Explaining socioeconomic inequalities in health behaviours

– the role of environmental factors

C.B.M. Kamphuis

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Explaining Socioeconomic Inequalities in Health Behaviours

– the role of environmental factors

Het verklaren van sociaaleconomische verschillen in gezondheidsgerelateerd gedrag

– de rol van omgevingsfactoren

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Co-promotor:	Dr. F.J. van Lenthe

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General Introduction

General Introduction

In general, those who are worse off in terms of power, knowledge and wealth are also worse off in terms of health. This inverse relation between socioeconomic status (SES) and health has been observed for centuries [1]. With few exceptions, the association exists regardless of the measure of SES that is employed (education, income, or occupation) or the health outcome studied. Still today, in a developed country like the Netherlands, considerable socioeconomic differences in health exist. Those with a lower socioeconomic position live three to five years shorter than their higher status counterparts (on average), and also spend ten to fifteen more years in poorer health [2]. Lower socioeconomic groups have higher rates of morbidity and mortality from cardiovascular diseases, obesity, type 2 diabetes and cancers [3, 4], report more health problems and complaints [5], and have poorer self-perceived health [6].

Despite all advances during the last century that have resulted in today's modern society, health inequalities have not reduced over time, in fact, they have even widened over the recent decades [7]. However, the common convention in nowadays' Western societies is that socioeconomic health inequalities should be reduced, for several reasons. First, health inequalities are considered unjust, as the poorer health of lower socioeconomic groups is at least partly due to societal and environmental processes which are beyond their individual control [8]. Secondly, good health and freedom of choice are valued high within our society, and good health is an important predisposition for every individual's opportunities in life. Thirdly, if the average health status of lower SES groups could be upgraded to the level of their more advantaged counterparts, this would have large gains for public health in general [8]. Lastly, variations in the magnitude of health inequalities over time and between countries suggest that health inequalities are, at least to some extent, modifiable [9]. Therefore, research is needed to find entry-points for policies and interventions to reduce socioeconomic health inequalities.

1.1 Possible explanations for socioeconomic health inequalities

Much remains to be understood about the ways in which SES and health are related. The influential Black report, published in the U.K. in 1980 [10], proposed three explanatory mechanisms for the observed socioeconomic patterns: causation, selection, and artefacts. The latter mechanism suggests that socioeconomic health differences are the result of artefacts due to, for instance, measurement error or inappropriate measures of health or SES. The strong and consistent findings for the association between SES and health, noted in many countries and across varying time periods, do not suggest that artefact plays a major role. The second mechanism, selection, can be either direct or

indirect. Direct selection involves a person's health status affecting their social position, i.e. healthy people may move up in the socioeconomic hierarchy, while unhealthy people may move down. Indirect selection effects may also play a role, in which indicators of good health affect SES, such as between height and SES, or physical attractiveness and SES; that is, taller and handsomer persons are more likely to be upwardly mobile [11]. However, the first mentioned mechanism, causation, where SES is related to health via intermediary factors, is believed to be the main explanatory mechanism for socioeconomic health differences.

Causation mechanisms assume that SES has an indirect effect on health through an unequal distribution of determinants of health across socioeconomic groups, with unfavourable determinants being more prevalent among the lower socioeconomic groups. Many causal pathways through which income, education and occupation may affect health have been postulated and investigated, including (1) material factors, i.e. exposure to household/work/neighbourhood environments that are not conducive to health, such as poor housing conditions, crowding, occupational hazards, and crime; (2) psychosocial factors, e.g. exposure to stressful situations, adoption of effective coping strategies, ability to control one's environment, availability of social relationships and support; (3) behavioural factors, i.e. distribution of health risk behaviours, such as smoking, excessive alcohol consumption, unhealthy diet, and inadequate exercise; and (4) healthcare-related factors, i.e. access to preventive and curative health care, or information regarding health risks [12, 13]. The four groups of explanatory factors seem to be interrelated, indicating that some mechanisms work through others rather than work independently from each other [3, 13]. Studies that have incorporated risk factors from several domains show that, for instance, income differences in cardiovascular mortality and all-cause mortality [3], and educational differences in all-cause mortality [13] were almost completely explained by a combination of multiple explanatory factors.

