

Neighborhoods and mental health

Socio-spatial inequalities and the role of neighborhood delineations, contextual mechanisms, and time

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DOI (link to publication from Publisher):
[10.54337/aau547407153](https://doi.org/10.54337/aau547407153)

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Jakobsen, A. L. (2023). *Neighborhoods and mental health: Socio-spatial inequalities and the role of neighborhood delineations, contextual mechanisms, and time*. Aalborg Universitetsforlag.
<https://doi.org/10.54337/aau547407153>

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NEIGHBORHOODS AND MENTAL HEALTH

**SOCIO-SPATIAL INEQUALITIES AND THE ROLE OF
NEIGHBORHOOD DELINEATIONS, CONTEXTUAL
MECHANISMS, AND TIME**

**BY
ANDREAS LINDEGAARD JAKOBSEN**

DISSERTATION SUBMITTED 2023



AALBORG UNIVERSITY
DENMARK

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Dissertation submitted 2023

Dissertation submitted: 28/2 2023

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PhD Series: The Doctoral School of Social Sciences
and Humanities, Aalborg University

Department: Department of Sociology and Social Work

ISSN (online): 2794-2694
ISBN (online): 978-87-7573-736-9

Published by:
Aalborg University Press
Kroghstræde 3
DK – 9220 Aalborg Ø
Phone: +45 99407140
aauf@forlag.aau.dk
forlag.aau.dk

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Printed in Denmark by Stibo Complete, 2023

ENGLISH SUMMARY

Mental health problems are considered a major global health challenge. Just like physical health, mental health is unequally distributed in society by individuals' social resources and positions, but it is also based on where people live.

This dissertation provides new evidence regarding how mental health is geographically distributed in the Danish population and how it may be affected by the social context in neighborhoods. This is an article-based dissertation based on four self-contained research papers, which are synthesized in these summary chapters.

Research paper 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) focuses on the importance of how neighborhoods are operationalized when studying socio-spatial inequalities and neighborhood effects on mental health. To do this, I compare the use of micro-areas divided by physical barriers and created using an automated redistricting algorithm with the use of two Danish administrative area types—parishes and postal codes—to investigate the association between neighborhood socioeconomic deprivation and psychiatric medication purchases using logistic multilevel models. The results show that neighborhood socioeconomic deprivation is associated with higher odds of redeeming prescriptions for psychiatric medication after controlling for individual-level sociodemographic characteristics. However, the adjusted significant association is present only for micro-areas, not for parishes or postal codes.

Research paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) focuses on identifying the relevant contextual mechanisms for the association between neighborhood socioeconomic status and mental health. In the study, we investigate whether neighborhood social characteristics in the form of social interaction, trust, safety, organization participation, and attachment mediate the association between neighborhood socioeconomic status and mental health. We find that neighborhood socioeconomic status is positively associated with mental health and that neighborhood trust significantly mediates this relationship, accounting for 34% of the association after controlling for other mediators and individual-level sociodemographic characteristics as possible confounders. These results indicate that higher levels of mental health in more socioeconomically affluent neighborhoods are partially explained by the higher levels of trust between neighbors.

Research paper 3 (Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals) examines how the social context in neighborhoods is related to suicide mortality; this is done by

investigating the association between neighborhood socioeconomic deprivation, social fragmentation, population density, and suicide mortality. After controlling for individual-level sociodemographic characteristics, we find higher suicide mortality for individuals living in the least densely populated neighborhoods and most socially fragmented neighborhoods. In addition, we find cross-level interactions between neighborhood population density and gender and ethnicity for those aged 40–59 years, as well as between neighborhood social fragmentation and ethnicity for those aged 20–39 years.

Research paper 4 (The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a multilevel cohort study) focuses on how living in a socioeconomically deprived neighborhood in early childhood at the age of 3 years can affect perceived levels of stress later in life in early adulthood. I find that neighborhood socioeconomic deprivation in early childhood is associated with higher levels of perceived stress in early adulthood, after controlling for individual and family characteristics in early childhood and neighborhood socioeconomic deprivation in early adulthood.

The summarizing chapters presented in this dissertation synthesize the results from the research papers and go more in depth regarding the theoretical background and methodology used throughout the empirical studies.

Based on empirical evidence, the findings from this dissertation show that different neighborhood social characteristics are related to mental health outcomes, ranging from psychiatric medication purchases and suicide mortality to self-reported mental health and perceived stress. In addition, I show that how neighborhoods are operationalized can be critical for the empirical results when studying socio-spatial inequalities and neighborhood effects on mental health outcomes, as this comes with the risk of underestimating or overlooking important associations when using administrative areas. Furthermore, I find that neighborhood trust can be seen as a contextual mechanism for explaining socio-spatial inequalities in mental health and that growing up in socioeconomically deprived neighborhoods in early childhood can have a long-term impact on perceived stress in early adulthood. Thus, I argue that the aspects of neighborhood operationalizations, contextual mechanisms, and potential long-term effects of neighborhoods are important aspects to consider when studying the possible effects of the social context in neighborhoods on mental health.

To conclude the dissertation, I discuss the methodological, theoretical, and policy implications of these findings, as well as prospects for further research, summarizing how the main findings contribute to new knowledge to the field.

DANSK RESUME

Mentale helbredsproblemer betragtes som en stor global sundhedsudfordring. Ligesom fysisk sundhed er mental sundhed ulige fordelt i samfundet ud fra individers sociale ressourcer og position, men også ud fra, hvor folk bor.

Denne afhandling bidrager med ny evidens for, hvordan mental sundhed er geografisk fordelt i den danske befolkning og potentielt påvirket af den sociale kontekst i nabolag. Dette er en artikelbaseret afhandling baseret på fire selvstændige forskningsartikler, som er syntetiseret i disse sammenfattende kapitler.

Forskningsartikel 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) fokuserer på vigtigheden af, hvordan nabolag operationaliseres, når man studerer socio-spatiale uligheder og nabolageffekter for mental sundhed. For at gøre dette sammenligner jeg brugen af mikroområder, opdelt af fysiske barrierer og konstrueret med en automatiseret kortlægningsalgoritme, med brugen af to danske administrative enheder sogne og postnumre, for at måle sammenhængen mellem nabolags socioøkonomiske deprivation og køb af psykofarmaka ved hjælp af logistiske multilevel modeller. Resultaterne viser, at efter kontrol for individuelle sociodemografiske karakteristika i områderne, er socioøkonomisk depriverede nabolag forbundet med højere odds for at indløse recepter på psykofarmaka. Denne justerede signifikante sammenhæng er dog kun til stede ved brugen af mikroområder og ikke for sogne eller postnumre.

Forskningsartikel 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) fokuserer på at identificere relevante mekanismer for sammenhængen mellem nabolags socioøkonomiske status og mental sundhed. I undersøgelsen undersøger vi, om nabolags sociale karakteristika i form af social interaktion, tillid, tryghed, organisationsdeltagelse og områdetilknytning medierer sammenhængen mellem nabolags socioøkonomiske status og mental sundhed. Vi finder, at nabolags socioøkonomiske status er positivt forbundet med mental sundhed, og at tillid i nabolag medierer 34% af sammenhængen efter kontrol for andre medierende variable og individuelle sociodemografiske karakteristika som mulige confounders. Disse resultater indikerer, at højere niveauer af mental sundhed i mere socioøkonomisk ressourcestærke nabolag delvist kan forklares med højere niveauer af tillid mellem naboer.

Forskningsartikel 3 (Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals) undersøger, hvordan den sociale kontekst i nabolag er relateret til selvmord, ved at undersøge sammenhængen mellem nabolags socioøkonomiske deprivation, sociale

fragmentering, befolkningstæthed og selvmord. Vi finder, at højere selvmordsdødelighed kan observeres for individer, der bor i de mindst tætbefolkede nabolag og de mest socialt fragmenterede nabolag, efter at have kontrolleret for individuelle sociodemografiske karakteristika. Derudover finder vi interaktioner mellem nabolags befolkningstæthed og køn og etnicitet for personer i alderen 40-59 år, samt mellem nabolags sociale fragmentering og etnicitet for personer i alderen 20-39 år.

Forskningsartikel 4 (The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a multilevel cohort study) fokuserer på, hvordan det at leve i et socioøkonomisk depriveret nabolag i den tidlige barndom i en alder af 3 kan påvirke det oplevede stressniveau senere i livet i den tidlige voksenalder. Jeg finder, at nabolags socioøkonomisk deprivation i den tidlige barndom er forbundet med højere niveauer af oplevet stress i den tidlige voksenalder, efter at have kontrolleret for individuelle- og familiekarakteristika i den tidlige barndom og nabolags socioøkonomiske deprivation i den tidlige voksenalder.

De opsummerende kapitler, der præsenteres i denne afhandling, syntetiserer resultaterne fra forskningsartiklerne og går dertil mere i dybden med den teoretiske baggrund og metodologi, der er brugt på tværs af de empiriske studier i afhandlingen.

Baseret på empirisk evidens viser resultaterne fra denne afhandling, at forskellige sociale karakteristika i nabolag er relateret til forskellige mentale sundhedsudfald fra køb af psykofarmaka og selvmord til selvrapporteret mental sundhed og oplevet stress. Derudover viser jeg, at operationaliseringen af nabolag kan have stor betydning for de empiriske resultater, når man studerer socio-spatiale uligheder og naboskabseffekter på forskellige mentale sundhedsudfald, med risiko for at undervurdere eller overse vigtige sammenhænge ved brug af administrative områder. Ydermere finder jeg, at nabolagstillid kan ses som en kontekstuel mekanisme til at forklare socio-spatiale uligheder i mental sundhed, og at en opvækst i socioøkonomisk udsatte nabolag i den tidlige barndom kan have en langsigtet betydning for oplevet stress i den tidlige voksenalder. Derfor argumenterer jeg for, at aspekter af nabolags operationaliseringer, kontekstuelle mekanismer og potentielle langsigtede effekter af nabolag er vigtige aspekter, når man studerer de mulige effekter af den sociale kontekst i nabolag på mental sundhed.

Som afslutning på afhandlingen diskuterer jeg metodiske-, teoretiske- og policy-implikationer af disse resultater samt perspektiver for yderligere forskning og opsummerer, hvordan hovedresultaterne bidrager til ny viden på området.

ACKNOWLEDGEMENTS

Writing a PhD dissertation has not only been a personal and educational journey, but also a collective effort, which I greatly appreciate having been given the opportunity to go through. As a result, I owe thanks to many people.

First, I would like to thank my main supervisor, Anja Jørgensen. This project would not have come to fruition without Anja and her strong belief in the relevance of the project and belief that I could carry out the task. Throughout the project, Anja has given both personal and professional support. She has believed in my ideas and given me the freedom to pursue them, and I have always felt I could come to her if I needed to discuss something or ask for her help. The same goes for my co-supervisor, Lene Tølbøll, whom I want to also thank for her support and feedback.

I also want to thank all members of the research group SocMap. From the start of the project, I have always felt welcome in SocMap, and when presenting my research project and research papers, I have always been given valuable feedback and excellent sparring.

From SocMap, I would like to especially thank Rolf Lyneborg Lund. Rolf has always helped me, and he has been a great support since my first days as an employee at Aalborg University. I owe Rolfs thanks for providing priceless sparring throughout the project. It is no secret that without Rolf's work on developing the "micro-areas" used in this dissertation, this project could never have been carried out the way it has been. Furthermore, I would like to thank many of my other great colleagues from Aalborg University for their support and feedback.

In addition, I would like to thank the research group Public Health in Denmark at the National Institute of Public Health for a great and inspiring stay and the Research Unit for Health Promotion, University of Southern Denmark, and the Institute for Analytical Sociology, Linköping University for two interesting short visits. Furthermore, I want to thank Sisse Buch Johnsen, the North Denmark Region for her help and work related to the second research paper in this dissertation.

Finally, I would like to thank my family, friends, and especially Mie for the support throughout the project. Mie has undoubtedly provided the most indispensable personal support throughout the project and helped me go through both the happy and less happy times. Thank you.

RESEARCH PAPERS AND THEIR PUBLICATION STATUS

In addition to this summary report, the present dissertation comprises four self-contained research papers listed below, along with their publication status.

Research paper 1: Jakobsen, A. L. (2021). Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study. *Health & Place*, 72, 102675. (Published)

Research paper 2: Jakobsen, A. L., Jørgensen, A., Tølbøll, L., & Johnsen, S. B. (2022). Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms. *Health & Place*, 77, 102905. (Published)

Research paper 3: Jakobsen, A. L., & Lund, R. L. (2022). Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals. *Social Science & Medicine*, 311, 115320. (Published)

Research paper 4: Jakobsen, A. L. The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a multilevel cohort study. *Journal of Epidemiology & Community Health* (In review)

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CHAPTER 1. INTRODUCTION

Mental health problems are considered a major global health challenge. As examples of this, mental disorders are among the leading causes of disability, suicide is the fourth leading cause of death among 15–29-year-olds, and people with severe mental health conditions die about 10–20 years earlier than the general population (World Health Organization, 2022). In Denmark, it is estimated that approximately 40–50% of the population will have a mental disorder in their lifetime, and among children and young people, approximately 15% will be diagnosed with a mental disorder before they turn 18 (Danish Health Authority, 2022b). In addition, the latest Danish National Health Survey from 2021 published by the Danish Health Authority showed a decrease in mental health for all age groups since the last survey in 2017 (Danish Health Authority, 2022a). People’s mental health can have a significant impact on all areas of their lives, including relationships with friends and family, school or work performance, and the general ability to participate in the community (World Health Organization, 2022). Hence, it is important to study the factors affecting mental health from a population and public health perspective.

So why is it that some people develop mental illnesses or experience low mental well-being or symptoms of depression or anxiety while others stay mentally healthy and happy throughout most of their lives? One general explanation is that our moods and mental states are caused by our personalities and biological factors such as genes and neurochemicals. The typical treatment for mental health problems involves participation in psychotherapeutic therapy and the intake of psychotropic drugs to either alter the way people view the world or affect the chemistry of the brain. Thus, as Horwitz states, “typical approaches to the nature, causes, and cures of mental health problems emphasize individual traits, temperaments, and behaviors” (2010, p. 6).

In contrast to this, the sociological tradition within mental health research represents a radically different perspective (Horwitz, 2010). One of the most profound sociological observations regarding mental health rests on an empirical foundation of numerous studies clearly demonstrating that various mental health outcomes tend to cluster within specific social strata, showing that mental health is not equally distributed in the population (Hill & Maimon, 2013). These unequal patterns, also known as social inequality in health, have been recognized for centuries, often with a focus on how lower socioeconomic status (SES) typically characterized along three dimensions—income, employment, and education—predicts worse health (Glymour et al., 2014). However, these social characteristics are often only measured at the individual level (Hill & Maimon, 2013), making such measures inadequate indicators of the social environment surrounding people in their everyday lives (Carpiano, 2014). If we only focus on individual-level social factors and inequality, then we miss out the impact of place and the possible interactions between individuals, social groups, and the social context surrounding people.

