, we need to weigh this against the bias of using a self-reported measurement tool—especially when the target population is older adults, who might have difficulties in recalling their behavior, or be more susceptible to social desirability bias or social approval bias [41, 42]. Future research could address this issue by including a social desirability measure within the questionnaire to control for potential bias. As depicted in Fig. 1, VERITAS collected daily mobility and GPS measured daily mobility are very different and have each their strengths and limitations. Almost 60% of participants’ GPS measured trips and VERITAS identified destinations within 7 days seemed to match, which may be argued as either a high or a low number. Assessing each participant’s data in QGIS, it became clear that a lot more destinations were identified through VERITAS than measured by GPS trips. This might be due to the fact that most of the participants did not wear the GPS device for 7 days, so trips may have been missed. Alternatively, participants may have overestimated the number of destinations when self-reporting. Additionally, none of VERITAS recreational routes matched with the GPS measured walking trips. There may be several reasons for this; because we do not compare the same time periods, the participants might not have walked those identified VERITAS routes while wearing the GPS device for only 7 days; or as participants are older adults, they may have reported on walks that they would like to have taken or been seen to have taken suggesting social desirability bias or social approval bias, as well as recall bias might be an issue. This issue is particularly important for use of these devices in an intervention trial. Ability to measure change over time depends on a reliable baseline. If participants miss report at baseline, the chances of detecting change over time are diminished. Furthermore, from self-reported physical activity data in trials we know that participants also over-report change due to even greater social desirability than likely here in this observational study. Based on the assessment of the three main criteria and their subcriteria, VERITAS seems to be more qualified at measuring our definition of daily mobility for this specific target population. Recruitment was easier, compliance was higher,
data quality was better, and the daily mobility variables were assessed not only for the last 7 days (GPS approach), but through a more general picture of participants’ daily life (habitual approach). Whereas the GPS device might be sufficient to use for other mobility measures like lifespaces.

CONCLUSION
This is the first study to assess the feasibility and practicality of VERITAS in measuring mobility in older adults. Our findings suggest that using a GPS device on older adults living in a socially deprived community on a larger scale may not be feasible. Recruitment rates were low and its ability to measure daily mobility was somewhat limited. Better communication strategies might have increased participation. Greater compliance with VERITAS completion and the depth and quality of the responses may support its use in some studies, especially in low socioeconomic populations who respond well to a guided interview. Researchers need to invest personal time in this particular population, as relationship development is key to conducting research with vulnerable populations. In-person spatial interviews like VERITAS might be a better fit when studying older adults living in disadvantages communities. We believe that this study will contribute to the next generation of built environment studies focusing on older adults’ mobility, physical activity, and aging-in-place, as it provides recommendations on specific methods to assess mobility in specific populations.

Acknowledgments: We thank Copenhagen Municipality in particular the Areal Renewal Office in Sydhavn for their support and collaboration. We also thank all involved persons at the two social housing areas “Tranehavegård” and “Engholmen Nord” for their enthusiastic participation in the study. Y.K. holds a Canada Institutes of Health Research applied public health Chair in Urban Interventions and Population Health. All data and the findings reported have not been previously published, and the manuscript is not being simultaneously submitted elsewhere.

Funding: This study was funded by The Danish Foundation for Culture and Sports Facilities and The Velux Foundation. The funders have no role or authority in conducting the research project.

Authors’ Contributions: T.S. conceived and coordinated the study, was responsible for its design, acquisition of data, data cleaning, data analyses, and explicitly asking the respondent if he or she had understood everything in specific populations.

Ethical Approval and Informed Consent: All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and national research committee in Denmark and with the 1964 Helsinki declaration and its later amendments. The study and its data management procedures have been approved by the Danish Data Protection Agency (2015–57-0008). According to the Danish National Committee on Health Research Ethics, formal ethical approval was not required as the project was not a biomedical research project. Each face-to-face appointment with the senior participants started with a researcher explaining the purpose and procedures of the study once more when studying older adults living in disadvantages communities. We believe that this study will contribute to the next generation of built environment studies focusing on older adults’ mobility, physical activity, and aging-in-place, as it provides recommendations on specific methods to assess mobility in specific populations.

References

Primary Data: The authors have full control of all primary data and agree to allow the journal to review our data if requested.

Compliance with Ethical Standards
Conflict of Interest: We hereby declare that coauthor Yan Kestens holds shares in the company that sells VERITAS (Treksoft Solutions). The remaining authors declare that they have no potential conflict of interest.


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Schmidt T, Kerr J, Schipperijn J. *Associations between Neighborhood Open Space features and Walking and Social Interaction in Older Adults – a mixed methods study*. Geriatrics 2019; 4 (3): 41. [https://doi.org/10.3390/geriatrics4030041](https://doi.org/10.3390/geriatrics4030041)
Associations between Neighborhood Open Space Features and Walking and Social Interaction in Older Adults—A Mixed Methods Study

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Received: 23 May 2019; Accepted: 5 July 2019; Published: 6 July 2019

Abstract: Neighborhood Open Spaces (NOS) such as public spaces around people’s homes, parks and village greens, may support activity and socializing for older adults. These spaces might be especially important for older adults as they typically are less mobile and have smaller activity spaces and social networks than other age groups. The present exploratory sequential mixed methods study investigates the association between built environment features, social interaction, and walking within NOS, among older adults living in a low socio-economic neighborhood in Copenhagen. Interviews, the Community Park Audit Tool, and the System for Observing Play and Recreation in Communities (SOPARC) were used to capture quantitative and qualitative data on 353 older adults (59–90 years old) within 11 NOS. Walking was predicted by the condition and shade along paths, seating and landscaping. Social interaction was negatively associated with walking, suggesting that older adults tend to sit down when engaging in social activities. Interviews highlighted the importance of social interaction within NOS. Future designs of NOS should acknowledge the importance of social meeting places, but at the same time provide walkable spaces for older adults to promote healthy aging.

Keywords: older adults; neighborhood open space; walking; social interaction

1. Introduction

Older adults (60+) are a rapidly growing population group in most industrialized countries. They are expected to increase to 22% of the worldwide population by 2050, resulting in more older adults than children [1]. This increase will lead to major financial burdens on governments. Health care costs usually increase with age due to greater health problems, physical impairments and mental health problems [2]. Some of the most common health issues among older adults are chronic diseases related to obesity, diabetes, arthritis, hypertension, heart disease, and cancer [3], as well as depression [4] and anxiety [5]. Regular physical activity (PA), for example walking, has been shown to have numerous health benefits for older adults, such as preventing cardiovascular disease, hypertension, diabetes, depression, anxiety, cancer, high cholesterol and blood pressure, obesity, and risk of falls [6–8]. For older adults, walking within their community may be a safe and easy way to meet PA guidelines. However, worldwide almost a third of 60–79 year olds and half of 80+ year olds, do not meet the recommended PA guidelines of at least 150 min of moderate-intensity aerobic PA per week [9] and over a third of 60+ year olds in Denmark do not meet the recommended levels of PA [10]. Creating spaces in communities which meet older adults’ specific needs might help decrease sedentary time, increase PA through walking, and improve health [11,12].
Disparities in health and environments by socioeconomic status (SES), especially in older adults, suggest that understanding specific predictors in low-income neighborhoods would be beneficial. Low SES older adults are less active with poorer health then older adults with a higher SES [13–15]. Low-SES neighborhoods also provide fewer activity-friendly public open spaces and are less walkable than high-SES neighborhoods [13,16,17]. Studies of parks have reported less frequent use, poorer perceived accessibility and safety, and poor perceived distance to public parks in more deprived areas [18,19]. Given the impacts of environment and activity on health and healthcare costs, understanding the perceived barriers and facilitators for walking within low-income communities and how specific built environmental features may promote walking should thus be a key concern of health promoters and urban planners.

Neighborhood Open Spaces (NOS) are defined as public open spaces near where people live, such as public spaces around people’s homes, neighborhood parks and community gardens, as well as village greens [20]. Since NOS are close to people’s homes and often act as social meeting places [21,22], they might be especially important for older adults, who typically are less mobile and have smaller activity spaces and smaller social networks than other age groups [23–25]. Especially for disadvantaged neighborhoods, small-scale changes to the built environment within NOS may be particularly beneficial, as they are easier and less costly than having to make improvements on larger scales e.g., the walkability of the whole neighborhood. Studies of low-income NOS are needed.

Several studies have investigated the association between built environment characteristics and walking, mobility or physical activity in older adults [26–31] and found safe, walkable, green and aesthetically pleasing neighborhoods with access to different destinations and services to be important. However, these studies have focused on the overall characteristics of neighborhood built environments rather than specific attributes within NOS associated with walking. Studies on attributes of NOS and their association with walking within these NOS for older adults are limited. One study by Sugiyama et al. [32] used self-reported data on older adults’ time spent outdoors walking and quality of life, and its association with self-reported quality of NOS, and found safety and pleasantness in NOS to be relevant for older adults’ life satisfaction, as well as the quality of paths to open spaces to be associated with total walking. Another study by Sugiyama and Thompson [33], conducted in the United Kingdoms (UK), found that the quality of paths to NOS, lack of nuisance, attractiveness, and facilities within the NOS (e.g., toilets) were associated with total recreational and transport-related walking. Lastly, a study by Aspinall et al. [20] found similar features like nuisances, attractions, as well as trees and heavy traffic to be of relevance for older people’s park preference—not specifically walking. Studies not focusing specifically on NOS but on gardens or parks, also found safety concerns, as well as accessibility and walkability to be associated with walking [18,34]. Although studies presented similar results, they also had similar limitations. First, most of the studies were conducted in the UK, leaving the question of whether these attributes are relevant in other European countries. Second, they used self-reported data on walking or built environmental attributes. Third, they did not investigate walking within NOS but rather walking or physical activity in general. Studies with objective measures of walking within NOS are needed.