The relative importance of different (groups of) explanatory factors for socioeconomic health differences is under debate. Some argue for a primarily material explanation, in which inequalities in health are the result of differential exposure to material deprivation (the 'neo-material' interpretation [14]), i.e. unequal access to tangible material conditions. Others argue that relative material standards, rather than absolute standards, are influential (the 'psychosocial interpretation'). They consider socioeconomic health inequalities largely the direct or indirect effects of stress stemming from being lower on the socioeconomic hierarchy, or living under conditions of relative disadvantage [14]. Another part of the literature merely focuses on health behaviours as explanation for socioeconomic health differences. Health behaviours have been ranked as one of the main explanations since the 1980's [15, 16], and have been found

to explain about 30-50% of socioeconomic differences in mortality [3, 13, 17, 18], although other studies found only modest contributions [19]. Lastly, some studies suggest that unequal access to health care contributes to socioeconomic differences in health, however in the Netherlands, health care utilisation could not explain socioeconomic differences in the course of diabetes and heart disease [20, 21]. Instead, lower SES groups were found to visit their GP more often and spend more nights in hospital compared to higher SES groups, even when taking into account their worse health status [22] (however, they were less likely to consult a specialist).

Despite all research pointing to possible explanatory factors for the consistent association between SES and health, still, it is unclear *why* these risk factors are differentially distributed by SES. In this thesis, we will focus on the behavioural explanation for socioeconomic health differences, as behaviour is in principal changeable, and determinants of health behaviours may offer good entry-points to reduce socioeconomic health inequalities. We will ascertain why these are differentially patterned across SES-groups for two health behaviours, namely physical activity and diet.

1.2 Socioeconomic differences in health-related behaviours

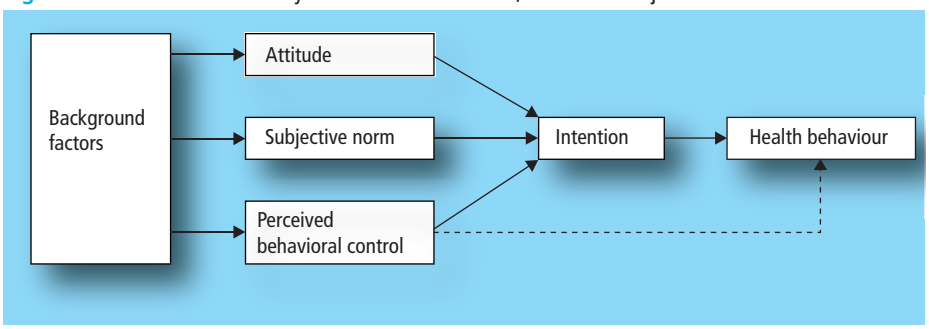
Physical activity and diet are important determinants of health. The protective effects of physical activity for total mortality, cardiovascular disease, and diabetes are widely known and supported by a large amount of evidence [23-25]. Physical activity also increases chances for longevity: life expectancy for sedentary people at age 50 years is 1,5 years shorter than for people engaging in moderate daily physical activity, and more than 3,5 years shorter than for people with high physical activity levels [26]. How much activity is required to achieve health benefits is still a topic of debate. While many studies show that moderate intensity exercise, like walking, is sufficient to reduce the risk of cardiovascular disease [27, 28], others conclude that only heavy or vigorous activity, like sports, confers benefit [29-31]. As walking is more easily implemented on a daily base and more attainable for sedentary people than vigorous exercise, the focus of current physical activity recommendations is to promote moderately intense types of physical activity [32, 33]. Substantial epidemiological evidence points to a protective role for fruit and vegetables in the prevention of several cancers and coronary heart disease, and evidence is accumulating for a protective role in stroke [34]. Low fruit and vegetable intake is one of the leading risk factors for death from cancer worldwide, together with smoking and alcohol use [35]. Since fruits and vegetables are a valuable source of dietary fibre, their consumption may also protect against weight gain and obesity [36, 37].

Compared to people from high socioeconomic groups, people from lower socioeconomic groups are more likely to be physically inactive [38-40], not to walk for recreation or transport [41], to have lower levels of leisure time physical activity [42, 43], and to show decreases in leisure physical activity over time [44]. Dietary patterns also differ between socioeconomic groups [45]. Lower socioeconomic groups are less likely to consume any fruit or vegetables [46-48], have lower average levels consumption of both fruits and vegetables [49-53], and consume fewer varieties of fruits and vegetables than their more advantaged counterparts [46, 47]. To be able to reduce socioeconomic differences in physical activity and fruit and vegetable consumption, one needs to know which factors may offer good entry-points for interventions, i.e. factors that are related to the health behaviour *and* patterned by SES. To ascertain the relevant determinants, theoretical models that try to explain and predict variations in health behaviours are consulted.