In recent decades, the number of studies linking place of residence to health has grown exponentially, indicating a growing recognition of the importance of the surrounding environment in relation to health (Diez Roux, 2016). When focusing on mental health outcomes, several studies have demonstrated inequalities not only related to personal characteristics but also across the areas people live in. To investigate these socio-spatial differences, studies have often focused on the socioeconomic conditions in neighborhoods, with several studies showing that neighborhood socioeconomic context is associated with mental health outcomes, even when accounting for the fact that socially disadvantaged individuals tend to live in socially disadvantaged neighborhoods (Blair et al., 2014; Julien et al., 2012; D. Kim, 2008; Mair et al., 2008; Paczkowski & Galea, 2010; Richardson et al., 2015; Visser et al., 2021). Taken together, these patterns are of particular sociological interest because they emphasize the social origins of mental health and that these socio-spatial inequalities cannot only be explained by the dominant psychiatric model that locates the causes of mental health conditions within individuals (Hill & Maimon, 2013). In addition, these findings emphasize the view of places with an eye to its meaning for people and, thus that places cannot only be considered from a purely geographical perspective as spaces with natural and physical dimensions and a geometric location (Macintyre & Ellaway, 2013).

Although the focus on neighborhood effects on mental health has evolved into a large scientific research field across various disciplines over the past few decades, it is important to recognize how this focus can be traced back to the early twentieth century during the emergence of sociology as a formal discipline (Carpiano, 2014).

1.1. THE BEGINNING OF SOCIOLOGICAL STUDIES ON PLACE AND MENTAL HEALTH

One of the earliest and most famous studies focusing on the association between social context and mental health and disorders comes from the foundational sociologist Durkheim (1951) and his empirical study from 1897 focusing on observed geographic variations in suicide rates as evidence for his theory on *social facts*. According to Durkheim, social facts can be seen as collective forces external to the individual that constitute the ways of feeling, acting, and thinking that individuals would not have if they lived in different social groups. Thus, these social forces are more than the sum of their individual parts, instead comprising a distinct level of analysis (Horwitz, 2022). More specifically Durkheim studied how social integration and regulation may affect the risk of suicide, with the conclusion that too low or too high levels of social integration and moral regulation can increase the risk of suicide (Durkheim, 1951).

A few years later, in his essay “The Metropolis and Mental Life” from 1903, Simmel compared urban and rural life with a reflection on how the urban context changes the psychology of the individual (Simmel, 1950). The idea behind Simmel’s work and much sociological research of the nineteenth and early twentieth centuries was the

focus of the many societal transformations during that time, such as migration, technological developments, and urbanization. Cities were hypothesized as generating more crime, deviant behavior, and mental illness than rural places because of factors such as a high population density, heterogeneity of cultures, and geographic size. These ideas later influenced the work of various scholars affiliated with the Chicago School of Sociology, including Robert Park and Ernest Burgess. The work of the Chicago School was characterized by the use of the city of Chicago as an urban laboratory, which revealed internal variations in the city and patterns across neighborhoods in terms of various social phenomena like crime and social disorganization (Carpiano, 2014). This sociological focus on socio-spatial distributions led to the famous and pioneering study by Faris and Dunham (1939). In the study, Faris and Dunham examined the spatial distribution of various mental disorders in Chicago, finding that schizophrenia was centered in the disorganized areas near the center of the city, while for manic-depressive psychoses, the mapping showed a random distribution. Furthermore, they tried to explain the higher rate of mental disorders in the disorganized areas by using the characteristics of the areas themselves:

successful transmission of the essential standardized cultural view of the world, and therefore successful production in the person of a sufficiently normal mental organization, requires a normal family life, normal community life, reasonable stability and consistency in the influences and surroundings of the person, all supported on a continuous stream of intimate social communication. In the disorganized areas of the large industrial city many of these necessary conditions are lacking. (Faris & Dunham, 1939, p. 158)

The study led to an increased scientific interest in socio-spatial inequalities in mental health; not only related to urban-rural differences, but also within cities as differences between neighborhoods. However, in the following decades, other researchers began focusing more on individual social factors, indicating a shift from studying places to studying people. Some of the reasons for the decreasing focus on environmental contextual factors were the view on ecological approaches as inferior to individual-level studies, and the concern for ecological fallacies (Carpiano, 2014).

In the 1990s, a renewed interest in studying the relationship between place and health emerged (Carpiano, 2014; Macintyre & Ellaway, 2000). This shift was driven by several factors, including critiques of the individualistic focus in chronic disease epidemiology and calls to consider the role of ecologic factors in health disciplines, such as epidemiology, geography, medical sociology, and health psychology (e.g., Curtis & Rees Jones, 1998; Kearns & Joseph, 1993; Schwartz, 1994). There was also recognition of the limitations of individualistic approaches in understanding health inequalities (Robert, 1999), a view influenced by urban sociology research on neighborhood inequalities (Wilson, 2012). The development and availability of geographic information systems (GIS) and multilevel modeling methods and

software also contributed to a reconsideration of the ecological factors in research because these methods can enable the analysis of variance in health outcomes within and between neighborhoods for individuals grouped by their neighborhood location (Carpiano, 2014; Voss, 2007).

1.2. RECENT EMPIRICAL EVIDENCE

In the past few decades, the amount of research focusing on place effects on mental health has rapidly grown (Diez Roux, 2016). This attention toward the possible effects of place on mental health reflects not only sociological research, but also other disciplines, including epidemiology, geography, and psychology (Carpiano, 2014). While a large number of studies have focused on urban-rural differences in mental health conditions with traffic, pollution, noise and artificial light as examples of potential harmful urban characteristics (Okkels et al., 2017; e.g., Peen et al., 2010; N. Rose & Fitzgerald, 2022), another branch of studies have sought to move beyond rural-urban dichotomies to more precisely investigate how social differences in smaller areas such as neighborhoods may affect mental health outcomes, also known as neighborhood effects on mental health. The large number of published studies have resulted in several review studies, which have provided overviews and evaluations of the evidence; most have focused on the association between socioeconomic characteristics of areas and depressive symptoms as the main outcome (Blair et al., 2014; Julien et al., 2012; D. Kim, 2008; Mair et al., 2008; Paczkowski & Galea, 2010; Richardson et al., 2015). However, the findings have been mixed. The systematic reviews by Kim (2008), Mair et al., (2008) Paczkowski and Galea (2010), and Richardson et al. (2015) found significant associations between lower neighborhood SES and depression in approximately half of the reviewed studies after controlling for possible confounding factors. Furthermore, an integrative review by Julien et al. (2012) focusing on older adults, found an association between neighborhood socioeconomic disadvantage and depression in only 25% of the studies. Other recent studies have focused on neighborhood effects and mental health outcomes such as suicide (e.g., Dykxhoorn et al., 2021; Hagedoorn & Helbich, 2022), schizophrenia (e.g., Pedersen et al., 2022), and life satisfaction (e.g., Mouratidis, 2020). Because most studies have focused on depression, it is important to keep investigating a broader range of mental health outcomes in relation to neighborhoods (Hill & Maimon, 2013).

One of the biggest challenges when trying to isolate the potential causal effect of neighborhoods on mental health is the possible selection bias, because people's mental health may affect which areas they live in (Sampson et al., 2002). One particularly important study intended to overcome this problem was the Moving to Opportunity for Fair Housing Demonstration (MTO) (Leventhal & Brooks-Gunn, 2003), which was launched in 1994 by the US Department of Housing and Urban

Development. The MTO was designed as a randomized controlled experiment in which families with children who lived in public housing in high-poverty neighborhoods were given the opportunity to move to less poor neighborhoods. Families who volunteered for the program were assigned to one of three groups: (1) the experimental, or treatment, group, whose members received housing vouchers and special assistance to move only to low-poverty neighborhoods, (2) the comparison group, whose members received housing vouchers under the regular, geographically unrestricted program, or (3) the control group, whose members did not receive vouchers but continued to receive project-based assistance.

At the three-year follow-up, 550 families were reinterviewed, with the results showing that the parents who moved to low-poverty neighborhoods reported significantly less distress than parents who remained in high-poverty neighborhoods. In addition, boys who moved to less poor neighborhoods reported significantly fewer anxious/depressive and dependency problems compared with boys who stayed in public housing. Even though mental health was not originally anticipated as an important outcome, the MTO was the first study to demonstrate links between neighborhood residence and mental health, with the use of a randomized controlled design. The study has been followed up with further studies using the MTO experiment and other data to demonstrate experimental and quasi-experimental evidence of neighborhood effects on mental health (Boje-Kovacs et al., 2022; Foverskov, White, Frøslev, et al., 2022; Foverskov, White, Norredam, et al., 2022; Graif et al., 2016; Ludwig et al., 2013; Schmidt et al., 2020).

Despite the growing scientific interest including experimental evidence and a general recognition of the importance of neighborhoods in relation to mental health, there are still several aspects where more research-based knowledge is needed to expand our insights into how and why the social context in neighborhoods might affect the mental health status of the residents.

According to Matthews (2008), “One of the weakest theoretical areas of current practice in health and environment research is the conceptualization of place” (p. 257). Very often, census-based or administrative areas such as census tracts, wards, or parishes are used as neighborhood units in published papers because these areas may be the only practical alternative in many cases (Flowerdew et al., 2008; Petrović et al., 2022). Nevertheless, the use of such areas is limited because administrative areas rarely correspond to any theoretical definition of a neighborhood and with no defined effect or meaning to the residents, making such areas problematic for the study of social processes (Sampson et al., 2002). This issue is often highlighted in review studies (Diez Roux, 2001; Ellen et al., 2001; Mair et al., 2008; March et al., 2008; Richardson et al., 2015; Truong & Ma, 2006; Visser et al., 2021), but with only a small proportion of the studies trying to investigate and compare alternative neighborhood operationalizations. For example, two studies by Chaix et al. (2005, 2006) found that the strength of the association between area deprivation and mental disorders increased with decreasing size of the areas. A similar pattern has been found for suicide mortality (Rehkopf & Buka, 2006; Rezaeian et al., 2006), which indicates

that the possible mechanisms linking area deprivation to mental disorders and suicide may operate only in smaller areas. Other studies have systematically compared the use of different area delineations for other health outcomes, with studies finding that the use of different areal units affected the results (Cockings & Martin, 2005; Flowerdew et al., 2008; Franzini & Spears, 2003; Jablonska et al., 2020; Messer et al., 2012; Parenteau & Sawada, 2011), which highlights that the type of area used can be of great importance for the empirical results.

In addition, previous studies have often identified the correlations between individual outcomes and neighborhood characteristics without explicitly identifying the potential causal mechanisms (van Ham et al., 2012), with a minority of the studies taking on the challenge of opening the “black box” of neighborhood effects (G. C. Galster, 2013; Jivraj, Murray, et al., 2019; van Ham et al., 2012). Aspects of neighborhood disorder generally defined as the presence of features such as trash, vacant buildings, and crime (Ross & Mirowsky, 2001) have been found to be mediating factors for the association between neighborhood deprivation and depression (Joshi et al., 2017; J. Kim, 2010; Ross, 2000), psychological distress (Schmidt et al., 2020), and overall mental health (Greene et al., 2020). Other studies found that aspects of neighborhood social cohesion/social capital such as resources from social networks, including trust and norms of reciprocity (Putnam, 2000), were mediating factors for depression (Bassett & Moore, 2013; Haines et al., 2011), psychological distress (Erdem et al., 2015; Rios et al., 2012), overall mental health (Jonsson et al., 2020), and quality of life (Drukker & van Os, 2003). Because most of these studies investigated how disadvantaged and socioeconomically deprived neighborhoods might influence the symptoms of depression or anxiety, it is essential to broaden our knowledge of the mechanisms that can explain how and why neighborhoods can affect overall mental health, including both the positive and negative aspects of mental health (Blair et al., 2014; Diez Roux & Mair, 2010), because the mechanisms that influence ill-being may not be the same as those of well-being (Huppert, 2009).

Finally, most studies linking neighborhood factors to mental health outcomes have been conducted using a cross-sectional design. However, living in certain areas may have long-term mental health effects, indicating spatiotemporal relationships, which are not captured in cross-sectional studies (Jivraj, Murray, et al., 2019; Ruiz & Chaix, 2019). A few studies have found evidence for such long-term effects with neighborhood socioeconomic deprivation in early childhood being linked to psychiatric disorders in adulthood (Foverskov, White, Frøslev, et al., 2022), internalizing and externalizing behavior problems in adolescence (D. Wang et al., 2020), and depressive symptoms in both young adulthood to middle age (Elovainio et al., 2020). Further studies are needed to investigate whether neighborhood deprivation in childhood causes later life poor mental health and whether there are certain sensitive periods during the life course (Jivraj, Norman, et al., 2019).

1.3. RESEARCH QUESTIONS

Based on the literature and the challenges and gaps described in the previous sections, the overall aim of the present PhD dissertation is to shed new light on the association between the social context in neighborhoods and multiple mental health outcomes, with a special focus on the operationalization of neighborhoods and the potential empirical consequences of using different neighborhood delineations. In addition, the present dissertation focuses on the mechanisms explaining the association between neighborhood SES and mental health, and the possible long-term neighborhood effects from a life course perspective.

In addition to these summary chapters, the present dissertation is structured as four self-contained research papers. In these papers, I try to answer four independent, but interrelated research questions related to the overall aim of the current dissertation. The first research question focuses on the importance of conceptualizing and operationalizing neighborhoods and the potential implications of using different neighborhood delineations when studying socio-spatial inequalities in mental health treatment for the entire adult population of Denmark. Thus, my first research question is as follows:

- 1) Is living in a socioeconomically deprived neighborhood associated with an increased probability of psychiatric medication purchases, and to what extent is this possible association affected by how neighborhoods are delineated when comparing micro-areas¹ with Danish parishes and postal codes?

After addressing this primarily descriptive and methodological first research question, I move on to investigate a more explanatory research question with a focus on what mechanisms can explain how neighborhood SES might affect the overall mental health status of the residents. More specifically, my second research question reads as follows:

- 2) What social-interactive characteristics of neighborhoods can mediate the association between neighborhood SES and mental health?

Next, I move on from studying the association between neighborhoods and mental health outcomes from a cross-sectional perspective to focusing on the longitudinal association between different social characteristics of neighborhoods and suicide mortality over a five-year period, with a special focus on the interaction between individual and neighborhood social characteristics. In addition to neighborhood

¹ The micro-areas are explained in detail in chapter 3.

socioeconomic deprivation, I also investigate neighborhood population density and social fragmentation, as these factors have been linked to suicide in other recent studies (Dykxhoorn et al., 2021; Hagedoorn et al., 2020; Hagedoorn & Helbich, 2022; Kanamori et al., 2020). Thus, my third research question is as follows:

- 3) Are neighborhood population density, social fragmentation, and socioeconomic deprivation associated with suicide mortality, and does the association vary by the individual sociodemographic characteristics gender, age, and ethnicity?

Finally, I focus on the relationship between the social context in neighborhoods and mental health over the life course. As previous studies have linked stressors in childhood to perceived stress later in life (McLaughlin et al., 2010; Scorza et al., 2022) and neighborhood socioeconomic deprivation might affect mental health through stress pathways (Ribeiro et al., 2018), I focus on the possible long-term impact of living in a socioeconomically deprived neighborhood in early childhood on perceived stress in young adulthood through the following research question:

- 4) What is the potential long-term impact of living in a socioeconomically deprived neighborhood in early childhood on subsequent perceived stress in early adulthood?

By answering these four research questions, I contribute with important empirical, theoretical, and methodological knowledge to the literature on neighborhood effects on mental health, with a special focus on new knowledge related to the operationalization of neighborhoods, contextual mechanisms to explain neighborhood effects on mental health, and the potential importance of investigating neighborhood effects from a longitudinal and life course perspective.