Having a built environment that supports walking may also affect social interaction and social support among older adults. One study by Richard et al. [35] found that having a local environment that was unsupportive for walking might decrease social interaction, which consequently might lead to a decline in physical functioning due to less activity and an increase in isolation due to less social support [36]. However, living in more walkable neighborhoods supporting social interactions and having built environment features that facilitates social interaction like porches, was related to fewer depressive symptoms, less anxiety and higher quality of life [37–39]. A few studies have investigated the relationship between green spaces within neighborhoods and social interaction for older adults, and found that social interaction is influenced by the availability of trees, grass and greenness of the green space, along with safety and maintenance [40–42]. While social interaction is important for older adults, it is not clear whether features that support social interaction might detract from walking [32].
Older adults often have cognitive and cardiovascular challenges to walking and talking. However, research suggests that older adults sometimes develop highly fixed walking routines to maintain well-being, and social interaction might be part of these routines [43–45]. As routines usually do not take much effort, it may be possible to engage in some social interaction like talking, while walking. It is therefore important to explore social interaction as a mediator of the relationship between NOS attributes and walking.

A key issue that should concern urban planners, architects and landscape designers is how to design or reshape existing NOS to improve physical and social health in older adults with low SES. The limited amount of research in this area may have resulted in NOS which do not seem suitable or favorable for active living by disadvantaged older adults. Consequently, in order to inform improved designs of NOS for older adults, it is necessary to increase our knowledge on what specific NOS features are important for their walking behavior and how social interaction may also arise. Previous studies have relied on self-reported data, which consequently may have biased their results. However, as older adults are a quite heterogeneous group (e.g., differences in physical abilities, mental disorders, socio-economic status), and older adults living in disadvantaged neighborhoods are found to have more negative perceptions of their neighborhood [18], researchers should also not rely solely on objective measurements. To incorporate both views, researchers have proposed the use of triangulation [32]. A mixed-methods approach, applying qualitative and quantitative measurements, may improve the evidence base for designing NOS and may provide a more comprehensive understanding.

To fill this gap in the literature, the aim of this study was to identify specific features within NOS, like greenery and facilities, associated with older adults’ objectively measured walking behavior within the NOS, and to assess the association between social interaction and older adults’ walking behavior in a deprived neighborhood of Copenhagen. This was done using a sequential exploratory mixed method design with equal emphasis on QUANT and QUAL. First, we analyzed findings from several interviews conducted with older adults and identified perceived key features important for NOS use. This initial qualitative step was used to identify and adapt the most suitable auditing tool to capture those features in the NOS. Second, we quantitatively assessed the association between the identified features within the NOS, social interaction and walking among older adults and discussed the results in relation to the qualitative findings.

2. Materials and Methods

2.1. Design and Setting

This study is part of a larger quasi-experimental intervention study (Move The Neighbourhood Study), which builds on principles from Community-Based Participatory Research and uses co-design approaches to develop tailored interventions within NOS in senior-housing areas to improve physical activity and social interaction for older adults living in a deprived neighborhood of Copenhagen, Denmark (DK) [46]. The quantitative and qualitative data collected in this larger intervention study are used for this paper to specifically investigate NOS walking behavior.

The study took place in one of Copenhagen’s most disadvantaged neighborhoods, as 32.0% has no formal education (21.3% on average in DK) and 40.2% has a low income (30.6% on average in DK), with a life expectancy of 73.0 years; one of the lowest in Denmark and well below the average of 80.6 years [47]. The area is called Sydhavnen (South Harbor), and has 10.276 inhabitants [48] within a 1.2 km² area, framed by high-traffic corridors. This neighborhood consists of several different types of housings, for all age groups and needs. There are several senior housing areas with apartment blocks designed for seniors’ needs, including public open spaces in and around the apartment blocks. Out of the three existing and invited housing associations within Sydhavnen containing senior housing, two of them agreed on participating in the study. The land use surrounding the first housing area consists primarily of residential buildings, a school, a pub, and a large cemetery that is also used as a recreation area. The second housing area is situated in a more urban context surrounded by mixed land use.
including residential buildings, shops, cafés, pubs, community centers, a school, and a town square. Eleven NOS surrounding the two senior housing areas were selected to be part of the data collection based on the following criteria: (1) they had to be next to or close to (max 400 m walking distance) one of the two senior housing areas; (2) they had to be public open spaces accessible by the target population and the general public; and (3) they had to be large enough for people to be able to stay in the NOS and do activities (e.g., small grassy spots were excluded). Figure 1 depicts all 11 NOS within the two senior housing areas.
Figure 1. Map of Copenhagen, Sydhavnen and all 11 Neighborhood open spaces within the two senior housing areas. The map (on the left) includes information on parks (green), water (blue), major roads (grey lines), and the train system (dotted lines). White arrows show the entrances to the buildings.
2.2. Ethics

The study and its data-management procedures were approved by the Danish Data Protection Agency (2015–57-0008). All participants signed a consent form agreeing to take part in the study. In order to ensure the participants’ anonymity, names were changed when analyzing and drafting this paper. Participants could withdraw from the study at any time. Public observations of NOS behavior did not require consent as no identifiable information was collected on participants.

2.3. Mixed-Methods Approach

A mixed-methods approach, called an exploratory sequential mixed methods design [49], was used to investigate the specific design features within NOS on older adults’ walking behavior and its association with social interaction. The first purpose of the exploratory sequential mixed-methods design was to adapt and apply a quantitative measurement instrument to the specific population being investigated. This approach leads to a culture or setting-specific quantitative instrument which reflects the specific target population or setting being investigated [49]. This approach makes it possible to investigate the association between NOS features and walking for a particular study population, older adults, with specific needs, physical and mental limitations and other barriers, which are not common for other age groups. Using a measurement instrument that is not adapted to this specific target population could lead to unclear results and consequently, poor recommendations for NOS design for older adults. The second purpose of this mixed methods design was to further qualify the quantitative results by including qualitative data from the specific population being studied in the discussion of the results.

The design and structure of the sequential mixed methods approach used in this study is explained in Figure 2. The mixed methods approach is divided into four stages. In the first stage (the exploratory stage), home-administered structured interviews were carried out in the fall of 2016 to assess the experiences of local older adults with outdoor open spaces, regarding barriers and facilitators to use them.

In the second stage (the development stage), a validated quantitative instrument called the Community Park Audit Tool (CPAT) [50] was used and adapted based on the themes that emerged from the results of the structured interviews. In the third stage, quantitative data were collected using the adapted CPAT instrument as well as the System for Observing Play and Recreation in Communities (SOPARC) [51] in both the fall of 2016 and spring of 2017. These data were analyzed using Binomial Logistic Regression analyses to explore associations between specific NOS features, social interactions and walking in older adults. In the fourth stage, semi-structured home interviews were carried out in spring 2018 to explore older adults’ use or none-use of NOS that might support or contradict the quantitative findings. Finally, integrated conclusions were drawn based on a compilation of the qualitative and quantitative results, using stories and quotes from the qualitative interviews. The individual steps are described in details in the following.

![Sequential mixed method design](image-url)

**Figure 2.** Mixed Methods diagram explaining the design and structure of this study. Qual = qualitative, Quan = quantitative.
3. Stage 1—Exploration

3.1. Sampling

For the exploratory stage, seniors living in the two pre-identified senior housing areas were invited to participate in the home-administered structured interview. Recruitment took place during social activities hosted by the housing areas. Everyone aged 60 years and above could participate no matter their physical ability and potential impairment. Both verbally and in writing, participants were invited to be visited at home for the interviews or to meet the researcher at their local office.

3.2. Procedure

The aim of this exploratory investigation was to gain knowledge about older adults’ perceived and experienced barriers and motivators for using the local environment. Structured home-administered interviews were carried out to assess attitudes towards specific built environmental features identified in the literature to be important for older adults to use their local neighborhood. During August and September 2016, 34 face-to-face interviews were carried out. Respondents were asked if they experienced a range of built environmental barriers in their neighborhood like not enough green space, lack of seating options, safety issues, and quality of paths. Participants were also able to add any barriers not covered by the interviewer in an open-ended question. Additional demographic information was recorded and the interview took 20–30 min. The answers were written down by the interviewer.

3.3. Analysis

To analyze the data from the first structured home interviews, a deductive thematic approach [52] was used to code the open-ended questions into categories of different built environmental features not covered by the initial structured interview questions. The coded categories were together with the structured interview categories combined in a matrix to identify how many respondents comment on the different categories to identify level of importance.

