Health-risk behaviour in deprived neighbourhoods:

Socioeconomic inequalities and the role of perceived stress, social isolation, and loneliness

PhD thesis

Maria Holst Algren

Unit for Health Promotion Research

Department of Public Health

Faculty of Health Sciences

University of Southern Denmark

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Correspondence

Maria Holst Algren, MSc

Unit for Health Promotion Research, Department of Public Health, University of Southern Denmark, Denmark

Email: mholst@health.sdu.dk

Academic supervisors

Associate Professor Pernille Tanggaard Andersen, PhD (Main supervisor)

Unit for Health Promotion Research, Department of Public Health, University of Southern Denmark, Denmark

Senior Advisor Ola Ekholm, MSc

National Institute of Public Health, University of Southern Denmark, Denmark

Analyst Carsten Kronborg Bak, PhD

Unit of Strategy and Analysis, Region of Southern Denmark, Denmark

Assessment committee

Associate Professor Bernard Jeune, MD (Chairman)

Department of Epidemiology, Biostatistics and Biodemography, University of Southern Denmark, Denmark

Professor Anne Ellaway, Dr.

MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, Scotland, UK

Associate Professor Henrik Bøggild, PhD

Public Health and Epidemiology Group, Department of Health Science and Technology, Aalborg University, Denmark

Preface and acknowledgements

My research on health-risk behaviour in deprived neighbourhoods is driven by my interest in social inequalities in health behaviour, including how social determinants influence health behaviour. Such knowledge is valuable in the process of reducing social inequalities in health, and it has been a privilege to be able to immerse myself in this research area.

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List of original contributions

The present thesis is based on the following papers:

Paper I

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Paper II

Algren MH, Ekholm O, van Lenthe F, Mackenbach J, Bak CK and Andersen PT. **Health-risk behaviour among residents in deprived neighbourhoods compared with those of the general population in Denmark: A cross-sectional study**. *Health & Place*. 2017; 45: 189-198.

Paper III

Algren MH, Ekholm O, Nielsen L, Ersbøll AK, Bak CK and Andersen PT. **Associations between perceived stress, socioeconomic status, and health-risk behaviour in deprived neighbourhoods in Denmark: A cross-sectional study**. *BMC Public Health 2018;18:250.* Accepted 09/02/2018.

Paper IV

Algren MH, Ekholm O, Nielsen L, Ersbøll AK, Bak CK and Andersen PT. **Social isolation, loneliness, socioeconomic status, and health-risk behaviour in deprived neighbourhoods in Denmark: A cross-sectional study**. *Submitted*.

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Abbreviations

CI	Confidence interval
CFA	Confirmatory factor analysis
DHMS	Danish Health and Morbidity Survey 2010
DNHPS	Deprived Neighbourhood Health Profile Survey
EFA	Exploratory factor analysis
OR	Odds ratio
PSS	Perceived Stress Scale
RMSEA	Root mean square error of approximation
SDU	University of Southern Denmark
SES	Socioeconomic status
SRMR	Standardized root mean square residual
WHO	World Health Organization

Summary

Introduction

Social inequalities in health have increased in recent decades, and reducing social inequalities in health-risk behaviour has thus become an important public health concern. Greater knowledge about the underlying mechanisms of social inequalities in health-risk behaviour is needed in the development of effective policies and intervention programmes. Previous studies have found that health-risk behaviours are more prevalent among residents of deprived neighbourhoods than those of non-deprived neighbourhoods. However, there is limited research-based knowledge on health-risk behaviour in deprived neighbourhoods in Denmark. Further, knowledge about which aspects should be prioritized in intervention programmes in deprived neighbourhoods is warranted. Perceived stress, social isolation, and loneliness have been associated with health-risk behaviour, but their influence on health-risk behaviour in deprived neighbourhoods remains unclear.

Aims

The overall aim of this PhD thesis was to examine health-risk behaviours in deprived neighbourhoods compared with those in the general Danish population, and to investigate the role of perceived stress, social isolation, and loneliness on health-risk behaviour in deprived neighbourhoods. The specific aims of the thesis were:

- To conduct a systematic review of recent studies on health-risk behaviour among adults who live in deprived neighbourhoods compared with those who live in non-deprived neighbourhoods and to summarize what kind of operationalisations of neighbourhood deprivation that were used in the studies (**paper I**)

- To compare the health-risk behaviours (including the co-occurrence of health-risk behaviours) of residents in deprived neighbourhoods with those of the general Danish population and to examine the associations between sociodemographic and socioeconomic characteristics and health-risk behaviours in deprived neighbourhoods (**paper II**)

- To compare perceived stress among residents in deprived neighbourhood with that in the general Danish population, to investigate the associations between perceived stress and health-risk behaviours among residents of deprived neighbourhoods and to examine whether perceived stress modified the associations between socioeconomic status (SES) and health-risk behaviours (**paper III**)

- To compare loneliness among residents in deprived neighbourhoods with that in the general Danish population, to investigate whether social isolation and loneliness were associated with health-risk behaviours among residents of deprived neighbourhoods and to examine whether social isolation and loneliness modified the associations between SES and health-risk behaviours (**paper IV**).

Material and methods

A systematic literature review was conducted as an initial step to summarize available literature on health-risk behaviours in deprived neighbourhoods compared with those in non-deprived neighbourhoods (**paper I**). The other studies (**paper II-IV**) in the thesis were based on data from the cross-sectional *Deprived Neighbourhood Health Profile Survey*, which was undertaken by the Danish Health Authority in 12 deprived neighbourhoods in Denmark in 2011. A total of 5,113 interviews were collected (response rate: 63%). Data for the general population were extracted from the *Danish Health and Morbidity Survey 2010*, which was conducted by the National Institute of Public Health at the University of Southern Denmark in 2010. A total of 15,165 individuals completed the questionnaire (response rate: 61%).

The sociodemographic and socioeconomic characteristics measured were sex, age, ethnic background, educational level, employment status, and cohabitation status. SES was assessed by information on highest educational level and employment status. Health-risk behaviour was measured with the following behaviours: low intake of fruit or vegetables; daily or heavy smoking; high-risk alcohol intake; and physical inactivity. Health-risk behaviour also included the co-occurrence of health-risk behaviours, using a risk factor score calculated by adding the number of health-risk behaviours for each respondent in relation to fruit and vegetable consumption, smoking, alcohol intake, and physical activity. Perceived stress was assessed by four questions taken from Cohen's Perceived Stress Scale. Social isolation was based on a measure of the individual's social network, using a modified version of the Berkman-Syme Social Network Index. Loneliness was measured by one question asking about feeling unwillingly alone. Indexes for perceived stress and social network were constructed through exploratory factor analysis and confirmatory factor analysis, respectively. **Papers II-IV** used multiple logistic regression analyses that were adjusted for sex, age, ethnic background, highest completed education, cohabitation status, and employment status. Analyses of modification in **paper III-IV** included interaction analyses of the examined indicators. Further, the joint effect of SES and the examined indicators were analysed.

Results

The systematic review (**paper I**) showed that residents in deprived neighbourhoods had a higher odds of smoking and physical inactivity compared to those in non-deprived neighbourhoods. The results were ambiguous for low fruit and vegetable consumption and alcohol consumption, and no clear differences were found. The studies operationalized neighbourhood deprivation in numerous different ways. **Paper II** showed that residents in deprived neighbourhoods had higher odds of health-risk behaviours (except high-risk alcohol intake) compared to the general Danish population, even after adjustment for socioeconomic characteristics. In the deprived neighbourhoods especially men, residents with lower educational level, unemployed, disability pensioners and residents living alone were more likely to have health-risk behaviours. **Paper III-IV** found that residents in deprived neighbourhoods had higher odds of perceived

stress and loneliness than the general Danish population. Overall, perceived stress, social isolation, and loneliness were associated with health-risk behaviour in deprived neighbourhoods, although no significant associations were found for high-risk alcohol intake. Perceived stress modified the associations between SES and physical inactivity, and between SES and having two or more health-risk behaviours. Perceived stress was more strongly associated with physical inactivity and having two or more health-risk behaviours among residents with medium/high SES compared to residents with low SES. Social isolation and loneliness did not modify the associations between SES and health-risk behaviour.

Conclusion

The findings presented in this thesis suggest that residents in deprived neighbourhoods were more likely to have health-risk behaviour than the general population, indicating the need for health promotion interventions that are targeted towards deprived neighbourhoods. Perceived stress, social isolation, and loneliness appear to be associated with health-risk behaviour in deprived neighbourhoods. Although further studies are needed to clarify the underlying mechanism, health promotion interventions in deprived neighbourhoods may benefit from incorporating strategies to reduce perceived stress, social isolation, and loneliness in the effort to reduce health-risk behaviours.

Resumé (Danish summary)

Introduktion

Social ulighed i sundhed er steget gennem de seneste årtier, og reducering af social ulighed i sundhedsrisikoadfærd er derfor blevet et vigtigt område inden for folkesundheden. Mere viden om de underliggende mekanismer bag social ulighed i sundhedsrisikoadfærd er efterspurgt til udviklingen af effektive politikker og interventionsprogrammer. Tidligere studier har vist, at sundhedsrisikoadfærd er mere udbredt blandt beboere i udsatte boligområder end blandt beboere fra ikke-udsatte boligområder. Der er dog begrænset forskningsbaseret viden om sundhedsrisikoadfærd i socialt udsatte boligområder i Danmark. Derudover er der behov for mere viden om, hvilke indsatsområder der skal prioriteres i interventionsprogrammer i udsatte boligområder. Stress, social isolation og ensomhed er blevet forbundet med sundhedsrisikoadfærd, men det er fortsat uklart, hvilken betydning disse faktorer har for sundhedsrisikoadfærden i udsatte boligområder.

Formål

Det overordnede formål med denne ph.d.-afhandling var at undersøge sundhedsrisikoadfærd i socialt udsatte boligområder sammenlignet med den generelle danske befolkning, samt at undersøge betydningen af oplevet stress, social isolation og ensomhed for sundhedsrisikoadfærd i udsatte boligområder. De specifikke formål med afhandlingen var:

- At udføre en systematisk litteraturgennemgang af studier, der sammenligner sundhedsrisikoadfærd hos voksne i udsatte boligområder og ikke-udsatte boligområder, samt at opsummere hvordan udsatte boligområder var operationaliseret i disse studier (**artikel I**)

- At sammenligne sundhedsrisikoadfærd (inklusiv ophobning af sundhedsrisikoadfærd) blandt beboere i udsatte boligområder med den generelle danske befolkning, samt at undersøge sammenhængene mellem sociodemografiske og socioøkonomiske karakteristika og sundhedsrisikoadfærd i udsatte boligområder (**artikel II**)

- At sammenligne oplevet stress blandt beboere i udsatte boligområder med den generelle danske befolkning, at undersøge sammenhængene mellem oplevet stress og sundhedsrisikoadfærd blandt beboere i udsatte boligområder, samt at undersøge hvorvidt oplevet stress modificerede sammenhængene mellem socioøkonomisk status (SES) og sundhedsrisikoadfærd (**artikel III**)

- At sammenligne ensomhed blandt beboere i udsatte boligområder med den generelle danske befolkning, at undersøge sammenhængene mellem social isolation samt ensomhed og sundhedsrisikoadfærd i udsatte boligområder, samt at undersøge hvorvidt social isolation og ensomhed modificerede sammenhængene mellem SES og sundhedsrisikoadfærd (**artikel IV**)

Materiale og metode

Indledningsvist blev den eksisterende forskning om sundhedsrisikoadfærd i udsatte boligområder sammenlignet med ikke-udsatte boligområder sammenfattet i en systematisk litteraturgennemgang (**artikel I**). De øvrige studier (**artikel II-IV**) i afhandlingen var baseret på tværsnitsdata fra *Nærmiljø-sundhedsprofilundersøgelsen*, som blev udført af Sundhedsstyrelsen i 12 udsatte boligområder i Danmark i 2011. I alt blev der gennemført 5.113 interviews (svarprocent: 63 %). Data om den generelle danske befolkning var fra *Sundheds- og sygelighedsundersøgelsen 2010*. I alt 15.165 personer gennemførte spørgeskemaundersøgelsen (svarprocent: 61 %).

Målingen af sociodemografiske og socioøkonomiske karakteristika omfattede køn, alder, etnisk baggrund, uddannelsesniveau, beskæftigelsesstatus og samlivsstatus. SES var baseret på information om højeste fuldførte uddannelsesniveau og erhvervsmæssig stilling. Sundhedsrisikoadfærd var målt på baggrund af følgende adfærd: lavt indtag af frugt eller grøntsager; daglig rygning; storrygning; højrisiko alkoholindtag; og fysisk inaktivitet. Sundhedsrisikoadfærd inkluderede også risikoophobning af sundhedsrisikoadfærd, der var baseret på en risikofaktorscore beregnet ved at summere antallet af respondentens sundhedsrisikoadfærd i forhold til frugt og grønt, rygning, alkohol og fysisk aktivitet. Stress blev målt gennem fire spørgsmål, som også er en del af Cohens Perceived Stress Scale. Social isolation var baseret på en måling af individets sociale netværk, hvor en modificeret version af Berkman-Syme Social Network Index blev anvendt. Ensomhed blev målt via ét spørgsmål omhandlende følelsen af at være ufrivillig alene. Indekser for stress og socialt netværk blev dannet på baggrund af henholdsvis en eksplorativ og konfirmatorisk faktoranalyse. I **artikel II-IV** blev analyserne foretaget via multiple logistiske regressionsanalyser, der var justeret for køn, alder, etnisk baggrund, højeste fuldførte uddannelse, samlivsstatus og erhvervsmæssig stilling. Modifikationsanalyserne i **artikel III-IV** inkluderede interaktionsanalyser af de undersøgte indikatorer. Endvidere blev der foretaget joint effekt analyser af SES og de undersøgte indikatorer.

Resultater

Den systematiske litteraturgennemgang (**artikel I**) viste, at beboere i udsatte boligområder havde en højere odds for at for at ryge og for at være fysisk inaktive sammenlignet med beboeren i ikke-udsatte boligområder. Resultaterne var tvetydige for lavt indtag af frugt og grønt samt for alkoholforbrug, og der blev ikke fundet nogen klare forskelle. Studierne operationaliserede udsatte boligområder på mange forskellige måder. **Artikel II** viste, at beboere i udsatte boligområder havde højere odds for sundhedsrisikoadfærd (undtagen højrisiko alkoholindtag) sammenlignet med den generelle danske befolkning, selv efter justering for socioøkonomiske karakteristika. I de udsatte boligområder var det især mænd, beboere med lavere uddannelsesniveau, arbejdsløse, førtidspensionister og beboere der bor alene, der var mere tilbøjelige til at have sundhedsrisikoadfærd. I **artikel III-IV** blev det fundet, at beboere i udsatte boligområder havde en højere odds for stress og ensomhed sammenlignet med den generelle danske

befolkning. Desuden blev det fundet, at stress, social isolation og ensomhed var associeret med sundhedsrisikoadfærd i de udsatte boligområder. Dog blev der ikke fundet nogle signifikante associationer i forhold til højrisiko alkoholindtag ved stress og ensomhed. Stress modificerede sammenhængene mellem SES og fysisk inaktivitet, samt mellem SES og det at have to eller flere sundhedsrisikoadfærd. Stress var stærkere associeret med fysisk inaktivitet og det at have to eller flere sundhedsrisikoadfærd blandt beboere med mellem/høj SES sammenlignet med beboere med lav SES. Social isolation og ensomhed modificerede ikke sammenhængene mellem SES og sundhedsrisikoadfærd.

Konklusion

Afhandlingens resultater antyder, at beboere i udsatte boligområder var mere tilbøjelige til at have sundhedsrisikoadfærd sammenlignet med den generelle befolkning, hvilket indikerer et behov for sundhedsfremmende interventioner målrettet udsatte boligområder. Stress, social isolation og ensomhed forekommer at være associeret med sundhedsrisikoadfærd i udsatte boligområder. På trods af at der er behov for yderligere studier til at afklare de underliggende mekanismer, kan sundhedsfremme interventioner i udsatte boligområder med fordel inkorporere strategier til at mindske stress, social isolation og ensomhed i indsatsen mod at reducere sundhedsrisikoadfærd.

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1 Introduction

This chapter provides a general introduction to socioeconomic inequalities in health and their key determinants, with a special focus on health-risk behaviour, neighbourhood deprivation, perceived stress, social isolation, and loneliness. The relevance of research in these fields is outlined by highlighting the knowledge gaps that lead up to the specific research aims of this PhD.

1.1 Socioeconomic inequalities in health

It is well documented that individual socioeconomic characteristics (such as income, education, and occupation) are associated with health [1,2]. Socioeconomic status (SES) is one of the most influential determinants of health [3], and lower SES is correlated with increased risks of almost every major cause of premature mortality [4]. The existence of socioeconomic inequalities in health has been observed for centuries in many European countries [5,6]. The World Health Organization (WHO) consider reducing socioeconomic inequalities in health as one of the most important and greatest challenges in public health [7-9]. Reducing social inequalities in health is stated in the health policy goals in Denmark, just as in most other countries [10]. Despite increased international attention to health inequalities from researchers and policy-makers, inequalities still exist and have in fact widened in recent decades [10-16]. Denmark and other Nordic Countries have had relatively low income inequality for many years due to universal welfare systems, but have still not achieved low social inequality in health [10,17-19]. This phenomenon has been termed "the Scandinavian Welfare Paradox of Health" [20]. Changes in the level of socioeconomic health inequalities over time indicate that health inequalities can be altered to some extent; if inequalities in health can widen, then in theory they can also be reduced. We need more knowledge about the complex determinants of socioeconomic differences in health to allow development of effective policies and intervention programs to reduce socioeconomic health inequalities [7].

1.2 Determinants of health inequalities

Different possible determinants explaining socioeconomic health inequalities have been proposed [21-23]. The influential Black Report on Health Inequalities, published in 1980 [23,24], is one of the first systematic attempts to understand the causes of health inequalities [3]. The report suggested social causation as one of the explanatory mechanisms for socioeconomic inequalities in health, and this is now believed to be the main explanatory mechanism [25,26]. The social causation mechanism presumes that SES has an indirect influence on health through an unequal distribution of health determinants between socioeconomic groups, where the unfavourable determinants are more frequent in the lower socioeconomic groups [26]. These determinants can be divided into *material factors* (e.g. neighbourhood environment with negative effects on health, such as crowding and poor housing), *psychosocial factors* (e.g. stressful situations, availability of social relationships and support, adoption of effective coping strategies) and *behavioural factors* (e.g.

health-risk behaviours such as unhealthy diet, smoking, high alcohol intake, and physical inactivity) [27,28]. The explanatory factors seem to be interconnected, suggesting that some mechanisms affect health through others rather than working directly, e.g. that social relationships affect health through health behaviour [28]. In this thesis, I will both focus on the material, psychosocial, and behavioural factors that can explain socioeconomic inequalities in health and health-risk behaviour, as described in the following sections.

1.3 Health-risk behaviour as a key determinant for health inequalities

The higher prevalence of health-risk behaviour in lower socioeconomic groups than in higher socioeconomic groups is one of the mechanisms linking lower SES to poorer health [23,29,30]. The following section first summarizes the health consequences of health-risk behaviour and then describes the association between SES and health-risk behaviour.

1.3.1 Health consequences of health-risk behaviour

Health-risk behaviours, such as unhealthy diet, smoking, high alcohol intake, and physical inactivity, are recognized as major determinants of morbidity and mortality [1,2,10,31]. Health-risk behaviours have in recent research been suggested to contribute even more to socioeconomic inequalities in mortality than previously thought [29].

Substantial evidence shows a protective role of the intake of fruit and vegetables for several cancers types and cardiovascular diseases [32,33]. Fruit and vegetables are good sources of dietary fibre and thus may protect against weight gain and obesity [34,35]. In Denmark, the recommended intake of fruit and vegetables for adults is at least 600 g/day (where half should be vegetables) [10].

Smoking has a wide range of health-damaging effects [10]. It can lead to cancer and premature death and is the most important preventive risk factor in the European Union [36,37]. Daily smoking increases the risk of lung cancer and chronic obstructive lung disease by 15−20 times, and the risk of ischaemic heart disease and stroke by 2−4 times [10].