CHAPTER 2. THEORETICAL FRAMEWORK

2.1. MENTAL HEALTH AND THE POPULATION PERSPECTIVE

Despite a general scientific consensus on the severity of mental health problems, the understanding of mental health and the possible causes of it has varied substantially across different disciplines and over time. From a focus on mental disorders and dysfunction to well-being and positive mental health (Galderisi et al., 2015), as well as a focus on biological causes of mental health such as genes and neurochemicals to a focus on social circumstances, such as social structures and life events (Horwitz, 2010).

The different understandings of mental health can be seen in the light of different major conceptions of health that have dominated throughout human history: the *pathogenic* approach, which views health as the absence of disability, disease, and premature death, and the *salutogenic* approach, which views health as the presence of positive states of human capacities and functioning in thinking, feeling, and behavior (Keyes & Michalec, 2009). As an example, recent years have witnessed a shift in the research and understandings of mental health from a focus on disorders and mental dysfunction to a focus on positive mental health that incorporates subjective well-being (Huppert, 2009). This understanding and new focus are clearly exemplified in the definition by the World Health Organization stating that mental health is a:

... state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community.
(World Health Organization. Department of Mental Health and Substance Abuse. et al., 2004, p. 12)

By this definition, mental health is clearly seen as more than just the absence of disorder, with mental health understood as a foundation for well-being and effective functioning for individuals and communities (World Health Organization. Department of Mental Health and Substance Abuse. et al., 2004).

So how should we measure mental health, and moreover, what is the most important aspect to study to promote better mental health on a population level? One possible answer to this question is the *complete state* paradigm. This approach represents a third perspective of health that combines the pathogenic and salutogenic approaches (Keyes & Michalec, 2009). From this perspective, mental health can be viewed as a continuum or spectrum ranging from *flourishing* in the form of high positive emotions and high psychological and social functioning to *languishing* in the form of low well-

being and mental disorders (Huppert, 2009; Keyes, 2002). Furthermore, mental health can be divided into two separate categories in the form of hedonic well-being and eudaimonic well-being (Keyes & Michalec, 2009). The hedonic aspect covers subjective well-being, including positive emotions and general life satisfaction. In contrast, the eudaimonic aspect focuses on psychological well-being and functioning (Keyes, 2013). These two distinct categories can be used to understand both cases of flourishing and languishing. In the same way that depression as a mental illness requires symptoms of *an*-hedonia, high mental health consists of symptoms of hedonia, such as emotional vitality and positive feelings toward one's life; in the same way that depression consists of symptoms of *mal*-functioning, mental health consists of symptoms of positive functioning (Keyes & Michalec, 2009). Thus, it is important to study mental health from both a hedonic and eudaimonic perspective, as well as both the positive and negative aspects because the mechanisms that influence these different aspects of mental health may not be the same (Huppert, 2009; Waterman, 1993). Furthermore, evidence indicates that the absence of mental health does not imply the presence of mental illness, and the absence of mental illness does not imply the presence of mental health. Thus, neither the pathogenic nor salutogenic approaches alone can fully describe the mental health status of a population (Iasiello et al., 2020; Keyes & Michalec, 2009).

Most current mental health practices focus only on interventions for the group of individuals with mental disorders or the languishing group with people with a high risk of developing mental disorders. However, evidence suggests that the majority of people who develop mental disorders comes from the general population, not the high-risk group. As a result, by only using targeted approaches focusing primarily on high-risk groups, this will always result in new cases of disorders from the general population. Therefore, although current individual treatment options have a crucial role to play in the short term, the population approach suggests that the way to reduce the prevalence of common mental disorders in the long term is to intervene at the general population level (Huppert, 2009; G. Rose et al., 2008).

Even though the magnitude of the effect sizes found in a large number of studies investigating neighborhood effects on mental health are modest at the individual level (Richardson et al., 2015), small effect sizes are potentially still important from a population-level perspective (Foverskov, White, Frøslev, et al., 2022) because even small individual-level effects can accumulate to have a substantial impact on population levels of mental health outcomes, which means that neighborhoods can potentially be important for mental health promotion at a population level.

As mentioned in the introduction, most studies investigating neighborhood effects on mental health outcomes have focused on depression (Hill & Maimon, 2013). To gain a more comprehensive and holistic understanding of the relationship between neighborhood social context and mental health, the present dissertation looks at different mental health outcomes in the different research papers, to cover both positive and negative elements, as well as hedonic and eudaimonic aspects of mental

health. Instead of discrete psychiatric conditions, the outcomes used in the current dissertation measure more global qualities of positive and negative aspects of mental health. These outcomes range from self-reported overall mental health and perceived stress to psychiatric medication purchases and suicide mortality. The operationalization of these specific mental health outcomes will be presented and discussed in chapter 3, where I will additionally discuss the theoretical, methodological, and practical reasons for using these outcomes in the different research papers.

2.2. DEFINING NEIGHBORHOODS AND PLACE

Studies showing that social life is embedded in some kind of space seems so obvious for sociologists, that one can question the relevance of this type of research (Gans, 2002). However as emphasized by Gieryn (2000), one important distinction is the difference between space and place. Space is what place becomes when the unique gathering of things, meanings, and values are removed. Furthermore, place is not just a background or context for other phenomena that receive sociological attention but should instead be understood as a potential force with measurable and independent effects on individuals and social life (Gieryn, 2000). Like the broad distinction between space and place, both the conceptualization and operationalization of specific types of places are important aspects to consider.

When focusing on neighborhoods, where people typically spend most of their time (Guo & Bhat, 2007), the first issue is that several definitions of neighborhoods exist (G. Galster, 2001). This issue applies not only to scholarly definitions, but is also clearly evident in relation to residents' own perceptions and understandings of their neighborhood (Deng, 2016). As a result, critics may claim that neighborhoods are simply a social construct void of causal power, but as Sampson (2011) notes, few social scientist would infer that various social conceptions such as church, family, or nations lack causal power just because their definition and form are socially constructed, permeable, and variable.

Despite different understandings of neighborhoods, most scholarly definitions focus on either small geographical areas with social interaction among residents or small areas with similar attributes (Haynes et al., 2007). However, in practice, existing administrative areas such as census tracts, wards, or parishes are often used as neighborhoods in empirical studies because these areas may be the only practical alternative in many cases, with little or no attention paid to how these areas correspond with the definition at hand (Flowerdew et al., 2008). This practice and use of such areas can be seen as highly problematic because they rarely correspond to theoretical definitions of neighborhoods, instead becoming arbitrary units with no defined effect or social meaning to the people living inside these areas (Sampson et al., 2002).

The potential problem of using administrative areas as neighborhoods in health studies has been highlighted in several studies because the use of different areas can lead to different results (Diez Roux, 2001; Ellen et al., 2001; Mair et al., 2008; March et al., 2008; Richardson et al., 2015; Truong & Ma, 2006; Visser et al., 2021), which is also known as the modifiable areal unit problem (MAUP), a concept composed of both a scaling problem (size of the areas) and aggregation/zonation problem (how the areas are shaped) (Openshaw, 1983). Another problem related to the operationalization of neighborhoods is the uncertain geographic context problem (UGCoP), which highlights how contextual effects on individual outcomes can be affected by the method used to delineate areas because of the spatial uncertainty in the actual areas that exert the contextual effects under study and temporal uncertainty in which the individuals have experienced these contextual influences (Kwan, 2012).

For the scaling problem, previous studies have found smaller areas to perform empirically better compared with larger areas when focusing both on shared perceptions of neighborhood attributes and social behavior (Haynes et al., 2007), sociodemographic homogeneity (Lund, 2018), and the strength of the association between neighborhood deprivation and mental health treatment (Chaix et al., 2005, 2006). When focusing on the aggregation problem, an alternative to the use of administrative areas is the use of physical features of the landscape, such as larger roads and railroad tracks, as neighborhood dividers. These physical barriers may also function as social dividers, thereby promoting or hindering social interaction (Feld, 1981; R Grannis, 1998), resulting in high within-group sociodemographic homogeneity (Foster & Aaron Hipp, 2011; Lund, 2018). Furthermore, residents may use such physical barriers to help identify their neighborhoods from surrounding areas (Campbell et al., 2009; Rick Grannis, 2009; Lynch, 1971). As a result, using physical barriers rather than administrative areas to create neighborhood delineations may better capture the causally relevant geographical context when studying the impact of the neighborhood social context on mental health (Cutchin et al., 2011; Jakobsen, 2021).²

To address the UGCoP, it is relevant to focus not only on neighborhoods but also on other types of areas, as done in research papers 1 and 3 (Jakobsen, 2021; Jakobsen & Lund, 2022). For example, political and economic influences might exert a greater effect in larger areas such as municipalities, while mechanisms related to social

² A more thorough discussion on the conceptualization of neighborhoods can be found in research paper 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) (Jakobsen, 2021)

interaction might be more important in smaller areas such as neighborhoods (Kanamori et al., 2020; Rehkopf & Buka, 2006). In other words, the neighborhood context cannot be fully understood in isolation from the macro framework, which represents the “context of context” (Petrović et al., 2022). Furthermore, it is relevant to address the possible temporal dimensions of neighborhood influences on mental health, as done in research paper 4 (The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a multilevel cohort study). The life course perspective on health emphasizes that there can be certain sensitive periods where the effects of exposure can have a larger impact (Ben-Shlomo et al., 2014). For example, the early years of a child’s life represent a sensitive period for the development of the brain because the rapid growth of children’s brains during this time makes them particularly sensitive to environmental stimuli (Minh et al., 2017). Therefore, neighborhoods in one’s early childhood might have long-term consequences for mental health that are not captured when studying people’s current place of residence (Elovainio et al., 2020; D. Wang et al., 2020).

2.3. NEIGHBORHOOD FACTORS AND MECHANISMS

The present dissertation focuses on socio-spatial inequalities in mental health and, more specifically, on the socioeconomic conditions in neighborhoods. Socioeconomic conditions in neighborhoods in relation to mental health have received much attention in the research (Ellen et al., 2001; Julien et al., 2012; Mair et al., 2008; March et al., 2008; Richardson et al., 2015; Silva et al., 2016); however, there is no single definition of neighborhood SES, and different conceptualizations have been used in different studies. In addition to studies focusing on the independent effects of place deprivation, area-level measures of socioeconomic deprivation have historically been used by the authorities to target interventions and allocate resources to specific places or study associations between social position and various outcomes when the individual-level variables of SES have not been available (Allik et al., 2020; Meijer et al., 2013). Different composite deprivation indices have been developed in various countries, such as the English Indices of Deprivation (Noble et al., 2019) and the Carstairs index (Carstairs & Morris, 1989). Despite the differences among various indices, most deprivation measures include those domains related to education, income, and employment; these domains reflect deprivation because income and unemployment limit material resources and because low levels of education create disadvantages in accessing various resources, such as better jobs (Allik et al., 2020).

Although several studies have found that socioeconomic conditions in neighborhoods are associated with various types of mental health outcomes that are independent of individual-level characteristics of the residents (e.g., Crump et al., 2011; Fone and Dunstan, 2006; Galea et al., 2007; Huang et al., 2020; Ludwig et al., 2013), the question of how such conditions in the neighborhood can affect mental health is often

left empirically unexamined (G. C. Galster, 2013; Jivraj, Murray, et al., 2019). As a result, the possible causal pathway between socioeconomic conditions in the neighborhood and residents' mental health remains to be somewhat of a 'black box' in many studies. This lack of focus on mechanisms is not reserved for studying neighborhood effects but can be seen as an aspect that has often been overlooked in sociological research (Hedström & Swedberg, 1998; Hedström & Ylikoski, 2010). However, information on how and why neighborhoods can affect mental health outcomes is essential in designing possible future neighborhood-level interventions that aim to improve mental health (Blair et al., 2014). As stated by Diez Roux and Mair (2010), studies in neighborhood effects do not only require thorough attention to the methodology being used, but they also require more attention to the theoretical models underlying the associations being investigated. This means that conceptual models and testable hypotheses about the causal processes involved, and the specification and measurement of the specific neighborhood-level characteristics are vital to broadening and nuancing our understanding of the link between neighborhoods and health.

Within the field of neighborhood effects studies, a vast number of theoretical explanations exist to explain the potential causal pathways for different health and behavioral outcomes. These explanations can be divided into two broad domains: features of the neighborhood's physical environment and of the neighborhood's social environment (Diez Roux & Mair, 2010). In the present sociological dissertation, the focus is on features of the neighborhood social environment, hence leaving out traditional environmental exposures such as air and water pollution. However, the physical features of neighborhoods also include aspects of the man-made built environment such as street design, public spaces, and access to resources, which may affect or interact with the social interactions taking place inside neighborhoods. In an attempt to nuance the broad distinction between physical and social features, Galster (2013) synthesized different types of neighborhood mechanisms into the following four categories:

- 1) *Social interactive*, which refers to the social processes within neighborhoods such as social cohesion.
- 2) *Environmental*, which refers to natural and human-made attributes of the local space that may directly affect the health of residents without affecting their behaviors, such as exposure to violence and decayed physical conditions of the built environment.
- 3) *Geographic*, which refers to the spatial aspects that may affect residents' life courses purely because of the neighborhood's location relative to larger-scale political and economic forces, such as a lack of access to public transportation and, thereby, job opportunities or inferior public services.
- 4) *Institutional* mechanisms, which involve the actions by those typically not residing in the given area but instead that control the important institutional resources located there; such mechanisms can be the stigmatization of an

area, which may negatively affect the opportunities and self-esteem of the residents (G. C. Galster, 2013).

In the present dissertation, the focus is mainly on social-interactive mechanisms. Examples of social-interactive mechanisms include multifaceted concepts, such as social capital (e.g., resources from social networks including trust and norms of reciprocity) (Putnam, 2000), social cohesion (e.g., strength of social relationships, sense of belonging, shared values, common identity, trust, and the existence of equal opportunities versus social exclusion within a community) (Berger-Schmitt, 2002), and collective efficacy (social cohesion, trust and informal social control) (Sampson et al., 1997). Despite the differences between these concepts, they share key similarities. In paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms), I focus on the specific social-interactive characteristics: neighborhood social interactions, neighborhood organization participation, neighborhood trust, neighborhood attachment, and neighborhood safety (Jakobsen et al., 2022).

Another aspect of the pathways between neighborhoods and health is the biological mechanisms explaining how certain neighborhood characteristics can “get under the skin” of the residents, leading to specific health outcomes (Ribeiro et al., 2018; Van Deurzen et al., 2016). One possible biological pathway linking certain neighborhood characteristics to mental health outcomes is through stress, meaning that living in deprived areas may increase the stress burden residents are exposed to, increasing their likelihood of poor mental health (Prior et al., 2018). Neighborhood environmental factors may act as stressors if they are perceived as a threat or challenge. Examples could be when residents experience a lack of respect between residents or that the social control is broken because of antisocial behavior, such as criminality and vandalism, and because people often live a fairly long time in the same neighborhood, these circumstances can become a chronic stressor for the residents (Van Deurzen et al., 2016). Chronic stressors are known to have substantial damaging effects for both mental and physical health (O’Connor et al., 2021; Thoits, 2010).

On the other hand, positive social-interactive characteristics such as social cohesion might promote mental health because of greater positive affect and by buffering the effects of daily stressors (Robinette et al., 2013) and negative life events such as economic crises (Loureiro et al., 2019).