3.4. Results

The results from the first home interviews were used to qualify the CPAT instrument. Categories not found to be important for the respondents were not included in the CPAT tool, whereas additional categories which many of the respondents mentioned as important were included in the CPAT tool, if they were not already present. The mean age of the respondents was 74, 73.5% were female and 70.6% lived alone. Categories found to be the most important for the respondents were: weather condition, condition of paths (uneven surfaces, curb cuts, to narrow paths for wheelchair users), lack of seating, and safety concerns (large groups of people, traffic, crime and lighting). Categories found to be least inadequate were green spaces, as well as cycle paths and pedestrian paths (please see the supplementary Table S1 for more information on the results).

4. Stage 2—Adaption of the CPAT Instrument

Procedure

CPAT was preliminarily chosen because of its good content validity and reliability in mapping of community parks [50]. CPAT is a user-friendly auditing tool that allows reliable auditing in different community parks and other green spaces and assesses their potential to promote physical activity. While there are other tools relevant for older adults, most do not consider perspectives of low-income neighborhoods and physical activity, which is why CPAT was chosen. It consists of four sections including several questions about access and surrounding neighborhoods, park activities, and park quality and safety. The original full version of CPAT can be found on the Active Living Research website [53].
During stage 2, CPAT was adapted for the specific target population and purpose of the study, by identifying similarities and differences between CPAT variables and stage 1 identified barriers and motivators (see the modified tool in the supplementary File S1). Built environment features that were identified as important during stage 1, but not part of CPAT, were added to the auditing tool, and items in CPAT that did not fit the specific context, were removed or revised. Elements excluded from CPAT were those in ‘Section 3: Park Activity Areas’ related to specific activity areas not found in NOS, like a sport field, basketball court and skate park. Questions about general activity areas like ‘trail’ and ‘green space’ were kept in the instrument.

5. Stage 3—Exploration

5.1. Sampling

For the second exploratory stage, the same seniors living in the two pre-identified senior housing areas and who participated in the first interview were invited to participate in the semi-structured home interview. Both verbally and in writing, participants were invited to be visited at home for the interviews or to meet the researcher at their local office.

5.2. Procedure

The aim of this second exploratory investigation was to gain knowledge about older adults’ use of NOS, their reasons for using or not using the different NOS, their qualities and challenges. Using semi-structured interviews allowed for guiding the conversions on specific topics, but at the same time allowed in-depth questions about topics that may or may not be covered by the interview-guide. During spring 2018, 10 face-to-face semi-structured home interviews were carried out. Topics covered in the interview were their use or none-use of their NOS, what they liked or did not like, and social interaction. Mainly, the interviews had the form of a natural conversation and questions were asked based on the elements in the neighborhood, which prompted reactions by the participants. A mobile phone was used for voice recording after asking for the respondent’s permission to use it.

5.3. Analysis

To analyze the semi-structured interviews, the same deductive thematic approach [52] was chosen as for the first home-interviews, which allowed for the specific CPAT categories to direct the findings. The researcher first transcribed the audio-recorded interviews, and afterwards created themes that matched the CPAT categories. The transcripts were then coded into these CPAT themes. Lastly, a thematic analysis was conducted to create a detailed description and understanding of the transcripts. Using triangulation, by comparing quantitative data with qualitative data enhanced the understanding and rigor. The transcription software called NVIVO [54] was used to transcribe and code the interviews.

5.4. Results

The following table (Table 1) highlights the main characteristics of the participants in the second interviews. In total, 10 older adults (69–89 years old, mean age 78.7, 33.3% men) participated in the interview. None of the participants worked anymore. Years of living in the neighborhood span from 3.5–25 years highlighting the variety of interviewed participants. Four out of 10 participants used a mobility aid allowing the researcher to study multiple ways of moving around the neighborhood. The majority of the participants lived alone which may influence the importance of social relations outside their individual flat [55].
Table 1. Demographics of participants from the second interviews.

<table>
<thead>
<tr>
<th>Housing Area</th>
<th>Gender</th>
<th>Age</th>
<th>Mobility Aid</th>
<th>Living Situation</th>
<th>Years of Living in Sydhavnen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>75</td>
<td>None</td>
<td>Alone</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>Female</td>
<td>74</td>
<td>Mobility scooter</td>
<td>With cousin</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>Female</td>
<td>85</td>
<td>Mobility scooter and walker</td>
<td>Alone</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>Male</td>
<td>78</td>
<td>None</td>
<td>Alone</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>Female</td>
<td>89</td>
<td>Walker</td>
<td>Alone</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>74</td>
<td>None</td>
<td>Alone</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>83</td>
<td>None</td>
<td>Alone</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>69</td>
<td>None</td>
<td>Alone</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>82</td>
<td>Mobility scooter and walker</td>
<td>Alone</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>78</td>
<td>None</td>
<td>Alone</td>
<td>4</td>
</tr>
</tbody>
</table>

The thematic categories identified as the most important by the interviewed older adults based on CPAT variables, in the following order, were: seating (benches or picnic tables), social interaction, landscaping (trees, bushes, and flower beds), shelter, wheelchair friendliness, and shade. The specific barriers and motivators for each identified theme, including quotes, are presented in the additional file together with the CPAT variables (Please see the supplementary Table S2). Categories identified as important were included in the quantitative analysis and further used in the discussion of the quantitative results.

6. Stage 3—Quantitative Observation

6.1. Measures

The 11 NOS surrounding the two senior housing areas were used to collect quantitative data in stage 3. Users of all 11 NOS were observed using SOPARC, and each of the 11 NOS’ built environment features were mapped using CPAT, chosen based on the preliminary qualitative analysis.

6.1.1. SOPARC: behavioral observation tool

SOPARC was employed to observe walking behavior (dependent variable) and social interaction (independent variable) within the preselected NOS for all age groups. SOPARC is a validated and reliable tool [51] which has been used in many studies for several years to record the use of mostly parks and urban green spaces [56], but can be used for NOS as well. The original version of SOPARC was created by Thomas McKenzie and colleagues in 2006 [51], and it was modified to fit the purpose of this study. Information about age, gender, social interaction (i.e., two or more persons talking, walking, running, biking, and sitting together) and primary activity (e.g., walking, sitting and talking, and biking), as well as weather conditions, lighting, and the time of observation was captured by trained researchers using the tool pictured in the additional electronic file (Please see the supplementary Figure S1).

Based on an earlier study by Cohen and colleagues [57], we decided that 4 days of observations (3 weekdays and 1 weekend day) with four observations each day (morning, lunch, afternoon, evening) in each of the 11 NOS, would be sufficient to capture the use of those NOS. To ensure high variability in observations, the same NOS was never observed twice on the same day, and all observations were conducted twice over a 1\(\frac{1}{2}\) month period during the fall of 2016 and spring of 2017.

6.1.2. CPAT: Environmental Observation Tool

As the CPAT tool was adapted based on findings from stage 1, which was carried out in the fall of 2016, the tool was only used during the second data collection conducted in spring 2017. There was no indication that the 11 NOS had changed between the fall of 2016 and spring of 2017 and weather conditions in Denmark are similar during the spring and fall. During the spring of 2017 data collection, a trained researcher visited all 11 NOS with a paper version of the adapted CPAT and audited each
NOS accordingly. The CPAT data were digitized and matched with the SOPARC observations for each of the 11 NOS.

7. Stage 4—Quantitative Analysis

7.1. Analysis

The analysis of the qualitative interviews identified different built environment attributes along with social interaction as important for the participants, in order to use their NOS for various activities (see Table S1 in online supplementary material). Based on an integrated analytical approach, these qualitative data were used to inform the quantitative analysis by guiding decisions about the inclusion of variables in the analysis. For the quantitative analysis, Binomial Logistic Regression analysis was employed using IBM SPSS Statistics 24. Logistic regression can be used to understand whether an outcome, in this case walking behavior, can be predicted based on a range of independent variables, in this case built environmental features and social interaction. Based on the relatively small sample size (n = 353), we were not able to include all variables identified by the older adults to be important. Thus, we chose to include those variables in the model that the qualitative analysis identified to be important by the majority of the interviewed population.

The following variables collected by the CPAT instrument were included in the regression model: benches (the number of benches within a NOS), picnic tables (the number of picnic tables within a NOS), landscaping (flower beds, pruned bushes), green space shade (whether there is shade within a green space), path shade (whether there is shade on a walking path), path wheelchair friendly (is a wheelchair able to pass, get on/off the path, wide enough path), and path conditions (whether the path conditions are good or bad based on the presence of holes and uneven surface). To test the importance of social interaction identified in the qualitative analysis, the variable social interaction (if two or more people were observed to talk, walk or sit together, they were considered to interact socially with each other) was included in the model as a binary variable (0 = no social interaction, 1 = social interaction) as an independent variable. The outcome variable walking was also coded as a binary variable based on the SOPARC observations (0 = no walking, 1 = walking).

Covariates included in the model were age (60+), gender and NOS size (size of each NOS in square meters). The size of each NOS was included in the model as this might affect the number of people visiting the NOS and the availability of different built environment features.

7.2. Results—Association between Observed Walking, Social Interaction and CPAT Features

A total of 353 older adults were observed in the 11 NOS during data collection. Descriptive statistics are presented in Table 2. Mean age is quite low (66.73) indicating that mostly younger older adults were observed. A high percentage of older adults are walking within the NOS (72%), which, not surprisingly, matches the relatively low percentage of older adults engaging in social interaction (30%). Gender is evenly distributed (48.2% females). Forty-five percent of older adults were observed in NOS that had landscaping, and an average of 5.37 benches was registered, whereas less than on average 1 picnic table was registered in all the NOS.