High alcohol intake increases the risk of numerous diseases such as liver cirrhosis, cancer, gastrointestinal diseases, stroke, alcohol dependency, and alcohol psychosis [10,38]. The Danish Health Authority defines high-risk alcohol intake as a consumption of more than 14 standard drinks per week for women and more than 21 for men [39]. The vast majority of alcohol-related deaths occur among people who drink above these limits [40].

Physical inactivity increases the risk of premature death and a variety of diseases such as cardiovascular disease, obesity, and type 2 diabetes [10,41,42]. The Danish Health Authority recommends that adults are physically active for at least 30 minutes a day [43]. This include activities besides regular short-term, everyday activities and should be of moderate to high intensity for 18-64 year-olds [43] and of moderate intensity for persons aged over 64 years [44].

Finally, persons with no healthy behaviours have on average a 14-year lower life expectancy than persons who engage in four healthy behaviours: at least five servings of fruit and vegetables a day, current non-smoker, moderate alcohol intake (1–14 units a week for men and women), and physically active [45].

1.3.2 Socioeconomic inequalities in health-risk behaviours

Health-risk behaviours explain much of the socioeconomic inequality in morbidity and mortality [29,46,47]. Despite the consequences of health-risk behaviour being well known to most people, a strong socioeconomic gradient exists where individuals with lower SES are more likely to have health-risk behaviour than individuals with higher SES [29,48]. European comparative analyses have found that the most common inverse social gradients relate to poor diet, smoking, and physical inactivity [49]. Unlike the other health-risk behaviours, alcohol intake is more complex. The association between socioeconomic factors and alcohol intake in Denmark is very modest when compared to other Western countries [50]. In Denmark, high-risk alcohol intake is more prevalent among individuals with basic school as their highest level of education in the youngest age groups, whereas in the older age groups, the most risk-prone are those with the highest education [51].

1.4 Explanations for socioeconomic inequalities in health-risk behaviour

"*Why do poor people behave poorly?*" (Lynch et al., 1997: 809) [48] is a complex question to answer. Although a variety of explanations have been suggested, the mechanisms behind socioeconomic differences in health-risk behaviour are still poorly understood [48,52]. Such information is, however, important in developing interventions to reduce socioeconomic inequalities in health. Many prevalent diseases and causes of death can be largely prevented through healthier behaviour [53], and health-risk behaviours are modifiable through health promotion and intervention programmes [10]. Thus, there is a clear need to identify target populations (especially among lower socioeconomic groups) with high levels of health-risk behaviours and to widen our knowledge about relevant factors to be included in interventions that promote healthy behaviours (i.e. factors associated with both health-risk behaviours and SES patterns). Given that health-risk behaviours cluster in lower socioeconomic groups, the main underlying determinants are most likely to be found among factors to which socioeconomic groups are differentially exposed, such as living in deprived neighbourhoods. Residents in deprived neighbourhoods thus constitute a potential target population.

1.4.1 Neighbourhood deprivation as an explanation for inequalities in health-risk behaviour

It is well documented that residents living in deprived neighbourhoods have higher morbidity and mortality than those in more affluent neighbourhoods [54-56], hence the increased interest in the influence of neighbourhood deprivation on individual health-risk behaviour [57]. Even after adjustment for individual-level sociodemographic and socioeconomic characteristics, residents in deprived neighbourhoods generally

are more likely to have health-risk behaviours (i.e. smoking, physical inactivity), indicating an independent influence of neighbourhood deprivation on health-risk behaviours [46,54,58-62]. **Paper I** in this thesis is a systematic review of the literature on health-risk behaviours in deprived neighbourhoods compared to non-deprived neighbourhoods [63]. The results appear in *Chapter 4*.

It has been suggested that neighbourhoods might affect health-risk behaviour through mechanisms such as the availability of and access to healthy foods or recreational facilities, normative attitudes towards health behaviour, and social support (for further description see section 2.3.1) [54,63]. The association between neighbourhood characteristics and health behaviours has been explored in many studies [60,64-67]. Physical aspects of neighbourhoods can affect the health behaviour of residents through access to health-promoting (such as gyms and parks) and health-damaging facilities (such as the quality of built environment) [68]. Previous studies have found that exposure to particular aspects of the social and physical neighbourhood environment is associated with health behaviours such as smoking, diet, and physical activity [69,70].

The underlying mechanisms of the independent association between living in a deprived neighbourhood and health-risk behaviours are rather complicated and poorly understood [54,63,71]. As suggested by the Black Report, psychosocial factors are interconnected with material and behavioural factors, and psychosocial factors can affect health indirectly through health behaviour [27,28]. The following sections, describe the existing evidence for perceived stress and social relationships (particularly social isolation and loneliness) as possible modifying mechanisms in the association between living in a deprived neighbourhood and health-risk behaviours.

1.4.2 Perceived stress as an explanation for inequalities in health-risk behaviour

Stress is an increasing public health problem and has a negative influence on a range of psychological and health outcomes [72,73]. The association between stress and health-risk behaviours have been documented in many previous studies [72,74-81], and occurrence of stress has been associated with unfavourable changes in health-risk behaviour [81]. Ng and Jeffery (2003) found that high levels of perceived stress were associated with health-risk behaviours such as poor diet, smoking, and less physical activity [74], although not with alcohol intake [74]. Researchers have suggested that these associations are largely due to the use of health-risk behaviours as tools to cope with stress [47,74,75,82-87] as they can bring immediate pleasure [74]. People experiencing stress may be less motivated to exercise [47], and prompt satisfaction is often more accessible through a sedentary activity. However, there is evidence that physical activity can reduce stress over time [74,80,88,89], and some people do exercise to control their stress [90]. Health-risk behaviour as a coping mechanism is described in further detail in section 2.4.1.

People who are socioeconomically disadvantaged experience more stressful life events [91], and when these events do occur, they are perceived as more stressful by these people, possibly due to their limited inter- and intrapersonal resources to cope with stressors [92,93]. Stress might explain some of the

association between neighbourhood deprivation and health-risk behaviours [47,54,57,94], as residents of deprived neighbourhoods have a higher risk of perceived stress than those in non-deprived neighbourhoods with similar sociodemographic and socioeconomic characteristics [54,95]. Living in a deprived neighbourhood may in itself lead to increased stress through factors such as overcrowding, high crime rates, perceived danger, poor transportation, poor housing, disrepair, limited health and social services, poor infrastructure, and a lack of social support [95-100]. Studies have found neighbourhood deprivation to be a self-determining source of stress, independent of individual SES and other factors [99], however only one study appears to have examined the influence of perceived stress on health-risk behaviours among residents in deprived neighbourhoods [101]. The authors reported both cross-sectional and longitudinal associations between perceived stress and more frequent fast-food consumption and reduced leisure-time physical activity among women in deprived neighbourhoods in Australia [101]. There is therefore at need for more evidence into the association between perceived stress and health-risk behaviours in deprived neighbourhoods [100]. Furthermore, it remains uncertain whether perceived stress aggravates or can modify the associations between SES and health-risk behaviour in deprived neighbourhoods.

1.4.3 Social relationships as an explanation for inequalities in health-risk behaviour with a focus on social isolation and loneliness

Social relationships between interdependent individuals (e.g. spouses, relatives, colleagues, neighbours, and friends [102]) is an important social determinant of health [83]. The potential effect of social relations on health outcomes emerged in the seminal works by Cassel (1976) and Cobb (1976) on social relations as a generalised protective factor in health [103]. Berkman was a pioneer in the field by studying the association between social relationships and mortality, finding that social isolation was associated with a more than doubled mortality risk after accounting for baseline health status [104]. An important mediating factor between social relationships and health outcomes is health behaviour [103]. Social relationships are thought to promote general health-protective behaviours such as healthy diet and physical activity [103,105] and to reduce health-risk behaviours such as smoking and high-alcohol intake [106,107]. Family and friends play an important role in promoting healthy behaviours, including smoking cessation and reduction in alcohol intake [108,109], while the size of a person's social network has been positively associated with physical activity [110,111], and fruit and vegetable consumption [110]. However, it has also been argued that social relationships could be a key factor in spreading health-risk behaviour such as smoking [112]. Studies have shown that social support from family and friends is positively correlated with physical activity, while social support and social norms are strong predictors for fruit and vegetable intake [108].

The negative aspects of social relationships are often conceptualized as social isolation and loneliness. Social isolation can be defined as living alone or having infrequent social contact with family and friends [113,114] and is typically a more objective, quantifiable measure of the lack of social

relationships [115]. In contrast, loneliness or perceived isolation is the subjective experience of being lonely [116,117] (for further description see section 2.4.2). Social isolation is associated with less healthy diet, smoking, high alcohol intake, physical inactivity, and multiple health-risk behaviours [114,118-120]. The associations between loneliness and health-risk behaviours are however ambiguous; some studies have found no significant differences in health-risk behaviour between lonely and non-lonely individuals [121,122], while others have found that lonely people are more likely to smoke [123] and be less physical active than non-lonely people [124].

Most studies in this research area have focused either on social isolation or on loneliness and, to our knowledge, only few studies have examined both aspects in regard to health-risk behaviour [114,115]. As feelings of loneliness are not highly correlated with social isolation [125,126], these may be two separate concepts that can occur without each other. Thus, some people with frequent social contacts may still feel lonely, while others with infrequent contacts do not necessarily feel lonely. Due to the conceptual difference between social isolation and loneliness, investigating their relative importance on health-risk behaviour may provide with important knowledge on the research area.

In regard to developing effective health promotion interventions to reduce health-risk behaviour in deprived neighbourhoods, it seems important to understand the influence of social isolation and loneliness.

But the research on the association between social relationships and health-risk behaviour in deprived neighbourhoods is very limited [127,128]. Yu et al. (2011) found an association between low physical activity and weak social networks and social support in six deprived neighbourhoods in London [128]. Another study by Yu et al. (2011) showed that a better social network contributed to more leisure-time physical activity among residents in 40 deprived neighbourhoods in London [127]. Further, previous studies have found high prevalence of loneliness in deprived neighbourhoods [129,130].

It could be assumed that social isolation and loneliness are important negative influences on health-risk behaviour among residents with lower SES in deprived neighbourhoods [131]. However, it remains unclear whether social isolation and loneliness act as effect modifiers. Understanding the influence of social isolation and loneliness on health-risk behaviour in deprived neighbourhoods could provide important knowledge in relation to identify groups at risk and to target interventions for reducing health-risk behaviour.

1.5 Aims of this thesis

Despite the research interest in health-risk behaviour in deprived neighbourhoods, there are several gaps in the existing literature: i) we know little about health-risk behaviour in deprived neighbourhoods compared with that in the general Danish population, ii) we need to identify the health-risk behaviours requiring the greatest attention in health promotion programmes in deprived neighbourhoods, iii) more research is needed on the co-occurrence of health-risk behaviours in deprived neighbourhoods [132,133], iv) further research on the distribution of health-risk behaviour according to sociodemographic and socioeconomic characteristics in deprived neighbourhoods could help to identify the most risk-prone residents for targeted interventions, v) evidence on the effect of perceived stress and social relationships on health-risk behaviour in deprived neighbourhoods is very limited, and vi) understanding the influence of perceived stress and social relationships on health-risk behaviours in deprived neighbourhoods may provide useful knowledge for improving health promotion interventions aimed at reducing health-risk behaviour in deprived neighbourhoods.

The overall aim of this thesis is thus to contribute with new knowledge of these research areas by examining health-risk behaviours in deprived neighbourhoods compared with those in the general Danish population and by investigating the effect of perceived stress, social isolation, and loneliness on health-risk behaviour in deprived neighbourhoods. The work is based on the conceptual frameworks described in *Chapter 2*. The thesis includes four papers and is based on the hypothesized associations between sociodemographic and socioeconomic characteristics, neighbourhood deprivation, health-risk behaviours, perceived stress, social isolation, and loneliness that are illustrated in **Figure 1** on the next page. The numbers in the figure refer to the specific aims presented below and the arrows in the figure indicate the potential causality of the associations examined the studies.

The specific aims of the thesis are:

- To conduct a systematic review of recent studies on health-risk behaviour among adults who live in deprived neighbourhoods compared with those who live in non-deprived neighbourhoods (1) and to summarize what kind of operationalisations of neighbourhood deprivation that were used in the studies (**paper I**)

- To compare the health-risk behaviours (including the co-occurrence of health-risk behaviours) of residents in deprived neighbourhoods with those of the general Danish population (2a) and to examine the associations between sociodemographic and socioeconomic characteristics and health-risk behaviours in deprived neighbourhoods (2b) (**paper II**)

- To compare perceived stress among residents in deprived neighbourhoods with that in the general Danish population (3a), to investigate the associations between perceived stress and health-risk behaviours among residents of deprived neighbourhoods (3b) and to examine whether perceived stress modifies the associations between SES and health-risk behaviours (3c) (**paper III**)

- To compare loneliness among residents in deprived neighbourhoods with that in the general Danish population (4a), to investigate whether social isolation and loneliness are associated with health-risk behaviours among residents of deprived neighbourhoods (4b) and to examine whether social isolation and loneliness modify the associations between SES and health-risk behaviours (4c) (**paper IV**).
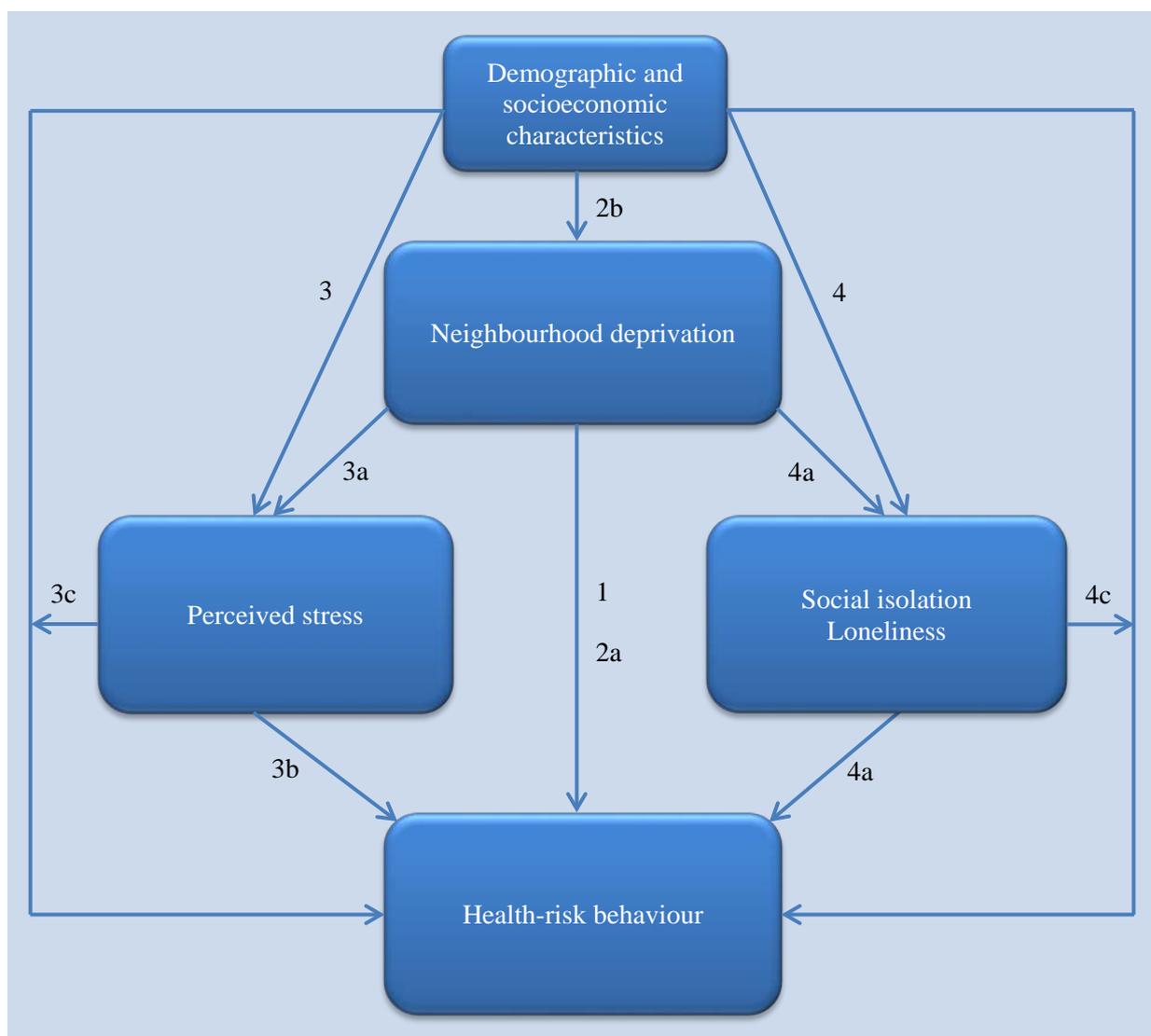
Figure 1: Model of the hypothesized associations between demographic and socioeconomic characteristics, neighbourhood deprivation, perceived stress, social isolation, loneliness, and health-risk behaviours.

1.5.1 Hypotheses

Based on previous evidence, I hypothesize that:

- Residents in deprived neighbourhoods have higher odds of health-risk behaviours compared to the general Danish population, even after adjustment for sociodemographic and socioeconomic characteristics.
- Health-risk behaviours will vary among the different sociodemographic and socioeconomic subgroups among the residents in the deprived neighbourhoods.
- Residents in deprived neighbourhoods have higher odds of perceived stress compared to the general Danish population.
- Residents living in deprived neighbourhoods who have perceived stress have higher odds of health-risk behaviours than residents with no perceived stress.
- Perceived stress can to some extent modify the associations between SES and health-risk behaviours in deprived neighbourhoods.
- Residents in deprived neighbourhoods have higher odds for being lonely than the general Danish population.
- Residents living in deprived neighbourhoods who are socially isolated and lonely have higher odds of health-risk behaviours.
- Being socially isolated and lonely can to some extent can modify the associations between SES and health-risk behaviours in deprived neighbourhoods.

1.5.2 Outline of the thesis

Chapter 2 describes the conceptual frameworks of the thesis. Chapter 3 summarizes the methods and data material used and describes the assessment of the indicators examined. *Chapter 4* summarizes the results from papers I-IV. *Chapter 5* presents and discusses the main findings of the thesis, as well as its strengths and limitations, including potential biases. *Chapter 6* presents the main conclusions and their implications for public health practice and future research.

2 Conceptual frameworks

This thesis is informed by four conceptual frameworks. The first framework concerns the conceptualization of health-risk behaviour, including a critical perspective on whether health-risk behaviour is an individual choice. The second framework concerns social determinants of health and the understanding and conceptualization of socioeconomic inequalities in health. The third framework is the socio-ecological model of health behaviour with emphasis on the important effect that environment has on health behaviour, including the conceptualization of deprived neighbourhoods. The fourth framework is the psychosocial framework concerning the influence of perceived stress, social isolation and loneliness on health-risk behaviour, including the conceptualization of perceived stress and coping, social isolation and loneliness.

2.1 Health-risk behaviour

Health behaviour has been defined in various ways. It is generally defined as an overall expression of those actions that we carry out alone or with others and which influence our health in the short or long term [134]. In this thesis, I conceptualize health behaviour in accordance with WHO's definition, i.e. *"Any activity undertaken by an individual, regardless of actual or perceived health status, for the purpose of promoting, protecting or maintaining health, whether or not such behaviour is objectively effective towards that end.* (Nutbeam, 1998: 8) [135]. It is useful to distinguish between behaviours that are purposefully adopted to promote or protect health (as in WHO's definition), and those that may be adopted regardless of the health consequences. *Health behaviours are distinguished from risk behaviours,* which are defined as *"specific forms of behaviour which are proven to be associated with increased susceptibility to a specific disease or ill-health"* (Nutbeam, 1998: 18) [135]. In using the term *health-risk behaviour*, I adopt a traditional approach to health behaviour, where it is defined as diet, smoking, alcohol intake, and physical activity [134]. This approach has been applied in many other studies within the field of health behaviour research [136-138].

2.1.1 Health-risk behaviour as an individual choice

Health behaviour is often used synonymously with the concept of lifestyle [139], which draws attention to the individual's responsibility for their own life [140] and whether health-risk behaviour is an individual choice. In recent years there has been a discussion about the degree to which health is a personal choice [10]. In Denmark, many of the non-communicable disorders are termed "lifestyle diseases", which indicates a certain degree of free choice is involved [10]. It is still a common prejudice that individual health behaviour is dependent on individual choice and willpower to resist health-risk behaviour. However, many other psychological factors influence health-risk behaviour. The theoretical frameworks most commonly used to describe individual-level factors that determine health behaviours are the Health Belief Model (HBM) [141], the Theory of Planned Behaviour (TPB) [142] and the Social Cognitive Theory (SCT) [143].