1.3 Social-cognitive models: individual cognitions and health behaviours

Among the most commonly-employed theoretical models to predict health behaviours are two social cognitive theories: the Theory of Planned Behaviour and the Social Cognitive Theory [54, 55]. Fishbein and Ajzen's Theory of Planned Behaviour (TPB) assumes that one's intention to change his/her behaviour (e.g. I want to become physically activity on a daily basis) is determined by attitudes towards the behaviour (e.g. daily physical activity is fun; daily physical activity is healthy), subjective norms that are associated with the behaviour (e.g. family and friends think that I should be physically active on a daily base), and perceived behavioural control to perform the behaviour (e.g. I'm sure I could be physically active daily) (see Figure 1.1).

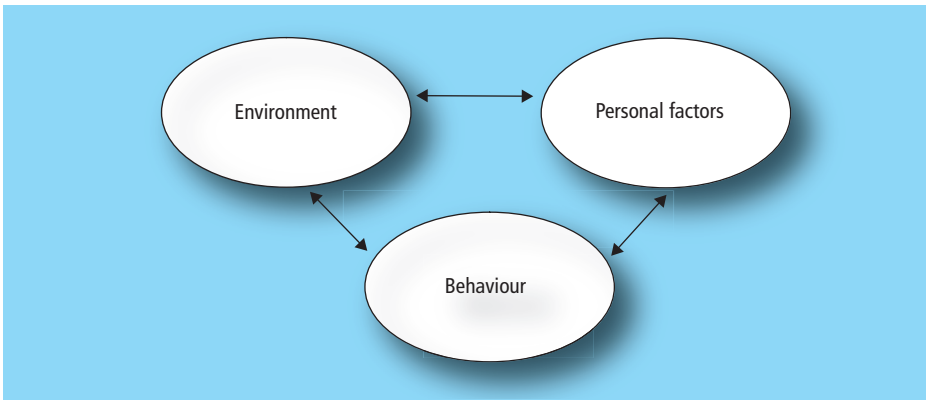
Figure 1.1 Core of the Theory of Planned Behaviour, Fishbein & Ajzen



Bandura's Social Cognitive Theory (SCT) proposes that behaviour change is affected by social environmental influences, personal factors, and attributes of the behaviour itself. Each of these factors may affect or be affected by either of

the other two (see Figure 1.2). The SCT has some similarities with the TPB. Comparable to the TPB construct of 'attitude' is the SCT construct of 'outcome expectancies', which are anticipated, either positive or negative outcomes of a particular behaviour (e.g. daily physical activity will cost too much time; daily physical activity will be good for my health). Very similar to the construct of perceived behavioural control in the TPB, is the SCT construct of self-efficacy, which is the confidence a person feels about performing a particular behaviour (e.g. I'm sure I could be physically active daily). The social component, however, receives more attention in the SCT than TPB. The effects of expected reinforcement from the social environment (e.g. social support for daily activity by friends and family) and observation and modelling (e.g. friends and family are daily active as well) are considered crucial in the adoption of health behaviours.

Figure 1.2 Social Cognitive Theory, Bandura



Attitudes, subjective norms and perceived behavioural control predict general variations in health behaviours, accounting for 27% and 39% of the variance in behaviour and intention, respectively [56]. Also, social support and modelling and, in particular, self-efficacy are strong correlates of health behaviours [57]. These individual cognitions have been utilised less frequently for understanding *socioeconomic* variations in health behaviours. However, lower socioeconomic groups have shown to be less health consciousness and having stronger beliefs about effects of destiny on health, which were associated with less healthy behavioural choices [58]. Knowledge is thought to be an important prerequisite for making decisions about health and health behaviours, as these are partly based on beliefs of what causes disease and whether or not those causes can be overcome. A Canadian study has shown that knowledge of the main modifiable cardiovascular risk factors was strongly and positively related to SES [59]. Similar, having more nutrition knowledge is likely to be one of

the reasons why people of higher SES eat more fruit and vegetables [58]. Self-efficacy, enjoyment of physical activity, and intentions were found to contribute to the explanation of socioeconomic differences in walking [41].