Table 3 represents results from the Binomial Logistic Regression analysis on walking. The model is significant ($p = 0.000$) and predicts 78.5% of all cases correctly. Odds ratio, 95% confidence intervals, crude rate for participants walking (crude %), and significance levels of each variable are presented in the table, and variables with acceptable $p$-values (<0.05) are highlighted. Age, landscape, picnic tables, path (shade), path (condition), and social interaction are all significantly associated with walking in older adults, some negatively and some positively. Social interaction seems to have a negative impact on walking (odds ratio = 0.223), as 80.2% walk alone, whereas only 52.8% walk while engaging in social interaction. This indicates that older adults tend to be sedentary when socializing. This might also explain why benches are not significantly associated with walking ($p = 0.223$). Shady paths was also negatively associated with walking (odds ratio = 0.023), as older adults were less likely to walk
if shade was present. This suggests that they rather want to walk in sunny places; however, shady green space was not significantly associated with walking. The odds of walking within NOS is greatly affected by the condition of walking paths (odds ratio = 9.695), suggesting that well-maintained paths are important for older adults to walk. Landscaping (odds ratio = 0.303) was surprisingly negatively associated with walking, as one might think that the presence of flower beds and bushes have a positive impact on the odds of walking. The odds of walking were 1.569 times higher for each additional picnic table in the NOS, suggesting that the presence of some kind of seating is important for walking. Lastly, the odds of walking were significantly affected by age. The covariates’ gender and NOS size were not significantly associated with walking.

Table 2. Descriptive of data from SOPARC observations and CPAT registrations.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>%</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking (yes)</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Interaction (yes)</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (female)</td>
<td>48.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (count)</td>
<td>66.73</td>
<td>60–90</td>
<td></td>
</tr>
<tr>
<td>NOS size (square meters)</td>
<td>10,148,7920</td>
<td>2622.85–19,659.36</td>
<td></td>
</tr>
<tr>
<td>Bench (count)</td>
<td>5.37</td>
<td>0–10</td>
<td></td>
</tr>
<tr>
<td>Picnic table (count)</td>
<td>0.57</td>
<td>0–4</td>
<td></td>
</tr>
<tr>
<td>Landscape (flower beds, pruned bushes) (yes)</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green space (shade) (yes)</td>
<td>46.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path (shade) (yes)</td>
<td>64.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path (condition) (Good)</td>
<td>65.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path (wheelchair friendly) (yes)</td>
<td>57.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: NOS = Neighborhood open spaces, % = Percentage, N = 353.

Table 3. Binomial Logistic Regression analysis on walking (dependent variable).

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Crude % or Mean</th>
<th>OR</th>
<th>95% CI for OR</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall percentage of cases predicted by the model = 78.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Age (count)</td>
<td>353</td>
<td>67</td>
<td>1.047</td>
<td>1.000, 1.095</td>
<td>0.046</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Female</td>
<td>170</td>
<td>72.9%</td>
<td>1.353</td>
<td>0.799, 2.290</td>
<td>0.261</td>
</tr>
<tr>
<td>Male</td>
<td>183</td>
<td>71.0%</td>
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<td>NOS size (square meters)</td>
<td>353</td>
<td>10,574.36</td>
<td>1.000</td>
<td>1.000, 1.000</td>
<td>0.987</td>
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<td>Landscape</td>
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<tr>
<td>Bushes, flower beds</td>
<td>159</td>
<td>68.6%</td>
<td>0.303</td>
<td>0.104, 0.882</td>
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<td>194</td>
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<td>Bench (count)</td>
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<td>5</td>
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<td>Picnic table (count)</td>
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<td>1.569</td>
<td>1.092, 2.255</td>
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<tr>
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<tr>
<td>Path shade</td>
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<tr>
<td>Shade</td>
<td>229</td>
<td>71.2%</td>
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<td>124</td>
<td>73.4%</td>
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<td>Good</td>
<td>231</td>
<td>73.6%</td>
<td>9.695</td>
<td>1.261, 74.550</td>
<td>0.029</td>
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<tr>
<td>Bad</td>
<td>122</td>
<td>68.9%</td>
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<td></td>
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<tr>
<td>Path wheelchair friendly</td>
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<td></td>
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<tr>
<td>Yes</td>
<td>202</td>
<td>72.8%</td>
<td>1.788</td>
<td>0.502, 6.366</td>
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<td>151</td>
<td>70.9%</td>
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<td>106</td>
<td>52.8%</td>
<td>0.223</td>
<td>0.129, 0.384</td>
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<td>247</td>
<td>80.2%</td>
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Note: N = total population, Mean = mean for participants walking (continuous variables), Crude % = crude rate for participants walking (categorical variables), Sig. = significance < 0.05 (in bold), 95% CI = Confidence intervals, OR = Odds Ratio, NOS = Neighborhood open spaces.
8. Discussion

The aim of this mixed-methods study was to investigate the association between walking behavior within NOS and different built environmental features of NOS, and how social interaction might affect this behavior.

To our knowledge, this is the first study using a mixed-methods approach to investigate built environment characteristics within NOS and its association with older adults’ walking behavior and social interaction in NOS, rather than general walking behavior or walking to and from NOS as seen in previous studies. By using a mixed-methods research design, an adapted quantitative tool to assess built environment features within NOS, and afterwards qualify these findings using qualitative data, we were able to consider the specific population in the assessment of NOS rather than relying on standardized tools. During stage 1, several built environment features were identified to be important for the local older adults like seating and path conditions. Additionally, by combining qualitative and quantitative results, we were able to analyze qualitative identified built environment features in a quantitative statistical model and discuss these quantitative results using qualitative themes and quotes, which strengthened the analysis and interpretation of results.

The results from the regression analysis indicate that built environmental features found to be associated with walking within NOS were shady paths and their condition, the presence of picnic tables, and landscaping like bushes and flowerbeds. Social interaction was also found to be highly significantly associated with walking; when social interaction was taking place, walking was less likely to occur.

Older adults can be more fragile and might need to use assistive devices like a cane or a walker for active transportation [58]. Thus, the condition of paths within NOS may be especially important for this age group, as uneven surfaces or holes on the paths can make it difficult for older adults to navigate. This might also explain the positive association found between picnic tables and walking. As older adults are less mobile, having the option of sitting and taking a rest while walking around may be important for older adults. However, benches within NOS were not associated with walking. The study by Aspinall and colleagues on preferences of specific NOS attributes also found seating to be of importance [20], although it was only the ninth most important out of 15 attributes. However, this might be because study did not look specifically at walking in older adults. Another study found seating to be important for older adults’ walking behavior within the neighborhood [59]. Another reason could be that there is usually more activity in places that include seating, as they attract different groups of people to sit and talk, rest, read a book, and have a picnic. This might be especially attractive for older adults, as they can be socially isolated, thus, walking in a neighborhood with open space with lots of people and activity may be more interesting for older adults, as they may feel safer, which previously has been found to be important [32], less alone and more entertained with the possibility of talking to other community members [60]. As one resident mentioned; “But I greet them all, because now I know them … they wave at me … and we exchange some words …”.

Our results indicate that shady paths have a negative influence on walking, which contradicts previous research on shades’ association with walking [61,62]. However, both studies were conducted in Australia where summer temperatures can be really hot. Denmark has quite mild summers and dark winters, which might explain why too much shade within NOS has a negative effect on walking, as people want to enjoy the sun when it is finally shining. Additionally, data were collected during spring and fall where temperatures are quite mild. To summarize, well-maintained and sunny walking paths and the possibility of seating seem to promote walking within NOS. These physical features are relatively small and easy to implement, which is an advantage in low SES neighborhoods were funds for renovations may be limited. Contradictory, previous studies investigating different built environmental features and its association with walking in older adults, recommend rather extensive and costly neighborhood changes like improving the street connectivity and greater land-use mix [13,26,63,64]. Making small-scale changes in the local neighborhood environment may be as effective as large-scale improvements and easier to implement in smaller communities.
Social interaction was found to be negatively associated with walking within NOS, indicating that older adults are potentially less active when interacting socially. This suggests that they may tend to sit down when engaging in social activities within NOS, rather than walking or playing together like other age groups tend to do [65,66]. This might also explain why benches were not associated with walking. By analyzing the qualitative data (found in the additional electronic file), it became clear that especially the social relationships or casual encounters around seating places with different neighbors were important for the residents. As one interviewed woman said: “We just sit and chat, just for a couple of hours or three and then we leave again . . . I have brought coffee with me and we just sit and enjoy . . . I really don’t want to sit there all by myself”. This person talked about a paved space area with benches, trees and flower beds just outside her apartment building, were people usually hang out and make small talk with passing neighbors. Thus, these places seem to be for social encounters rather than walking, which may also explain the negative association found between landscaping and walking. Several interviewed people talked about these meeting places just outside their apartment buildings as a place they cherished. As most of the interviewed older adults lived alone, these social outdoor spaces in their immediate surrounding seem to be especially important for them. As one interviewed man put it: “ . . . well a lot of people are alone right . . . but then they meet down there (by the benches and raised beds) and talk . . . ” This quote highlights the importance of outdoor social spaces in order for older adults to maintain social engagement and counteract the loneliness that is often associated with aging. The results suggest that social interaction occurs while seating, which may be because it is easier for older adults to engage in social activities while sitting. However, other studies found that older adults do interact during routine walking as it mentally might takes less effort leaving room for social encounters [43–45]. The different findings might suggest that the behavior observed in this paper may be related to this specific study population of older adults living in disadvantaged communities, which were characterized by low socio-economic status and great disabilities, both mentally and physically.