The factors include knowledge, intention and attitudes, subjective norms, perceived behavioural control, perceived benefits and perceived barriers, and self-efficacy.

The SCT focuses on the social element and proposes that behaviour change is affected by the social environment (e.g. social support from friends and family to behave healthily or observation of friends and family who behave healthily). However, in accordance with the HBM [141], interventions and campaigns to promote health behaviours typically focus on changing knowledge, intentions, and attitudes towards the targeted health-risk behaviour. These interventions and campaigns have not been particularly effective in improving health-risk behaviour, especially among people with lower SES. On the contrary, it seems to be contributing to increased social inequalities in health. The individual orientation of health promotion has been criticized for the notion that the individual's perception is always a result of conscious and "rational" considerations [134]. Although health-risk behaviour is ultimately an individual choice, it seems unlikely that people freely choose to be e.g. overweight or tobacco-dependent, and that the consistently higher prevalence of health-risk behaviour in lower socioeconomic groups is entirely determined by individual considerations.

Although some of the differences in health-risk behaviours between socioeconomic groups can be explained by individual cognitions, the social-cognitive theories give limited attention to environmental factors that are beyond the individual's control [144]. To obtain a more comprehensive understanding of why people behave unhealthily and how to increase the chance of behaviour change, it is also important to understand health-risk behaviour as imbedded in the context [144], which is closely related to the second framework of this thesis: social determinants of health. The increased interest in environmental factors for health-risk behaviour has shifted the focus from social-cognitive towards socio-ecological models of health behaviours, as described in the third framework of this thesis: the socio-ecological model of health behaviour.

2.2 Social determinants of health

In the present thesis, I apply a social epidemiological approach to health-risk behaviour in deprived neighbourhoods. Social epidemiology has been defined as "*the branch of epidemiology that studies the social distribution and social determinants of states of health*" (Berkman and Kawachi, 2014: 5) [145]. Social determinants of health refer to specific features of and pathways by which societal conditions affect health and that potentially can be altered by informed action [145,146]. The WHO Commission on Social Determinants of Health defined social determinants as *"… the condition in which people are born, grow, live, work, and age"* (Commission on Social Determinants of Health, 2008: 1) [8]. Health-risk behaviour of residents living in deprived neighbourhoods is, among other factors, affected by the neighbourhood community, society, family and friends. In this thesis, I focus on exploring and understanding adults' health-risk behaviour in their social context. Here, the social context is defined as the neighbourhoods where individuals live their daily lives, and the collective way of life expressed by the local residents

through their relations to the characteristics of the neighbourhood, and their similarities in term of social practices [134]. The framework of social determinants of health is closely related to the third framework of this thesis: the socio-ecological model of health behaviour.

2.2.1 Social inequalities in health

The framework of social determinants of health focuses on social differences and gradients in health [1]. The term *health inequality* generically refers to differences in the health of individuals or groups [147]. Social inequalities in health are according to Whitehead and Dahlgren defined as *"systematic differences in health between different socioeconomic groups"* [148] within a society. However, the definition of health inequality does not include any moral judgement on whether the observed differences are fair or just [147]. Instead, the term *health inequity*, or health disparity, represents a specific type of health inequality, where differences in health are considered unjust [149]. Despite this, the term "inequalities in health" has increasingly been used in European research with the same meaning as "inequities in health", including the denotation of unfairness and injustice [150]. In relation to the definition of social inequalities in health, Whitehead also underlines that "*As they are socially produced, they are potentially avoidable and are widely considered unacceptable in a civilised society.*" (Whitehead, 2007: 743) [150]. This implies that differences in health between socioeconomic groups are judged to be unfair and avoidable. In the present thesis, I use the term "inequalities" when referring to socioeconomic differences in health, as I share the opinion that the socioeconomic differences in health are potentially avoidable and changeable, and hence, unjust.

Conceptualization of socioeconomic status

I use *socioeconomic status* (SES) as a measure of the social gradient in health-risk behaviour of residents in deprived neighbourhoods. SES thus refers to *differences* between individuals and groups in the possession of resources such as educational level, employment status, or income [3]. Many different indicators for measuring SES exist [147], and there has been great debate regarding the most relevant measures of SES for specific health outcomes [3]. In this thesis, SES is based on highest educational level and employment status, as described further in the chapter on *Material and methods* and discussed in the *Discussion* chapter.

I do not see SES as *static*, but as *dynamic*, as it can change as individuals move through multiple stages in their life. This dynamic approach also implies that health and SES are reciprocally, dynamically affected by each other [151], which has implications for how I perceive the causal nature of SES inequalities in health. For example, a chronic disease in childhood can prevent a child from achieving the educational level he or she could have attained if she did not have the disease (direct selection according to the Black Report [23]). SES in this thesis is perceived to be the exposure of the health consequences examined.

I have chosen to use the terminology of SES and not socioeconomic position, as SES includes the assumption that it is possible to "de-compose" SES as a categorical concept to understand the relationship between its constituent parts and health outcomes [3].

2.3 Socio-ecological model of health behaviour

In the past decades, there has been a move towards a more socio-ecological approach in health research [144,152]. The socio-ecological models emphasize that besides intrapersonal and interpersonal factors, the environment also has an important effect on health behaviours, and that these factors interact [144,152]. The socio-ecological models thus assume that health behaviour is not only the result of conscious individual choices, but also a result of interactions between individual-level and environmental-level factors. Thus, people can influence their environment, and the environment can influence people's health behaviour. In regard to understanding the complex relationship between people's health behaviour and the contexts in which those health behaviour choices are made, the socio-ecological model of health behaviour attempts to explain the multiple influences on health behaviour. Several different environmental settings may influence health behaviour, e.g. factors from the neighbourhood environment, but also city- and country-level factors (e.g. policies, regulations) [144]. Environments can restrict people's actions in a healthy way by promoting (and sometimes demanding) other actions and by discouraging or prohibiting health behaviours [144]. The socio-ecological model of health determinants by Dahlgren and Whitehead [21] from 1993 illustrates the complexity of the different determinants that together influence health behaviours (**Figure 2**).
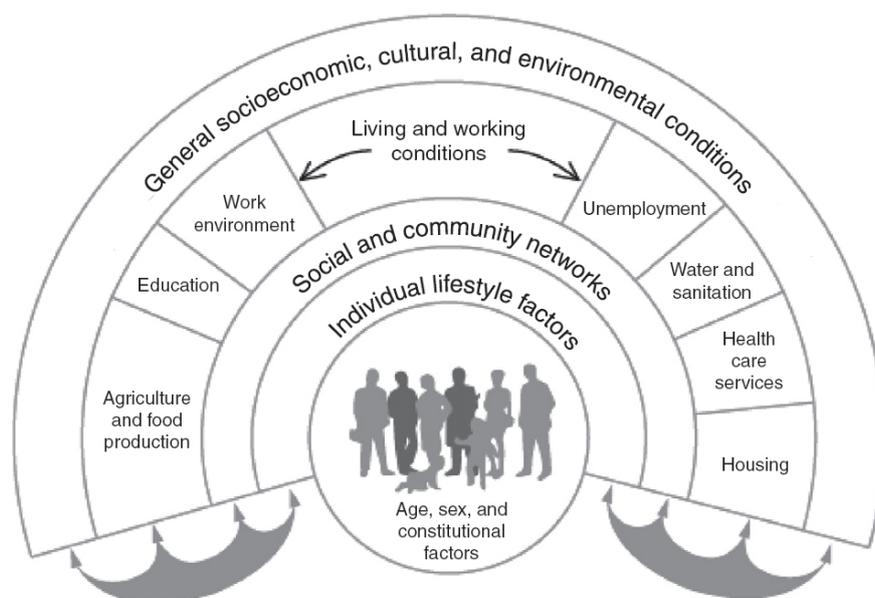
Figure 2: The socio-ecological model of health determinants.
Source: Dahlgren and Whitehead, 1993 [21].

The model shows the individual placed in the centre, having several fixed individual characteristics, such as sex, age, and constitutional factors. Encircling the individual are the factors that influence health, such as individual lifestyle factors, social and community networks, and structural factors such as living and working conditions. As illustrated by the arrows in the model, the different levels in the model interact.

2.3.1 How neighbourhood context can affect health

The shift in the focus from social-cognitive towards socio-ecological models of health behaviours has increased the interest in the importance of environmental factors for health and health behaviours, which is also supported by the growing body of evidence for neighbourhood effects on health [55,144]. Previous research has investigated how neighbourhood context affects the health of residents by adopting an overall conceptual model in which individual health outcomes are affected by the social and physical environment of the neighbourhood [57,94,153-155]. In a review, Diez Roux and Mair (2010) summarized several intermediate factors through which the social and physical environment can affect health-risk behaviour [57]. The social environment of neighbourhoods can affect residents' health through factors related to safety/violence, social relations/cohesion, norms and attitudes towards health behaviour, and social support. Residents can affect each other's health behaviour by exchanges of norms, values, and social sanctions practiced in the neighbourhood [54,63]. For example, if a resident in a deprived neighbourhood sees neighbours bicycling, running, or buying healthy food, the resident is more prone to replicate this behaviour [156]. The physical environment can affect health behaviour through the built environment, aesthetic quality/natural spaces, quality of housing, and the availability of and access to healthy food and recreational facilities [54,63].

People create places, and places create people

The differences in health behaviour between neighbourhoods have often been suggested to be the result of differences in the kinds of residents living in these neighbourhoods (a compositional explanation), or because differences in the characteristics of the neighbourhoods (a contextual explanation) [55,68]. The compositional explanation indicates that differences in health behaviour result from similar people (in terms of personal characteristics related to health) clustering together in neighbourhoods. This clustering can stem from personal preferences, for instance because of a common cultural background, or lack of choice of neighbourhood due to financial resources. In the present thesis, I focus mainly on compositional effects, including an examination of how different individual factors affect health-risk behaviour in deprived neighbourhoods.

The contextual explanation focuses on the beneficial or harmful health effects of the characteristics of the neighbourhoods themselves [157]. In contrast to the compositional explanation, the contextual explanation indicates that people with similar personal characteristics can expect to have different health behaviour depending on where they live [157]. The compositional-contextual distinction has previously been

criticized for not recognizing that there is a mutually reinforcing and reciprocal relationship between people and place [55,155,158]. The debate has led to a more holistic approach suggesting that there is a reciprocal relationship, i.e. where people affect neighbourhoods, and neighbourhoods affect people [55,153,155,158]. As stated by Macintyre and Ellaway (2003): "*people create places, and places create people*" (Macintyre and Ellaway, 2003: 26) [158].

The sociodemographic and socioeconomic composition of residents shapes the resources available within a neighbourhood (e.g. residents with high SES might help to improve neighbourhood resources), which in turn can be affected by the resources available, (e.g. low neighbourhood resources may be a reason for a resident to move to another neighbourhood with more resources) [159]. The choice of neighbourhood may not always be a free choice, but may be influenced by personal restrictions or desires such as financial resources, distance to work, cultural or ethnical background, reputation of the neighbourhood, resources provided in the neighbourhood, etc. I see neighbourhoods as dynamic, as their contextual and compositional characteristics change over time, and thus adopt a dynamic understanding of the influence of social context on health-risk behaviour in deprived neighbourhoods. It is not only the neighbourhood (social context) that acts on individuals, but individuals are constantly re-creating the conditions of the neighbourhood. The social context is therefore a reflection of both the neighbourhood and the characteristics and behaviour of the individuals living there. Neighbourhoods cannot influence individuals' health-risk behaviour without groups of individuals who are influencing the neighbourhood through their behaviour [160]. Thus, there is dialectic between the neighbourhoods and the residents living there, which is in accordance with the sociological approach to reciprocal processes between context (structure) and behaviour (action) given by Giddens [161].

The higher prevalence of unhealthy behaviours among people with low SES can therefore partly be due to direct or indirect effects from their neighbourhood of residence [144]. People with low SES living in a deprived neighbourhood can therefore be considered to be exposed to double disadvantages [162]. Here it is relevant to mention environmental justice, which has been defined as the unequal exposure to and burden of harmful environmental conditions experienced by people of lower SES [163]. To achieve environmental justice (with all people having equal access to health-promoting environments), it is important to improve neighbourhood conditions for low socioeconomic groups [144].

Conceptualization of deprived neighbourhoods

There is no clear definition of *neighbourhood*, although many researchers describe it as the area within a defined distance or radius from a person's home [164]. The term neighbourhood deprivation is a frequently used term but has no single definition [54]. It has been argued that if disadvantaged people are concentrated in a geographically defined area, then disadvantage becomes a characteristic of the area as well [165]. In this thesis, *deprived neighbourhood* is thus defined as a geographically bounded area with a high proportion of adults with low SES, as characterized by indicators such as unemployment, low income, low education,

and low-paying jobs. A corresponding definition of deprived neighbourhood has been used in other Danish studies on neighbourhood deprivation and health [166-168]. Ross and Mirowsky (2001) claim that the disadvantage of neighbourhoods may take two forms: physical disorder such as abandoned buildings, noise, graffiti, vandalism, filth, and disrepair; and social disorder such as crime, loitering, public drinking or drug use, conflicts, and indifference [169]. Thus the composition of the residents in a neighbourhood influences the physical and social disorder of a neighbourhood, which in turn can affect the health of the residents. This emphasizes the mutually reinforcing and reciprocal relationship between residents and their neighbourhood that was described in the section 2.3.1.

2.4 The psychosocial framework of health behaviour

The psychosocial perspective has also received increasing attention in the explanation of health inequalities [26]. As stressed by Elstad (1998), the study of health inequalities should consider both material and psychosocial environment, and their mutual interaction [170]. The psychosocial framework addresses the behavioural and endogenous biological responses to human interactions [171]. In focus is the "*health-damaging potential of psychological stress*" (Elstad, 1998: 600) [170], as "*generated by despairing circumstances, unsurmountable tasks, or lack of social support*" (Elstad, 1998: 601) [146,170]. Elstad (1998) have identified three core assumptions in the psychosocial perspective in regard to social inequalities in health: (1) the distribution of psychological stress is an important determinant of health inequalities in present-day affluent societies, (2) psychological stress is strongly influenced by the quality of social and interpersonal relations, and (3) the latter are determined to a large extent by the magnitude of society's inequalities [170]. Factors such as perceived stress, social isolation, and loneliness therefore seem to play an important role in the adoption and maintenance of health-related behaviour. In the following sections, the conceptual perspectives of perceived stress, loneliness, and social isolation on health-risk behaviour are presented.

2.4.1 A perceived stress and coping perspective on health-risk behaviour

Three different approaches can be used to study stress: epidemiological, psychological, and biological approaches [172]. In this thesis, I apply the psychological model in my understanding of health-risk behaviour as a coping tool regarding the experience of perceived stress. The psychological perspective arises from the recognition that the same event can be experienced as stressful for some individuals but not for others [173]. Researchers with the psychological perspective generally define stress as an experience that occurs when individuals simultaneously appraise events as threatening or harmful and their coping resources as inadequate [173]. Therefore, the experience of a stressful event depends on how such an event is interpreted by the individual. When an individual experiences a potential stressful event, he or she appraises the situation and evaluates the available coping resources: if the individual perceives the environmental demands to be greater than the available coping resources, the individual considers him or

herself as stressed [172]. It is the specific recognition of coping resources as mediating processes that makes this the model of choice for the present thesis. As described in section 1.4.2, previous research has also suggested that coping may act as a mediator between stress and health-risk behaviour.

This approach is represented by Lazarus and Folkman's (1966) Transactional Model of Stress and Coping [174,175], which provides a conceptual framework for understanding health-risk behaviour as a coping tool for perceived stress. The model construes stressful experiences as person–environment *transactions,* in which the impact of an external stressor is mediated by the person's appraisal of the stressor and the psychological, social, and cultural resources at his or her disposal [176-178]. The model proposes that people appraise both the degree of potential threat posed by events (primary appraisal) and the availability of resources needed to cope with them (secondary appraisal) [173]. A threat appraisal without the belief that effective coping responses are available is experienced as stress. The model distinguishes between problem-focused and emotion-focused coping strategies [175]. Problem-focused coping strategies are directed at changing the stressful situation including active coping, problem solving, and information-seeking [178]. Emotion-focused coping strategies are the way one thinks or feels about a stressful situation such as seeking social support, avoidance, and denial and can result in health-risk behaviours such as smoking or poor eating habits [178]. The model assumes that problem-focused coping strategies are most adaptive for stressors that are changeable, whereas emotion-focused strategies are most adaptive when the stressor is unchangeable or when this strategy is used alongside problem-focused coping strategies [178]. Reactions to stressors can promote or prevent health behaviour, and influence the individual's motivation to practice a behaviour that promotes general health [178]. Altered health behaviour, such as beginning to smoke, can thus be viewed as a way of coping with feelings of stress [179].

Conceptualization of perceived stress and coping

I conceptualize *perceived stress* as the degree to which a situation in one's life is appraised as stressful [180], and items from Cohens Perceived Stress Scale (PSS) have been used to operationalize the level of perceived stress [180]. The PSS focuses on the individual's experiences during the last month and assesses the degree to which the individual feels that the demands in their lives exceed their ability to cope effectively [173]. Based on Lazarus and Folkman (1984) [175], I conceptualize coping as the cognitive and behavioural efforts of an individual to manage the internal and external demands experienced during a specific stressful situation. This definition indicates that coping responses are not fixed and are changeable throughout an intervention.

2.4.2 Social relationships and health behaviour with focus on social isolation and loneliness

Different conceptual models for social relationships and health have been suggested within social epidemiology [83,181]. In general, the models describe social relationships by their structural and functional features. The structural aspects relate to the structure of the social network, such as the size of

the social network and the frequency of contact between its members. The functional aspects relate to the function of the social network, such as a person's perception of the quality of the support provided [182]. My hypothesis about how social isolation and loneliness influence health-risk behaviour is based on the conceptual model developed by Berkman, where she links social relationships (as she denoted social networks) and health [83]. This model is rooted in social epidemiology, where social relationships are part of a larger conceptual framework. Social relationships are embedded between upstream and downstream factors, where the structure of social relationships is a consequence of *upstream social-structural conditions* (macro) such as socio-cultural factors, socioeconomic factors, politics, and social change, while *social relationships* (mezzo) function as the structure through which downstream factors such as *psychosocial mechanisms* (micro) including social support, social influence, social engagement, person-to-person contact, access to resources and materials, and negative social interactions can be transferred. These factors are linked downstream to behavioural, psychological, and physiological pathways that may influence health [83]. In Berkman's model, the mezzo level focuses on the structure and characteristics of social relationships (including the level of social integration), while the perceptions of the relationships (such as the feeling of loneliness) operate at the micro level.

In the following, I briefly describe the psychosocial mechanisms of how social isolation and loneliness may affect health-risk behaviour, with focus on social support and social influence. *Social support* refers to the resources provided by others in a person's social network and may consist of instrumental and financial support; informational support; appraisal support; and appraisal support [83]. Social support has been hypothesized in the epidemiological literature to be one of the key mechanisms by which social relationships influence health [183]. People who are socially isolated and feel lonely may have reduced access to social support, which may be due to few or no social relationships, or because they do not feel they can rely on their relationships [184]. *Social influence* includes a variety of ways that social relationships can influence norms around, for example, health behaviour. People who are socially isolated and feel lonely may not be exposed to health-promoting behaviours, but are also not exposed to negative social influences on their health behaviour. Thus, social relationships can influence health behaviour through social support (e.g. diffusion of knowledge) for health behaviour decisions, and moreover by providing the possibility for people to share health behaviour norms through informal social control [83]. In addition, social relationships can influence psychosocial processes by providing or not providing (as in the case of social isolation and loneliness) opportunities for social engagement, such as meeting with family and friends or attending community events. Being part of a meaningful social context can help to develop shared values and provide a sense of belonging or attachment. Social engagement can for example enhance the ability to cope with minor stressful situations [185]. This is closely related to the Cohen's stress-buffering model, which hypothesizes that social support from relationships can affect the harmful potential of a situation by enhancing a person's appraisal of their ability to cope with a stressful event [183]. This is also connected to the perceived stress and coping perspective of health-risk behaviour described above.