Although some of the variations in health behaviours can be accounted for by individual cognitions, social-cognitive theories have been criticized for their focus on such motivational factors only, paying little attention to environmental, non-voluntary factors which are beyond the individual's control. To better understand why people behave as they do, and to increase the likelihood of behaviour change, it is important to put behaviour into context. This renewed interest in environmental factors for health and health behaviours has shifted the focus from social-cognitive towards ecological models of health-behaviours.

1.4 Ecological models: environmental factors and health behaviours

Ecological models emphasize that besides intrapersonal and interpersonal factors, the environment also has an important effect on health behaviours. All these factors together function to promote or hinder an individual's engagement in health behaviours [60]. Many different environmental settings may impact on behaviours, e.g. factors from the neighbourhood, work, or household environment, but also city- and country-level variables (e.g. policies, regulations, media). Ecological models state that individual-level and environmental-level factors interact: people influence their settings, and environmental settings influence health behaviours. Environments can restrict people acting in a healthy way by promoting (and sometimes demanding) other actions and by discouraging or prohibiting health behaviours. A criticism of ecological models is that they are often stated in rather broad terms and not behaviour or context-specific. [61]

Findings from numerous cross-sectional studies support the ecological hypothesis that environmental variables and health behaviours are correlated. For physical activity, literature reviews conclude that research on environmental determinant shows promising results, however, more research with stronger study designs is needed before firm conclusions can be drawn about their role [57, 62-65]. However, the objective and perceived availability and accessibility of facilities, as well as the objective and perceived general design of neighbourhoods (e.g. the presences of sidewalks, traffic safety) and perceived aesthetics have found to be positively associated with various types and levels of physical activity [64]. Although the body of research that investigated environmental influences on diet to date is even more limited, diverse -mainly U.S.- studies support the principle that nutrition environments may influence eating behaviour. One study reported that African-American adults' fruit and vegetable intake increased with each additional supermarket in their area of residence

[66]. Two other U.S. studies reported positive associations between proximity to supermarkets/health food stores and dietary patterns [67, 68]. The growing number of fast food establishments present in neighbourhoods has been linked to the current obesity epidemic, as fast food consumption is associated with weight gain and intakes less consistent with dietary recommendations [69, 70].

1.5 Environmental factors and socioeconomic inequalities in health behaviours

One may hold the opinion that it is an individual's choice to eat less healthy, do less exercise and smoke. However, in view of the collective nature of multiple health behaviours being less favourable among the disadvantaged, it is rather unlikely that these behaviours are purely the result of individual choices. Choices in relation to food and activity are not solely individual matters, but it is more likely that neighbourhood, household or material conditions constrain and govern choices to a considerable extent, as suggested by ecological models. The cost and accessibility of products and facilities, the physical area where households of lower SES groups are located, and less favourable social circumstances may make it less easy for lower SES groups to behave in a healthy manner [43, 71-73]. The growing body of evidence for place effects on health supports this hypothesis. Even after adjustment for individual-level variables such as age, gender, and individual SES, residents of disadvantaged neighbourhoods were found to be in poorer health [74-77] and have higher rates of unhealthy behaviours, i.e. smoking [74, 78-81], physical inactivity [78, 80-83] and poor diet [81, 84]. This means that the higher prevalence of unhealthy behaviours among people of low SES may be partly due to either direct or indirect adverse effects of their neighbourhood of residence. Although there is some promising evidence that neighbourhood factors may influence physical activity and dietary behaviours, little is known about the contribution of specific neighbourhood characteristics to socioeconomic differences in health behaviours.