The importance of social interaction for older adults is highlighted in several studies [34,40,41,67,68]. The study by Finlay et al. discusses the importance of social green spaces particularly for people who live alone as they are at greater risk of isolation and loneliness; and Milligan et al. points out the importance of communal gardening to combat social isolation and a supportive community environment helping less able members of the group. Consequently, older adults from low socio-economic neighborhoods who live alone and have various physical challenges like the current study population may especially benefit from NOS. Hence, even though social interaction might not occur with walking in older adults within NOS, it seems to be a vital part for the elderly’s quality of life, as their social gatherings in the NOS give them a reason to get out of their apartments, which on the other hand makes them walk, as they have to leave the apartment to meet friends and neighbors in NOS. If so, walking may not occur extensively within the NOS, but on the way to the NOS, and NOS as such, are more important for social interaction than for walking. As many older adults face loneliness due to loss of their partner and friends, social relations may be especially important for this age group. One study by Yung et al. [69], investigating older adults living in urban renewal districts in Hong Kong, stressed that older adults consider social spaces and activities as their most important needs, rather than walkable and safe open spaces. This is further confirmed in another study by Yung et al. [70], who stressed the need to focus more on social spaces when planning and designing public parks, and to include the population in decision making. Consequently, it may be more important to focus on improving NOS which support social interactions for older adults rather than focusing on walkable NOS alone. By creating spaces in their immediate surroundings which support social activities or random interactions, it might be possible to decrease loneliness and increase walking to and from these NOS. However, this has to be further tested. Since many NOS already seem to be social meeting places, landscape designers and architects might focus on improving the walkability within already existing social NOS to promote walking behavior. This dilemma of where to focus your money on—walkability or social interaction—highlights the importance of using mixed methods designs, as researchers, landscape
designers and decision makers need to include local older residents to pinpoint the specific needs of the local community, whether it is social meeting places or walkable places.

Methodological Considerations

The strength of this study was the use of mixed methods to adapt the most appropriate mapping tool for the specific population and low SES environment being investigated and using an integrated analytical approach in the analysis and interpretation of the results. Further, previous studies on NOS and walking in older adults have relied on self-reported data which might be biased by participants’ perceptions or social desirability. The use of systematic observations and structured audits in this study is a strength, especially in combination with qualitative data to confirm findings of this heterogeneous group.

Several limitations of the study should be considered. Using cross-sectional data limits our ability to present any causal relationships between the outcome ‘walking’ and the different demographic and built environment variables. Second, as the data were collected within a disadvantaged area of Copenhagen, it is uncertain whether the results are generalizable to other Danish or international more advantaged or disadvantaged communities. Nonetheless, the results are important in supporting the relevance of social and walkable NOS within deprived neighborhoods in a Danish and European context, which is in most need of supportive neighborhood built environments, due to their low life-expectancy, and increased health-related problems. Third, other observational tools may have been more suitable for investigating NOS in older adults, as CPAT was not specifically created for this purpose. This might explain why many of the included variables in the quantitative analysis were not significant. Fourth, even though SOPARC is a validated and reliable tool when used by trained researchers, basic skills like judgement of age can be difficult. However, since the qualitative interviews indicated the same results as the results from the regression analysis, misjudgment in age probably did not occur. Additionally, SOPARC observations were only done within the NOS and as such, information about walking to the NOS was missing, which may contribute to total daily walking. Other observational methods like go-along interviews may have provided more insight into walking routines and social encounters. Mobile assessments of walking in seniors through accelerometers and GPS might elucidate how much activity occurs on the way to NOS as well as within. Fifth, data were collected during the spring and fall, thus it is uncertain if our findings would be similar if data were collected during winter or summer.

9. Conclusions

This study adds to the accumulated knowledge on how to use mixed methods to qualify measurement tools and analysis for specific target populations. Given the diversity of older adults’ health, functional status and lifestyle—especially in low SES neighborhoods—this target population may have very different attitudes and preferences for qualities within NOS, highlighting the need for using context-specific and highly tailored measurement tools in feature studies. The study further adds to the limited knowledge on how to improve NOS in disadvantaged neighborhoods for older adults, to encourage walking in the Danish (and European) context which is more densely populated and less car-dependent than in the US. NOS may be easy and affordable public spaces to promote walking in older adults by ensuring well-maintained walking paths with some shade and access to seating. These relatively affordable and small changes can easily be introduced by the municipality in disadvantaged neighborhoods and hereby promote walking and lower costs for large-scale community renovations. In contrast, other studies have focused on large neighborhood-wide and expensive changes like street connectivity and greater land use mix, which may not be feasible in low-income neighborhoods. Results from this study suggest that much social interaction occurs in NOS but this may promote sedentary behavior rather than walking. However, walking may still occur as people have to walk to and from the NOS, which will generate some level of walking. Since these NOS seem to act as social spaces rather than spaces for walking activities, landscape designers, architects...
and urban planners should acknowledge the importance of designing or improving NOS for older adults focusing on both social and physical health, by promoting walking to and from the NOS and simultaneously social interaction within the space. More intervention studies are needed to investigate the longitudinal effects of changing older adults’ NOS to fully understand how to design such public open spaces in order to improve both physical and social health. Future studies should assess walking to and from NOS as well as walking within NOS in combination with social interaction, to investigate how NOS promote walking and social interaction.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2308-3417/4/3/41/s1, Figure S1: SOPARC observation scheme used in the present study, Table S1: Results from Stage 1: Built environment categories, Table S2: Match between quantitatively analyzed CPAT variables and qualitatively identified barriers/motivators for using NOS, File S1: Modified CPAT Audit Tool

**Author Contributions:** T.S. conceptualized the paper, performed the quantitative and qualitative data collection and analysis, and wrote the manuscript. J.S. supervised the writing and revision of the manuscript and J.K. contributed to the conceptualization and the methodology. All authors discussed the findings and contributed to the final manuscript.

**Funding:** This research was funded by The Danish Foundation for Culture and Sports Facilities, The VELUX Foundations, and TrygFonden.

**Acknowledgments:** We thank the APEN/Move the Neighbourhood research team that have collaborated on the overall research setup and provided insight and expertise that greatly assisted the project: Rene Kural, Kamilla Nørtoft & Sidse Carroll, The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, Bettina Lamm, Anne Wagner & Laura Winge, University of Copenhagen and Jens Troeslen, Charlotte Skau Pawlowski & Tanja Schmidt, University of Southern Denmark. This research was supported by Områdeforøsnelsen Sydhavnen, The Danish Foundation for Culture and Sports Facilities, The Velux Foundations, and TrygFonden.

**Conflicts of Interest:** The authors declare no conflict of interest.

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Schmidt T, Pawlowski C, Kerr J, Schipperijn J. *Investigating the WHAT and WHY on Older Adults’ Use of Neighborhood Open Spaces Following an Environmental Intervention.* Submitted to Translational Behavioral Medicine. Currently undergoing review
Investigating the WHAT and WHY on Older Adults’ Use of Neighborhood Open Spaces Following an Environmental Intervention

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ABSTRACT

Background: Using neighborhood open spaces (NOS) may be an easy way for older adults to maintain healthy aging through physical activity and social interaction. However, little is known about older adults’ use of NOS, their preferences and barriers for using them.

Purpose: This paper presents older adults’ use of NOS before and after an intervention, and factors promoting or inhibiting their use, assessed using convergent mixed methods design.

Methods: A participatory research approach was employed involving older adults in the intervention. The System for Observing Play and Recreation in Communities was used to observe older adults’ use of 13 NOS in spring 2017 (baseline) and spring 2018 (follow up). Ten interviews were conducted in 2018 to identify barriers and facilitators for using NOS. Two NOS had a pavilion built and in one NOS benches were renovated, including building raised flower beds and tables for the benches.

Results: At baseline, 209 older adults were observed, whereas 329 were observed at follow up. More (44%) older adults were observed at follow up in the NOS with the renovated benches. No use of the two pavilions were observed. The interviews identified six factors important for older adults’ use of NOS: weather, support for social care takers, support for resourceful volunteers, organized activities, social interaction and sense of ownership.

Conclusions: Organizational resources like social care takers and volunteers, are important to promote older adults’ use of NOS. Social interaction is a key factor for older adults use of NOS and should be prioritized by health promoters.

Keywords: Older adults, Social interaction, Mixed Methods, Neighborhood open spaces
INTRODUCTION

In the coming decades, the worldwide population of older adults (65+) is expected to increase to 22%, resulting in more older adults than children by the year 2050 [1]. As older age is often associated with functional limitations, as well as physical and mental health problems, this will lead to major financial burdens on the health care sector due to an increase in institutionalization and home care [2]. Therefore, maintaining good physical and mental functioning as well as quality of life in older adults and consequently healthy aging through independent community-based living, is essential. Regular physical activity like walking, contributes to numerous health benefits for older adults [3-5] and thus, may contribute to physical functioning. Walking within the neighborhood may be a safe and easy way for older adults to meet physical activity guidelines and achieve such health benefits. However, globally almost a third of 60-79-year-old and half of 80+ year old, do not reach the recommended 150 weekly minutes of moderate-to-vigorous physical activity to improve their health [6]. Walking in the neighborhood may also contribute to mental health and quality of life through social interaction with neighbors and use of green spaces [7-9]. Studies have demonstrated associations between health outcomes such as improving stress levels, depression, social coherence and sense of community with the availability or use of green spaces or public open spaces [10-13].