Furthermore, access to social relationships and a person's perception of their social relationships may both reduce the effect of a stressful event. Lastly, the perceived functionality of a person's social relationships may buffer physiological and/or behavioural responses to a stressful event [83,174,183].

Conceptualization of social isolation and loneliness

Different concepts of social relationships have been used in health research, including e.g. social network, social integration, social isolation, and social support. In the present thesis, I have chosen to examine the concepts of social isolation and loneliness in respect to health-risk behaviour in deprived neighbourhoods. This decision was based on previous research evidence and future perspectives concerning intervention opportunities. *Social isolation* is conceptualized as an objective, quantifiable concept capturing the absence of social relationships or contacts with other people [115,116]. I have operationalized the concept of social isolation via the Berkman-Syme Social Network Index [104], which is further described in section 3.4.5. *Loneliness*, also referred as perceived isolation, is the subjective experience of being lonely related to the dissatisfaction with the discrepancy between the desired and the actual frequency of social contact [116,117]. Studying social isolation and loneliness together gives the opportunity to gain knowledge on both the objective and the perceived effects of social relationships on health-risk behaviour.

3 Materials and methods

This chapter gives an overview of the data and applied methods used in the present thesis. **Table 1** summarizes the aims, designs, data sources, study populations, measures and statistical methods of the four papers in the thesis. Thereafter, the methods used in the systematic review (**paper I**) are described, followed by a description of the data material, assessment of indicators, and analytical methods of **paper II-IV**. The chapter concludes with a section on ethical considerations.

Table 1: Overview of aims, designs, data sources, study populations, exposures/predictors, outcomes, and statistical methods used in **paper I-IV**.

	Paper I	Paper II	Paper III	Paper IV
Aim	To conduct a systematic review of recent studies on health-risk behaviour among adults who live in deprived neighbourhoods compared with those who live in non-deprived neighbourhoods, and to summarize what kind of operationalisations of neighbourhood deprivation that were used in the studies	To compare the health-risk behaviours of residents in deprived neighbourhoods with those of the general population in Denmark, and to examine the associations between sociodemographic and socioeconomic characteristics and health-risk behaviours in deprived neighbourhoods	To compare perceived stress among residents in deprived neighbourhoods with that in the general Danish population, to investigate the associations between perceived stress and health-risk behaviours among residents of deprived neighbourhoods, and to examine whether perceived stress modifies the associations between SES and health-risk behaviours	To compare loneliness among residents in deprived neighbourhoods with that in the general Danish population, to investigate whether social isolation and loneliness are associated with health-risk behaviours among residents of deprived neighbourhoods, and to examine whether social isolation and loneliness modify the associations between SES and health-risk behaviours
Design	Systematic review	Cross-sectional	Cross-sectional	Cross-sectional
Data source	Previous studies investigating health-risk behaviours in deprived neighbourhoods compared with non-deprived neighbourhoods	DNHPS[a] DHMS[b]	DNHPS DHMS	DNHPS DHMS
Study population	Adult populations in western societies	Adults aged ≥18 years DNHPS; N=5,113 DHMS; N=14,686	Adults aged ≥18 years DNHPS; N=5,113 DHMS; N=14,686	Adults aged ≥18 years DNHPS; N=5,113 DHMS; N=14,686
Exposures/ predictors	Neighbourhood deprivation	Neighbourhood deprivation Sex Age Ethnic background Educational level Cohabitation status Employment status	Neighbourhood deprivation Perceived stress Disposable income Economic deprivation Strain SES	Neighbourhood deprivation Social isolation Loneliness SES
Outcomes	Health-risk behaviour[c]	Health-risk behaviour[d]	Perceived stress Health-risk behaviour[d]	Social isolation Loneliness Health-risk behaviour[d]
Confounders	N/A	Sex Age Ethnic background Educational level Cohabitation status Employment status[e]	Sex Age Ethnic background Educational level Cohabitation status Employment status	Sex Age Ethnic background Educational level Cohabitation status Employment status
Statistical methods	N/A	Logistic regression	Logistic regression	Logistic regression

[a]Deprived Neighbourhood Health Profile Survey.
[b]Danish Health and Morbidity Survey 2010.
[c]Includes behaviours such as no or low consumption of fruits and vegetables, smoking, binge drinking or high-risk alcohol intake, and physical inactivity.
[d]Includes a low intake of fruit or vegetables, daily smoking, heavy smoking, high-risk alcohol intake, physical inactivity, and the co-occurrence of health-risk behaviours.
[e]These confounders were used in the comparison of health-risk behaviours in deprived neighbourhoods and the general population in **paper II**. The same indicators were used as predictors when examining the associations between sociodemographic and socioeconomic characteristics and health-risk behaviours in deprived neighbourhoods in **paper II**.

3.1 Systematic review (paper I)

A systematic literature review of epidemiological studies was conducted to assess the currently available evidence on health-risk behaviours in deprived neighbourhoods compared with those of non-deprived neighbourhoods (**paper I**) [63]. The PRISMA principles for systematic reviews were used as the reporting guidelines for the review [186,187]. An overview of the methods of the systematic review is presented in the following section. For a more detailed description of the methods, see **paper I** [63].

3.1.1 Data collection, inclusion criteria, and data extraction

Studies were identified by systematically searching electronic databases (PubMed, Embase, Web of Science, and Sociological Abstracts) using relevant search terms related to deprived neighbourhoods and health-risk behaviours (see the additional S1 File for **paper I** for a complete list of the search terms used in PubMed). The search strategy was restricted to studies that had been published between 1 January 1996 and 1 July 2014. A snowballing technique was used to scan reference lists in the already identified articles to detect further articles not identified through the database search. Included studies had to (i) be published in English in peer-reviewed journals; (ii) report data from a primary study that included a sample of a general adult population (16+ years) from deprived neighbourhoods in economically developed Western regions and countries; (iii) report how the concept of deprived neighbourhoods was operationalized; (iv) be quantitative observational studies with cross-sectional or longitudinal designs; (v) include health-risk behaviours such as either no or low consumption of fruits and vegetables, smoking, binge drinking or high-risk alcohol consumption, and physical inactivity as outcomes; (vi) compare risk estimates in deprived neighbourhoods with those in non-deprived neighbourhoods; (vii) adjust for at least one confounder besides sex and age; and (viii) be based on data from after 1996, as data prior to 1996 were considered outdated. Studies were initially screened by title and abstract and afterwards by full-text to assess eligibility according to the inclusion criteria [63].

3.1.2 Synthesis of studies

The results of the included studies were summarized in coding schemes (see tables in **paper I**) and synthesized qualitatively [63]. To asses risk of bias in the reviewed studies, the standardized quality assessment tool for quantitative studies from the Effective Public Health Practice Project [188] was used. This tool is recommended by the Cochrane Collaboration and involves assessment of selection bias, study designs, confounders, data collection methods, and approaches to analyses [63].

3.2 Study design and data sources of paper II-IV

The studies in **papers II-IV** were based on existing cross-sectional data from the *Deprived Neighbourhood Health Profile Survey* (DNHPS) and the *Danish Health and Morbidity Survey 2010* (DHMS).

3.2.1 The Deprived Neighbourhood Health Profile Survey

Data from the Deprived Neighbourhood Health Profile Survey (DNHPS) were provided by the Danish Health Authority. The DNHPS was part of the Danish Health Authority project 'Forebyggelsesindsatser i nærmiljøet' [Prevention Efforts in the community] [189], which was undertaken with funds targeting the social aspects of health and wellbeing [Satspuljeaftale] in 2010-2013 with a total grant of 87.6 million DKK. The overall objective of the project was to enhance the well-being and health of less resourceful residents. Municipalities were invited to apply for funds for prevention and health promotion initiatives in neighbourhoods with a high concentration of less resourceful residents [190]. Prior to the studies included in the present thesis, the DNHPS had not been used in research, and the researchers involved in this PhD project had exclusive access to the data.

Sampling

The DNHPS was not designed to be used in research projects, and thus the Danish Health Authority did not have any specific pre-defined criteria for the selection of deprived neighbourhoods. However, there were a number of criteria the municipalities had to fulfil to be selected as a project municipality. They had to provide evidence for the need and potential for health interventions in a relevant geographically bounded neighbourhood with a high proportion of less resourceful residents (for example, people on transfer income or with poor connection to the labour market). No specific criteria regarding demographic or socioeconomic characteristics were specified in the call for proposals by the Danish Health Authority [190], but the selection of deprived neighbourhoods was based on the following criteria [190]:

- Establishment of new prevention and health promotion interventions that qualified and expanded existing interventions in the local area
- Presentation of a model (selected by the Danish Health Authority) for recruitment and retention of less resourceful residents in interventions
- Location to represent a geographical distribution of deprived neighbourhoods in Denmark
- The readiness of the neighbourhood to work with an overall multidisciplinary approach
- Anchoring perspectives of the project, i.e. the extent to which the intervention would continue in the same or a revised form after project completion
- Extent of any local co-financing.

Setting

The 12 municipalities that were selected for the project were Esbjerg, Herlev, Hjørring, Høje-Taastrup, Køge, Langeland, Lolland, Silkeborg, Struer, Svendborg, Thisted, and Aalborg (**Figure 3**). It is important to emphasize that we did not have access to the concrete addresses of the deprived neighbourhoods, as we

only had access to the anonymized data and thus only knew the name of the municipality and of the area in which each neighbourhood was located.

Figure 3: Map of Denmark showing the geographical location of the 12 project municipalities. Source: NIRAS, 2015 [191].

Data collection

The DNHPS data were collected from January to March 2011 by SFI – the Danish National Centre for Social Research, a sector research institution under the Ministry of Social Affairs and the Interior. To accommodate the needs of the generally high proportion of non-Western immigrants in deprived neighbourhoods, information about the survey in Danish, English, Turkish, Arabic, and Serbo-Croatian was sent by postal letter prior to data collection [167]. The survey was conducted mainly through telephone interviews, supplemented by face-to-face interviews in the respondent's home with the use of interpreters to increase the participation of people of non-Danish ethnic background. A study from 2013 showed that the response rate in the DHMS was significantly lower among persons with other ethnic backgrounds than Danish compared to ethnic Danes, typically because of difficulties with understanding and completing the questionnaire [192].

The DNHPS questionnaire was designed by the Danish company NIRAS in collaboration with researchers from University of Southern Denmark (SDU) and approved by the Danish Health Authority. The

questionnaire consisted of 62 standardized questions and was prepared in accordance with previous research [193,194]. Most of the questions were identical to those used in the DHMS [193] and dealt with the following topics: general health, disease and individual deprivation, trust and security in the local community, social relations, stress, physical activity, diet, smoking, alcohol, and sociodemographic and socioeconomic characteristics.

Study population

A total of 22,659 persons aged 18 years or older lived in the 12 neighbourhoods studied. In each municipality, relevant addresses of the residents in the neighbourhood were identified in collaboration with a local project manager. The DNHPS was based on a stratified random sample of 8,835 households, where residents aged 18 years or older were invited to participate in the survey. The gross sample extraction in each neighbourhood comprised either of 800 households or in neighbourhoods with less than 800 households of all households. In Hjørring, the gross sample extraction covers all 888 households, since many uninhabited or temporarily vacated addresses in the neighbourhood required that the original household extraction was supplemented with all remaining well-known households. One person from each household was selected for interviewing, using quota sampling with respect to sex and age. A total of 5,113 interviews were undertaken, giving a response rate of 63% [71]. **Table 2** shows the number of households, number of residents aged 18 or older in the neighbourhood, the size of the gross sample, and the number of completed interviews in each of the 12 deprived neighbourhoods [191,195].

Table 2: Overview of the 12 deprived neighbourhoods.

Municipality and neighbourhood	Number of households[a]	Number of residents aged ≥18[b]	Number of gross sample	Number of completed interviews	Response rate (%)
Total	1,255 (average)	22,659	8,835	5,113	63.0
Esbjerg (Sædding, Ådalsområdet)	1,690	2,519	800	483	62.0
Herlev (Hjortegården, Lille Birkholm I, II & lll)	1,991	3,025	800	427	54.7
Hjørring (Hjørring Vestby)	575	777	*888	372	69.8
Høje-Tåstrup (Gadehavegård)	963	1,441	800	463	59.7
Køge (Ellemarken)	1,110	1,689	800	442	56.3
Langeland (Sydlangeland)	1,755	2,957	800	571	73.5
Lolland (Maribo Øst (Margrethevænget, Østre Park))	203	303	226	134	68.4
Silkeborg (Arendalsvej)	638	868	675	408	65.4
Struer (Thyholm)	1,586	2,715	800	560	73.4
Svendborg (Hømarken (Byparken, Skovparken))	741	922	800	419	61.5
Thisted (Solsikkeområdet)	611	828	646	407	66.6
Aalborg (Aalborg Øst)	3,190	4,615	800	427	54.2

[a]Number of households in the neighbourhoods registered by Statistics Denmark 1/1 2010.
[b]Number of residents aged 18 or older in the neighbourhoods registered by Statistics Denmark 1/1 2010.
*The local project managers found more households in the deprived neighbourhood in Hjørring than Statistics Denmark had registered.

3.2.2 The Danish Health and Morbidity Survey 2010

Data on the deprived neighbourhoods were compared with data on the general Danish population that were extracted from the Danish Health and Morbidity Survey 2010 (DHMS). This was a cross-sectional national health survey among the adult population (16 years or older) carried out by the National Institute of Public Health (NIPH) at SDU [193].

Sampling

The DHMS was based on data from 25,000 randomly selected adults (16 years or above) from the Danish Civil Registration System [196].

Data collection

The selected persons were mailed a postal questionnaire and a letter of introduction that briefly described the aims and content of the survey. The letter of introduction invited the selected persons to complete either

the postal questionnaire or an identical web questionnaire. The NIPH conducted the survey from February to April 2010.

Study population

In total, 15,165 adults completed the questionnaire (response rate was 61%) [193]. The study's comparison group included persons aged 18 years or above (N =14,686), reflecting the age distribution of the residents of the deprived neighbourhoods [71].

3.4 Assessment of indicators

The different indicators examined in the analyses in **paper II-IV** are described below. The variables were dichotomized, and cut-off points were chosen based on conceptual considerations.

3.4.1 Assessment of sociodemographic and socioeconomic characteristics

The sociodemographic and socioeconomic characteristics examined were sex, age, ethnic background, educational level, employment status, and cohabitation status. These were self-reported in the DNHPS, while in the DHMS, information on the respondents' sex, age, and ethnic background was extracted from the Danish Civil Registration System [196]. Ethnic background was classified into three groups: (a) Danish background, other (b) Western background (from the 28 European Union member states and Andorra, Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland, Vatican City, Canada, the United States of America, Australia, and New Zealand) or (c) Non-Western background (all other countries). Cohabitation status, the highest level of education completed, and employment status were based on self-reported data. Cohabitation status was classified in two groups: (a) Cohabiting and (b) Living alone. Education was classified in accordance with Statistics Denmark's definition of the highest completed education, ranging from "No education/Basic school" to "Long-cycle higher education [197]. Employment status was classified in six groups: (a) Employed; (b) Unemployed; (c) Student; (d) Disability pensioner; (e) Early retirement/age pensioners; and (f) Other non-employed.

An SES index was constructed from highest educational level and employment status and was dichotomized into (a) Low and (b) Medium/high SES, where the former category included respondents who had not studied beyond primary school and not were employed.

3.4.2 Assessment of health-risk behaviour

In the present thesis, four domains of health-risk behaviour were measured: low intake of fruit or vegetables, smoking (daily and heavy smoking, respectively), high-risk alcohol intake, and physical inactivity.

In the DNPHS the intake of fruit and vegetables was assessed by the following question: "How often do you eat fruit or vegetables?" In the DHMS the intake of fruit and vegetables was assessed by two separated questions. The question on fruit in DHMS was: "How many portions of fruit do you usually eat?", and the

question on vegetables was: "How often do you eat the following kinds of vegetables?" with the possibility to differentiate between: "Mixed salad, crudités"; "Other raw vegetables"; and "Prepared vegetables (cooked, baked, fried, cooked together or wok dishes)". A low fruit or vegetable intake was defined as respondents who did not eat fruit or vegetables every week and was categorized as "Low intake of fruit or vegetables".

Daily smoking was measured by asking the respondents whether they currently smoked each day. Daily smoking was assessed by the question: "Do you smoke?" that had response options of: *Yes*; and *No*. An affirmative response led to further specification as how often the respondent smoke (*Daily*; *At least once a week*; or *Less than once a week)*. In the DHMS, daily smoking was measured by an identically worded single question, but offering the following response categories: *Yes, every day*; *Yes, at least once a week*; *Yes, less often than every week*; *No, I have stopped*; and *No, I have never smoked*. Respondents who reported that they smoked on a daily basis were also asked to specify how many cigarettes they smoked per day. The prevalence of heavy smoking (15 or more cigarettes per day) was calculated on this basis.

The question used to assess alcohol intake in the DNHPS was: "How many standard drinks do you usually drink per week?", and in the DHMS the question was beverage-specific: "How many standard drinks do you typically drink on each of the days during the week?" The "sensible drinking" limits recommended by the Danish Health Authority were applied for the definition of high-risk alcohol intake (>14 standard drinks per week for women and >21 standard drinks per week for men) [40].

Physical inactivity was defined using a question about the respondent's typical level of physical activity in their leisure time during the past 12 months in terms of four pre-defined categories: *Heavy exercise and competitive sports regularly and several times a week*; *Exercise or heavy gardening at least four hours a week*; *Walking, biking or other light exercise at least four hours a week (include Sunday excursions, light gardening and cycling or walking to work)*; and *Reading, watching TV or other sedentary activity*. The latter category was used to define physical inactivity.

The questions used to assess health-risk behaviour were not validated, although the question on alcohol intake for each day of the week used in the DHMS has been shown to be feasible for use in epidemiological studies [198]. The question on physical activity has been used in the Danish Health and Morbidity surveys for 30 years, and it has been used to predict cardiovascular morbidity and mortality [199].

Information on the co-occurrence of health-risk behaviours was based on a risk factor score calculated by adding the number of the respondent's health-risk behaviours in relation to fruit and vegetable consumption, smoking, alcohol intake, and physical activity. In calculating the risk factor score, the following four health-risk behaviours were chosen: low intake of fruit or vegetables; daily smoking; high-risk alcohol intake; physical inactivity. Each health-risk behaviour was given a value of 1; a risk factor score of 4 thus means that the respondent has a low intake of fruit or vegetables, is a daily smoker, exceeds the high-risk drinking limits, and is physically inactive. In contrast, a risk score of 0 indicates that the respondent eats fruit or vegetables each week, is a non-smoker, does not exceed the high-risk drinking limits, and is not physically

inactive [71]. We assessed co-occurrence by two separate indicators: (1) Having two or more health-risk behaviours; and (2) Having three and more health-risk behaviours.

3.4.3 Assessment of perceived stress

Perceived stress was measured using four questions that are a part of the Perceived Stress Scale (PSS) and describe life stress in terms of feeling in control [180]. The specific questions were:

- "In the last month, how often have you felt nervous or stressed?"
- "In the last month, how often have you found that you could not cope with all the things that you had to do?"
- "In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?"
- "In the last month, how often have you felt that you were on top of things?"

The response categories were: *Never; Almost never; Sometimes; Fairly often;* and *Very often*. Responses to the three first questions were dichotomized into (a) *Very often/Often* and (b) *Never/Almost never/Sometimes*, with (a) indicating a high level of stress. Responses to the last question was dichotomized into (a) *Never/Almost never* and (b) *Sometimes/Often/Very often*, with (a) indicating a high level of stress. The second question "In the last month, how often have you found that you could not cope with all the things that you had to do?", used in the DHMS, was slightly modified in the DNHPS into: "In the last month, how often have you found that you could not cope with the things you would like to achieve in your daily life?"

An index of perceived stress was constructed based on the four items and was computed by summing the responses on the items. Perceived stress was defined by having one or more indicators of high level of stress. The applied measurement of perceived stress has not been validated, but the questions used to measure perceived stress are included in Cohen's PSS, which is a validated stress scale [180].

3.4.4 Assessment of disposable income, economic deprivation, and strain

The median minimum disposable income after fixed expenses among the residents of the deprived neighbourhoods was calculated to be DKK 4,000 per month (approximately USD 700/GBP 450, at 2011 currency rates of exchange) [166]. This level of disposable income was used as a cut-off point for comparing worse-off and better-off residents of the deprived neighbourhoods. Monthly disposable income was thus dichotomized into (a) Low disposable income (< DKK 4,000) and (b) High disposable income (≥ DKK 4,000).