CHAPTER 3. METHODOLOGY

In the present dissertation, the main association being studied is how the neighborhood social context is related to mental health with a particular focus on neighborhood SES and the mechanisms explaining this association. To analyze this is methodologically challenging in several ways. First, valid measures of both mental health outcomes, neighborhoods and neighborhood factors and important covariates are needed, and second, statistical models are needed, and these must be designed to handle data from both the individual and neighborhood level.

In this chapter, I outline how I have addressed these methodological challenges. Although the design and methodology for the different studies are described in detail in the research papers, this chapter will summarize several key aspects of the methodology across the individual papers. I begin by discussing the different data sources I have used in the papers, followed by a discussion of how I have operationalized the key variables of neighborhoods, mental health outcomes, and neighborhood characteristics. Then, I discuss how the association between the neighborhood social context and mental health outcomes can be measured using multilevel modeling. Finally, I conclude the chapter by discussing how I use mediation analysis to investigate the contextual mechanisms through which neighborhood SES is related to the mental health of residents.

3.1. DATA SOURCES

In the present dissertation, three different types of data have been used: 1) register data of the Danish population derived from various registers from Statistics Denmark and the Danish Health Data Authority (Baadsgaard & Quitzau, 2011; Jensen & Rasmussen, 2011; Pedersen, 2011; Wallach Kildemoes et al., 2011); 2) georeferenced data dividing the Danish population into parishes and postal codes and georeferenced micro-areas developed by Lund (2018); and 3) survey data from the Danish National Health Survey 2017 (DNHS-2017) and the North Denmark Region Health Survey 2017.

In Denmark, it is possible to merge and combine these different data sources at the individual level because all people in Denmark are required to hold a unique personal identification number (Pedersen, 2011). Statistics Denmark has collected a large number of register data in a basic databank which can be used for research purposes. Upon receiving approval for a specific project from Statistics Denmark, specific data relevant for the research purposes can be accessed through remote access servers. Only analytical results and aggregated tables or figures for which it is not possible to identify individual units such as persons, households, or families may be transferred from the servers.

3.2. DELINEATING NEIGHBORHOODS

In the present dissertation, the empirical analyses in the papers were conducted with the use of micro-areas instead of relying on administrative units as neighborhoods. The micro-areas were created by Lund (2018) using an automated redistricting algorithm to form the smallest areas possible separated by large physical barriers. The National Square Grid that assigns addresses in Denmark to “hectare cells”(100 m x 100 m) in 2000, 2005, 2010, and 2015 was used as georeferenced data.

The algorithm followed two overall steps. First, physical barriers in the form of highways, roads wider than 6 m, rivers, and streams wider than 3 m, railways, lakes, forests, coastlines, and intakes were applied. After this, the square grid was applied, and the grids were dissolved into the areas where the largest part of the square was located with borders formed by the squares. Therefore, the smooth borders were replaced by the borders of the squares in each area, making it possible to calculate how the population was distributed within the areas. From this step, 20,940 new inhabited areas were created. In the second step, the constructed areas were then further clustered to ensure that each area included at least 100 inhabitants according to the discretionary criteria of Statistics Denmark. In addition, criteria for the algorithm were established to ensure the smallest possible number of area merges and the smallest possible number of inhabitants in each area. This process resulted in 8,043 new areas with the criteria ensuring that the algorithm would create the same areas if the process was repeated (Lund, 2018)³. The micro-areas are shown in Figure 1 for all of Denmark. The black spots occur around urban areas because the micro-areas here are smaller and, thus, closer to each other. Figure 2 exemplifies the micro-areas when zooming in on an urban area focusing on the North Jutland town of Hjørring. The figure demonstrates how the micro-areas are shaped by physical barriers in the landscape, such as larger roads compared with parishes, which are the smallest administrative geographical units in Denmark.

³ For more detailed descriptions of the algorithm, see Lund (2018, 2019).

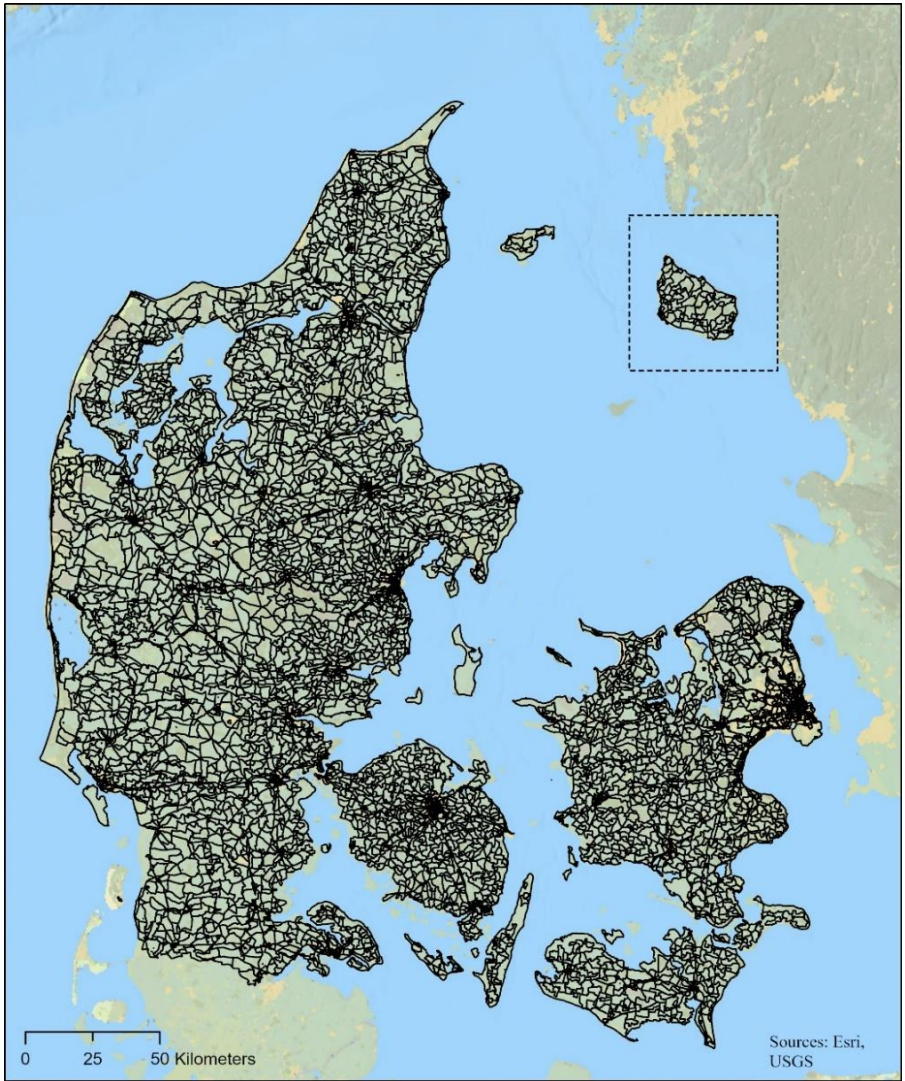


Figure 1. Micro-areas

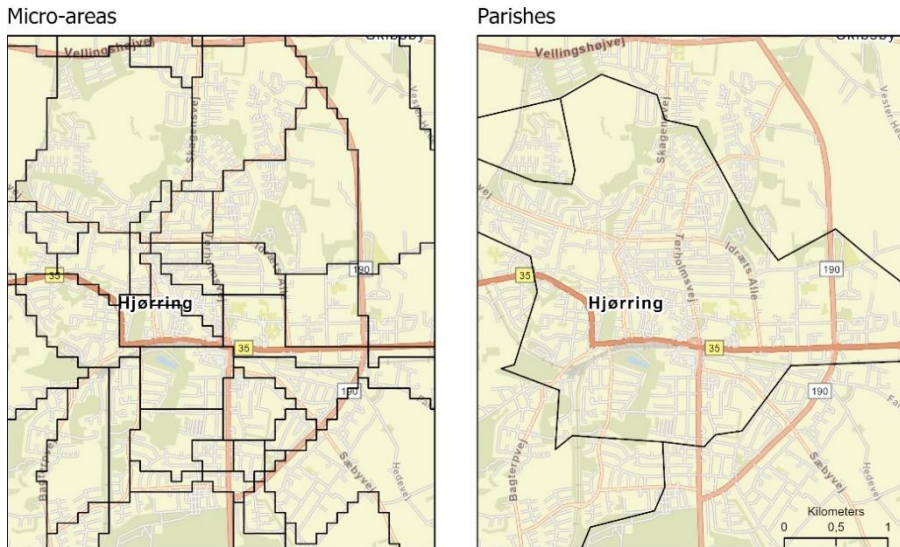


Figure 2. Example of micro-area delineations vs. parishes ⁴

3.3. MENTAL HEALTH OUTCOMES

Following the arguments presented in chapter 2, it is important to focus on various dimensions of mental health, ranging from both positive aspects related to mental well-being and negative aspects related to mental health problems and mental health conditions. In the sections below, I present how the different mental health outcomes used in this dissertation was operationalized in the research papers. Furthermore, I discuss how and why these specific mental health outcomes was used in the different research papers for both theoretical, methodological, and practical reasons.

PSYCHIATRIC MEDICATION PURCHASES

In paper 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) (Jakobsen, 2021), psychiatric medication purchases were used as the outcome variable. This variable was measured as a register-based

⁴ Note: Contains data from SDFE, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS and the Danish Agency for Data Supply and Efficiency, "DAGI", 2020.

indicator containing information on citizens who filled out one or more prescriptions for psychiatric medication in the year 2017. The following anatomical therapeutic chemical (ATC) code categories were included: N05 for antipsychotics, anxiolytics, hypnotics, and sedatives and N06A for antidepressants. The variable was constructed as a dichotomous variable coded as 1 for respondents who purchased one or more of the abovementioned medications in the given year and 0 for respondents who did not purchase any of these medications. Psychiatric medication purchases were used for the following reasons: First, the aim of the study was to investigate the potential impact of using different neighborhood delineations, here with a focus on the entire Danish population, not only a smaller selected area. Hence, a register-based variable was chosen because Danish register data cover almost the entire population. This gave me the possibility to map the prevalence rates of psychiatric medication purchases for the entire geography of Denmark, with only very few areas missing because of discretionary criteria by Statistics Denmark. Furthermore, most studies in this area have relied on self-reported measures of mental health conditions, which are subject to both responder and interviewer bias (Maguire et al., 2016). Fewer studies have focused on the association between neighborhood socioeconomic deprivation and mental health treatment with mixed findings (Annequin et al., 2015; Bocquier et al., 2013; Chaix et al., 2005, 2006; Crump et al., 2011; Ivert et al., 2013; Jablonska et al., 2020; Lofors & Sundquist, 2007; Maguire et al., 2016; Sariaslan et al., 2015; Tarkiainen et al., 2021; Verdoux et al., 2015) potentially because of the operationalization of neighborhoods. Despite these reasons for using psychiatric medications purchases, this measure also has several limitations. First, psychiatric medication purchases as a dichotomous measure clearly overlooks important aspects of mental health, including emotional well-being, psychological well-being, and social well-being (Keyes, 2009). Therefore, this variable cannot be used to measure whether people are mentally healthy or not. In addition, the use of psychiatric medication purchases fails to identify those mental health conditions that are untreated or treated without prescription medications. In addition, psychiatric medications are not always used to treat mental health conditions. For example, some types of psychiatric medication are used to treat nonpsychiatric conditions such as neuropathic pain, narcolepsy, spasticity, seizures, epilepsy, motion sickness, and/or allergies (The Danish Health Data Authority, 2021). Another option could be to use psychiatric hospital contacts (inpatient, outpatient clinic, or emergency services) with ICD codes for psychiatric disorders (Foverskov, White, Norredam, et al., 2022). However, such an approach would fail to detect individuals with a mental disorder who are being treated with psychiatric medication solely by a general practitioner and never diagnosed in a psychiatric hospital setting because diagnoses from general practitioners are not registered in national registers.

OVERALL MENTAL HEALTH

In paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022), overall mental health was measured using the mental component score (MCS-12) of the Rand 12-Item Short-Form questionnaire (SF-12) (Ware John et al., 1996). The SF-12 is a multipurpose generic assessment of health status covering eight different health concepts: physical function, limitations because of physical health and emotional problems, bodily pain, general health, vitality, social function, and psychological distress and well-being. From these items, both a physical component score (PCS-12) and mental component score (MCS-12) can be constructed (Ware et al., 1998). All 12 items are used to construct the MCS-12, but the scale places added emphasis on items covering the concepts of emotional problems, vitality, social function, and psychological distress and well-being. The MCS-12 is considered a valid measure of mental health (Cheak-Zamora et al., 2009) and has been used to measure mental health in both Danish and international studies (Christensen et al., 2014, 2020; Fong et al., 2010; Kontodimopoulos et al., 2007; Peterson et al., 2009).

The MCS-12 was used for the following reasons: First the aim of the study was to investigate how living in a more socioeconomically resourceful neighborhood can promote better mental health and what positive neighborhood characteristics could explain this possible association. Because most previous studies have investigated how deprived neighborhoods might influence symptoms of depression or anxiety, it is essential to also broaden our knowledge of the mechanisms that can explain how and why neighborhoods can affect both the positive and negative aspects of mental health (Blair et al., 2014; Diez Roux & Mair, 2010) because the mechanisms that influence ill-being may not be the same as those of well-being (Huppert, 2009). Therefore, it was important to capture both the positive and negative as well as hedonic and eudaimonic aspects of overall mental health as measured by the MCS-12, which could not have been detected with the use of a register-based variable such as psychiatric diagnoses or psychiatric medication purchases.

SUICIDE MORTALITY

In paper 3 (Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals) (Jakobsen & Lund, 2022), the outcome variable was suicide mortality. Data on suicide were obtained from the Danish Cause of Death Register, with suicide defined according to ICD10 (World Health Organization, 1993) codes X60–X84 and Y870. Although the link between suicide mortality and mental disorders has been well established, suicide also occurs in an impulsive manner because of negative life events such as financial problems or relationship break-ups. Suicide mortality was relevant to investigate because the

findings from similar previous studies have been mixed (Agerbo et al., 2007; Allen & Goldman-Mellor, 2018; Borrell et al., 2002; Collings et al., 2009; Cubbin et al., 2000; Dupéré et al., 2009; Dykxhoorn et al., 2021; Hagedoorn et al., 2020; Hagedoorn & Helbich, 2022; Jasilionis et al., 2020; Kanamori et al., 2020; Martikainen et al., 2004; O'Reilly et al., 2008; Zammit et al., 2014) and because the majority of previous studies have only used census or administratively defined areas. Thus, the influence of neighborhood context on suicide mortality requires further investigation because it remains unknown whether neighborhoods truly affect suicide mortality.

PERCEIVED STRESS

In paper 4, “The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a multilevel cohort study” the outcome variable was perceived stress as measured by a Danish version of Cohen’s 10-item Perceived Stress Scale (PSS) (Cohen et al., 1983; Eskildsen et al., 2015). PSS is a self-report measure of subjective stress, with respondents indicating how often they have found their life unpredictable, uncontrollable, and overloaded in the past month. The instrument has demonstrated good validity and reliability in previous studies (Lee, 2012). All items are scored on a 5-point Likert scale (0 = never, 1 = almost never, 2 = sometimes, 3 = fairly often, 4 = very often). Scores for the four positively stated items (Items 4, 5, 7, 8) are reversed. The sum score ranges from 0–40, with higher scores indicating higher levels of perceived stress.