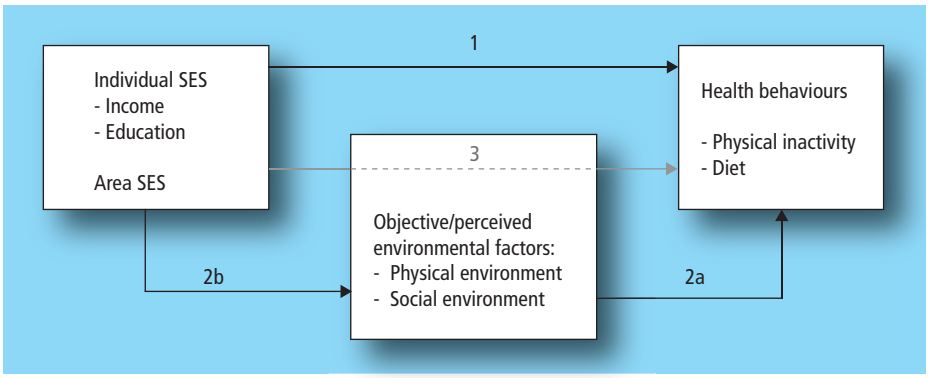
1.6 This thesis

The aim of this thesis is to investigate *why poor people behave poorly* [43], and to examine the contribution of environmental factors to the explanation of socioeconomic inequalities in health behaviours. Associations between SES, environmental factors, and health behaviours that will be tested in this thesis, are illustrated in Figure 1.3. Factors from many environmental settings may influence behaviour (e.g. work, household, media, national policies) and several of these will be examined in this thesis. However, in view of the above-mentioned evidence, that neighbourhoods in which poorer people live may be of poorer quality, and because the neighbourhood may offer good opportuni-

ties for (community) interventions, neighbourhood factors will be the main environmental factors examined in this thesis. The central research questions that will be addressed are:

1) To what extent do socioeconomic inequalities in specific types of physical inactivity and dietary behaviours exist?
2) To what extent are neighbourhood factors associated with specific physical inactivity and dietary behaviours (2a) and do they differ by SES (2b)?
3) To what extent and via which pathways are neighbourhood factors involved in the explanation of socioeconomic inequalities in physical inactivity and dietary behaviours?

Figure 1.3 Hypothesised associations between SES, environmental factors and health behaviours



The thesis is divided into three parts. Part 1 has started with the present chapter and continues with Chapter 2, introducing the conceptual framework, the stepwise study design and research methods that have been applied in several studies of this thesis. Chapter 3 presents a focus group study, with which we started off this project, to explore the research questions of this thesis in a qualitative way, i.e. by asking groups of adults from lower and higher socioeconomic backgrounds: what environmental factors in your daily life influence your physical activity and fruit and vegetable consumption?

In Part 2, the focus is on physical inactivity behaviours, and associations with SES and environmental factors are examined. First, we study the relative importance of neighbourhood factors for two specific outcomes of sports activity: doing any sports activity, and doing sports according to recommended levels (Chapter 4). The contributions of neighbourhood, household, and individual factors to the explanation of socioeconomic inequalities in sports participation are explored in Chapter 5. In Chapter 6, we examine how socioeconomic variations in recreational walking among older adults are mediated by neigh-

bourhood factors and individual cognitions. In the next chapter, Chapter 7, we study to what extent neighbourhood perceptions correspond with objective characteristics of neighbourhoods, and which other factors may play a role in how people form perceptions of their neighbourhood. The study described in the last chapter of Part 2, Chapter 8, has been carried out in Australia, and data were collected by the University of Melbourne, in collaboration with the Queensland University of Technology, Brisbane. We investigate how area variations in recreational cycling in Melbourne can be explained by objective area characteristics.

Next, in Part 3, associations between SES, environmental factors and diet are examined. Chapters 9 and 10 describe the results of two large literature reviews, focussing on environmental determinants of energy and fat intake, and environmental determinants of fruit and vegetable consumption, respectively. In Chapter 11, we examine associations of neighbourhood and household environmental factors with fruit and vegetable consumption, and whether these factors contribute to socioeconomic variations in fruit and vegetable consumption.

Finally, in Part 4, main results are put in a broader perspective and summarised. Chapter 12 captures the General Discussion of this thesis, providing a summary of the main results, a discussion of the strengths and weaknesses of the studies in this thesis, interpretations of the results in light of findings from other studies, and implications for future research and policy development. This thesis ends with summaries in English and Dutch.

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2

Investigating the contribution of environmental characteristics to socioeconomic inequalities in health-related behaviour in the GLOBE study: theoretical framework and study design

Van Lenthe FJ, Kamphuis CBM, Giskes K, Looman CWN, Huisman M, Brug J & Mackenbach JP. Investigating the contribution of environmental characteristics to socioeconomic inequalities in health-related behaviour in the GLOBE study: theoretical framework and study design (submitted to *BMC Public Health*)

Abstract

Background The higher prevalence of unhealthy behaviours (such as smoking, physical inactivity, and low fruit and vegetable intake) among lower as compared to higher socioeconomic groups is still largely unexplained. We conducted a study to investigate the contribution of environmental characteristics at the neighbourhood, household and work level to socioeconomic inequalities in unhealthy behaviours within an ongoing prospective cohort study, i.e. the Dutch GLOBE study.

Aim To describe the theoretical background, design, methods, and response of the study, and some baseline characteristics of the study sample.