Economic deprivation is defined as a situation in which an individual or family has been unable to pay their bills, afford dental check-ups, and buy birthday presents, medicine, clothes, and other items within the last

year [166]. The economic deprivation variable was dichotomized into (a) Having economic deprivation and (b) Not having economic deprivation.

Strain was measured using a question about whether, in the past year, the respondent had been strained by finances, housing situations, work situations, their relationship with their partner or children, illness in the family or among close friends, etc.

It was not possible to examine disposable income, economic deprivation, and strain in the general population, as none of these topics were included in the DHMS.

3.4.5 Assessment of social isolation

The assessment of social isolation was based on a measure of the individual's social network, in the form of a modified version of the Berkman-Syme Social Network Index, which assesses the degree of social integration [104].

The question used to assess cohabitation status was: "Who do you live with in your family?" with response categories of: *You live alone, with no children*; *You live alone, with one or more children*; *You live with your spouse/cohabitant, with no children*; *You live with your spouse/cohabitant, with one or more children*; *You live with your parents*; and *Other*. Responses were dichotomized into (a) Cohabitating and (b) Living alone (the two first response categories).

The questions used to assess contact frequency with family and friends were: "How often do you meet with your family, you do not live with?" and "How often do you meet with your friends and acquaintances?" with response categories of: *Daily; Several times a week; Several times a month; Less often than once a month;* and *Never*. Responses were dichotomized into (a) *daily or several times a week/month* and (b) *less often than once a month/Never*, with (b) indicating the most isolated status.

Membership of voluntary organizations was assessed using the question: "Are you a member of an association or network where you do volunteer work?" The response categories were: *Yes, I am a member of one or more associations; I have previously done volunteer work in an association or network, but do not do so currently*; and *No, I do not do voluntary work in an association or a network*. Responses were dichotomized, with the third response category indicating the most isolated status.

Ranging between 0 and 4, the social network index scores were categorized according to the standard described by Berkman and Syme [104], into either 0–1 (most isolated), 2 (moderately isolated), 3 (moderately integrated), and 4 (most integrated). Social isolation was then dichotomized into (a) Socially isolated (most/moderately isolated) and (b) Non-socially isolated (moderately/most integrated).

The measure used in **paper IV** was a modified version of the Berkman-Syme Social Network Index, which is a validated tool in categorising the level of social networks in previous studies [200]. Thus the presently used index for social isolation is not a validated index.

3.4.6 Assessment of loneliness

Loneliness was assessed by the question: "Are you ever alone, although you would prefer to be together with other people?" that had response options of "Yes" and "No". An affirmative response led to further specification as to whether the respondent felt unwillingly lonely (*Often*; *Occasionally*; and *Rarely).* In the DHMS, loneliness was measured by an identically worded single question, but offering the following response categories: *Yes, often*; *Yes, occasionally*; *Yes, rarely*; and *No*. Loneliness was dichotomized into (a) Lonely and (b) Non-lonely, with the "Often" response leading to categorization as "Lonely". The measure of loneliness is not validated, but has been used in many previous studies on loneliness [137].

3.5 Analytical methods

The following sections describe the analytical methods used in the studies included in the thesis, including the development of the indices for perceived stress and social network, the statistical analyses applied, the handling of missing values, and the use of weights.

3.5.1 Development of the index for perceived stress

As described in section 3.4.3, the measure of perceived stress was based on four questions. Exploratory factor analysis (EFA) was used for preliminary exploration of whether it was possible to construct an index of the items for perceived stress using varimax rotation (orthogonal). The EFA confirmed the possibility of forming a single factor for perceived stress with good internal consistency (Cronbach's alpha coefficient of 0.79; the results are presented in Additional file 1, Table A1 in **paper III**). A Cronbach's alpha coefficient equal to or above 0.7 is considered to indicate good internal consistency [201]. A complete case analysis was performed due to missing data; as the results were the same for all cases and complete cases, the missing values were assumed not to have affected the results.

3.5.2 Development of the index for social network

To measure social isolation, an index for social network was developed using the four questions described in section 3.4.5. The four questions were selected on a theoretical basic (as described in section 3.4.6) and a confirmatory factor analysis (CFA) was, therefore, used for preliminary exploration of whether it was possible to construct an index of the items for social network. CFA of this index for social network showed a root mean square error of approximation (RMSEA) of 0.0768. The RMSEA should ideally be 0.05 or less to indicate a good model fit, but a value of 0.08 or less is also acceptable [202]. The standardized root mean square residual (SRMR) was 0.0312, where an SRMR value of 0.08 or less indicates an acceptable model [203]. The Bentler Comparative Fit Index was 0.8228, where a value of 0.90 or greater is considered acceptable [203]. Overall, the values of the CFA for the constructed social network index were considered to show an acceptable model fit.

3.5.3 Statistical analyses

The statistical analyses used in the studies (**paper II-IV**) are described briefly here. For a more detailed description, please see **papers II-IV**.

Multiple logistic regression analyses were used in all analyses examining associations (**paper II-IV**). The results were presented as odds ratios (OR) with 95% confidence intervals (CI). The regression models were adjusted for sex, age, ethnic background, highest completed educational level, and cohabitation status. The selection of confounders was based on existing knowledge of their association with the exposure and outcome examined. When models were adjusted for educational level, the analyses were restricted to individuals aged 25 years or older, as a relatively large proportion of younger individuals are students. When adjustment for employment status was made, the analyses were restricted to respondents aged 25–64 years and to employed, unemployed, disability pensioners, and other non-employed (includes housewives, people on long-term sick leave, rehabilitated, benefit claimant and non-classifiable people).

Chi-square (χ^2) tests were used to determine statistically significant differences between sub-groups for categorical variables. A p-value below 0.05 was used as a cut-off point for statistical significance. Analyses of modification included interaction analyses by including a product term in the multiple logistic models of the examined indicators in **paper III-IV**. Furthermore, the joint effect of SES and the examined indicators was investigated to identify their combined effects on health-risk behaviours.

All analyses were carried out using SAS version 9.3.

3.5.4 Missing values

The response categories in the DNHPS questionnaire offered a "Do not know" category, which was coded as "Missing". Generally, there were low rates of missing data with less than 5% missing for most items in both surveys.

3.5.5 Weights

The estimates from the DHMS were weighted to reduce non-response bias, as proposed by Särndal and Lundström [204]. The weights were computed by Statistics Denmark based on register information on e.g. sex, age, educational level, income, and ethnic background for all persons invited to participate in the DHMS [193]. Thus, those who were less likely to respond on the questionnaire were given a higher weight in the analyses to represent the larger number of non-respondents with similar characteristics. Correspondingly, those who were more likely to respond were given a lower weight [197].

3.6 Ethical considerations

All the participants in the DNHPS and the DHMS were informed of the surveys' aims and content and that any information provided would be treated with confidence. The questionnaire data were anonymized before we were given access to the data. In Denmark, there is no formal institution for ethical assessment

and approval of questionnaire-based population studies. No ethical approval or written consent was required for the types of studies performed in the present thesis. The DNHPS and the DHMS were both approved by the Danish Data Protection Agency.

4 Results

In this chapter a summary of the main results of **paper I-IV** is presented.

4.1 Review of health-risk behaviour in deprived neighbourhoods compared with non-deprived neighbourhoods (paper I)

In **paper 1** the aims were to systematically review recent studies on health-risk behaviour among adults who live in deprived neighbourhoods compared with those who live in non-deprived neighbourhoods, and to summarize what kind of operationalisations of neighbourhood deprivation that were used in the studies.

Figure 4 shows a flow diagram of the identification, screening, eligibility assessment, and inclusion of the studies in the systematic review [186]. Out of 4,361 eligible studies, 22 studies were included in the systematic review [63].

The operationalization of neighbourhood deprivation varied widely between the studies. Ten studies used different predefined indexes [46,47,61,64,205-210], while two studies investigated deprived neighbourhoods by SES indicators such as education, occupation, and unemployment, which were aggregates of individual-level variables derived from census and survey data [211,212]. Two other studies used a summary score and a composite index of various SES indicators [213,214]. Six studies operationalized neighbourhood deprivation using different indicators [215-220], and two studies used a single indicator [221,222]. For a description of the operationalizations of neighbourhood deprivation used in the reviewed studies, see Table 2 in **paper I**.
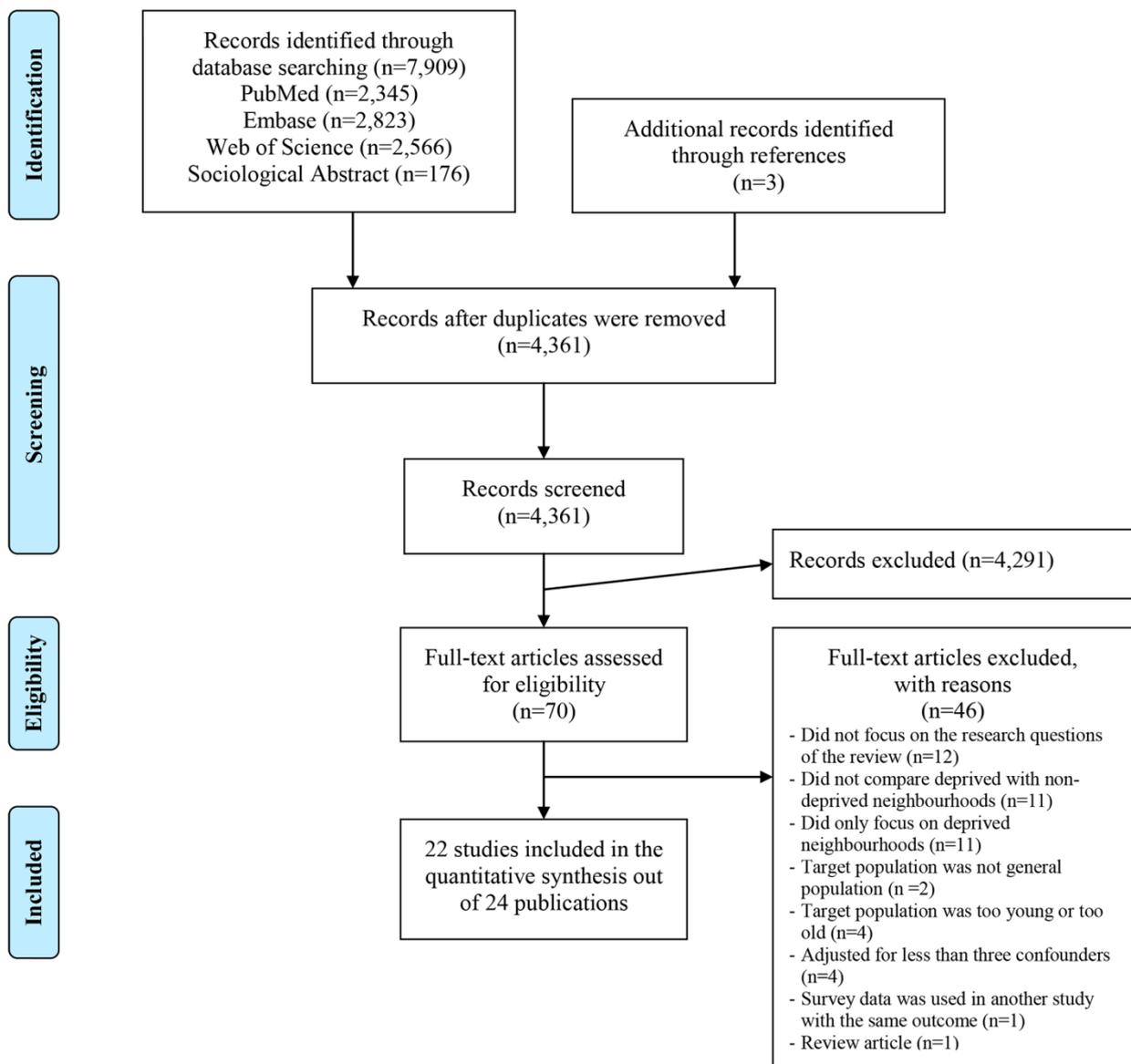
Figure 4: Flow diagram showing the literature search strategy [63].

The systematic review provided substantial evidence that residents in deprived neighbourhoods have higher risk of smoking and physical inactivity compared with non-deprived neighbourhoods.

Most of the studies found a positive association between living in deprived neighbourhoods and current smoking [46,47,61,205,207,208,212-215,218-220]. The majority of the reviewed studies found an association between living in deprived neighbourhoods and being physically inactive [47,61,62,205,210,214,215,220,223]. Mixed results were found regarding low fruit and vegetable consumption and alcohol consumption. Half of the studies found a positive association between living in deprived neighbourhoods and low consumption of fruit and vegetables [46,209]. Two studies found a positive association between living in deprived neighbourhoods and binge drinking [47,206]. The East of England Lifestyle Survey found a negative association of living in deprived neighbourhoods and exceeding recommended alcohol consumption limits [46]. See Table 3 in **paper I** for the risk estimates for health-risk behaviour in deprived neighbourhoods compared with non-deprived neighbourhoods of the reviewed studies. The ambiguous results regarding low fruit and vegetable consumption and alcohol consumption highlight the need for more research, which constituted the basis for **paper 2**.

4.2 Health-risk behaviour among residents in deprived neighbourhoods compared with those of the general population in Denmark (paper II)

The aim of **paper II** was to compare the health-risk behaviours of residents in deprived neighbourhoods with those of the general population in Denmark, and to examine the associations between sociodemographic and socioeconomic characteristics and health-risk behaviours in deprived neighbourhoods.

Table 3 shows the prevalence and ORs of health-risk behaviours among residents in deprived neighbourhoods compared with the general population in Denmark. When the analyses were adjusted for sex, age, ethnic background, and cohabitation status, residents in deprived neighbourhoods had significantly higher odds of low fruit or vegetable intake (OR: 6.34; 95% CI: 4.97-8.10), daily smoking (OR: 1.64; 95% CI: 1.51-1.78), heavy smoking (OR: 1.66; 95% CI: 1.55-1.84), physical inactivity (OR: 1.15; 95% CI: 1.04-1.27), having two or more health-risk behaviours (OR: 1.38; 95% CI: 1.23-1.56) and having three or more health-risk behaviours (OR: 1.77; 95% CI: 1.37-2.30) compared with the general Danish population. The residents in deprived neighbourhoods had lower odds of high-risk alcohol intake (OR: 0.53; 95% CI: 0.45-0.61). The results remained significant, except for physical inactivity, when the analyses were adjusted for employment status [71].

With regard to the second aim of the paper, we found that men were more likely to have health-risk behaviours (except physical inactivity) and co-occurrence of health-risk behaviour than women in the deprived neighbourhoods. The 18–24-year-olds residents had higher odds for low fruit or vegetable intake

(OR: 1.96; 95% CI: 1.42-2.71) and of having three or more health-risk behaviours (OR: 1.74; 95% CI: 1.02-2.98) compared with residents aged 25–44. Residents with non-Western background had lower odds of all health-risk behaviours (except physical inactivity) compared with residents with a Danish background. With regard to highest attained educational level, residents with no education/basic school had the highest odds for all health-risk behaviours (except for high-risk alcohol intake and having three or more health-risk behaviours). Disability pensioners had higher odds of all health-risk behaviours and of having co-occurrence of health-risk behaviours, compared with employed residents. Further, residents living alone had significantly higher odds of all health-risk behaviours and of having co-occurrence of health-risk behaviours than cohabiting residents. See Table 4 in **paper II** for the ORs of health-risk behaviours regarding the sociodemographic and socioeconomic characteristics in the deprived neighbourhoods.

4.2.1 Supplementary analyses

I performed supplementary analyses for the association between SES and health-risk behaviours among residents aged 25-64 in the deprived neighbourhoods. When the analyses were adjusted for sex and age, it was found that residents in deprived neighbourhoods with low SES had significantly higher odds of low fruit or vegetable intake (OR: 2.22; 95% CI: 1.67-8.10), daily smoking (OR: 1.69; 95% CI: 1.42-2.01), heavy smoking (OR: 1.72; 95% CI: 1.42-2.07), physical inactivity (OR: 1.82; 95% CI: 1.48-2.23), and having two or more health-risk behaviours (OR: 2.05; 95% CI: 1.65-2.54) than residents with medium/high SES. The results in regard to high-risk alcohol intake (OR: 1.10; 95% CI: 0.75-1.61) and having three or more health-risk behaviours (OR: 1.10; 95% CI: 0.75-1.61) were not statistically significant.

Table 3: Health-risk behaviours in deprived neighbourhoods and the general population. ORs with 95% CI for health-risk behaviours in deprived neighbourhoods compared with the general population.

			Unadjusted			Adjusted		
	Deprived neighbourhoods	General population	Deprived neighbourhoods			Deprived neighbourhoods		
	%	%	OR	(95% CI)	OR[a]	(95% CI)	OR[b]	(95% CI)
Fruit or vegetables								
Low intake of fruit or vegetables	7.6	0.8	**10.18**	**(8.25-12.56)**	**6.34**	**(4.97-8.10)**	**5.92**	**(4.35-8.07)**
Smoking								
Daily smoking	38.1	22.0	**2.18**	**(2.03-2.33)**	**1.64**	**(1.51-1.78)**	**1.55**	**(1.40-1.71)**
Heavy smoking	22.0	11.3	**2.22**	**(2.04-2.42)**	**1.66**	**(1.51-1.84)**	**1.53**	**(1.36-1.73)**
Alcohol								
High-risk alcohol intake	5.6	11.4	**0.51**	**(0.45-0.58)**	**0.53**	**(0.45-0.61)**	**0.46**	**(0.38-0.56)**
Physical activity								
Physical inactivity	19.1	13.7	**1.49**	**(1.37-1.62)**	**1.15**	**(1.04-1.27)**	1.11	(0.98-1.27)
Co-occurrence of health-risk behaviours								
Having 2 or more health-risk behaviours	15.1	8.4	**1.94**	**(1.76-2.14)**	**1.38**	**(1.23-1.56)**	**1.24**	**(1.07-1.44)**
Having 3 or more health-risk behaviours	3.3	1.2	**2.79**	**(2.24-3.47)**	**1.77**	**(1.37-2.30)**	**1.47**	**(1.06-2.03)**

Bold values indicate significant odds ratios (p-value <0.05).

[a] Adjusted for sex, age, ethnic background, educational level and cohabitation status. Analysis restricted to respondents aged 25 years or older.

[b] Adjusted for sex, age, ethnic background, educational level, cohabitation status and employment status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

4.3 Perceived stress, SES, and health-risk behaviour in deprived neighbourhoods (paper III)

The aims of **paper III** were threefold: First, to compare the prevalence of perceived stress among residents in deprived neighbourhood with that in the general population. Second, to examine the associations between perceived stress and health-risk behaviours among residents of deprived neighbourhoods. Third, to examine whether perceived stress modifies the associations between SES and health-risk behaviours.

Table 4 shows the prevalence and ORs of perceived stress among residents in deprived neighbourhoods compared to the general Danish population. The prevalence of perceived stress was 33.6% for residents of deprived neighbourhoods and 26.7% for the general Danish population. Compared with the general population, residents of deprived neighbourhoods had 1.30 times higher odds (95% CI 1.21–1.40) of perceived stress, when the analysis was adjusted for differences in sex, age, and ethnic background. The results remained significant when the analysis was also adjusted for differences in educational level, cohabitation status, and employment status.

Table 5 shows the prevalence and ORs of health-risk behaviours among residents in deprived neighbourhoods with perceived stress compared to residents with no perceived stress. When the analyses were adjusted for sex, age, ethnic background, educational level, and cohabitation status, residents with perceived stress had significantly higher odds of low fruit or vegetable intake (OR: 1.56; 95%: 1.22-1.99), daily smoking (OR: 1.59; 95% CI: 1.39-1.82), physical inactivity (OR: 1.95; 95% CI: 1.67-2.28), having two or more health-risk behaviours (OR: 1.93; 95% CI: 1.62-2.30), and having three or more health-risk behaviours (OR: 2.10; 95% CI: 1.48-2.98), compared with residents with no perceived stress. We found no significant association between perceived stress and high-risk alcohol intake (OR: 1.19; 95% CI: 0.90-1.57). When the analyses were further adjusted for employment status, the result for low fruit and vegetable intake was no longer significant.