Perceived stress was used as the outcome because stress responses might be an important mechanism linking neighborhood deprivation to negative health outcomes (Ribeiro et al., 2018), and stress have been linked to neighborhood deprivation and neighborhood disorder in previous Danish studies (Algren et al., 2018; Van Deurzen et al., 2016). Furthermore previous studies have linked adverse childhood experiences (ACEs), such as emotional and physical abuse and family violence, to later perceived stress in adulthood (McLaughlin et al., 2010; Scorza et al., 2022). Exposure to stressors in childhood can lead to increased perceived stress in later life through future stress exposures, which is known as stress proliferation (Ward, 2014), or through increasing negative responses to subsequent stressors, which is known as stress sensitization (McLaughlin et al., 2010). Because stressors in childhood are related to perceived stress in adulthood, with early childhood as a sensitive period for brain development (Minh et al., 2017) and because neighborhood deprivation might affect mental health through stress pathways (Ribeiro et al., 2018), it was hypothesized that neighborhood socioeconomic deprivation during early childhood might have long-term effects on subsequent perceived stress in early adulthood. However, to the best of my knowledge, no previous study has examined this association.

3.4. NEIGHBORHOOD CHARACTERISTICS

In sociological research various social characteristics are often measured at the individual level, such as gender, age, education level, or individual perceived measures such as perceived social support, perceived social status, and so forth. However, when trying to measure characteristics related to neighborhoods, measures related to single individuals may no longer be useful. For example, when measuring neighborhood socioeconomic deprivation, we can still use individual perceived measures. However, in the end, we are left with individual measures and not the contextual or collective measures of the neighborhood. Throughout the papers of the present dissertation, I have tried to measure various characteristics of neighborhood using other methodological strategies.

To measure neighborhood socioeconomic deprivation, I constructed a composite index with the following specific indicators inspired by other similar indices: proportion of the population between 30 and 64 years of age in the area who were unemployed at least half of the year, including recipients of sickness benefits, persons on leave, and recipients of cash benefits (Bender et al., 2015; Juhász et al., 2010; Meijer et al., 2013); proportion of the population between 30 and 64 years of age in the area with a total annual personal income in the lowest quartile (Bender et al., 2015; Meijer et al., 2013); and proportion of the population between 30 and 64 years of age in the area with basic education (levels 0–2), here based on the UNESCO International Standard Classification of Education (ISCED) (UNESCO Institute for Statistics, 2012) as the highest attained educational level (Bender et al., 2015; Juhász et al., 2010; Lund, 2020). The population between 30 and 64 was used to capture individuals who typically have graduated and are of working age.

Social fragmentation, which was used in research paper 3 (Jakobsen & Lund, 2022), was measured using three indicators: residential mobility in the area (the proportion of individuals who moved in the previous year), the proportion of people living alone in the area, and the proportion of unmarried individuals in the area (Congdon, 1996, 2013; Dykxhoorn et al., 2021; Hagedoorn et al., 2020). All indicators were standardized to z-scores and constructed to indices using unrotated principal component analysis (PCA), with the first principal component capturing the largest variance based on the linear combination of the indicators to determine the relative weight of each indicator. From these steps, each micro-area was assigned a socioeconomic deprivation and social fragmentation score, with higher scores

indicating a higher degree of socioeconomic deprivation and social fragmentation in the area.⁵

Population density, which was used in research paper 3 (Jakobsen & Lund, 2022), was measured as the total number of individuals of all ages per square kilometer (M. Helbich et al., 2017). To exemplify the geographical distribution of the various neighborhood characteristics, Figure 3 shows the distribution of socioeconomic deprivation mapped with micro-areas and divided into deciles.

⁵ In paper 2 “Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms,” (Jakobsen et al., 2022) the same score was used but reversed with higher scores, indicating higher neighborhood SES.

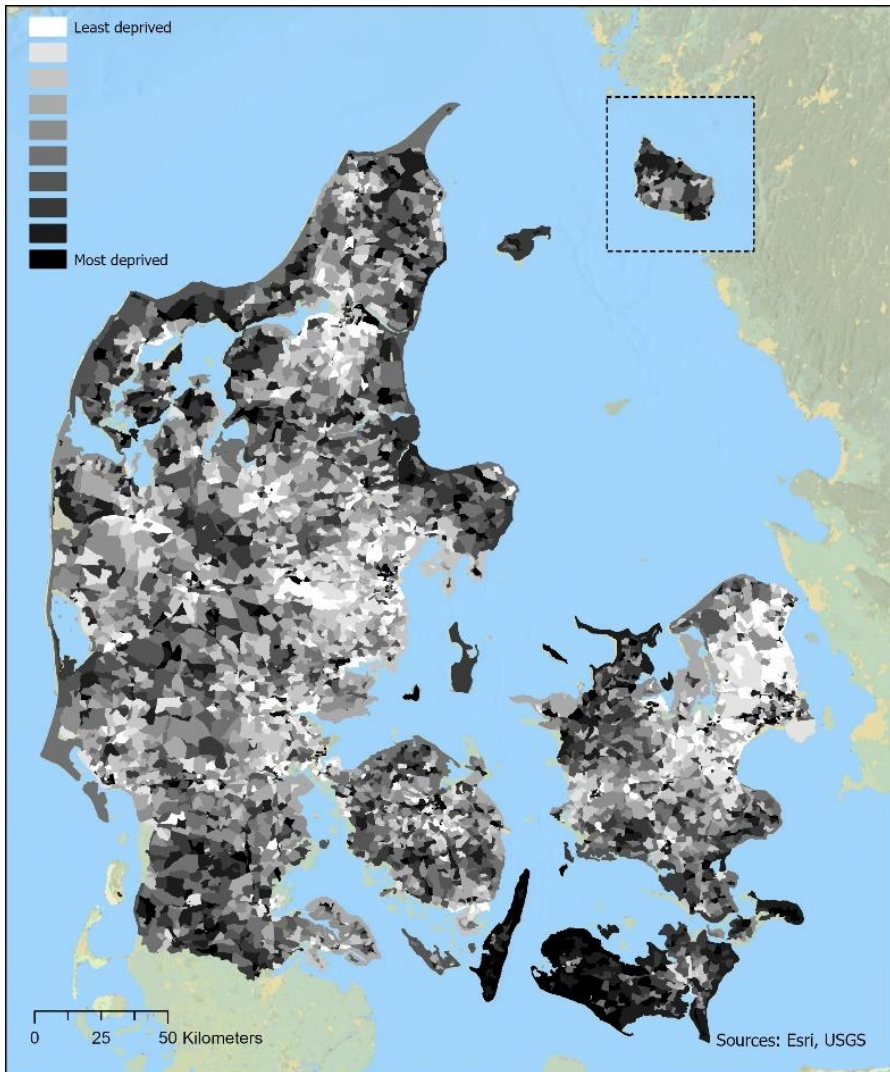


Figure 3. *Map of micro-area socioeconomic deprivation*

The advantage of using register data to measure neighborhood characteristics such as neighborhood socioeconomic deprivation is that the data are available for almost the entire population and that the indicators of education, income, and employment are objectively measured with a high validity and coverage (Baadsgaard & Quitzau, 2011; Jensen & Rasmussen, 2011; Pedersen, 2011). However not all neighborhood characteristics are possible to measure using register data, and although it is possible to cover structural characteristics such as socioeconomic characteristics, population

density, and so forth, characteristics based on the residents' own perceived view of the neighborhood call for other types of data. One possibility is using questionnaires based on surveys. In paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022), survey data were used to capture the following neighborhood characteristics: neighborhood organization participation, neighborhood trust, neighborhood safety, and neighborhood attachment. For example, neighborhood trust was measured using the question "To what extent do you trust people from your settlement/neighborhood/local area?" with response options (Trust them completely, Trust them a lot, Do not trust them very much, or Do not trust them at all) coded from 5 to 1. One possible approach would be to use this variable as a categorical individual-level variable; this would make it possible to study the association between individual levels of perceived trust in neighbors and mental health. However, the question is whether we should try to understand and measure the social context in neighborhoods by collecting only individual responses to how the neighborhood social context is perceived. This is an ongoing debate in the neighborhood effects literature because there is disagreement on whether neighborhood social characteristics should be measured individually or collectively (A. Ehsan et al., 2019; Sampson et al., 2002; Sampson, 2011). Both Sampson (2011) and Kawachi and Berkman (2015) argued that neighborhood characteristics such as collective efficacy and social capital should be seen as social and collective phenomena, so they simply cannot be captured through individual responses alone. In addition, there are some methodological problems associated with measuring the association between individual-level responses of neighborhood characteristics and individual-level mental health because of same-source bias. This means that the use of self-reported data for both the outcome and neighborhood characteristic generates a spurious association between the two because the measurement error in both reports is correlated. One possible reason for this is social desirability, which refers to a respondent's tendency to answer questions in a manner that will be viewed favorably by others (Van Ryckeghem & Crombez, 2022). It is also possible that the outcome affects the perception or report of the perceived neighborhood characteristic. For example, those who are depressed may be more likely to report less of a connection and cohesion between neighbors than those who are not. Even when the outcome is not self-reported, there might still be methodological problems associated with the use of single individual-level responses of neighborhood characteristics. One limitation is that such reports may have substantial errors caused by a simple lack of knowledge of the resident on certain conditions in the neighborhood or from the necessarily subjective nature of perceptions (Diez Roux, 2007).

One possible solution to the problem of using single individual responses to measure neighborhood characteristics is to aggregate the responses of several residents of the same neighborhood. Theoretically, by averaging over measurement error in individual responses, this aggregation process may result in more valid measures of the “objective” neighborhood characteristic of interest (Diez Roux, 2007). In addition, the aggregate measure no longer reflects only single individuals’ perceptions of the neighborhood, instead giving an average or collective measure, which might have a different and independent effect. However, there are also methodological problems associated with simple aggregation. First, the sample size between different clusters often varies, with some units potentially having many more individual observations than others. This is often the case when the study was not originally designed as a multilevel study. If we use a simple aggregation, all aggregated observations are treated in the same manner, irrespective of whether they were based on 100 observations or just five (Leyland & Groenewegen, 2020). Because of fluctuations, the neighborhoods with the highest or lowest averages could often be the neighborhoods with very few observations. Figure 3 demonstrates this problem of statistical fluctuations with an example of data from paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022). The Y axis represents the mean safety score of the micro-areas, and the number of observations can be found in the micro-areas on the X axis. We see that there is a lot more variation in safety scores for the micro-areas with few observations, with the variation becoming smaller for micro-areas with more observations.

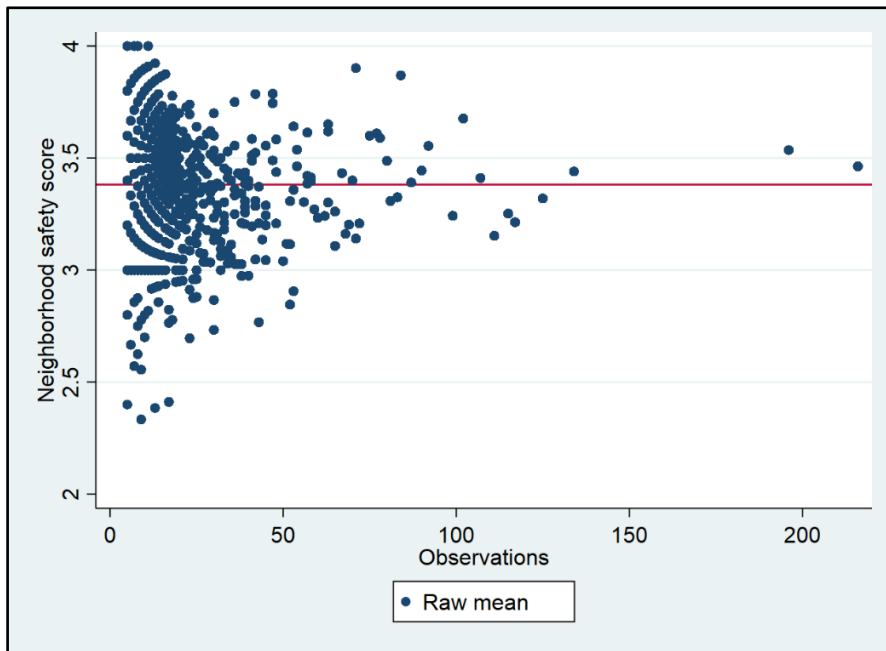


Figure 4. Raw mean neighborhood safety scores per micro-area

One simple solution would be to drop neighborhoods that have the number of observations below a chosen cut-off, here based on the argument that neighborhood characteristics that are measured from neighborhoods with very few observations would be too unreliable; however, this could result in losing a large amount of data⁶. In paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022), I try to handle this problem through the use of empirical Bayes estimates (EBEs) derived from the random effects of multilevel models, which will be described in the forthcoming section. These estimates work by borrowing strength across neighborhoods and shrinking estimates for neighborhoods with few observations toward the overall mean (Mujahid et al., 2007), with a shrinkage factor calculated as follows:

⁶ In this case, micro-areas with fewer than five observations were dropped because of discretionary criteria from Statistics Denmark

$$\text{Shrinkage factor} = \frac{\sigma_u^2}{\sigma_u^2 + \frac{\sigma_e^2}{n_j}} \quad (1)$$

where σ_u^2 is the level-2 variance, σ_e^2 the level-1 variance, and n_j the number of observations in neighborhood j in the sample (Hox et al., 2018). The less precise the group-specific estimate and less variability observed across groups, the greater the shift toward the overall group mean.

The strength of this approach is that it uses information from other neighborhoods to improve the estimates for unreliable neighborhoods (Diez Roux, 2002; Mujahid et al., 2008). Figure 4 demonstrates this, showing the same plot created above in Figure 3 but now with both the raw averages and the EBE averages after shrinkage. From this plot, it is clearly seen how the shrinkage effect is larger for the micro-areas with fewer observations.