Methods Data were collected following a stepwise approach, including focus group interviews, a large scale postal survey, in-depth interviews, and an audit of objective environmental characteristics. Focus group interviews were conducted to explore perceptions of environmental influences on health behaviours among higher educated persons residing in affluent neighbourhoods (N=24), and lower educated participants from deprived neighbourhoods (N=14). A total of 10.270 persons aged 25 years and older were invited to participate in a postal survey in 2004. The overall response was 64.4%. Among responders, 210 persons living in seven disadvantaged and 217 persons living in seven advantaged neighbourhoods were additionally interviewed (response 72.4%). For these fourteen neighbourhoods, objective environmental characteristics were assessed with systematic environmental audits.

Conclusions At the start of the study, there were many environmental characteristics of potential relevance for (socioeconomic inequalities in) health behaviours. Combining complementary methods of research in a stepwise approach is an efficient way of investigating the contribution of perceived and objective environmental determinants to socioeconomic inequalities in health-related behaviour and the pathways by which environmental characteristics are associated with health-related behaviours.

Introduction

in the Netherlands, males and females with the lowest educational level have a lower life expectancy at birth of 5 and 2,5 years, respectively, compared to those in the highest educational group [1]. Many unhealthy behaviours (smoking, physical inactivity, and low fruit and vegetable intake) are more prevalent in lower than in higher socioeconomic groups, and contribute substantially to socioeconomic inequalities in mortality [2, 3] and morbidity [4]. Explanations of socioeconomic inequalities in smoking, physical inactivity and low fruit and vegetable intake are still largely unknown, and this hinders the development of effective interventions to reduce socioeconomic inequalities in these health behaviours.

Socioeconomic inequalities in health-related behaviours may be the result of an unequal distribution of behavioural determinants or mediators across socioeconomic groups. For a long time, research on the determinants of health-related behaviour has focused on personal cognitive and other 'proximal' determinants. In recent years however, there has been a shift in perspective towards more distal and generic – environmental – determinants of health-related behaviours. For the explanation of socioeconomic inequalities in these behaviours, this shift may be particularly relevant: the collective nature of unhealthy behaviours within the lower socioeconomic groups suggests that health behaviours to some extent can be due to common environmental exposures, which may be more unfavourable in lower as compared to higher socioeconomic groups. But which environmental characteristics are important in the explanation of socioeconomic inequalities in health-related behaviour, and what are the pathways through which environmental characteristics are linked to health-related behaviours?

The prospective GLOBE study was initiated in 1991 with the aim to assess the contribution of groups of factors to the explanation of socioeconomic inequalities in health in the Netherlands. The design of the study, as well as key findings after ten years of follow up have been described in detail elsewhere [5, 6]. The most recent wave of data collection (which started October 2004) was conducted with the main purpose of investigating the explanation of socioeconomic inequalities in health-related behaviours (smoking, physical inactivity, and low fruit and vegetable intake) with a special emphasis on the role of environmental characteristics. Specifically, the study aimed at answering the following research questions:

1. What are the main environmental factors involved in the explanation of socioeconomic inequalities in smoking, physical inactivity, and low fruit and vegetable intake?
2. What are the specific pathways between exposure to these environmental factors and smoking, physical inactivity, and low fruit and vegetable intake?

3. What entry-points for interventions and policies to reduce socioeconomic variations in these health-related behaviours can be identified?