Consequently, the use of neighborhood open spaces (NOS) near where people live, may be especially important for older adults to maintain physical, mental and social health and thus, healthy aging. However, there has been little focus on building age-friendly NOS accommodating older adults’ needs. This may have resulted in NOS which inhibit rather than promote walking and social interaction in older adults. This may be especially concerning for disadvantaged neighborhoods which typically provide fewer activity friendly public open spaces and attractive green spaces [14-16]. Several studies on older adults and parks have reported poorer perceived accessibility and safety, and less frequent use in more deprived areas [17, 18]. Additionally, older adults with a low socio-economic status (SES) are typically less active and with poorer health than higher SES groups [14, 19, 20]. Several studies on older adults and parks have reported poorer perceived accessibility and safety, and less frequent use in more deprived areas [17, 18]. Inequalities in health and neighborhood environment by SES in older adults suggest that understanding the use of and specific needs for NOS in disadvantaged neighborhoods would be valuable.
Small-scale changes to the built environment within NOS may be particularly beneficial for disadvantaged neighborhoods, as they are less costly and easier to implement than large scale improvements of the whole neighborhood. However, to our knowledge no intervention studies exist that have tried to implement small-scale changes within NOS to promote more use by older adults, and to understand predictors of use. A key matter for health promoters and urban planners is how to design NOS in disadvantaged neighborhoods to promote physical and social health in older adults. Increased understanding of how to create spaces in NOS which meet older adults’ specific needs is important to promote walking and social interaction and thus, healthy aging. The current study aimed to address this issue by evaluating a participatory research driven intervention altering NOS to promote active living within a deprived neighborhood in Copenhagen, Denmark. This paper presents how older adults used NOS before and after the intervention, as well as factors promoting or inhibiting their use, focusing on social interaction and walking.

METHODS

Design
The Move the Neighborhood study was a quasi-experimental intervention study, using community-based participatory approaches to develop highly tailored urban installations within three NOS in two senior-housing areas in a deprived neighborhood of Copenhagen, Denmark (DK) [21]. The purpose of the Move the Neighborhood study was to increase the use of these NOS to promote active living through social interaction and physical activity. The intervention was evaluated using a mixed methods research design investigating changes in the use of NOS by older adults before and after the intervention. By using a mix of quantitative and qualitative methods, we were able to not only evaluate changes in behavior, but also understand perceived predictors of change.

Setting and case description
The study took place in one of Copenhagen’s most disadvantaged neighborhoods, Sydhavnen (South Harbor), where the average life expectancy is 73.0 years – one of the lowest in Denmark. The average life expectancy in Denmark is 80.6 years. In this neighborhood, 32.0% of the population had no formal education and 40.2% were low income [22]. Sydhavnen is composed of several types of housing for different needs; small apartments, family apartments and row- or duplex, including dedicated senior apartments designed for the
needs of older adults. The two social-housing associations within Sydhavnen with designated apartments for seniors agreed to participate in the study. The land use surrounding the first housing association was mixed, including residential buildings, shops, pubs, a community center, a school and a public square. The surroundings of the second housing association were primarily characterized by residential buildings, but there also was a school, a pub and a large cemetery which is used by many people as a park. Several public open spaces were located in and around the two housing associations. Thirteen of these spaces were categorized as NOS and included in this study based on their walking distance to one of the senior housing areas, their accessibility and their size (small grassy spots were excluded). Figure 1 depicts all thirteen NOS surrounding the two senior housing areas. Most of the NOS were characterized by being fairly green and having some seating options and paths to walk along, whereas a few NOS were mainly concrete with some flowerbeds and trees. Area 2B, 2D and 3DEF (see figure 1 and 2) depict the intervention sites where changes were made.

**Intervention description**

The intervention comprised three phases in both senior housing locations. Step one was the initiation of the participatory research approach, inviting local older adults from the two senior housing associations to participate in three workshops each during spring 2017. In this phase, the designers (with a background in architectural and anthropological research) and participants jointly explored and developed ideas which were visualized by the designers and then presented back to participants to make changes and finalize the plans. In the next step, the final ideas accepted by the participants were transformed into visual designs by the architects.

In step 3, the construction of the urban installations within the three NOS, was initiated. The construction phase was carried out by building professionals, but the senior residents were invited to participate in some of the construction activities based on their individual interests and capabilities. In both area 2B and 3DEF a pavilion was built based on participants’ ideas and wishes for social meeting places and in area 2D, local older adults, together with the designers and builders, renovated existing benches and designed and added a small table that could be used as arm-rest, coffee table and general support, as well as raised flowerbeds that provided shelter from the wind and added aesthetic values (see pictures in figure 2).
Design
A convergent mixed methods design was used to investigate older adults use of NOS (frequency of use, locations visited within NOS, and behavior within NOS) pre and post intervention and to understand their behavior and reasons for using some NOS and not others. Use of both the intervention sites and other NOS were assessed, as well as reasons for use or non-use of the intervention sites and non-intervention sites. The basic idea of a convergent design is to compare or combine results from quantitative and qualitative data analysis, with the purpose of achieving a more complete understanding of a phenomenon [23]. The mixed methods design consisted of four steps. In step 1, qualitative and quantitative data were collected simultaneously and afterwards analyzed in step 2, with the appropriate methods for each data type. Quantitative data were collected at baseline prior to the intervention and at follow up 0-6 months after completion of the three intervention sites. The qualitative data were collected at follow up at the same time as the quantitative data. In step 3, results of both the quantitative and qualitative analyses were presented separately and afterwards integrated to further the understanding of the results. Finally, integrated discussions and conclusions were drawn based on a compilation of the quantitative and qualitative results (step 4).

SOPARC
The System for Observing Play and Recreation in Communities (SOPARC) was used for structured observations of the 13 NOS during spring 2017 (baseline) and spring 2018 (follow up). SOPARC is a reliable and validated observation tool [24] used to record the use of parks and urban green spaces [25]. The original version of SOPARC was modified to fit the specific purpose of this study. Demographic information about estimated age and gender were registered to distinguish between older adults and all others. Further descriptive information like weather (sunny, cloudy, windy, rainy) and lighting (adequate lighting, poor lighting, none) was also registered. The main data captured were social interaction (two or more persons talking, walking, running, biking, sitting together) and activity level (sedentary, walking (light/moderate), vigorous) (see additional electronic file S1). Additional notes were taken to identify the specific place or behavior a person was observed in (e.g. sitting on a bench at the entrance, dog walking). Based on a previous study [26], it was decided to conduct 4 days of observations (3 weekdays and 1 weekend day) including 4 observation time points.
per day (morning, lunch, afternoon, evening) over a 6 week period in each of the 13 NOS (i.e. each NOS was observed during 16 separate observation sessions at both baseline and follow up). To ensure variability, observations were never conducted in the same NOS twice on the same day. Observations were carried out by trained researchers.

SOPARC observations were recorded on a paper observation sheet and afterwards digitized into a Microsoft Excel dataset. The dataset was transferred to the statistical program IBM SPSS Statistics 24 and analyzed using descriptive statistics due to small sample sizes. Several graphs were created to assess any possible change in social interaction or activity level (sedentary, walking) from baseline to follow up in each of the 13 NOS – comparing intervention sites to non-intervention sites. Further analysis of observation notes was conducted to identify where the observed persons were specifically observed, to distinguish between activity occurring on the new-built urban installations and activity occurring next to these urban installations.

**Interviews**

In spring 2018 following the interventions, older adults from the two senior housing areas were invited to participate in a home-administered semi-structured interview. Participants were recruited through social activities hosted by the housing associations, like bingo or a social lunch, and through recommendations from social caretakers working for the housing associations. The aim of the qualitative data collection was to gain knowledge about how and why older adults used NOS – including information about use of the specific intervention sites. Of further interest were their reasons for using or not using the intervention sites compared to using other NOS. Semi-structured interviews were carried out using a comprehensive interview guide to direct the conversation on these specific topics and make it easier to compare answers across participants. This method also allows follow up questions to gain further in-depth insight into specific issues [27]. Examples of questions from the interview guide are: “have you used the new pavilion – for what, and why/why not”, which NOS do you visit when you go outside your apartment, and why”. Ten home-based interviews were carried out using a mobile phone as voice recorder. Interviewees included both intervention participants and non-participants to assess any possible difference between these two groups. The interviews took between 30 min
and 1.5 hours depending on the respondents’ knowledge and use of the NOS. Interviewees included both intervention participants and non-participants.

Analysis

Using the transcription software called NVIVO (https://www.qsrinternational.com/nvivo/home) audio recordings were first transcribed verbatim and afterwards coded, categorized and summarized. We used a deductive thematic analysis approach to analyze the semi-structured interviews [28]. The data were coded in themes derived from the socio-ecological model (i.e. natural, political, built environment, social/cultural and individual) which was used as a theoretical framework [29]. Under each theme the coded comments were grouped into several categories based on similar content, and a thematic analysis was conducted to summarize and produce in-depth descriptions of the transcripts [28]. To enhance reliability, a second researcher independently conducted the same analysis, and afterwards the two researchers discussed similarities and discrepancies in the coded data to reach consensus [30].