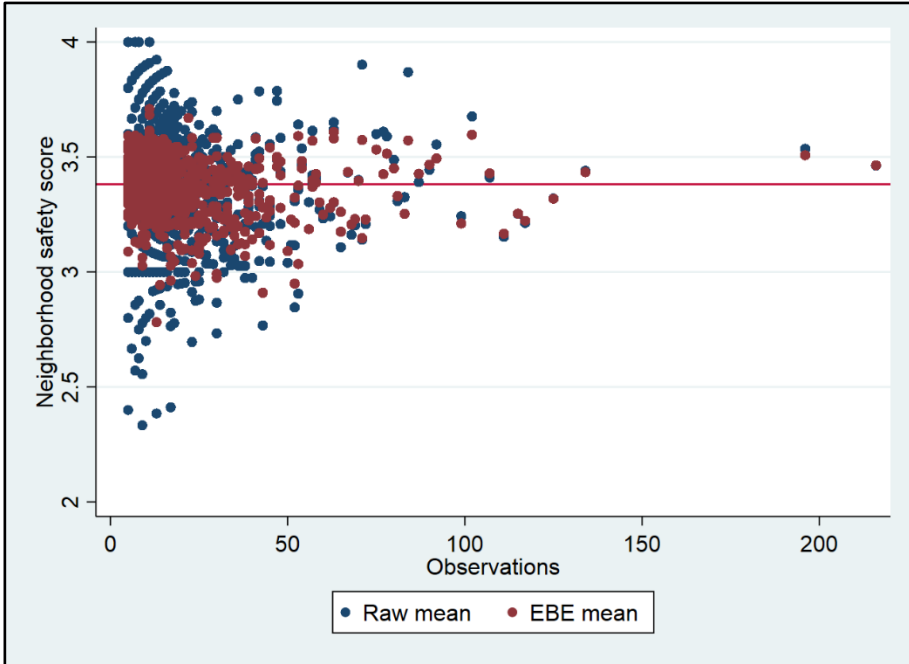


Figure 5. Raw and EBE mean neighborhood safety scores per micro-area

3.5. MULTILEVEL MODELING

In the present thesis, multilevel modeling (also known as hierarchical models or mixed models) was used to study the association between the neighborhood social context and mental health. When investigating individual mental health outcomes across different neighborhoods, the shared context introduces a possible correlation between individuals from the same neighborhood. This has consequences for both the estimation of the regression coefficients and for the standard errors of these estimates. Failing to take into account the correlation between individuals within their contexts when using single-level regression models leads to the phenomenon known as misestimated precision. This means that ignoring the clustering of individuals within higher level units can lead to an overestimation of the effective sample size and, hence, the tendency to type I error and thereby rejecting the null hypothesis when it is actually true. With multilevel models, this clustering is taken into account by the ability to partition the variance into the different levels of the data, such as the individual and neighborhood levels. In a linear two-level mixed model with mental health as the outcome variable, the neighborhood part of the variation consists of the variation of the average mental health measure of each neighborhood around the overall average (Leyland & Groenewegen, 2020). Because of the possible correlations between individuals nested within the same neighborhood, multilevel models can be viewed as the gold standard when examining the association between individual- and neighborhood-level exposures on health outcomes (Marco Helbich, 2018).

In a two-level linear mixed model with one individual-level predictor variable and one area-level variable as an example, we include an effect for each area the individuals are nested in.

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2j} + u_{0j} + e_{0ij} \quad (2)$$

y_{ij} is the outcome variable for individual i in area j . x_{1ij} is the individual-level predictor variable, and x_{2j} is the area-level predictor variable. This means that this variable takes the same value for all individuals living in area j . β_1 indicates the average change in the outcome variable associated with a one-unit increase of the individual-level predictor variable, and β_2 indicates the average change in the outcome variable associated with a one-unit increase of the area-level predictor variable. u_{0j} is the residual for area j . This is the difference that we expect to see in the outcome variable for an individual in area j compared with an individual in the average area, here after taking into account the individual- and area-level variables included in the model. The 0 in the subscript denotes that this is a random intercept residual, which means that a departure from the overall intercept β_0 applies equally to everyone in area j , regardless of individual-level characteristics (Leyland & Groenewegen, 2020).

3.6. CONTEXTUAL EFFECTS

When studying the possible impact of neighborhoods on individual outcomes, one of the most simple but important distinctions to make is the difference between contextual versus compositional effects. When looking at the crude association between neighborhood socioeconomic deprivation and mental health outcomes, the general conclusion from the research papers in the present dissertation is that neighborhood socioeconomic deprivation is negatively associated with mental health or positively associated with mental health problems. However, the problem with investigating this crude association is that we do not know whether the association is because of the composition of the individuals by which the areas are comprised (compositional effect) or attributable to the real effect of areal-level properties (contextual effects). To isolate the contextual effects, it is important to control for the individual levels of these variables, which here would be the individual levels of education, income, and employment. Therefore, the potential remaining effect of neighborhood socioeconomic deprivation can no longer be caused by the individual composition of these socioeconomic characteristics. In other words, this means that neighborhood socioeconomic deprivation matters for mental health over and above individual SES. From a counterfactual understanding, this would mean that the mental health of individuals moving to a more socioeconomically deprived area would be affected, regardless of the individuals' SES. However, as previously mentioned, there might still be other factors related to the selection into certain areas, including people's mental health, meaning that we cannot isolate the possible contextual effects with the use of observational data (Sampson et al., 2002).

Despite the differences between compositional or contextual effects, it is important to understand these concepts as interrelated and not mutually exclusive. Just because neighborhood differences are attributed to individual or compositional factors does not mean that place-based processes are not important. As Macintyre, Ellaway, and Cummins (2002) point out, individual factors such as SES are often the result of where someone lives, and on the other hand, contextual factors are often influenced by the individuals who live in a particular place.

In addition to the distinction between contextual or compositional effects, it is also important to distinguish between the general contextual effect (GCE) and specific contextual effects (SCEs) (Merlo et al., 2018). The GCE expresses how important the specific context—in this case neighborhoods—is for the outcome. In linear multilevel models, this is often measured with the intraclass correlation (ICC), which is calculated as follows:

$$ICC = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2} \quad (3)$$

where σ_u^2 is the level-2 variance and σ_e^2 is the level-1 variance. The ICC is the percentage of the total variance attributable to the area-level variance (Snijders & Bosker, 1999). Furthermore, the ICC is also a measure of the correlation in outcomes between two individuals in the same cluster, ranging between 0 and 1, with 0 indicating no similarity in the outcome between individuals from the same cluster and 1 indicating that all individuals from the same cluster share exactly the same outcome (Leyland & Groenewegen, 2020).

However, in logistic models, the individual-level variance is on the probability scale, and the area-level variance is on the logistic scale. Therefore, the ICC may not accurately represent the partitioning of variance, and it may have some interpretational drawbacks when used for binary responses. First, the ICC does not convey information regarding variation among clusters, and second, the ICC is not comparable to the fixed effects, which can be interpreted as the odds ratios (ORs) (Goldstein et al., 2002; Larsen & Merlo, 2005; Merlo et al., 2006). As an alternative, Larsen et al. (2000) and Larsen and Merlo (2005) suggested the use of the median odds ratio (MOR), which was used in paper 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) (Jakobsen, 2021):

$$\text{MOR} = \exp\left(\sqrt{2 \times \sigma_u^2} \Phi^{-1}(0.75)\right) \quad (4)$$

where $\exp(\cdot)$ is the exponential function, σ_u^2 is the level-2 variance, $\Phi(\cdot)$ is the cumulative distribution function of the normal distribution with a mean of 0 and a variance of 1, and $\Phi^{-1}(0.75)$ is the 75th percentile. The MOR quantifies the area-level variance as the median of the set of odds ratios obtained by comparing two individuals with identical covariates from two different, randomly chosen areas. The MOR is the median odds ratio between the person with the higher propensity and the person with the lower propensity. The higher the MOR is, the higher the variation between areas, with a MOR of 1 indicating no variation between areas (Chaix et al., 2005; Larsen & Merlo, 2005). In multilevel time-to-event models, median hazard ratios (MHR) can be calculated as in paper 3 (Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals) (Jakobsen & Lund, 2022) by using the same formula as the one described above for the MOR, here when the frailty terms follow a log-normal distribution (Austin et al., 2017). In general, there are no widely accepted thresholds that indicate a high versus low value for the ICC, MOR, or MHR. Typically, we might expect somewhere around 2–5% of the total variation to arise because of the differences between contexts (Leyland & Groenewegen, 2020), which correspond to the estimates found throughout the research papers in the present dissertation (Jakobsen, 2021; Jakobsen et al., 2022; Jakobsen & Lund, 2022).

3.7. MEDIATION ANALYSIS

To investigate the mechanisms through which neighborhood SES affects mental health, multilevel structural equation mediation models (MSEM) with a 2-2-1 design were used in paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022), as illustrated in Figure 6. The idea of mediation is when the relationship between two variables is fully or partially accounted for by a third variable that conceptually lies on the causal pathway between the exposure and outcome (Baron & Kenny, 1986). In mediation terminology, the relations between the variables can be divided into distinct paths: the path between the predictor and mediator (path a), the path between the mediator and outcome (path b), and the path between the predictor and outcome, which is also called the total effect (path c). Finally, the path between the predictor and outcome, once intervening mediated relations have been accounted for, is $c-ab$ (path c'), which is also called the direct path. The indirect effect of the predictor through the mediator that measures the amount of mediation can then be quantified as the product of a and b (i.e., ab). (Preacher & Hayes, 2008).

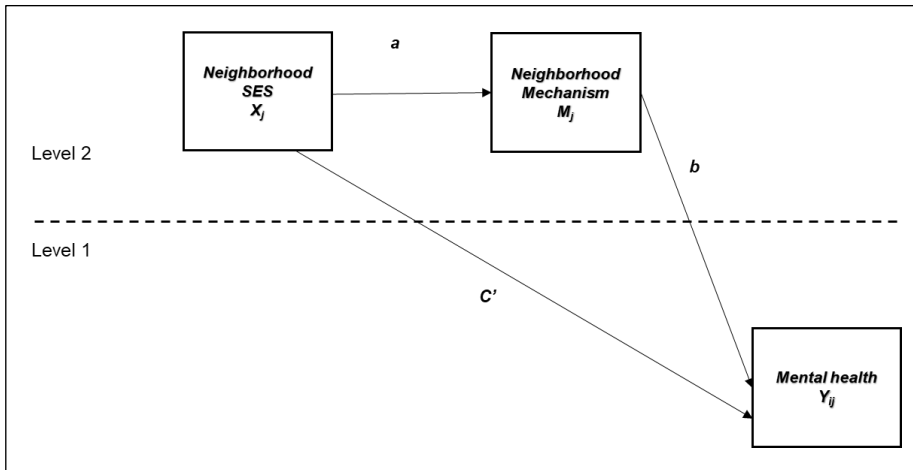


Figure 6. Illustration of a simple 2-2-1 multilevel mediation model

Note: modified figure from (Jakobsen et al., 2022)

Because of the skewness and non-normality of the sampling distribution of the indirect effect, common methods for estimating the confidence interval of the indirect effect, such as the *delta method* (Sobel, 1982), can result in a conservative underpowered test (MacKinnon et al., 2004; Preacher & Selig, 2012). To solve this problem, the Monte Carlo simulation method (MacKinnon et al., 2004) was used to

construct the confidence intervals for the indirect effects. To construct the confidence interval for the indirect effect, we first estimated the effects of \hat{a} and \hat{b} and their standard errors of $\hat{\sigma}_{\hat{a}}$ and of $\hat{\sigma}_{\hat{b}}$ from the sample. Next, a simulated sampling distribution was generated of the indirect effect ab by generating a distribution of 100,000 random samples with population values equal to the sample values of \hat{a} , \hat{b} , $\hat{\sigma}_{\hat{a}}$, and $\hat{\sigma}_{\hat{b}}$. Finally, percentiles of the sampling distribution were used as limits for a 95% confidence interval of the sample $\hat{a}\hat{b}$ (Jakobsen et al., 2022). The Monte Carlo simulation method has been shown to produce estimates comparable to those of bootstrap methods, and in addition this method is less computationally demanding and thereby much faster to implement in a large sample multilevel context (Preacher & Selig, 2012).

In paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022) the indirect effects were estimated with the use of both single and multiple mediation models. The single mediation models allowed us to investigate if the neighborhood characteristics acted as mediators. Next the multiple mediation model allowed us to study the possible mediating effect of the neighborhood characteristics when controlling for all other mediators and thereby the mechanism's unique ability to mediate the relationship between NSES and mental health (Preacher & Hayes, 2008). To quantify the strength of the indirect effects, the ratio of the indirect effect to the total effect were calculated as $\hat{P}_M = (\hat{a} \times \hat{b})/\hat{c}$. With this approach the strength of the mediation can be evaluated on a continuum, instead of only focusing on whether or not the indirect effects are statistically different from zero (Shrout & Bolger, 2002).

CHAPTER 4. THE RESEARCH PAPERS

4.1. WHERE TO GET THE RESEARCH PAPERS

The present dissertation is built on four research papers, with references provided below:

Research paper 1: Jakobsen, A. L. (2021). Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study. *Health & Place*, 72, 102675. <https://doi.org/10.1016/j.healthplace.2021.102675>

Research paper 2: Jakobsen, A. L., Jørgensen, A., Tølbøll, L., & Johnsen, S. B. (2022). Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms. *Health & Place*, 77, 102905. <https://doi.org/10.1016/j.healthplace.2022.102905>

Research paper 3: Jakobsen, A. L., & Lund, R. L. (2022). Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals. *Social Science & Medicine*, 311, 115320. <https://doi.org/10.1016/j.socscimed.2022.115320>

Research paper 4: Jakobsen, A. L. The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a multilevel cohort study. *Journal of Epidemiology & Community Health* (In review)

4.2. MAIN FINDINGS OF THE RESEARCH PAPERS

In paper 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) (Jakobsen, 2021), the objective was to compare the use of micro-areas constructed using an automated redistricting algorithm and divided by physical barriers, here by using the two administrative area types—Danish parishes and postal codes—to measure the association between neighborhood socioeconomic deprivation and psychiatric medication purchases.

Geographical data were linked to Danish register data of the Danish population from age 16 in 2017, $N = 4,347,001$, with logistic multilevel models used to measure the association between neighborhood socioeconomic deprivation as divided into deciles and psychiatric medication purchases.

From a visual and descriptive inspection of the socio-spatial patterns formed when using the different neighborhood delineations, the maps showed a tendency towards a more heterogeneous pattern for micro-areas that was gradually blended out when looking at parishes and postal codes. Furthermore, I found a larger GCE when using micro-areas (MOR = 1.33) compared with parishes (MOR = 1.23) and postal codes (MOR = 1.18). In addition, I found that living in the most socioeconomically deprived neighborhoods (decile 10) was associated with higher odds of buying psychiatric medication after controlling for individual-level sociodemographic characteristics. However, this association was present only for micro-areas (OR 1.17, 95% CI 1.15, 1.20) ($p < 0.001$), not for parishes (OR 1.02, 95% CI 0.98, 1.06) or postal codes (OR 1.01 95% CI 0.96, 1.05).

The findings show that smaller areas divided by physical barriers can reveal contextual neighborhood effects that are not present when administrative areas are used as neighborhoods. These findings indicate that the use of administrative areas as measures of neighborhoods presents the risk of overlooking or underestimating important socio-spatial differences in mental health conditions, as well as contextual factors that may explain these differences. The use of small areas divided by larger physical barriers may provide a useful alternative to administrative delineations. In general, the findings point to the continued importance of thorough conceptualizations and operationalizations of neighborhoods and the importance of comparing and validating neighborhood measures for future studies investigating socio-spatial inequalities and neighborhood effects on mental health.

In paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022), my coauthors and I aimed to investigate whether neighborhood social characteristics in the form of neighborhood social interaction, neighborhood trust, neighborhood safety, neighborhood organization participation, and neighborhood attachment would mediate the association between neighborhood SES and mental health.

We combined Danish register data with survey data from the North Denmark Region Health Survey 2017. Mental health was assessed using the Rand 12-Item Short-form Survey (SF-12). The sample consisted of 14,969 individuals nested in 1,047 micro-areas created with an automated redistricting algorithm. We fitted multilevel structural equation mediation models and used a Monte Carlo simulation method to estimate confidence intervals for the indirect effects.