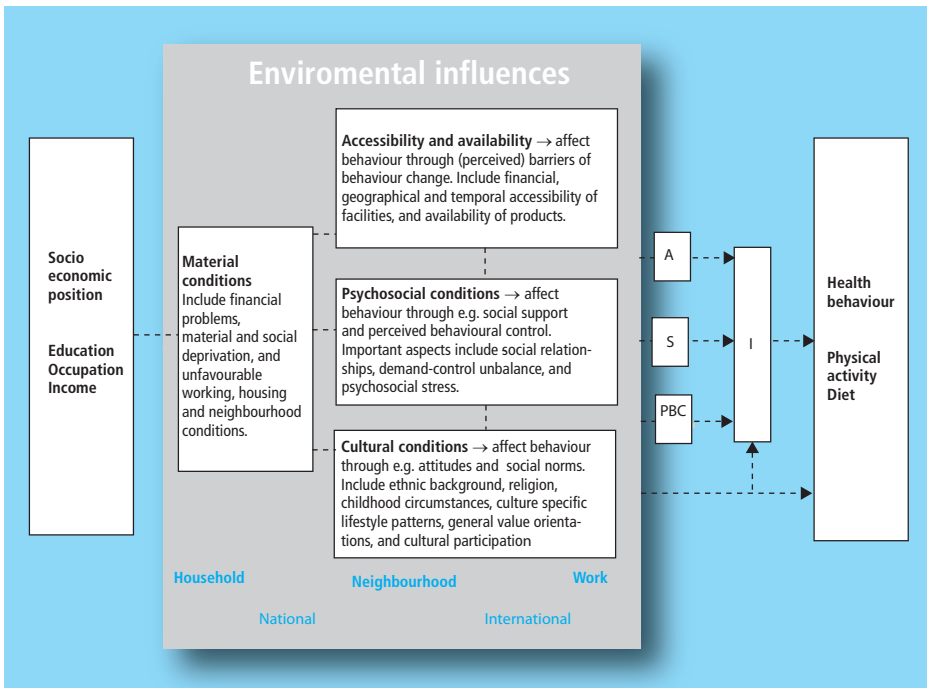
To answer the first and second research questions empirically, a stepwise protocol was adopted, in which different research methods were employed. It is the aim of this paper to describe the study protocol of this wave of data collection.

Design, participants and methods

A conceptual theoretical model

At the start of the study there appeared to be no established conceptual model linking indicators of socioeconomic position (SEP) to (detailed) environmental and individual characteristics and, ultimately, to health-related behaviours. Using an eclectic approach, a conceptual model was developed (Figure 1).

Figure 2.1 A framework of environmental determinants contributing to the explanation of socioeconomic inequalities in health behaviours



Notes: The grey panel incorporates four boxes of environmental determinants. The terms household, neighbourhood and work are examples of the different settings in which these determinants may influence health behaviours. The abbreviations in the right hand boxes represent the following constructs: A= attitude; S= social influences, like social support, subjective norms, and modelling; PBC= perceived behavioural control; I=intention. These constructs are derived from the Theory of Planned Behaviour (33)

For this purpose, we based the model on existing knowledge about mechanisms leading to socioeconomic inequalities in health, i.e. a social causation mechanism was assumed to be operating. According to this mechanism, SEP is related to health-related behaviour via intermediary factors. Inspiration for such intermediary environmental factors came from leading reports [7] and empirical evidence on the explanation of socioeconomic inequalities in health [8], general ecological models [9], the Triadic Influence Model [10], and the separation of environmental groups in the Angelo model [11]. Eventually, environmental characteristics of the neighbourhood, household, and work setting were included, which focussed on material conditions, access and availability, psychosocial and cultural conditions. These groups of factors were thought to be linked to health-related behaviours via individual characteristics as derived from the Theory of Planned Behaviour [12]. This model served as a general framework for data collection and analysis.

Design: A stepwise approach

To answer the research questions, a stepwise approach was used. This approach included focus group discussions, a postal survey and in-depth oral interviews. It was recognised that both perceived and objective environmental characteristics could be relevant for health-related behaviours, and that these would not automatically be overlapping, since people may differ in their perceptions of objectively equal environmental characteristics [13]. Therefore, objective environmental data were also collected. The use of personal data in the GLOBE study is in compliance with the Dutch Personal Data Protection Act and the Municipal Database Act, and has been registered with the Dutch Data Protection Authority (number 1248943). No formal approval of the Medical Ethical committee was required for the study.

1 Focusgroups

As a first step, focus group discussions were conducted to investigate whether environmental factors (as captured by the conceptual model) were indeed perceived as relevant for participants' health behaviours, and whether additional environmental factors were perceived relevant by participants. Participants of the focus groups were selected from the existing GLOBE study sample, as we had information on their educational level and neighbourhood socioeconomic characteristics. In this way, we were able to apply a purposive sampling approach, selecting participants from contrasting socioeconomic backgrounds, and to investigate whether perceptions of environmental factors differed between socioeconomic groups.

Two focus groups were conducted among individuals with high education residing in one of the eight most affluent neighbourhoods of Eindhoven, and two groups among individuals with low education residing in one of the eight

most deprived neighbourhoods. Potential participants were invited via letters and follow-up phone calls. Discussions were organised at the city municipality hall, as this was considered a central and neutral setting for potential participants. Table 1 shows the number of participants included in the focus groups. Two interviews (one in a high and one in a low SEP group) focused mainly on smoking behaviour, with some questions at the end of the interviews addressing fruit and vegetable intake and physical activity, while the other two predominantly focused on fruit and vegetable intake and physical activity with some brief questions addressing smoking behaviour.