Ethics

All participants signed a consent form agreeing to participate in the interviews, but it was explicitly stated that they could withdraw from the study at any time. Names were changed during the analysis of the interviews to protect participants’ anonymity. No consent was needed to collect observational data, as no identifiable information was collected and no interaction with observed people took place. The study was registered in The International Standard Randomized Controlled Trial Number registry (ISRCTN50036837) and its data-management procedures were approved by the Danish Data Protection Agency (2015-57-0008).

RESULTS

SOPARC

A description of the results is presented in figure 3. A total of 1149 people were observed at baseline and 1590 people at follow up, of which, respectively, 18.2% and 20.7% were older adults (estimated 60+ years old). The gender distribution of older adults observed was similar at both data collection time points. The proportion of
activity changed from baseline to follow up. At baseline 31.1% of older adults engaged in social interaction. This number was 53.8% at follow up. At least 27.8% of observed older adults mainly engaged in sedentary behavior in the NOS at baseline, whereas 47.4% of older adults were sedentary at follow up. As sedentary behavior was more prevalent at follow up compared to baseline, walking activity became less prevalent with 65.6% of observed older adults walking at baseline, whereas only 45.6% walked at follow up. However, since more older adults were observed at follow up, the absolute number of observed older adults walking within NOS was larger at follow up (n= 156) compared to baseline (n= 137).

Digging deeper into the data, it became clear that there were considerable differences in the number of observed older adults and their activity level for the individual NOS. The number of observed older adults in the 13 NOS at baseline and follow up is presented in figure 4. Focusing on the three intervention sites (2B, 2D and 3DEF) some NOS were used more by older adults than others. In area 2B, four older adults were observed at baseline and only one at follow up. Whereas in area 3DEF, two persons were observed at baseline and 12 at follow up. Even though similar constructions were built in both senior housing areas (pavilions), in area 2B fewer older adults were observed, whereas considerably more older adults were observed in area 3DEF. However, when looking further into the data, it became clear that the observed persons within area 3DEF did not use the newly built pavilion at follow up, but rather the existing ‘old’ terrace within the NOS. More older adults (52) were observed in intervention area 2D compared to 29 persons observed at baseline. Of these 52 persons, 22 were observed sitting on the renovated benches, whereas only four persons were observed there at baseline. However, a similar picture occurs when comparing intervention site 2D with the similar NOS 1B. In area 1B, 10 older adults were observed at baseline, whereas 31 were observed at follow up. Except for areas 1A, 2A, 2B and 2C, more older adults were observed at follow up, compared to baseline.

Interviews
Based on the deductive thematic analysis with the socio-ecological model as a framework, factors were identified at all levels of the ecological model. Six factors were identified to be important for the respondents’ use of the different NOS – and specifically use or none-use of the three intervention sites. These factors were: weather, support for social care takers, support for resourceful volunteers, organized activities, social interaction, and sense of ownership. The following sections provide an in-depth description of the most important factors.

**Natural environment - Weather**

Most of the interviewed persons talked about the necessity for shelter from rain and especially wind to use the NOS, as one interviewed person said when asked about where she likes to be in area 3DEF:

> “Well, in that square place [talking about a terrace next to the pavilion], and that’s where most of the others also are sitting, but maybe that’s just a habit. And then down at the terrace [next to their building]. Well, it depends on the weather, where you can find shelter” (female person 1, 75 years old, housing area 2)

Shelter from wind was also mentioned several times as one of the main reasons for not using the new pavilions. Respondents argued that the pavilions were too open to provide sufficient protection from the wind and asked for additional improvements to create better shelter. Some respondents also mentioned that the pavilion would be too hot to use on a warm summer day because the roof would heat up the pavilion, as one interviewee said:

> “But we are sitting down there [talking about area 3DEF], we sit in that square place right in front [in front of the pavilion]. We can’t sit under that thing [pavilion], because it is crazy hot underneath”

(female person 2, 89 years old, housing area 2)

**Political environment – Support**

An issue raised by older adults living in both senior housing areas was the lack of resourceful older adults who could contribute to the community by doing volunteer work and had the energy to participate in activities. As one women pointed out:
“… it’s really bad right, we are putting pressure on everyone we can for something to happen out here. The municipality has 100% housing allocation rights. We have housings for mentally ill people... and that’s okay... we have nothing against mentally ill people, but we do not like them placing mentally ill people in our senior apartments. We also have a lot of people who drink a lot. When they do not know where to put them, they just toss them in here, and we don’t want that anymore. If they keep on allocating weak people, we do not have the people needed. We are too few at the moment who have the strength to participate and help out.” (female person 3, 69 years old, housing area 1)

Respondents argued that the municipality allocates mentally sick and very old and frail people to apartments in the area and these people cannot contribute to the community, organizing activities within NOS or just participate in them, which they saw as an issue that needed to be addressed. Another factor was the lack of economic support from the municipality assigning social care takers to help organize activities within NOS and prevent loneliness. In one of the senior housing areas, funding for social care takers was reduced, so they now rely on resourceful older adults to organize activities, mainly the residents’ board. In the other senior housing area, they had two social care takers employed which they paid for through the rent, who relied on help from volunteers to organize some activities.

Socio/cultural environment – Organized activities

The issue of too few resourceful residents and lack of support from social care takers was also evident at the micro level. The support from the social care takers seemed very important as they were responsible for organizing activities and might be especially important when introducing new facilities like the pavilions. A lack of support for organizing activities using the new facilities might reduce use, as the older residents did not have the capacity to organize things themselves. As one resident puts it:

“I knew that the pavilion wouldn’t be used that much, because they [older residents] have to get up the stairs and get to it with their coffee and so on. As far as I understand, the two social care takers we have, were not at all interested in this project. It means more work for them” (female person 4, 85 years old, housing area 2)
Especially the inconvenience of having to carry things to the pavilions was mentioned in both senior housing areas as a reason for not using them often. Having someone to organize some activity or gathering seemed to be essential for respondents to even consider using the NOS. As one man put it when asked how he thinks the pavilion could be used:

“Well, there needs to be coffee, if there should be a gathering, right... so if something could be organized there... a group making coffee once a week. I don’t know if you can get people to do that here but...it takes some manpower right. I think it would be used a lot if something would be organized” (male person 1, 82 years old, housing area 1)

Getting people to do things was mentioned by several interviewees to be an issue. The municipality assigns sick and frail people to their apartment buildings which posed a threat for the residents’ ability to organize activities, as they depend on resourceful volunteers, as one man puts it:

“Well, unfortunately everything happens on a voluntary basis. People are getting old and don’t have the energy needed. Within the next five years, we won’t have any volunteers left. Some of the volunteers have passed away, and no one new has taken their place” (male person 2, 78 years old, housing area 2)

However, while the organization of activities seemed crucial for the seniors to visit a NOS, this was only the case for those NOS that were further away from their doorstep. NOS right outside of their apartments did not depend on organized activities, but even more on chance encounters and gatherings. One man expressed it as:

“Well, I have always been going down here and sat [right outside his entrance door]. I have my own table and chair down here right. I sit there, and sometimes someone visits and sits with me” (male person 1, 82 years old, housing area 1)

**Socio/cultural environment - Social interaction**

Having people to organize activities seemed not only to be important due to the lack of resources. Having someone to talk to or sit with within the NOS seemed to be the most important factor for all the interviewed persons. Especially the ‘fear’ of going outside and being alone was mentioned by some as a reason for not visiting a NOS, as a woman mentioned:
“I can’t sit up here [in her apartment] and see if there is someone down there, and I really don’t want to go down there if there is no one” (female person 5, 74 years old age, housing area 2)

Having someone to sit and talk with was a major reason for going outside and use their NOS. They were aware of issues like loneliness and the importance of social connections, and cherished those spots outside their apartment building where they could ‘bump into’ people, as a woman pointed out:

“Well, there are many [people] who are alone right, it’s always like that right. But then they meet down there [NOS outside their apartment entrance] and talk…they get out” (female person 6, 83 years old age, housing area 1)

These places close to their homes seemed to attract many residents and created a pleasant environment, where people did not have to organize things to engage in social interaction but were certain to casually meet and greet people on their way. This created natural meeting places where people casually stopped and talked when they met someone, or just said ‘hello’ on the way out on the street. This was highlighted by one of the interviewed residents:

“I think it is nice to go down there in the morning and walk past there with my little stroller, and then they sit there and drink coffee and talk, with the flowers surrounding them and so on. I greet them all because I know them, right. They wave back when I am on my way to something. So, I know them and say ‘hello’, and exchange a few words, but to sit with them... well, unless they one day ask me to sit down and have a cup of coffee, I might do it” (female person 7, 74 years old, housing area 1)

This particular NOS seemed to be very important for many of the residents, and seemed to be cherished even more after the renovations, as some mentioned that the benches were used more and that the place was more inviting and nicer to look at and visit, now that raised flower beds had been built and the benches were upgraded.