Table 6 shows the adjusted ORs health-risk behaviour by combinations of SES and perceived stress among residents in deprived neighbourhoods. The analyses revealed that residents with low SES and perceived stress had higher odds of all health-risk behaviours (except for high-risk alcohol intake) and co-occurrence of health-risk behaviour than residents with higher SES and no perceived stress. Among residents with low SES, perceived stress had an aggravating negative effect on their health-risk behaviour, except in relation to high-risk alcohol intake. The modification analyses showed that perceived stress modified the associations between SES and physical inactivity (p = 0.0227) and between SES and having two or more health-risk behaviours (p = 0.0275). We found that perceived stress was more strongly associated with physical inactivity and having two or more health-risk behaviours among residents with medium/high SES compared to residents with low SES.

Table 4: Perceived stress in deprived neighbourhoods and the general population. ORs with 95% CI for perceived stress in deprived neighbourhoods compared with the general population.

			Unadjusted				Adjusted			
	Deprived neighbourhoods	General population	Deprived neighbourhoods				Deprived neighbourhoods			
	%	%	OR	(95 % CI)	OR[a]	(95 % CI)	OR[b]	(95 % CI)	OR[c]	(95 % CI)
Perceived stress	33.6	26.7	**1.39**	**(1.30-1.49)**	**1.30**	**(1.21-1.40)**	**1.10**	**(1.01-1.19)**	**1.19**	**(1.07-1.32)**

Bold values indicate significant odds ratios.

[a] Adjusted for sex, age and ethnic background.

[b] Adjusted for sex, age, ethnic background, educational level and cohabitation status. Analysis restricted to respondents aged 25 years or older.

[c] Adjusted for sex, age, ethnic background, educational level, cohabitation status and employment status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

Table 5: Associations between perceived stress and health-risk behaviours in deprived neighbourhoods. ORs with 95% CI for health-risk behaviours.

	%		Unadjusted				Adjusted				
	Perceived stress	No perceived stress	OR	(95% CI)	OR[a]	(95% CI)	OR[b]	(95% CI)	OR[c]	(95% CI)
Fruit and vegetables										
Low intake of fruit or vegetables	10.1	6.4	**1.63**	**(1.32-2.01)**	**1.83**	**(1.47-2.28)**	**1.56**	**(1.22-1.99)**	1.25	(0.94-1.68)
Smoking										
Daily smoking	46.6	33.9	**1.71**	**(1.51-1.92)**	**1.71**	**(1.51-1.93)**	**1.59**	**(1.39-1.82)**	**1.49**	**(1.27-1.75)**
Alcohol										
High-risk alcohol intake	5.9	5.5	1.07	(0.83-1.38)	1.27	(0.98-1.64)	1.19	(0.90-1.57)	1.20	(0.86-1.67)
Physical activity										
Physical inactivity	25.1	15.6	**1.81**	**(1.56-2.09)**	**1.91**	**(1.65-2.22)**	**1.95**	**(1.67-2.28)**	**1.56**	**(1.29-1.90)**
Co-occurrence of health-risk behaviours										
Having 2 or more health-risk behaviours	20.9	12.3	**1.89**	**(1.61-2.21)**	**2.03**	**(1.73-2.39)**	**1.93**	**(1.62-2.30)**	**1.59**	**(1.28-1.96)**
Having 3 or more health-risk behaviours	5.1	2.4	**2.17**	**(1.59-2.97)**	**2.57**	**(1.86-3.55)**	**2.10**	**(1.48-2.98)**	**1.57**	**(1.03-2.38)**

Bold values indicate significant odds ratios.
[a] Adjusted for sex, age and ethnic background.
[b] Adjusted for sex, age, ethnic background, educational level and cohabitation status. Analysis restricted to respondents aged 25 years or older.

[c] Adjusted for sex, age, ethnic background, educational level, cohabitation status and employment status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

Table 6: Adjusted ORs with 95% CI for health-risk behaviours by combinations of SES and perceived stress in deprived neighbourhoods.

	OR[a] (95% CI)					
	Low intake of fruit or vegetables	Daily smoker	High-risk alcohol intake	Physical inactivity	Having 2 or more health-risk behaviours	Having 3 or more health-risk behaviours
Combined indicator of SES and perceived stress	p = 0.6103*	p = 0.3293*	p = 0.6430*	**p = 0.0227***	**p = 0.0275***	p = 0.3178
Low SES and perceived stress	**3.10 (2.02-4.78)**	**3.44 (2.79-4.23)**	1.38 (0.77-2.48)	**2.47 (1.80-3.38)**	**3.17 (2.27-4.43)**	**2.06 (1.04-4.10)**
Low SES and no perceived stress	**2.50 (1.62-3.86)**	**1.99 (1.52-2.62)**	1.21 (0.69-2.14)	**2.19 (1.59-3.02)**	**2.66 (1.91-3.71)**	1.61 (0.80-3.25)
Medium/high SES and perceived stress	**1.46 (1.04-2.04)**	**1.69 (1.42-2.00)**	1.39 (0.96-1.98)	**1.90 (1.53-2.35)**	**2.03 (1.61-2.56)**	**2.10 (1.33-3.32)**
Medium/high SES and no perceived stress	1.00	1.00	1.00	1.00	1.00	1.00

Bold values indicate significant odds ratios.

[a] Adjusted for sex, age, ethnic background and cohabitation status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

*P-value for interaction between SES and perceived stress in regard to each health-risk behaviour. **Bold values** indicate significant interactions.

4.4 Social isolation, loneliness, SES, and health-risk behaviour in deprived neighbourhoods (paper IV)

The aims of **paper IV** were first to compare loneliness among residents in deprived neighbourhoods with that in the general population, second to investigate whether social isolation and loneliness are associated with health-risk behaviours among residents of deprived neighbourhoods, and third to examine whether social isolation and loneliness modify the associations between SES and health-risk behaviours.

Table 7 shows the prevalence and ORs of loneliness among residents in deprived neighbourhoods compared to the general Danish population. The prevalence of loneliness was 8.4% among residents of deprived neighbourhoods and 5.4% for the general population. After adjustment for differences in sex, age, and ethnic background, educational level, and employment status, residents of deprived neighbourhoods had 1.45 times higher odds (95% CI 1.20–1.75) of being lonely compared with the general population.

Table 8 shows the prevalence and ORs of health-risk behaviours among residents in deprived neighbourhoods who are socially isolated compared to non-socially isolated. When the analysis was adjusted for sex, age, ethnic background, educational level, and employment status, social isolation was significantly associated with higher odds of low fruit or vegetable intake (OR: 2.30; 95% CI: 1.67-3.16), daily smoking (OR: 1.29; 95% CI: 1.06-1.57), physical inactivity (OR: 1.48; 95% CI: 1.18-1.8), having two or more health-risk behaviours (OR: 1.99; 95% CI: 1.57-2.52), and having three or more health-risk behaviours (OR: 1.96; 95% CI: 1.26-3.07). The association between social isolation and high-risk alcohol intake (OR: 1.37; 95% CI: 1.01-1.86) was only significant when the analysis was adjusted for sex, age, ethnic background, and educational level. In regard to daily smoking, a significant interaction was found between sex and social isolation (p-value = 0.004). Socially isolated men had 1.37 times higher odds (95% CI 1.03-1.83) of being daily smokers compared to men who were non-socially isolated, when the analysis was adjusted for differences in sociodemographic and socioeconomic characteristics. Among women, no difference was found with regard to social isolation and daily smoking (data not shown).

Table 7: Loneliness in deprived neighbourhoods and in the general population. ORs with 95% CI for loneliness in deprived neighbourhoods compared to general population.

	Deprived neighbourhoods	General population	Unadjusted						Adjusted				
	%	%	OR	(95% CI)	OR[a]	(95% CI)	OR[b]	(95% CI)	OR[c]	(95% CI)	OR[d]	(95% CI)	
Loneliness	8.4	5.4	**1.61**	**(1.42-1.82)**	**1.51**	**(1.33-1.72)**	1.11	(0.97-1.26)	**1.53**	**(1.33-1.77)**	**1.45**	**(1.20-1.75)**	

Bold values indicate significant odds ratios.
[a] Adjusted for sex, age and ethnic background.
[b] Adjusted for sex, age, ethnic background and cohabitation.
[c] Adjusted for sex, age, ethnic background, and educational level. Analysis restricted to respondents aged 25 years or older.
[d] Adjusted for sex, age, ethnic background, educational level, and employment status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

Table 8: Associations between social isolation and health-risk behaviours in deprived neighbourhoods. ORs with 95% CI for health-risk behaviours.

	Socially isolated	Non-socially isolated	Unadjusted						Adjusted			
	%		OR	(95% CI)	OR[a]	(95% CI)	OR[b]	(95% CI)	OR[c]	(95% CI)		
Fruit and vegetables												
Low intake of fruit or vegetables	13.3	6.4	**2.25**	**(1.79-2.82)**	**2.70**	**(2.13-3.43)**	**2.83**	**(2.20-3.65)**	**2.30**	**(1.67-3.16)**		
Smoking												
Daily smoking	44.8	36.6	**1.40**	**(1.21-1.62)**	**1.52**	**(1.31-1.76)**	**1.48**	**(1.27-1.73)**	**1.29**	**(1.06-1.57)**		
Alcohol												
High-risk alcohol intake	6.7	5.3	1.29	(0.96-1.73)	1.29	(0.96-1.74)	**1.37**	**(1.01-1.86)**	1.42	(0.96-2.08)		
Physical activity												
Physical inactivity	29.7	16.8	**2.10**	**(1.78-2.47)**	**2.01**	**(1.70-2.37)**	**1.94**	**(1.63-2.30)**	**1.48**	**(1.18-1.85)**		
Co-occurrence of health-risk behaviours												
Having 2 or more health-risk behaviours	24.6	13.1	**2.17**	**(1.82-2.59)**	**2.33**	**(1.94-2.79)**	**2.39**	**(1.98-2.89)**	**1.99**	**(1.57-2.52)**		
Having 3 or more health-risk behaviours	5.9	2.7	**2.25**	**(1.61-3.14)**	**2.42**	**(1.72-3.42)**	**2.51**	**(1.75-3.61)**	**1.96**	**(1.26-3.07)**		

Bold values indicate significant OR.
[a] Adjusted for sex, age and ethnic background.
[b] Adjusted for sex, age, ethnic background and educational level. Analysis restricted to respondents aged 25 years or older.

[c] Adjusted for sex, age, ethnic background, educational level and employment status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

Table 9 shows the prevalence and ORs of health-risk behaviours among residents who are lonely compared to non-lonely residents in deprived neighbourhoods. The analyses showed that loneliness was significantly associated with higher odds of all the health-risk behaviours (except high-risk alcohol intake) and the co-occurrence of health-risk behaviours. When the analyses were further adjusted for employment status, the association between loneliness and daily smoking was no longer significant.

Table 10 shows the adjusted ORs of health-risk behaviours by the combination of SES and social isolation among residents of the deprived neighbourhoods. Socially isolated residents with low SES had higher odds of health-risk behaviour (except for high-risk alcohol intake) and co-occurrence of health-risk behaviour compared with non-socially isolated residents with higher SES. However, it was found that residents with medium/high SES being socially isolated had higher odds of high-risk alcohol intake than non-socially isolated residents with the corresponding SES. We found no statistically significant interactions between SES and social isolation with respect to health-risk behaviour (all p-values > 0.05).

Table 11 shows the adjusted ORs of health-risk behaviours by the combination of SES and loneliness among residents of the deprived neighbourhoods. Lonely residents with low SES had higher odds of health-risk behaviour (except for high-risk alcohol intake) and of having two or more health-risk behaviours than did non-lonely residents with higher SES. Further, it was found that lonely residents with medium/high SES had higher odds of having three or more health-risk behaviours compared to non-lonely residents with corresponding SES. No statistically significant interactions were found between SES and loneliness with regard to health-risk behaviour (all p-values > 0.05).

Table 9: Associations between loneliness and health-risk behaviours in deprived neighbourhoods. ORs with 95% CI for health-risk behaviours.

	Lonely	Non-lonely	Unadjusted				Adjusted				
	%		OR	(95% CI)	OR[a]	(95% CI)	OR[b]	(95% CI)	OR[c]	(95% CI)	
Fruit and vegetables											
Low intake of fruit or vegetables	15.8	6.9	**2.52**	**(1.89-3.36)**	**2.72**	**(2.02-3.65)**	**1.84**	**(1.31-2.58)**	**1.83**	**(1.25-2.67)**	
Smoking											
Daily smoking	48.6	37.2	**1.60**	**(1.31-1.95)**	**1.58**	**(1.29-1.93)**	**1.32**	**(1.06-1.65)**	1.18	(0.90-1.53)	
Alcohol											
High-risk alcohol intake	7.2	5.4	1.36	(0.92-2.01)	1.45	(0.98-2.17)	1.27	(0.83-1.95)	1.15	(0.70-1.90)	
Physical activity											
Physical inactivity	34.0	17.7	**2.40**	**(1.93-2.98)**	**2.44**	**(1.96-3.04)**	**2.26**	**(1.79-2.85)**	**1.82**	**(1.37-2.42)**	
Co-occurrence of health-risk behaviours											
Having 2 or more health-risk behaviours	28.3	13.9	**2.44**	**(1.94-3.07)**	**2.49**	**(1.97-3.15)**	**2.08**	**(1.62-2.69)**	**1.77**	**(1.31-2.39)**	
Having 3 or more health-risk behaviours	9.2	2.8	**3.53**	**(2.42-5.14)**	**3.81**	**(2.59-5.61)**	**2.14**	**(1.44-3.48)**	**2.04**	**(1.23-.3.37)**	

Bold values indicate significant OR.

[a] Adjusted for sex, age and ethnic background.

[b] Adjusted for sex, age, ethnic background, educational level and cohabitation status. Analysis restricted to respondents aged 25 years or older.

[c] Adjusted for sex, age, ethnic background, educational level, cohabitation status and employment status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

Table 10: Adjusted ORs with 95% CI of health-risk behaviours by combinations of SES and social isolation in deprived neighbourhoods.

	OR[a] (95% CI)					
	Low intake of fruit or vegetables	Daily smoker	High-risk alcohol intake	Physical inactivity	Having 2 or more health-risk behaviours	Having 3 or more health-risk behaviours
Combined indicator of SES and social isolation	p = 0.2004	p = 0.6374	p = 0.2790	p = 0.6737	p = 0.8091	p = 0.2708
Low SES and socially isolated	**5.28 (3.26-8.54)**	**2.80 (1.95-4.01)**	1.46 (0.71-3.00)	**2.64 (1.81-3.84)**	**4.85 (3.33-7.07)**	**2.91 (1.38-6.13)**
Low SES and non-socially isolated	**2.86 (1.97-4.15)**	**1.84 (1.47-2.29)**	1.37 (0.84-2.22)	**1.76 (1.36-2.84)**	**2.10 (1.58-2.78)**	**1.80 (1.00-3.26)**
Medium/high SES and socially isolated	**2.82 (1.96-4.07)**	**1.37 (1.10-1.70)**	**1.77 (1.16-2.70)**	**1.67 (1.28-2.16)**	**2.17 (1.65-2.85)**	**2.82 (1.73-4.62)**
Medium/high SES and non-socially isolated	1.00	1.00	1.00	1.00	1.00	1.00

Bold values indicate significant OR.

[a] Adjusted for sex, age and ethnic background. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

Table 11: Adjusted ORs with 95% CI of health-risk behaviours by combinations of SES and loneliness in deprived neighbourhoods.

	OR[a] (95% CI)					
	Low intake of fruit or vegetables	Daily smoker	High-risk alcohol intake	Physical inactivity	Having 2 or more health-risk behaviours	Having 3 or more health-risk behaviours
Combined indicator of SES and loneliness	p = 0.0719	p = 0.7102	p = 0.8012	p = 0.1482	p = 0.0665	p = 0.1831
Low SES and lonely	**3.39 (1.85-6.21)**	**2.35 (1.46-3.79)**	1.59 (0.70-3.62)	**2.67 (1.63-4.39)**	**3.15 (1.90-5.22)**	2.24 (0.91-5.52)
Low SES and non-lonely	**2.63 (1.86-3.72)**	**1.88 (1.53-2.33)**	1.12 (0.70-1.78)	**1.80 (1.41-2.29)**	**2.29 (1.77-3.00)**	1.54 (0.89-2.68)
Medium/high SES and lonely	**2.65 (1.69-4.14)**	**1.40 (1.04-1.88)**	1.24 (0.68-2.23)	**2.35 (1.70-3.25)**	**2.49 (1.77-3.51)**	**3.13 (1.79-5.50)**
Medium/high SES and non-lonely	1.00	1.00	1.00	1.00	1.00	1.00

Bold values indicate significant OR.

[a] Adjusted for sex, age, ethnic background and cohabitation status. Analysis restricted to respondents aged 25-64 years and employed, unemployed, disability pensioners and other non-employed.

5 Discussion

The research in this thesis was conducted to gain a deeper insight into health-risk behaviour in deprived neighbourhoods compared to that of the general population and how perceived stress, social isolation, and loneliness are associated with health-risk behaviours among residents in deprived neighbourhoods. In this chapter, the main findings of the thesis are presented and discussed in relation to findings from previous studies. Further, I discuss socioeconomic inequalities in health-risk behaviour in deprived neighbourhoods in the light of the conceptual frameworks and present my thoughts on causality in the interpretation of the results. Finally, I present the most important strengths and limitations, including potential biases, of the four studies.

5.1 Main findings

The results from the included studies and their interpretation have been described in detail in Chapter 4 of this thesis. The main findings for the four studies were:

- In the systematic review, the available literature showed a positive association between smoking and physical inactivity and living in deprived neighbourhoods compared with non-deprived neighbourhoods. No clear differences were found in relation to low fruit and vegetable consumption, and the results in relation to alcohol consumption were ambiguous. Numerous different operationalizations of neighbourhood deprivation were used in the reviewed studies (**paper I**) [63].

- Residents in deprived neighbourhoods had higher odds of health-risk behaviours (except high-risk alcohol intake) compared to the general Danish population, even after adjustment for socioeconomic characteristics. In the deprived neighbourhoods especially men, residents with lower educational level, unemployed, disability pensioners and residents living alone were more likely to have health-risk behaviours (**paper II**) [71].

- Residents of deprived neighbourhoods had higher odds of perceived stress than the general Danish population. Perceived stress was significantly associated with higher odds of health-risk behaviours (except high risk-alcohol intake) in deprived neighbourhoods. Perceived stress modified the associations between SES and physical inactivity, and between SES and having two or more health-risk behaviours. Perceived stress was more strongly associated with physical inactivity and having two or more health-risk behaviours among residents with medium/high SES than residents with low SES (**paper III**).

- Compared with the general Danish population, residents of deprived neighbourhoods had higher odds of loneliness. Both social isolation and loneliness were significantly associated with higher odds of health-risk behaviours (except high-risk alcohol intake) in deprived neighbourhoods. However, the association between social isolation and high-risk alcohol intake was significant when the analysis was adjusted for sex, age, ethnic background, and educational level. When social

isolation and loneliness were combined with low SES, strong associations with health-risk behaviour were found. However, social isolation and loneliness did not significantly modify the associations between SES and health-risk behaviour (**paper IV**).

5.2 General discussion and consistency with previous research

In the systematic review (**paper I**), we found consistent evidence that smoking and physical inactivity were more prevalent among adult residents in deprived neighbourhoods than among residents in non-deprived neighbourhoods [63]. This is in line with the conclusions of previous systematic reviews [54,58,59]. No clear differences between deprived and non-deprived neighbourhoods were found in relation to low fruit and vegetable consumption or alcohol consumption in the systematic review. There were only four previous studies on fruit and vegetable consumption, so these results should be interpreted with caution. Our result on alcohol consumption was in line with another systematic review on disadvantaged areas and substance use outcomes by Karriker-Jaffe (2011), who also reported equivocal findings for alcohol consumption [59]. We presumed that these equivocal findings could be due to cultural differences between countries; however we did not find any geographical pattern across countries. Another hypothesis was that the varying results on alcohol consumption were caused by different proportions of residents with a Muslim background in the deprived neighbourhoods, as Muslims traditionally have low levels of alcohol intake [216]. However, all but one of the studies had adjusted for ethnicity or the proportion of Muslim residents in their analyses on alcohol consumption; thus, it could not explain the results.