The ICC for mental health was 2.5% (SE=0.004). This is comparable to other similar studies using the SF-12 or SF-36 (Fone & Dunstan, 2006; Peterson et al., 2009). In addition, we found that neighborhood SES was positively associated with mental health after adjusting for individual characteristics as potential confounders ($p < 0.001$). In the single mediation models, social interaction, trust, attachment, and safety were significant mediators. Neighborhood trust showed the largest mediation effect, accounting for 43% of the association between neighborhood SES and mental health,

followed by neighborhood safety, accounting for 31%. In the multiple mediation model only neighborhood trust was a significant mediator of the relationship between neighborhood SES and mental health ($p < 0.05$), accounting for 34% of the association after controlling for other mediators and potential confounders.

The results indicate that higher levels of mental health in more socioeconomically affluent neighborhoods are partially explained by higher levels of trust between neighbors. Improving neighborhood trust could mitigate the socio-spatial inequalities in mental health. However, further studies are needed to develop and evaluate specific public health interventions targeted at the neighborhood level on mental health.

In paper 3 (Neighborhood social context and suicide mortality: A multilevel register-based 5-year follow-up study of 2.7 million individuals) (Jakobsen & Lund, 2022), my coauthor and I investigated how the social context in neighborhoods are related to suicide mortality, here by investigating the association between suicide mortality and neighborhood socioeconomic deprivation, social fragmentation, and population density. Although the other research papers in the present dissertation focus on neighborhood SES, the current paper also looked at population density and social fragmentation as recent empirical evidence have highlighted these factors as potentially important for suicide (Dykxhoorn et al., 2021; Hagedoorn et al., 2020; Hagedoorn & Helbich, 2022; Kanamori et al., 2020).

The geographic data were linked to register data on the Danish adult population in the age range of 20 to 59 years in December 2013 ($N = 2,672,799$ individuals nested into 7,943 neighborhoods). This cohort was followed for five years to evaluate the association between neighborhood characteristics at baseline divided into quintiles and risk of suicide mortality at follow-up. Because previous research indicates that the associations between area-level factors and suicide mortality may vary with age, we examined the models per age group (20–39 years and 40–59 years) based on previous studies using similar age groups (Agerbo et al., 2007; Hagedoorn et al., 2020; O’Farrell et al., 2016).

After controlling for individual characteristics, higher suicide mortality was observed for individuals living in the least densely populated neighborhoods (HR: 2.20, 95% CI: 1.51, 3.19) ($p < 0.001$) for the younger age group and (HR: 1.42, 95% CI: 1.10, 1.83) ($p < 0.05$) for the older age group. Furthermore, a higher risk was found for people living in the most socially fragmented neighborhoods (for the younger age group, HR: 1.89, 95% CI: 1.21, 2.97, $p < 0.05$; for the older age group, HR: 1.43, 95% CI: 1.08, 1.90; $p < 0.05$).

The results indicate that, beyond individual characteristics, the neighborhood social context including population density and social fragmentation may affect the risk of suicide, especially for people aged 20–39 years. The findings may be explained by mechanisms such as social isolation and lack of integration in less densely populated and socially fragmented neighborhoods, as well as community attitudes toward mental illness and help seeking being negatively affected by poor mental health literacy

(Solmi et al., 2017). Furthermore, we found cross-level interactions between neighborhood population density and gender and ethnicity for those aged 40–59 years, as well as between neighborhood social fragmentation and ethnicity for those aged 20–39 years. Hence, a higher suicide risk associated with population density was observed for men compared with women and for individuals with a non-Danish ethnicity compared with ethnic Danes and a higher risk was associated with living in highly socially fragmented neighborhoods for ethnic Danes compared with individuals with a non-Danish ethnicity. To explain these findings, we hypothesize that men living in remote and rural areas may be prone to certain masculinity ideals, which may result in less help-seeking behavior during hardship and despair (Alston, 2012; Kanamori et al., 2020). In addition, non-native individuals might be prone to fewer social interactions and lower social integration than ethnic Danes in less densely populated areas. We do not have a clear explanation for the interaction between ethnicity and social fragmentation. Therefore, additional research on this topic is warranted.

Finally, in the fourth paper, “The long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood: a prospective cohort study” I investigated how living in a socioeconomically deprived neighborhood in early childhood at age 3 can affect perceived levels of stress later in life in early adulthood at age 20–24.

Data from the Danish National Health Survey 2017, in which perceived stress was measured, were used to follow a cohort consisting of all survey respondents aged 20–24 years born between 1992 and 1996. The respondents were linked to register data, including data on the parent(s) with whom the respondents lived to measure family-level socioeconomic characteristics, parental mental health problems, and neighborhood socioeconomic deprivation at age 3 for each respondent. Furthermore, the respondents were linked to georeferenced neighborhoods. Linear mixed models were used to estimate the association between neighborhood socioeconomic deprivation at age 3 and perceived stress at age 20–24, here controlling for individual and family characteristics and neighborhood socioeconomic deprivation in early adulthood.

Neighborhood socioeconomic deprivation in early childhood was associated with higher levels of perceived stress in early adulthood ($p < 0.001$). The association was attenuated but remained statistically significant ($p < 0.01$) after controlling for individual and family characteristics in early childhood and neighborhood socioeconomic deprivation in early adulthood.

The results indicate that children growing up in more socioeconomically deprived neighborhoods may be prone to higher levels of perceived stress later in life, meaning that early childhood may be a sensitive period for neighborhood effects on later mental health outcomes. Further studies are needed to identify and test the mechanisms linking early childhood neighborhood deprivation to perceived stress in early adulthood.

CHAPTER 5. CONCLUSION, DISCUSSION, AND PERSPECTIVES

In this concluding chapter, I synthesize the insights from the four individual research papers. Based on this synthesis and the existing literature, I critically discuss how the findings from the present dissertation contribute theoretically and methodologically to the field of neighborhood effects on mental health. Finally, I discuss potential policy implications and provide some concluding remarks.

The overall aim of the current PhD dissertation was to investigate and shed new light on the association between the social context in neighborhoods and mental health. In addition, the aim was to address some of the frequent limitations and gaps associated with previous research in this field, including the operationalization of neighborhoods, the identification of neighborhood mechanisms, and investigation of long-term neighborhood effects from a life course perspective. Several important findings were reported.

First, the use of different neighborhood delineations can have a substantial impact on the empirical findings when studying how the social context in neighborhoods can affect the residents' mental health. The use of micro-areas generated with an automated redistricting algorithm and divided by physical barriers, such as large roads (Lund, 2018), revealed larger GCEs, as well as significant SCEs that could not be detected when using the smallest administrative areas in Denmark as neighborhoods. This finding adds to the literature demonstrating the effects of using different areas as neighborhoods when studying neighborhood effects on health outcomes (Chaix et al., 2005, 2006; Cockings & Martin, 2005; Cutchin et al., 2011; Flowerdew et al., 2008; Franzini & Spears, 2003; Messer et al., 2006; Parenteau & Sawada, 2011).

Second, different neighborhood characteristics were significantly associated with different mental health outcomes, even after controlling for individual-level sociodemographic characteristics. More specifically, living in the most socioeconomically deprived areas was associated with higher odds of purchasing psychiatric medications, and living in more socioeconomically affluent neighborhoods was associated with better overall mental health. Furthermore, living in neighborhoods with a low population density and highly socially fragmented neighborhoods was associated with a higher risk of suicide. These findings add to the literature demonstrating significant neighborhood effects on similar mental health outcomes (Cheung et al., 2012; Crump et al., 2011; Drukker & van Os, 2003; Greene et al., 2020; Jablonska et al., 2020; Jonsson et al., 2020; Kanamori et al., 2020; Maguire et al., 2016), including two recent Danish quasi-experimental studies finding evidence for a causal link between socioeconomically deprived neighborhoods and

treatment with psychiatric medication (Boje-Kovacs et al., 2022; Foverskov, White, Norredam, et al., 2022).

Third, the positive association between neighborhood SES and mental health can partially be explained by higher levels of neighborhood trust in more socioeconomically affluent neighborhoods. This means that variations in trust between neighbors in different neighborhoods can be seen as a contextual mechanism explaining socio-spatial inequalities in mental health. This finding adds to the literature that highlights the mediating effect of positive social-interactive characteristics such as collective efficacy, including measures of neighborhood trust (Bassett & Moore, 2013; Drukker & van Os, 2003; Erdem et al., 2015; Haines et al., 2011; Jonsson et al., 2020; Rios et al., 2012).

Fourth, growing up in a socioeconomically deprived neighborhood during early childhood may have long-term effects on people's levels of perceived stress later in life. To the best of my knowledge, no other study has investigated the long-term impact of neighborhood socioeconomic deprivation in early childhood on perceived stress in early adulthood, but the findings are consistent with other studies linking socioeconomic deprivation during early childhood to mental health problems later in life, including depressive symptoms (Elovainio et al., 2020), internalizing and externalizing behavior problems (D. Wang et al., 2020), and psychiatric disorders (Foverskov, White, Norredam, et al., 2022).

5.1. STRENGTHS AND LIMITATIONS

In addition to the strengths and limitations of the four individual studies, which are described in detail in the research papers, there are several common strengths and weaknesses in the current dissertation running across the individual studies.

One major strength for all four studies was my ability to test the use of micro-areas (Lund, 2018) and compare these to administrative areas as neighborhood units. In all of the published papers, sensitivity analyses showed that the use of micro-areas affected the results, with the micro-areas showing larger GCEs for both psychiatric medication purchases in paper 1 (Jakobsen, 2021), overall mental health (MCS-12) in paper 2 (Jakobsen et al., 2022), and suicide mortality in paper 3 (Jakobsen & Lund, 2022), along with larger SCEs for psychiatric medication purchases in paper 1 (Jakobsen, 2021) and overall mental health in paper 2 (Jakobsen et al., 2022), when compared with parishes, which are the smallest administrative areas in Denmark.

Second, the use of unique high-quality Danish register data encompassing almost the entire population linked to very large survey data samples was another key strength of the present dissertation, which would not be possible in most other countries. This

made it possible to study neighborhood effects on a population level for almost the total geography of Denmark instead of smaller selected areas. In addition, the use of both surveys and register data made it possible to measure different important mental health outcomes and neighborhood characteristics, as well as important confounding factors from both self-reported data and administratively collected register data, thereby reducing the risk of same-source bias. Another approach could have been to focus exclusively on a single mental health outcome and a single specific neighborhood factor in all the research papers, for example, psychiatric medication purchases and socioeconomic deprivation, to obtain more specific knowledge about the relationship between these two variables. However, instead of this I have chosen to include different aspects of the neighborhood social context and different aspects of mental health based on the arguments presented in chapters 2 and 3, in order to investigate both register and self-reported positive and negative aspects of mental health and to use measures of mental health and the neighborhood social context that were particularly relevant to the various research questions I have chosen to examine.

Another important strength is the use of different designs to investigate neighborhood effects from both a short-term perspective using cross-sectional designs (papers 1–2) (Jakobsen, 2021; Jakobsen et al., 2022), as well as with a 5-year follow-up (paper 3) (Jakobsen & Lund, 2022) and from early childhood to early adulthood (paper 4), as a way to investigate potential long-term effects.

One major limitation is the use of only observational data. Hence, despite the use of longitudinal designs in papers 3 and 4 (Jakobsen & Lund, 2022) and the inclusion of several possible confounding variables to control for selection into neighborhoods, the causal inferences based on these associations are limited. As mentioned earlier, it is possible that the selection mechanism into neighborhoods is not independent from the mental health outcomes studied. This means that the associations found in the present dissertation could be the result of reverse causality. However, empirical evidence of possible causal neighborhood effects on mental health outcomes have been found in previous studies, including both Danish and international studies using experimental or quasi-experimental research designs (Boje-Kovacs et al., 2022; Foverskov, White, Norredam, et al., 2022; Leventhal & Brooks-Gunn, 2003; Ludwig et al., 2013; White et al., 2017).

Another limitation is the inability to fully test the MAUP by separating the issues of scaling and aggregation. As a result, it is not clear whether the differences found between the micro-areas and administrative areas were because of the use of physical barriers or only the smaller size of the micro-areas or both. As previously mentioned, this was tested by Lund (2018), who found that the micro-areas showed a higher degree of socioeconomic homogeneity compared with parishes and variations of parishes (e.g., reduced to quarter size) and areas based on random clustering with a minimum of 100 inhabitants but with the physical barriers removed. These results indicate that the use of physical barriers can be useful as meaningful separators

between areas. It would be useful to conduct further studies to examine the impact of using physical barriers to operationalize neighborhoods for neighborhood effects on mental health outcomes, where the size of the areas is held constant.

5.2. THE IMPORTANCE OF NEIGHBORHOODS AND TRUST

In modern times of individualization, digitalization, and globalization, it is easy to question the relevance of place with people being “elsewhere” rather than placed (Sampson, 2012). Furthermore, with more than half the world’s population living in cities and the continuously increasing urbanization throughout the world (Okkels et al., 2017), it may seem relevant to reduce the question of place to the possible effects of cities in contrast to rural areas. However, the findings from the present dissertation emphasize the enduring importance of studying socio-spatial inequalities in relation to mental health beyond the urban–rural dichotomy, with a focus on the social context at a small-area neighborhood level occurring both in urban and rural settings. Although there may be significant variations in mental health across larger geographic areas such as counties, municipalities, and urban-rural differences, it is important not to uncritically homogenize our view on such larger areas, but to keep an eye on the heterogeneity and internal socio-spatial variations related to the immediate social environment in people’s neighborhoods.

In addition to the general importance of investigating socio-spatial inequalities from a neighborhood perspective, the findings from the present dissertation highlight how contextual and place-based understandings of concepts such as neighborhoods, socioeconomic deprivation, and neighborhood trust differ from an individual perspective. An individual resident living in a socioeconomically deprived neighborhood may not necessarily be affected by social problems, low income, low education, and unemployment, but the general surrounding deprivation may still have an impact on this person. At the same time, a person may live in an affluent area but still become unemployed, with potential consequences for that person’s economy and mental health. When focusing on the effects of SES, the importance of both individual and contextual characteristics calls for a more holistic view on social inequalities in mental health.

The difference between individual versus collectively oriented understandings of social phenomena also applies for people’s perceptions of their neighborhood. In paper 2, (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) neighborhood trust was found to be the only significant mediator, and neighborhood-level was the predictor of mental health in the full models adjusting for other possible mediators and confounding factors (Jakobsen et al., 2022). Trust is often viewed as a key cognitive component of social cohesion,

social capital (Delhey & Newton, 2003; Kawachi & Berkman, 2015) and collective efficacy (Sampson & Graif, 2009). Social trust can be conceptualized as a type of moral resource that facilitates reciprocity exchanges within networks (Adjaye-Gbewonyo et al., 2018) and that allows social interactions to proceed on a simple and confident basis (Lewis & Weigert, 1985). In the literature, trust is often divided into generalized trust, which conceptualizes the belief that most people, including strangers, can be trusted, and particularized trust, which is trust in known individuals or groups such as trust in neighbors (Uslaner, 2002). Furthermore, trust can be measured at both the individual level by focusing on an individual's tendency to trust others, which reflects individual personal traits, versus collective or ecological trust, which focuses on the trustworthiness of specific groups or places such as neighborhoods (Kawachi & Berkman, 2015).