*Individual level – Sense of ownership*
Even though not many older adults were observed using the two NOS where a pavilion was built, the interviews identified an unexpected positive outcome which may promote maintenance rather than use. As a man described it:

“I walk this way, when I walk down there in the morning to get my paper. I walk past there almost every single morning and just check if something looks bad” ... “But I can see, that when I walk by and look if all the chairs are still there...some are already missing” (male 2, 78 years old age, housing area 2)

They seemed to care about the two pavilions, how they were treated and if everything was in place. They worried that they were not treated properly and felt the need to monitor the NOS. Those interviewed who took care of the pavilions had all participated in the intervention, which indicated a sense of ownership and the need to maintain the NOS. This was also present in the NOS intervention site where the benches were renovated and raised flower beds built. As a female respondent mentioned:

“They take good care of them this year [raised flower beds]. Last year they hadn’t really found the rhythm of watering them and so on, right!... But now I see that some people have taken it upon themselves to water them” (female person 7, 74 years old, housing area 1)

The respondent indicated that volunteers from the neighborhood managed the raised flower beds, which suggested a sense of ownership. The analysis also indicated an increase in use by those who participated in the intervention, as they may have felt a sense of ownership towards the NOS and thus use it more. A female said:

“Those who participated in creating these raised flower beds are also the ones who always sit down there. But if it was the other way around... that those who always sat there before also made the raised flower beds, I don’t know” (female person 3, 69 years old, housing area 1)

However, as the respondent mentioned, it is uncertain if those who used the NOS before the intervention, also were the ones participating in the intervention.
DISCUSSION

The present study set out to contribute new knowledge on how to create spaces within NOS for older adults, to increase their use of NOS and promote active living. Different effects were visible at the three intervention sites. The pavilion in area 2B did not seem to promote use of the NOS, whereas area 3DEF experienced substantially more use and social interaction. However, the observed older adults did not use the new pavilion but instead the already existing facilities within the NOS. Area 2D was used more, especially for social interaction. The intervention did not increase walking within the NOS but seemed to have promoted a sense of ownership. Six key factors were identified to be important for older adults’ use of NOS: weather, support for social care takers, support for resourceful volunteers, organized activities, social interaction and sense of ownership was additionally identified as a result of the intervention. The results are discussed jointly highlighting the mixed methods approach.

Natural factors

The difference in use of the three NOS may be explained by weather conditions and facilities to protect against the weather. The weather was particularly hot and dry during follow up data collection, although it was also spring time at the first data collection. The warmer weather might explain the increase in users at many of the observed NOS, including area 2D and 3DEF. Area 2B was used less and in the pavilion within area 3DEF no use was observed. The weather was mentioned by several residents as important for even considering leaving their apartment and where to sit within the NOS. Lack of shelter and shade on windy or sunny days seemed to be a reason for not using the pavilions. Area 2D seemed to provide sufficient shelter and shade, explaining the high use of this NOS despite the hot and sunny weather. The importance of weather for older adults’ outdoor walking or use of different spaces is highlighted in several other studies [31-34]. As the weather cannot be controlled, sheltering and other solutions to prepare for different weather conditions could be considered.

Organization and Social Interaction factors

The importance of organizational factors was highlighted at both the political and social/cultural level by the participants. The limited use of the two pavilions was perceived by the respondents to be caused by lack of volunteers to organize activities or maintain the facilities, little enthusiasm by the social care takers for such tasks, and lack of participation by the residents due to their capacity to be involved. The municipality allocates
a certain number of apartments in their senior housing area to frail older adults who do not have the strength or will to volunteer or organize gatherings within the pavilion or other NOS locations. Several respondents highlighted the inconvenience of having to carry several things outside to the pavilion and the lack of support from the social care takers to organize activities. Other studies have also shown the importance of community engagement and the availability of community activities for older adults. A study from Finland highlighted that older adults choose to move into community housings for seniors because of the availability of organized activities which promotes social interaction [35]. And older adults living in senior housings in Sweden expressed the importance of being part of a community and engaging in activities [36]. However, as identified in this study and confirmed in other studies, these activities and participation in the community rely on organizational support and the use of volunteers, which seem to be more and more scarce [37, 38]. Although, the present intervention seemed to have promoted some types of volunteering through the need to take care of the new installations. This sense of ownership and consequently volunteer work might promote some long-term behavioral changes by increasing use of NOS and engaging in social interactions.

Social interaction was highlighted as probably the most important reason for using a NOS. This may also explain the high use of area 2D and the use of other facilities within area 3DEF but not the actual new pavilion. The possibility or reassurance of social interaction was connected to the need for organizational resources, as many respondents state that they would not visit a NOS unless they are sure to meet some people there. Creating activities or gatherings within these NOS ensures some social interaction and may consequently promote more use of NOS. The pavilions were not used by the residents as no one else was using them and they did not want to be using them alone. Loneliness was recognized to be an important issue in old age and as such, several studies focus on decreasing loneliness and increased social interaction [39, 40]

The fear of being lonely might also explain why the residents used area 3DEF but not the pavilion. Some respondents mentioned that they would like to sit in the pavilion, but they did not since others were sitting elsewhere in the NOS, and they rather wanted to sit with them. Other studies also identify social interaction to be important for older adults’ use of public open spaces or green spaces [41, 42]
The importance of social interaction may also explain the high use of area 2D. This NOS is right outside the residents’ doorstep, which encourages casual social interactions with neighbors. The residents pass this NOS when leaving their apartment and as such, do not need to walk to a NOS with the risk of being alone. Some studies found distance to public open spaces to be important for older adults’ park use [43, 44], whereas others did not [45]. But in this case, it might not solely be the distance, as much as the convenience and opportunity for social interactions close to their homes. Several of the respondents mentioned the delight of meeting and greeting people as soon as they walk through that NOS and having small conversations before walking around. Consequently, the small but frequent social encounters might be more valuable for the older residents than large and rare organized gatherings.

Strengths and limitations
The strength of this study was the use of a mixed methods approach investigating the results of a longitudinal intervention study. Using mixed methods enabled a richer understanding of the phenomenon being investigated and highlighted the importance and relevance of including qualitative data in the interpretation of quantitative results – namely, to understand the mechanisms for a specific behavior.

The relatively small sample size of observed older adults within the NOS limited the analysis to only include descriptive observational results, and it is thus difficult to draw any conclusions about the effect of the intervention. Additionally, it is unknown whether the interviewed respondents were representative for the whole study population, as participants were recruited through social activities, limiting the variability in respondents to only include socially active older adults. However, after talking to the local social care takers, it became clear that this would be the most realistic way of recruitment, as residents in this area were difficult to contact.

A challenge during the qualitative analysis was the use of the socio-ecological model. The model simplifies the world by dividing it into several layers, and as such, several different versions of the model exists that suggest interactions across the levels. We experienced some difficulties dividing the qualitative analysis into these different layers (e.g. the natural and built environment level), as many of the factors were connected at different layers and could not be separated. Hence, we decided to link those layers in the discussion. Our results
thus confirm that the different levels do interact and intervening on one level without considering the others is challenging.

Furthermore, at the different intervention sites construction work was completed at different time points due to delays and in area 2B construction had only just been completed when the observations started, whereas construction in area 3DEF and 2D had been completed several months earlier. Consequently, area 2B may not have had the necessary time to be ‘discovered’ by the residents and therefore not yet used by them, explaining the small number of observed older adults. However, the results did not differ between area 2B and 3DEF, which both had a pavilion built. Further, SOPARC observations only provides momentary glimpse of the use of NOS, and it is thus unsure if older adults used the intervention sites at other time points when observations were not conducted. Lastly, we only looked at walking within the NOS, which limited the knowledge on total walking behavior. Thus, we should have included walking to and from the NOS to assess the potential increase of walking behavior outside the NOS.

CONCLUSION
The aim of this study was to investigate the use of NOS by older adults in a disadvantaged neighborhood before and after an intervention and to investigate reasons for using some NOS but not others. The quantitative observational data identified some change in use of the different NOS after the intervention. The two pavilions were not observed used by the older adults, whereas the third intervention site (raised flower beds and renovated benches) was used more after the intervention. Six key factors were identified in the qualitative interviews to be important for older adults’ use of NOS. These factors were: weather conditions, support for social care takers, support for resourceful volunteers, organized activities, social interaction and sense of ownership. While we cannot control the weather, facilities can accommodate the needs for shelter and shade to eliminate some barriers of using a NOS. Organizational resources and social interaction were closely linked and of great importance for the respondents. Especially chance social encounters in the immediate surroundings were found to be of importance. As such, health promoters and planners may focus more on creating sociable NOS on the doorstep of housing complexes to increase use of NOS, social interaction and consequently, walking to and from these NOS in older adults. This might also be more cost-effective as
building large parks or green spaces can be expensive and may not generate health benefits for those without access. The amenities within some NOS may not be as important as the opportunity for social interaction. Proximity and informal social encounters might be the key factors for small successful NOS, whereas organizational support and volunteers might be necessary to promote higher use of larger more distant NOS.

REFERENCES


Figure 1: Map of Sydhavnen, the two senior housings (marked in black), and all neighborhood open spaces (marked with white)
Figure 2: Before and after pictures of the three intervention sites. The pictures on the left are before the intervention and the pictures on the right are after the intervention.
Figure 3: Observed age, gender and activity at baseline and follow up in percentage of distribution.
Figure 4: Observed activity at baseline and follow up for each NOS, described as counts.