The reviewed studies operationalized neighbourhood deprivation in different ways. Some studies used multiple neighbourhood socioeconomic characteristics to rank neighbourhood deprivation, and others used indexes, while others only used income or unemployment as a neighbourhood deprivation measure. It appears that the indicators used were mainly based on the availability of data rather than on conceptual considerations. Most of the studies were not explicit on why the selected indicators were used to assess neighbourhood deprivation. The different operationalizations of deprived neighbourhoods may partly explain the ambiguous results regarding the alcohol consumption and the low intake of fruit and vegetables. Researchers should in the future provide their reasons, both practical and theoretical, for choosing the specific measures in the assessment of neighbourhood deprivation.

In **paper II,** we found overall that residents in deprived neighbourhoods were more likely to have health-risk behaviours than those in the general population in Denmark [71].
Compared with the general population, residents in deprived neighbourhoods were significantly more likely to have a low intake fruit or vegetables. The results were consistent with previous research in finding a lower prevalence of fruit and vegetable consumption among deprived neighbourhoods compared with non-deprived neighbourhoods [46,209]. Possible mediating environmental factors between living in a deprived

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neighbourhood and low fruit and vegetables consumption may be the limited availability of shops selling healthy foods, difficulty in accessing supermarkets, and higher prices of healthy foods in deprived neighbourhoods [211]. However, findings from empirical studies on this research area remain inconsistent [224]. In studies from the UK, large supermarkets were more likely to be located in deprived neighbourhoods, and when there were differences in the price of the food, these tended to be slightly cheaper in deprived neighbourhoods [162,225,226]. Similar findings have been reported in the Netherlands [227] and in Australia [228]. In contrast, a study from the US showed that the food shop environment in deprived neighbourhoods was less beneficial in regard to buy healthy food than in non-deprived neighbourhoods [229]. In a review by Cummins and Macintyre (2006), the main conclusion was that even though neighbourhood socioeconomic differences in diet are found in many Western countries, evidence of neighbourhood influence on diets exists only for North American neighbourhoods [162,224]. This inconsistency may reflect differences among countries in their social, structural or economic environments, or in the regulatory factors influencing fruit and vegetable consumption [224].

The residents in the deprived neighbourhoods were more likely to be daily and heavy smokers than the general population, which several previous studies have confirmed [46,205,207,208,213-215,220]. In accordance with the socio-ecological conceptual model of health behaviour, the higher prevalence of smoking in deprived neighbourhoods can be caused by shared norms, sanctions, values, and attitudes of those around them [156,208]. For example, if smoking is socially acceptable in deprived neighbourhoods it may thus be more acceptable to start smoking, and it may also be more difficult to stop smoking. In a qualitative study by Stead et al. (2001), it was found that social support and networks among residents in deprived neighbourhoods appeared to encourage smoking and formed barriers to quitting [230].

Compared with the general population, residents in deprived neighbourhoods were less likely to have a high-risk alcohol intake. As the analyses were adjusted for ethnic background, the lower alcohol intake in the deprived neighbourhoods is unlike to be caused by the higher proportion of persons of Muslim background, who as described earlier traditionally have low levels of alcohol intake [216]. Previous studies that have examined alcohol intake in deprived neighbourhoods compared with non-deprived neighbourhoods have shown ambiguous results. A study based on 26,290 adults aged 16 or above in the 2008 East of England Lifestyle Survey also found lower odds of exceeding the recommended alcohol intake limits among deprived neighbourhoods compared with non-deprived neighbourhoods [46]. Furthermore, Pollack et al. (2005) showed that abstaining from alcohol and moderate drinking was more prevalent in deprived neighbourhoods than in non-deprived neighbourhood [231]. It was found that even though alcohol availability was easily available in the most deprived neighbourhoods, residents in deprived neighbourhoods were less likely to be heavy drinkers. In contrast, some studies have found higher odds of binge drinking among deprived neighbourhoods [47,206], while other studies reported no significant differences between deprived and non-deprived neighbourhoods [216,222]. Some studies have showed that abstaining from alcohol and moderate drinking are more prevalent in deprived versus non-deprived

neighbourhoods [46,231]. These conflicting results may be due to differences in cultural and group norms among the various nationalities with regard to alcohol intake [232]. Ahern et al. (2008) have found that neighbourhood norms concerning drunkenness were associated with individual drinking patterns, independent of friend, family and individual norms [232]. It could be hypothesized that the presence of residents with a non-Western background in the deprived neighbourhood could influence the local social norm for alcohol use [216].

A different pattern with regard to the association between age and high-risk alcohol intake was found among residents of the deprived neighbourhoods compared with the general population. Interestingly, while the younger generation of the general population was more likely to have a high-risk alcohol intake, this pattern was not seen in the deprived neighbourhoods. However, it is important to note that alcohol intake in Denmark is a complex issue in terms of the interaction between age and educational level; high-risk alcohol intake in the younger age groups is thus most prevalent among those with elementary school as their highest level of education, whereas in the 65+ age group, the most risk-prone are those with the highest education [51].

Physical inactivity was more prevalent in deprived neighbourhoods than among the general population. Previous studies have also shown that residents in deprived neighbourhoods are more likely to be physically inactive than residents in non-deprived neighbourhoods [47,61,205,210,214,215,220]. Studies have found evidence for a positive association between the perceived closeness to sports facilities (such as gyms) and other neighbourhood facilities (such as parks) and the likelihood of being physically active [62]. In the US, the lack of facilities for sports, sidewalks, or bike paths has been suggested as a possible reason for physical inactivity in deprived neighbourhoods [233]. High crime rates in deprived neighbourhoods may also affect the level of physical activity because of the perceived danger of being outside [219]. In this regard, it has been found that lower perceived safety is associated with a decreased likelihood of being physically active [62]. So even though deprived neighbourhoods may offer equally good (or poor) opportunities for neighbourhood activities in the physical environment as non-deprived neighbourhoods, they are less likely to be used if residents perceive them as unsafe. Part of the explanation why the neighbourhood affects health behaviour may also be found in the contagion hypothesis, according to which it is assumed that health behaviour is spread through social exchange [47]. If, for example, residents regularly see their neighbours cycle or run, there is a high chance that such behaviour is replicated [156]. In a study by Wilcox et al. (2000), the frequency of not seeing others exercise was found to be associated with an increased likelihood of physical inactivity [234].

Finally, we found that co-occurrence of health-risk behaviours among residents in deprived neighbourhoods was greater than in the general population. Other studies conducted in similar populations support this result [132,133], indicating that interventions that simultaneously tackle multiple unhealthy behaviours may be more appropriate in deprived neighbourhoods. This is also supported by studies showing that

multiple-behaviour interventions have a greater impact on public health than single-behaviour interventions [235].

In the third study (**paper III**), we found a significantly higher risk of perceived stress among residents of deprived neighbourhoods compared with the general population. This is consistent with prior research in similar populations [54,95]. Overall, we found that perceived stress was associated with increased odds of health-risk behaviours in deprived neighbourhoods. However, perceived stress was not associated with high-risk alcohol intake. The findings of this study are supported by similar studies of associations between stress and health-risk behaviour in other populations [72,74-81].

The association between stress and low fruit or vegetable intake has also been documented by prior research [77,236]. The reason why people with higher levels of stress have unhealthier eating habits may be that unhealthy foods are perceived as a 'comfort' or a 'reward', and are used to cope with stress [237].

In keeping with our results on smoking several studies have shown that high levels of perceived stress are associated with increased smoking levels, smoking initiation, and a reduced likelihood of quitting smoking [72,74,75,79-81,238]. There is strong evidence that cigarette smoking can be a coping mechanism that provides a respite from stressful physical environments such as overcrowding, low-quality housing, traffic, and neighbourhood noise [208,239].

The absence of an association between perceived stress and high-risk alcohol intake in deprived neighbourhoods is supported by the study by Ng and Jeffery (2003) [74].

The association between perceived stress and physical inactivity among residents of deprived neighbourhoods has also been reported in previous international studies [72,74,80,81]. Many people might respond to stress by engaging in less physical activity as they may find sedentary physical activity more rewarding in the short term, despite evidence that physical activity can reduce stress over time [74,80,88,89].

In line with our finding on the association between perceived stress and the co-occurrence of health-risk behaviours, Fine et al. (2004) reported that persons with high mental distress are twice as likely to have three or four health-risk behaviours than none or one health-risk behaviour [240].

Our results indirectly support the suggestion that health-risk behaviour works as a coping tool for people who experience stress. Research has yet not been able to provide results that with certainty could establish evidence for the hypothesis that health-risk behaviours are used as coping tools for stress [84]. The reason might be that researchers seldom examine whether people directly use health-risk behaviours as coping tools, even though it is seems like a common perception in previous literature. In a focus group study of residents in low-income communities, the participants described a direct causal pathway between stress and poor health as well as an indirect pathway through health behaviours, including uncontrolled eating, smoking, and physical inactivity [238]. The participants recognized that the health-risk behaviours were unhealthy ways of coping with their stress, but they expressed various mechanisms for the link between

stress and health-risk behaviour, such as self-medication, adaptive behaviour, discounting the future, depletion of willpower, and competing priorities [238].

In **paper III**, we also found that residents with low disposable income who had economic deprivation and strain had a higher level of perceived stress. These results could indicate that the residents in deprived neighbourhoods who have financial worries and personal challenges in their everyday life experience a higher level of perceived stress. Residents in deprived neighbourhoods struggle with a wide range of day-to-day social and economic challenges and may not always prioritize healthy behaviour, as they have other more important issues to deal with [241]. This may partly explain why residents of deprived neighbourhoods have a higher prevalence of perceived stress and of health-risk behaviours than the general population.

The Transactional Model of Stress and Coping assumes that problem-focused coping strategies are most adaptive for stressors that are changeable, whereas emotion-focused coping strategies (such as health-risk behaviour) are most adaptive when the stressor is unchangeable [178]. This can further explain why residents in deprived neighbourhoods may cope with stressors through health-risk behaviours, because factors such as disposable income and economic deprivation are not immediately possible to change. The same applies to the physical environment that residents in deprived neighbourhoods are exposed to.

Wilkinson (1996) has suggested that the poor suffer doubly from deprivation: besides the direct material effects, deprivation also affects health through psychosocial channels [242]. Being at the bottom of society's hierarchy may lead to stress that arises from feelings of bitterness based on invidious social comparisons [243], and the perception of social inequality can be an incentive for health-risk behaviour [82]. In the same way, living in a neighbourhood that is deprived not only in absolute terms, but also relative to nearby neighbourhoods and compared to society in general, can induce feelings of exclusion and stigmatization, and residents in deprived neighbourhoods may resort to health-risk behaviours to cope with these perceptions [244].

In the final study of this thesis (**paper IV**), we found significantly higher odds of loneliness among residents of deprived neighbourhoods compared with the general population. Previous studies have also found high prevalence of loneliness in deprived neighbourhoods [129,130].

In addition, we found overall that social isolation and loneliness in deprived neighbourhoods were associated with increased odds of health-risk behaviours. Though, the association between social isolation and high-risk alcohol intake was only significant when the analysis was adjusted for sex, age, ethnic background, and educational level.

The association between social isolation and low fruit or vegetable intake has also been found in prior research [119]. Locher et al. (2005) found that individuals with a relatively weak social network reported less healthy diets [120]. However, Cacioppo et al. (2002) reported that lonely and non-lonely individuals did not differ significantly on diet quality [121].

Our result on smoking is supported by Shankar et al. (2011), who found an association between social isolation and smoking [114]. Mixed results have been found with regard to the association between loneliness and smoking; while Lauder et al. (2006) found that lonely people were more likely than non-lonely people to be smokers [123], others discovered no association [121].

The absence of an association between social isolation and high-risk alcohol intake in deprived neighbourhoods was not found any in previous studies. In regard to loneliness, Cacioppo et al. (2002) found no differences between lonely and non-lonely individuals concerning alcohol intake [121].

Many previous Western studies support our results on social isolation and loneliness in regard to physical inactivity [49,114,118,119,124,245,246].

In line with our finding of an association between social isolation, loneliness, and the co-occurrence of health risk behaviours, the Alameda County Study showed that individuals who were less socially integrated were more likely to report multiple health risk behaviours [247]. Furthermore, Shankar et al. (2011) found that both social isolation and loneliness were associated with a greater risk of reporting multiple health-risk behaviours [114].

It has been proposed that social isolation and loneliness may themselves act as stressors [114,129], which may in turn influence their health-risk behaviours. In addition, residents who are socially isolated and feel lonely may not be exposed to health-promoting behaviours. Researchers have suggested that social relations may influence health via the adoption and maintenance of healthy behavioural norms through social control over deviant health-related behaviour [83]. Social networks may additionally provide opportunities for social support to resist risky behaviour and maintain healthier choices [47,83]. However, a person's social relationships may have both beneficial and harmful effects on health behaviour, depending on the social norms prescribed in the social network.

5.3 Socioeconomic inequalities in health-risk behaviour in deprived neighbourhoods

In **paper II** we found large socioeconomic differences in health-risk behaviours among the residents in the deprived neighbourhoods [71]. Further, we found in supplementary analyses (section 4.2.1) that residents with low SES overall had higher risk of health-risk behaviours compared to residents with higher SES. Socioeconomic inequalities in health-risk behaviour could be due to differential exposure to risk factors and differential vulnerability among the socioeconomic groups.

In relation to different risk factors effecting health-risk behaviour in deprived neighbourhoods, we found in **paper III-IV**, that residents with low SES had higher prevalence of perceived stress and of being socially isolated and lonely compared to residents with higher SES. These results indicate that residents in deprived neighbourhoods with low SES are more prone to experience perceived stress and have challenges in regard to being social isolated and lonely. It has also been argued, that living in a deprived neighbourhood may

exacerbate the effect of stressors (such as financial strain) or resources at the individual level among residents with low SES since they may be more dependents on locally provided facilities and services [248].

In **paper III-IV** we found that perceived stress, being socially isolated and lonely among residents with low SES generally were associated with high odds of health-risk behaviours. The results regarding social isolation are supported by a study showing that the combination of poor social relations and low socioeconomic position (defined by income) displayed stronger associations with adverse health behaviours [119]. This can indicate that differences in access to psychosocial resources may lead to increased vulnerability to health-risk behaviour especially among residents with low SES. However, we found that residents with medium/high SES being socially isolated had higher odds of high-risk alcohol intake than non-socially isolated residents with corresponding SES. We believe that the results in **paper III-IV** are sufficient to draw conclusions about the importance of perceived stress, social isolation, and loneliness among residents with low SES in deprived neighbourhoods in regard to their increased odds of health-risk behaviour. These results may also reflect a common tendency towards increased vulnerability among low-SES residents in deprived neighbourhoods, whose everyday lives are frequently exposed to cumulative burdens in the form of several different and possibly interacting physical, social, and behavioural risk factors [10,119].

In **paper III** we found an effect modification between perceived stress and SES in regard to physical inactivity and having two or more health-risk behaviours. The results showed that perceived stress was more strongly associated with physical inactivity and having two or more health-risk behaviours among residents with medium/high SES compared to residents with low SES. This may indicate that residents with medium/high SES with perceived stress are more likely to be physical inactive and having two or more risk behaviours than residents with low SES.

In **paper IV** the interaction terms between SES and social isolation and loneliness were not significant for health-risk behaviour. However, we found that social isolation was especially harmful for residents with medium/high SES in regard to low intake of fruit or vegetables and having three or more health-risk behaviours). This could indicate that social isolation particularly are harmful for residents with medium/high SES in regard to low intake of fruit or vegetables and having three or more health-risk behaviours compared to residents with low SES. In addition, the results may as well indicate that loneliness especially had a negative effect on residents with medium/high SES in regard to low intake of fruit or vegetables, physical inactivity and co-occurrence of health-risk behaviours than among residents with low SES. This could suggest that residents with medium/high SES living in deprived neighbourhoods are more affected by being socially isolated and lonely in regard to the above mentioned health-risk behaviours than residents with low SES. It has been suggested by Stafford and Marmot (2003) that those of high SES living

in more-deprived neighbourhoods are atypical individuals [248]. Residents with medium/high SES in deprived neighbourhoods may thus be atypical from residents in non-deprived neighbourhoods. However, it remains unclear in what way. This hypothesis may explain why we did not find any significant interactions between SES and social isolation, and between SES and loneliness regarding health-risk behaviours in deprived neighbourhoods. Had the same analyzes been performed in a non-deprived neighbourhoods, we might have found some other results.

5.4 Thoughts on causality in the interpretation of the results

My causal interpretation of the associations found in this thesis is based on the conceptual frameworks described in *Chapter 2*. My approach to the study of health-risk behaviour in deprived neighbourhoods has emphasized the importance of the social setting in which people live. In line with the socio-ecological model of health behaviour, my intention was to move health-risk behaviour research beyond an individual focus by considering the importance of social determinants of health-risk behaviour. Overall, the findings have confirmed the importance of the social context (living in a deprived neighbourhood) for health-risk behaviour as described in the framework of social determinants of health and the socio-ecological model of health behaviour.

The findings on perceived stress, social isolation, and loneliness have highlighted the relevance of the psychosocial framework in research on health-risk behaviour in deprived neighbourhoods. All the observed associations support the pathways described in the conceptual frameworks, suggesting that such frameworks are useful for studies such as the present ones. However, this is of course also a self-fulfilling prophecy, as the aims examined in this thesis were constructed on hypotheses based on these frameworks.

As the analyses in **paper II-IV** are based on cross-sectional data (i.e. the measurement of exposure and outcome was measured at the same time), it is not possible to determine the directions of causations in the relationships between the associations examined in the studies. This hampers the causal inference. It is therefore plausible that there is a reverse causation in some of the observed associations, e.g. that physical activity can reduce stress [74,80,88,89].

Another important issue is *self-selection*, which is especially relevant in the interpretation of the association between living in a deprived neighbourhood and being physically inactive. Selection refers to people tending to place themselves into neighbourhoods, social groups, and other clusters [147]. For instance, people with an active lifestyle and who value physical activity may be more likely to choose to live in activity-friendly neighbourhoods with green areas and facilities that provide them with good opportunities for being physically active. However, I do not believe that living in a deprived neighbourhood and being physically inactive represents an association between a demotivation to be physically active and a choice

of not choosing to live in a neighbourhood that promotes good facilities for being physically active. Especially, people with low SES are limited in their choice of residential place to live due to economic constraints caused by, e.g. unemployment or social inheritance.

As described in section 1.2, social causation could explain the inequalities in health, where SES affects health-risk behaviour. According to the conceptual framework of social determinants in health, I find it more likely that the SES of the residents in the deprived neighbourhoods affects their health-risk behaviour than the health-risk behaviour of the residents in the deprived neighbourhoods influences their SES. The results in **paper II** and in the supplementary analyses (section 4.2.1) support the social causation hypotheses, since we found socioeconomic inequalities in health-risk behaviour in deprived neighbourhoods. The opposite direction is also possible, however. For example, a person with a heavy alcohol problem may have a higher risk of being unemployed [249]. This is related to the selection hypotheses in the Black Report [23], which states that both direct selection (with health determining SES) and indirect selection mechanisms (with determinants of health influencing both SES and health) contribute to inequalities in health [26].

5.5 Strengths

The studies included in this thesis benefitted from a number of strengths.

In the systematic review (**paper I**), we provided an update of studies comparing health-risk behaviours among adults living in deprived and non-deprived neighbourhoods from economically developed Western countries in the period between 1996 and 2014.

One of the main strengths in **paper II-IV** was the large sample (n=5,113) of residents living in 12 deprived neighbourhoods in Denmark with a response rate of 63%. This is remarkable, since residents of deprived neighbourhoods are generally less likely to participate in health research [216,250] and tend to be underrepresented in health profile surveys [72,251]. The DNHPS was undertaken in 12 neighbourhoods in different municipalities that are geographically distributed in Denmark, which increases the external validity of these findings as compared to single neighbourhood studies. A further strength is the large number (n=15,165) of persons, who participated in the DHMS, with a response rate on 61%. An additional strength is that DNHPS and DHMS were conducted almost at the same time of the year, i.e. January to March, and February to April; thus the comparability between the surveys increases.