Previous studies have found that trust as a cognitive component of social capital is a particularly important factor for mental health. A study from the UK found that generalized trust was the only indicator of social capital, showing a significant longitudinal association with better psychological health overtime. In contrast to this, the frequency of talking to neighbors and social participation in local groups had no effect (Giordano & Lindström, 2011). In addition, a review by Ehsan and De Silva (2015) concluded that the cognitive aspects of social capital, including individual and ecological measures of trust, were associated with a reduced risk of common mental disorders, but for indicators of structural social capital, there was no overall association. However Garoon et al. (2016) pointed out the following:

It is one thing to note that, on average, a given level of personal trust and/or social engagement within a given neighborhood at a given time results in corresponding levels of self-reported health. It is another to consider the collective interactions that lead to such correlations. (p. 14)

To understand the possible effect from neighborhood trust on mental health, high levels of neighborhood trust may reflect a neighborhood environment with supportive social relationships that are beneficial for mental health (Adjaye-Gbewonyo et al., 2018). Furthermore, a trusting neighborhood environment might positively influence mental health by lowering the “transaction costs” in daily life, here through collective action, reciprocity, and social reinforcement. Routinely low daily life transaction costs, therefore, imply reduced psychosocial stresses and anxiety (Giordano et al., 2019). In addition, neighborhood trust may be affected by the socioeconomic conditions of neighborhoods. With neighborhood trust being a mediator of the association between neighborhood SES and mental health, the higher mental health levels of residents in more socioeconomically affluent neighborhoods can be partially explained by higher levels of neighborhood trust (Jakobsen et al., 2022). The positive link between neighborhood socioeconomic conditions and trust may be explained by high rates of home ownership, safety, and stability in more affluent neighborhoods, whereas socioeconomically deprived neighborhoods may be characterized by

perceptions of neighborhood disorder including noise, vandalism, and crime (Sampson & Graif, 2009).

If high levels of trust between neighbors reflects stable and positive place-based social relations this provides a theoretical explanation for the link between neighborhood trust and mental health because a large body of empirical research has found consistent evidence that positive social relationships are beneficial for mental health (Gariépy et al., 2016; Rueger et al., 2016; Santini et al., 2015; Wickramaratne et al., 2022). However, only a few studies have focused on evaluating specific interventions aimed at increasing aspects of both neighborhood social capital, including trust and mental health. Therefore, further high-quality controlled trials establishing causality are needed before recommending interventions aimed at promoting trust at the neighborhood level as a mental health–promoting intervention (Flores et al., 2018).

In addition to neighborhood trust, further studies are still needed to dissect the potential causal pathways explaining the link between neighborhoods and mental health, including both potential social and biological mechanisms. Furthermore, when neighborhoods are hypothesized to affect children’s and adolescents mental health with possible long-term consequences, the neighborhood environment might affect children and adolescents indirectly through family, peer, and school processes (D. Wang et al., 2020), pointing to the importance of considering possible social mechanisms at several different social levels.

Another ongoing challenge is the conceptualization of constructs to capture various important aspects of the neighborhood social environment. A number of measures have been used in different studies, including the 10-Item Collective Efficacy Scale developed by Sampson et al. (1997), yet no consensus exists on how measures of the neighborhood social environment are conceptualized or operationalized (Martin et al., 2017). As alternatives to the use of survey or register-based data, other novel approaches include image recognition with the use of machine learning models to estimate residents’ perceptions of their neighborhood, such as neighborhood safety (R. Wang et al., 2019) and virtual reality experiments to examine the effects of simulated neighborhoods on immediate stress and emotional responses (Hackman et al., 2019). In addition to the conceptualization of the social neighborhood environment, further studies should continue to conceptualize and test plausible biophysiological mechanism such as allostatic load (Ribeiro et al., 2018) and potential gene-environment interactions (Lei & Simons, 2021) to bridge the gap between the social context in neighborhoods and the mind.

In conclusion the complete pathways between neighborhoods and mental health are likely complex and potentially include individual, social, environmental, structural, cognitive, and biological factors. Ideally, future studies should investigate more complex pathways and different types of mediators and the potential moderators

occurring at different levels to further broaden and nuance our understanding of the link between neighborhoods and mental health (Jakobsen et al., 2022).

5.3. BEYOND ADMINISTRATIVE AREAS

In the present dissertation, I have not only focused on investigating the association between the two key concepts in focus—neighborhood social context and mental health—but I have also demonstrated how the methodology used to measure this association can affect the results. As mentioned earlier, several review studies have highlighted how the operationalization of neighborhoods can lead to different analytical results, thereby providing an explanation for mixed findings between studies beyond differences in samples, study designs, and variables across studies (Diez Roux, 2001; Ellen et al., 2001; Mair et al., 2008; March et al., 2008; Richardson et al., 2015; Truong & Ma, 2006; Visser et al., 2021).

One of the major points of criticism for common neighborhood delineations is that such delineations place several people in fixed areas, which does not take into account the individual's unique spatial location or perception of the area. As a result, neighborhood effects are, as demonstrated in paper 1 (Neighborhood socioeconomic deprivation and psychiatric medication purchases. Different neighborhood delineations, different results? A nationwide register-based multilevel study) (Jakobsen, 2021), affected by the MAUP and UGCoP because different neighborhood delineations may include different people and because we cannot know the true relevant causal context when studying different outcomes. One proposed solution to this problem has been to use individualized areas when trying to capture neighborhood effects such as 200 or 400 m circular buffer zones. However, even though we may more accurately be able to detect the near spatial context and possible relevant exposure area surrounding unique individuals or households, this method may fail to capture potentially relevant contextual and collective social phenomena (Voigtländer et al., 2013) and the importance of specific delimited places, which may be important despite individual differences in the understanding and perceptions of neighborhoods. As mentioned earlier, neighborhoods being social concepts just like families and nations may not lack true causal power, even though their forms are socially constructed, permeable, and variable (Sampson, 2011).

In the present study, the micro-areas used were divided by physical barriers such as larger roads. As previously mentioned, these can potentially serve as barriers for social interaction (Feld, 1981; R Grannis, 1998) and may reflect individuals' own perceptions of where known neighborhoods are separated from the surrounding neighborhoods (Campbell et al., 2009; Rick Grannis, 2009; Lynch, 1971). The empirical findings from the present dissertation indicate that the micro-areas were better at detecting important socio-spatial inequalities and potential neighborhood

effects compared with administrative areas. If neighborhood trust is one key mechanism linking neighborhood SES to mental health, as found in paper 2 (Opening the black box of the relationship between neighborhood socioeconomic status and mental health: Neighborhood social-interactive characteristics as contextual mechanisms) (Jakobsen et al., 2022), it becomes clear why the use of large administrative boundaries can lead to potential misleading results because it can be expected that the SES and average levels of trust in these areas reflects only a low degree the socially interactive environment that individuals experience and participate in on a daily basis.

Even though the micro-areas are potentially better at capturing the relevant social context in neighborhoods compared with larger administrative areas, it is important to emphasize that people's surroundings and socially relevant context cannot necessarily be reduced only to the immediate environment around their own residence. Instead, the areas that surrounds a neighborhood can also have an important impact, meaning that neighborhoods should not be understood as if they were isolated islands (Graif et al., 2016). A study using data from the MTO experiment found that people moving from concentrated income disadvantage to a less disadvantaged area in only the immediate neighborhood or the surrounding neighborhood—but not both—did not show improvements in mental health. However, for people, moving to a less disadvantaged immediate neighborhood surrounded by less disadvantaged neighborhoods, the results showed improvements in mental health (Graif et al., 2016).

Some of the mechanisms explaining the potential importance of surrounding neighborhoods on mental health may be that people often spend time out of their immediate neighborhood when they go to work, do grocery shopping, or use recreational facilities or other organizations nearby. Thus, spending time in a nearby neighborhood means increased exposure to nearby risk factors. Surrounding neighborhoods can also potentially affect people without them spending time there. For instance, if nearby neighborhoods are affected by crime, this may affect people's feeling of safety for themselves or their family, even if they do not have to walk through or spend time in the area (Graif et al., 2016). In addition to the inclusion of surrounding neighborhoods, studies have called for the use of global positioning system (GPS) tracking to more accurately capture people's movement and the places where people spend time during the course of their daily activities (Marco Helbich, 2018; Kwan, 2012). Future studies should continue to progress our methodological ability to estimate neighborhoods and other places' possible effects on mental health with a more precise, detailed, and dynamic approach compared to the common use of fixed administrative areas.

In conclusion, it is relevant to focus not only on the MAUP, but also on the UGCoP (Kwan, 2012). Particularly when neighborhood effects research is based on different administrative areas instead of theoretical understandings of how neighborhoods can be delineated, the results may suffer from both validity and reliability problems related

to the MAUP and UGCoP. Because one universal understanding of neighborhoods may be impossible to define and measure, the best way of operationalizing neighborhoods should depend on the plausible causal mechanisms linking the exposure to the outcome. Therefore, studies should not view the MAUP and UGCoP as barriers to conducting useful research on neighborhood effects but instead see them as points of attention that can help expand and nuance the complex interplay between health outcomes and the social environment people live in (Jakobsen, 2021).

5.4. POLICY IMPLICATIONS AND CONCLUDING REMARKS

Based on the above sections discussing the methodological and theoretical implications of the present dissertation in relation to the scientific field of neighborhood research and mental health, these findings may also have implications for current or future policy and practice.

In continuation of the work by Lund (2018, 2019), one of the main findings of the present dissertation is how the areas used in empirical analyses can seriously affect the results, not only in relation to the socio-spatial patterns we are able to visually identify (Jakobsen, 2021) but also in relation to how the social context and various neighborhood characteristics are associated with various aspects of mental health (Jakobsen, 2021; Jakobsen et al., 2022; Jakobsen & Lund, 2022). This means that administrative areas may not be suitable for identifying relevant socio-spatial differences in mental health outcomes and possible contextual factors that explain these differences. Furthermore, administrative areas may not be suitable for the delimitation of targeted interventions in local areas. Therefore, better operationalizations of neighborhoods are not only needed from a scientific perspective, but also for policy and practice. During the Covid-19 pandemic in Denmark, the Danish health authorities developed an online, freely available dashboard-solution combining GIS with Covid-19 incidence rates. First, this tool was based on the differences between regions and municipalities, but later, Danish parishes were also incorporated (Statens Serum Institut (SSI), 2021). In addition to this monitoring tool, automatic models for the lockdown of various institutions were also based on the number of confirmed Covid-19 infections in the areas (Ministry of the Interior and Health, 2021). Even though viral respiratory infections are completely different than mental health outcomes, it is still important to focus on the possible consequences of using arbitrary administrative delineations when mapping any type of health outcome, especially when such mappings are used politically with potential consequences for the residents, because these administrative divisions may not be the best areas to capture potential relevant contextual or environmental effects.

In addition to the important aspect of being able to detect significant socio-spatial inequalities and variations in mental health and to study the possible important

contextual effects, another aspect is to develop, evaluate, and implement interventions aimed at promoting mental health. Despite the fact that smaller areas may be better at predicting health-related outcomes, such as psychiatric medication purchases, these areas may also be more difficult to use as boundaries for the implementation of complex social interventions. One advantage of the micro-areas used in the present dissertation is that the algorithm can be adapted to form larger areas with a higher number of occupants, here still based on physical barriers as separators (Lund, 2018), which could be used to develop meaningful, and in some cases larger areas, than the micro-areas used in the present dissertation.

The socio-spatial inequalities related to factors such as neighborhood socioeconomic deprivation identified throughout the current dissertation call for intervening at policy level to address the “upstream” determinants of health, such as poverty, unemployment, poor income, and education inequality because these factors have the potential to influence population health more profoundly than individually oriented programs (Stock, 2013). Social policies at the national, regional, and local levels have the potential to develop neighborhoods with the aim of reducing residential segregation and lower differences between neighborhoods in terms of socioeconomic composition, leading to a more equal level of SES (Diez Roux, 2007; Stock, 2013). When focusing on already existing neighborhoods, processes of urban regeneration often intend to change the socioeconomic composition in deprived neighborhoods based on structural measures including relocation of residents, demolition of housing, building of new accommodation and renewal of the built environment. However, these processes may negatively affect the place-based social relations and well-being of the residents (Srivarathan et al., 2023) which indicates that urban regeneration should not be seen as an easy and unproblematic solution to mitigate potential negative effects of deprived areas for residents' mental health.

In contrast, other strategies aimed at directly improving the social environments and social relations in neighborhoods may benefit residents' mental health. In Denmark, various local health promotion projects have been established by focusing on social capital to promote active citizenship (Andersen, 2013); however, as mentioned earlier, further high-quality controlled trials establishing causal effects are needed before recommending social capital interventions at the neighborhood level to promote mental health (Flores et al., 2018).

In contrast to interventions aimed directly at the neighborhood level, other interventions have been developed and evaluated with the aim of improving population mental health in various settings. As an example, the “Act-Belong-Commit” (ABC) is the world’s first evidence-based comprehensive, population-wide, mental health promotion campaign (Donovan & Anwar-McHenry, 2016). Act-Belong-Commit is a practical framework for health and non-health professionals aimed at promoting mental health in both the general population and in specific

settings. The Act-Belong-Commit framework essentially promotes three evidence-based behavioral domains that contribute to enhancing mental health:

Act: Keep alert and engaged by keeping mentally, socially, spiritually, and physically active.

Belong: Develop a strong sense of belonging by keeping up friendships, joining groups, and participating in community activities.

Commit: Do things that provide meaning and purpose in life like taking up challenges, supporting causes, and helping others. (Donovan & Anwar-McHenry, 2016, p. 194).

In Denmark, the campaign has been implemented in several municipalities, with the partnership led by the Department of Psychology, University of Copenhagen and all partners having a shared responsibility in disseminating and promoting the ABC messages (Koushede & Donovan, 2022). While the Act-Belong-Commit domains are relevant in a variety of settings, one can argue that neighborhoods constitute a particularly important context to focus on in terms of promoting these behaviors. For example, the neighborhood and the surrounding local community can help facilitate opportunities to *act* by having areas that can be used for sports or exercise or having local organizations where people can participate in various activities. In addition, neighborhoods or local communities can help people develop a strong sense of *belonging* when interacting with their neighbors or when participating in community activities. Finally, neighborhoods and local communities can also increase people's opportunities to *commit* themselves and provide meaning and purpose by helping other people in their neighborhood, teaching music, art or sports voluntarily, or by joining a charitable organization. These behavioral actions may potentially not only benefit the individual, but also help promote a supportive and cohesive social environment in the area benefiting other residents as well.

In conclusion, the current dissertation points to the importance of neighborhoods for people's mental health. In line with a growing body of empirical evidence, the findings have indicated that the social context in neighborhoods, including factors such as neighborhood SES, social fragmentation, population density, and neighborhood trust, matter for different aspects of the resident's mental health. Furthermore, the social context in neighborhoods in early childhood may have long-term effects on mental health later in life, which points to the importance of also looking at the importance of neighborhoods for mental health from a life course perspective. Therefore, neighborhood factors are important to consider, in addition to already well-known individual-level risk and protective factors. In addition, the findings also show that it is important to consider how neighborhoods are defined and measured and that important socio-spatial inequalities and neighborhood effects might be overlooked or underestimated when using administrative areas as neighborhoods.

Future studies should continue to explore the relationship between neighborhoods and mental health with a nuanced understanding of neighborhoods and place-based social relations and with a methodological and theoretical focus on the complex pathway between the individuals' nearby social environment and their mental health. This will provide important insights that can inform public health interventions by focusing on promoting mental health from a population perspective.

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ISSN (online): 2794-2694
ISBN (online): 978-87-7573-736-9

AALBORG UNIVERSITY PRESS