Another important strength is that the studies in **paper II-IV** are the first carried out in a Danish context. Further, these studies examine simultaneously four central health-risk behaviours (low intake of fruit and vegetable, smoking, high-risk alcohol intake, and physical inactivity), and the co-occurrence of health-risk behaviours, which have not been investigated previously. The studies examine the effect of neighbourhood deprivation, sociodemographic and socioeconomic characteristics, perceived stress, social isolation, and loneliness on health-risk behaviour, and this provides a comprehensive picture of the complexity of factors

that influence the development of social inequality in health-risk behaviour. The studies included in this thesis contribute with new research-based knowledge that can help to develop more targeted intervention programmes aimed at reducing social inequalities in health-risk behaviour (for further description see section 6.1).

5.6 Limitations

Although the studies in **paper II-IV** were carried out with great care, the studies had some methodological limitations. These relate to the study design, the sample, and the measures for the examined indicators. Different types of bias may have affected the external and internal validity of the results presented in this thesis. While some of these limitations have been mentioned in **paper II-IV**, I will discuss the main limitations in more detail below.

The question of causality
The cross-sectional study design of the studies in the present thesis means that it is not possible to prove any causality in the observed associations (also pointed out in section 5.4). Furthermore, the cross-sectional design strongly limits the interpretation of perceived stress, social isolation, and loneliness as having a moderating role in the association between SES and health-risk behaviour examined in **paper III-IV** (see section 6.2 about the implications for future research in elucidating the direction of causality through longitudinal studies).

The representativeness of the sample of deprived neighbourhoods
The selection of deprived neighbourhoods by the Danish Health Authority was not based on any specific criteria regarding demographic or socioeconomic characteristics. The DNHPS is the only survey available for studying health-risk behaviour in deprived neighbourhoods in Denmark, and it is not a nationally representative sample of deprived neighbourhoods in Denmark. This limits the external validity or generalizability of the finding of **paper II-IV** to deprived Danish neighbourhoods in general. However, a non-response analysis for all the deprived neighbourhoods was performed by NIRAS (a Danish company who also participated in the design of the DNHPS questionnaire) to investigate whether certain resident groups are under- or overrepresented in the sample [195]. The analysis was based on a comparison of the sample with the composition of residents in the total population of residents in the deprived neighbourhoods (as measured by housing statistical key figures) obtained from Statistics Denmark. The comparison contained some uncertainties, e.g. the data for the total population in the deprived neighbourhoods were from 1. January 2010 (because this was the latest available data from Denmark Statistics), while the survey was collected in primo 2011. The analysis showed that the sample of the deprived neighbourhoods was generally representative in regard to the total population in the deprived neighbourhoods, with only minor differences. The age group 18-24 years old was slightly underrepresented among the responders in the

DNPHS, while residents in the age group 65 years and older were slightly overrepresented. This is a typical trend in health surveys, because young people are less willing to participate in such studies [193]. Residents living alone were also underrepresented in the present study, possibly due to households with single persons being generally harder to contact than households with more persons. NIRAS also performed analyses with data weighted for key indicators (age, ethnicity and household composition) of the total population, which showed a small variation in the results [195].

The findings of this thesis can be generalized to other countries with caution. The finding may be most applicable to countries that are similar to Denmark on socioeconomic differences in health-risk behaviours and cultural and policy environment. The Danish sociologist Esping-Andersen (1990) differentiates between three types of welfare regimes: the Liberal (e.g. Australia, Canada, UK, USA), the Conservative (e.g. Finland, France, Germany, Italy) and the Social democratic (e.g. Denmark, The Netherlands, Norway) [252,253]. In a social democratic regime, there is public responsibility for welfare and access to services (education, health etc.), and benefits are universal. The regime is further characterized by a commitment to full employment and income protection, and a strongly interventionist state promotes equality through a redistributive social security system [252]. This may influence the composition in regard to education and income among residents in deprived neighbourhoods in social democratic countries, resulting in a rather mixed neighbourhood composition in deprived neighbourhoods with people of low and high SES in the same neighbourhood (as shown in **paper II**). This might mean that living in a deprived neighbourhood in a social democratic country has less effect on health-risk behaviour than in liberal countries such as the USA, where people with low SES live highly concentrated [254].

Selection bias

Selection bias may have influenced the findings in this thesis. Selection bias is present if the association between a given exposure and a given outcome differs between the participants and the non-responders, and it can influence the internal validity of a study [255]. The respondents who participated in the DNHPS could for example be more health-conscious than non-responders, which could affect the results in regard to health-risk behaviour. If this was the case, I may have underestimated the proportion of residents with health-risk behaviour. Likewise, the proportion of residents with high levels of perceived stress and the association between perceived stress and health-risk behaviour may have been underestimated in **paper III**, since it could be expected the residents with a high level of perceived stress do not have the mental energy to participate in a survey [256]. The same could also be the case in relation to social isolation and loneliness in **paper IV** [256]. Although non-responders may have had a higher proportion of health-risk behaviour, perceived stress, social isolation or loneliness, I do not believe that this would have substantially affected the overall results of the studies in the present thesis.

Methodological differences in the DNHPS and DHMS

A limitation of this study is that different modes of data collection were used for the two surveys. DNHPS was primarily conducted through telephone interviews, and face-to-face interviews were used to increase the response rate among residents with non-Western background. Self-administered questionnaires (paper and web) were used in the DHMS (for further descriptions see section 3.2.1 and section 3.2.2). Feveile et al. (2007) found that the rate of missing responses was higher among questionnaire respondents than among telephone respondents [257]. Telephone interviewing may therefore be advantageous for deprived neighbourhoods to improve the overall response and item response rates. Comparison of the two studies requires caution, as different methods may elicit different patterns of response regarding health-risk behaviour, perceived stress and loneliness. Hoebel et al. (2014) found no significant differences in the reported prevalence of health-related behaviours (except regarding physical activity) between self-administered questionnaires sent by postal mail, self-administered web surveys, and computer-assisted telephone interviews [258]. Another study showed no significant differences in smoking rates between mailed questionnaires and telephone interviews [257]. Other studies have found that telephone respondents report better health and wellbeing than questionnaire respondents, and that the willingness to report undesirable behaviour is greater for questionnaires than for telephone interviews [257]. In a narrative review by Bowling (2005), interviews (both face-to-face and telephone interviews) had in general a higher potential for social desirability bias than self-administered questionnaires [259]. This may be because interviews involve social interaction and thus cause respondents to take social norms into consideration when answering, resulting in over-reporting of desirable behaviours and under-reporting of undesirable behaviours [259]. An interviewer effect in regard to ethnic background could also give information bias [260]; for example, if a Muslim was interviewed by a Muslim, alcohol intake might be underreported. People may also tend to under-report perceived stress, social isolation and loneliness in interviews than in self-administrated questionnaires, since these are sensitive topics which in general have been shown to be under-reported in interviews [261].

Another limitation of this study stems from the use of different questions for the assessment of alcohol intake and the intake of fruit and vegetables in the two surveys. In the DHMS the responders had the possibility to report how many standard drinks they drink on each of the days during a week, and in the DNHPS it was only possible to report the number of drinks during a week. It is well known that the more specific questions are, the higher is the reported alcohol intake [198]. The different questions used in DNHPS and DHMS may partly explain the differences in high-risk alcohol intake that was found among the residents of deprived neighbourhoods and in the general population. The same could also be the case in relation to low intake of fruit and vegetables.

Are the self-reported data prone to information bias?

Information bias may especially have occurred for questions on health-risk behaviour, perceived stress, social isolation, and loneliness, which can lead to a misclassification of these indicators. Differential misclassification can cause over- or underestimation of the associations examined in the studies in the present thesis. This can be due to *social desirability bias* [262], where respondents report socially acceptable behaviours, resulting in an under-reporting of their real behaviour. Self-reported data tend to underestimate smoking [263] and alcohol use [198], while people tend to overestimate their physical activity, which can be an indicator of social desirability bias [264]. Information bias may also occur due to *recall bias* in studies using self-reported measures [262], where recent health-risk behaviours generally are remembered better or in more detail than health-risk behaviours occurring in the longer past. However, I do not believe that the observed associations in regard to health-risk behaviour are considerably affected by misclassification.

The assessment of perceived stress was based on questions dealing with life stress in terms of feeling in control. Some respondents may under-report their actual situation in regard to perceived stress if they think it is not socially acceptable to lack control in one's own life. This could thus cause social desirability response bias.

The assessment of social isolation included questions on contact frequency with family and friends, which may activate a negative feeling of being socially unsuccessful, if the respondent rarely or never has contact to family and friend. This issue could potentially cause social desirability response bias.

Information on loneliness was obtained with the single self-reported item: *Are you ever alone, although you would prefer to be together with other people?* The question is an indirect way to assess loneliness [265]. *The direct way* of measuring loneliness includes the word "lonely" or "loneliness", which has been criticized for underestimating the actual level of the respondents' loneliness [266] due to social stigma [265] causing people not to be honest in their answer. The item used to assess loneliness in **paper IV** is an indirect way of measuring loneliness, but it could still potentially lead to information bias, as it could be expected that some people consider it to be socially stigmatizing to be alone, if you would rather be with others.

Is the observed association due to confounding?

In **paper III-IV**, the interpretation of the results may be confounded by risk factors of health-risk behaviour that are also associated with perceived stress, social isolation, and loneliness. Confounding occurs if an assessed association between exposure and outcome is affected by a common cause of the exposure and outcome [255]. Thus, a confounding variable is not an intermediate variable between exposure and outcome. In this thesis, confounding factors were identified by examining previous research. The potential confounding factors included in **paper II-IV** are shown in **Table 1** (Chapter 3). Controlling for these factors did not strongly influence the results. The observed association in the studies can, however, be caused by the lack of adjustment of relevant confounders not included in the analysis, also termed residual

confounding. This could have created bias in the observed associations in the thesis. It could for example be expected that income and individual preferences would act as confounders because they may influence which neighbourhood people live in. At the same time, they can have an effect on health-risk behaviour independent of neighbourhood of residence [159]. These potential confounding factors were not available in the data.

6 Conclusions and implications

The overall aim of this thesis was to contribute with evidence on health-risk behaviour in deprived neighbourhoods, with a focus on socioeconomic inequalities and the role of perceived stress, social isolation, and loneliness. The starting point of this thesis was two-sided. Firstly, from a research perspective, we lack knowledge about health-risk behaviour in deprived neighbourhoods in Denmark compared to the general population and the associated potential harmful effects of perceived stress, social isolation, and loneliness. Secondly, from a health promotion and prevention perspective, contributions that fill this knowledge gap could help to promote healthier behaviour among residents in deprived neighbourhoods through better targeted health-promotion strategies to reduce social inequalities in health.

Several important findings were reported in this thesis.

Firstly, the existing literature showed that residents in deprived neighbourhoods have a higher risk of smoking and physical inactivity compared to non-deprived neighbourhoods. The evidence on low fruit and vegetable consumption and alcohol intake were ambiguous, and no clear differences were found. We found that numerous different operationalizations of neighbourhood deprivation were used in the existing literature.

Secondly, residents in deprived neighbourhoods in Denmark had higher prevalence of health-risk behaviour compared to the general population, even after adjustment for sociodemographic and socioeconomic characteristics. However, residents in deprived neighbourhoods had lower prevalence of high-risk alcohol intake. Large sociodemographic and socioeconomic differences in health-risk behaviours were found among the residents in the deprived neighbourhoods.

Thirdly, residents in deprived neighbourhoods had higher odds of perceived stress and loneliness than the general Danish population. Perceived stress, social isolation, and loneliness were in general associated with health-risk behaviour in deprived neighbourhoods. No significant associations were found for high-risk alcohol intake regarding perceived stress and loneliness. Perceived stress modified the associations between SES and physical inactivity, and between SES and having two or more health-risk behaviours. Perceived stress was more strongly associated with physical inactivity and having two or more health-risk behaviours among residents with medium/high SES compared to residents with low SES. Social isolation and loneliness did not modify the associations between SES and health-risk behaviour.

The findings from this thesis add substantially to the limited knowledge on health-risk behaviour in deprived neighbourhoods in Denmark and the associated effects of perceived stress, social isolation, and loneliness. The results support the relevance of adopting socio-ecological models, where individual-level

factors and neighbourhood-level factors are considered to interact in explaining social inequalities in health-risk behaviour. The explanations presented in this thesis do not give a fully comprehensive overview of approaches in explaining social inequalities in health-risk behaviour, but indicate the complexity of the problem. The aim of this thesis was to investigate some central factors of social inequality in health-risk behaviour from the social epidemiological field. The findings add new important insights to the social epidemiological evidence on health-risk behaviour in deprived neighbourhood and associated factors, which can provide useful knowledge to public health practice and for future research.

6.1 Implications for public health practice

The results of this thesis provide useful knowledge for public health practice. The thesis highlights that living in a deprived neighbourhood is in general strongly associated with health-risk behaviour, thus indicating the existence of a neighbourhood effect beyond the individual level. This underlines the need to focus on deprived neighbourhoods as settings for intervention programmes to promote and support healthy behaviour. It has been proposed that a multi-level approach concerning interventions to increase people's agency and skills and changing environments and the resources they offer is crucial to reduce social inequalities in health through the setting approach [267]. The settings approach aims, by definition, to influence health and health behaviour through action on 'the places or social contexts in which people engage in daily activities, in which environmental, organizational and personal factors interact to affect health and well-being', as well as on people found within these settings [267,268]. In general, my recommendation would be to apply multi-level interventions and policies that target both individual and environmental factors to help prevent and reduce health-risk behaviour in deprived neighbourhoods. Optimally, both psychosocial factors (such as perceived stress and social relationships), physical environmental factors (availability of facilities that promote healthy behaviours), and policy factors (pricing strategies in regard to e.g. cheaper fruit and vegetables and more expensive cigarettes) should be considered [53].

The second study of the thesis contributes to identifying the most important health-risk behaviour to address in deprived neighbourhoods, and which residents of the deprived neighbourhoods would benefit from extra attention in future health promotion interventions. Health promotion intervention programmes in deprived neighbourhoods should especially target men, residents with lower educational level, unemployed, disability pensioners and residents living alone. Further, they should include elements of health education as well as specific health-promoting activities in the neighbourhood focused on smoking reduction and greater fruit and vegetable intake and physical activity. In addition, the results regarding co-occurrence of health-risk behaviour indicate that interventions that simultaneously tackle multiple health-risk behaviours may be more appropriate in deprived neighbourhoods. Given that high-risk alcohol intake is not worse in

deprived neighbourhoods than in the general population, the same campaigns to reduce high-risk alcohol intake can be applied both among the residents in deprived neighbourhoods as in the general population.

Despite the uncertainty in the direction of causality of the associations examined in this thesis, the results indicate that psychosocial factors such as perceived stress, social isolation, and loneliness should be considered in future intervention programmes aimed at reducing health-risk behaviour among residents in deprived neighbourhoods, especially among residents with low SES.

Future health promotion interventions in deprived neighbourhoods may benefit from incorporating stress reduction strategies to reduce health-risk behaviour, especially among residents with Non-Western ethnic background, unemployed, and disability pensioners. Based on this study, I believe that interventions should help residents in deprived neighbourhoods to cope with stress without resorting to health-risk behaviour by offering more effective and less harmful ways of coping with stress. According to the Transactional Model by Lazarus and Folkman, people can be taught to manage their stress and cope with their stressors [174]. Activities such as physical activity, relaxation techniques, communicating to others, or social activities have shown to be effective in managing stress [84,269], and Lipschitz et al. (2015) found a relationship between improved stress management over six months and decreased health-risk behaviour [270]. I suggest that practitioners assess perceived stress among residents in deprived neighbourhoods and refer their patients to stress reduction facilities when needed. In addition, prevention at the individual level should work to strengthen the residents' robustness in managing stressors in their daily life. According to Antonovsky (1998), robustness should be understood as the ability of the individual to handle challenges and stress and as the belief in their own abilities to succeed [271].

The findings of the fourth study of this thesis indicate that strategies to decrease social isolation and loneliness could be integrated into health promotion interventions to reduce health-risk behaviour in deprived neighbourhoods, especially among residents with western ethnic background and disability pensioners.

Social isolation in deprived neighbourhoods may be reduced by interventions that promote social relationships, e.g. through social activities such as communal eating, cooking classes, or joint exercise classes provided in a community centre [191]. The social activities can be an entrance to form new friendships and initiate changes in health behaviour. By building and supporting new networks and gathering places, it is possible to increase the social capital of the residential area [134]. Social capital is an expression of the cohesion of a society and for social networks to have a value [134]. According to Putnam (1993), arises social capital between people and can be defined as trust, norms and networks [272]. By creating social capital in a neighbourhood, each residents gains access to resources that surpass the mere

sharing amongst the residents [134]. By being part of a social network, the residents will find it easier to reach both individual and shared goals [273], such as eating healthier, stop smoking or exercising.

Being part of an inclusive community can prevent social isolation, yet it seems more complex to improve the feeling of loneliness [126]. Nevertheless, reducing social isolation through the strengthening of social relationships in deprived neighbourhoods should also reduce feelings of loneliness among some of the residents. Promoting social interactions in deprived neighbourhoods may result in improved social integration and social support, whereby self-efficacy and adaptive coping strategies can be strengthened [274], leading to improved health behaviour. Further, social relationships interventions in deprived neighbourhoods can promote knowledge of and influence social norms and attitudes to healthy behaviour through social diffusion mechanisms, whereby health-risk behaviour can be changed [275]. However, it is important to be careful about assuming that interventions to strengthen social relationships and improve perceptions of loneliness can reduce health-risk behaviours among residents in deprived neighbourhoods, since there is no current evidence for this.

6.2 Implications for future research

This thesis has several implications for future research. More research is needed to better understand why residents in deprived neighbourhoods have a higher prevalence of health-risk behaviour compared to non-deprived neighbourhoods and to identify how living in deprived neighbourhoods influences health-risk behaviours. The present thesis provides important entry-points for future intervention studies in deprived neighbourhoods aimed at reducing health-risk behaviours.

Research on the association between neighbourhood environmental factors and health-risk behaviour is lacking in Denmark, and more research is needed to determine which features of the neighbourhood environment are the most important for health-risk behaviours. More knowledge on the pathways between the neighbourhood environment and health-risk behaviour can support the development of effective interventions to tackle health-risk behaviours in deprived neighbourhoods. Longitudinal approaches with measurement of both neighbourhood characteristics and health behaviour outcomes could provide stronger evidence for the impact of the neighbourhood features on health-risk behaviours, and for the causality of the relation between neighbourhood deprivation and health-risk behaviour.

It would also be interesting to investigate how living in a deprived neighbourhood affects health-risk behaviour with a life-course approach. For example, are individuals more exposed if they grow up in a deprived neighbourhood compared to individuals who have only lived in a deprived neighbourhood in adult-life, and does it have any influence on their health-risk behaviour for how long they have been living in a deprived neighbourhood?

Since it was not possible to provide evidence for causal associations in **paper III-IV**, there is a need for longitudinal studies to elucidate the direction of causality in the associations between perceived stress, social isolation, and loneliness and health-risk behaviour.

In addition, more research is needed to understand the pathways by which perceived stress, social isolation, and loneliness affect health-risk behaviour. The analyses in this thesis were based solely on quantitative data. This allowed me to study associations, but provided limited insight into the reasons behind the possible mechanisms on how neighbourhood deprivation, perceived stress, social isolation, and loneliness affect health-risk behaviour. In future research, the use of qualitative interviews (focus groups, in-depth interviews) could provide deeper insights and understanding of the observed associations, and thus support more targeted interventions for residents in deprived neighbourhoods. Qualitative methods can be used to develop and strengthen the conceptual frameworks explaining the relationships between neighbourhood deprivation, perceived stress, social isolation, loneliness, and health-risk behaviour.

Another important topic for future research is the interaction between perceived stress and social relationships, referring to Cohen's stress-buffer hypothesis of social relationships to alleviate the negative health related consequences of stress [183,276]. Studies of this interaction are essential to identify potential relieving factors (such as social support) that can help people to cope with stressors and thereby potentially reduce health-risk behaviours. The stress-buffer model suggests that populations who experience high levels of stress might be at increased risk of experiencing health-damaging consequences of poor social relationships [183], which is in accordance with the results in **paper III** in this thesis. Cacioppo et al. (2003) have suggested that socially isolated and lonely individuals have higher levels of stress, which may in turn influence health [277]. Residents in deprived neighbourhoods have high risk of perceived stress, social isolation, and being lonely, and it would thus be highly relevant in future research to investigate whether social relationships can act as a buffer in the association between perceived stress and health-risk behaviours in deprived neighbourhoods.

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8 Paper I-IV