Table 2.1 Characteristics of focus group participants

	High educated people residing in advantaged neighbourhoods		Low educated people residing in disadvantaged neighbourhoods	
	Group 1	Group 2	Group 3	Group 4
Participants (N)	12	12	6	8
Women	5	3	3	6
Men	7	9	3	2
Age, mean (age range)	57 (39-81)	62 (39-74)	64 (58-75)	62 (29-75)

A semi-structured questioning route was developed to ensure consistency in questions asked across groups [14, 15]. Questions were pre-tested for understanding in a high and low SEP pilot group. Questions guiding the discussion included:

- Do you engage in this health behaviour? How often? Why or why not?
- Can you think of determinants in your living environment that may influence whether or not you engage in this behaviour?
- How do those environmental determinants influence your behaviour?

The interviews were led by experienced moderators and group members consented to the discussion being taped. Data analysis was performed following the framework approach [16], and results have been described in detail elsewhere [17]. Briefly, it followed from the interviews that environmental factors most often perceived as important to participants' health-behaviours, had all been included in the conceptual model. Some environmental factors were mentioned both in higher and lower socioeconomic groups (such as the importance of social support); other factors (such as price concerns) differed in relevance between both groups [17].

2 Postal survey

Results from the focus group study and from a series of systematic reviews on environmental determinants of health related behaviours [18] were used for

the final selection of environmental factors to be included in the postal survey. The main aim of the postal survey was to make quantitative estimations of the contributions of environmental characteristics to socioeconomic inequalities in health-related behaviours. In addition, the survey allowed selection of respondents for the in-depth interviews, and the further selection of variables to be included in the in-depth interview and in the objective measurement of neighbourhood characteristics.

Postal survey: Study sample

The total sample of persons invited to fill in the postal survey in October 2004 (N=10.271) comprised three sub-samples. The first sub-sample was recruited among the subjects who participated in baseline interviews of the GLOBE study in 1991 (n=5.667). These persons were by that time residing in the city of Eindhoven or in selected surrounding villages, born in the Netherlands, and were between 15 and 74 years of age. In 2004, these GLOBE-participants did not necessarily live in Eindhoven or the surrounding villages anymore; they could have moved to places all over the Netherlands and abroad. With the exception of those who emigrated, participants' addresses were traced through an annually updated administrative follow-up. Attrition due to death, emigration, refusal to be followed up longitudinally and addresses that could not be traced anymore, the sample invited consisted of 4.347 persons. The second sub-sample consisted of a random sample of subjects (n=2.190) who participated in the baseline postal survey of the GLOBE study in 1991 (n=18.973 minus those who were in the baseline interview sample (n=5.667) described above). To be eligible for invitation, these persons still had to live in the city of Eindhoven in 2004 and had to be between 25-75 years of age. This sample was included because it allowed for more robust longitudinal analyses among residents of the city of Eindhoven, for example for exploring changes in the environment in relation to changes in health-related behaviours. Because of attrition (due to illness, death, emigration, and loss to follow up) and in order to include persons that moved into the area since 1991, non-born Dutch persons (not approached in 1991) or persons who were too young in 1991, these two sub-samples of GLOBE-participants together would not be representative of the population of the region of Eindhoven in 2004, and therefore could not be used for cross-sectional analyses. Thus, a third sub-sample was invited to participate, including adults in the age range of 25 to 75 years, residing in Eindhoven or the selected surrounding villages and who were not previously approached in the GLOBE study (n=3,734).

The cross-sectional analyses aimed to answer the first research question. For this purpose, a cross-sectional sample was compiled, including a selection of persons from all three of the above-mentioned samples, i.e. adults between 25 and 75 years of age, residing in the city of Eindhoven or the surrounding villages in October 2004.

Postal survey: Response

The questionnaire was sent to 10.271 persons. Different cover letters were sent to those who had and those who had not participated in the GLOBE study before. As an incentive to respond, two bicycles were raffled among respondents. Some invited persons had died (n=106) and some questionnaires were returned because of incorrect addresses (n=84) or unknown reasons (n=183). These persons never had the opportunity to fill out the questionnaire, and therefore the number of persons who actually received a questionnaire (N=9,898) was used as the denominator when calculating the response. With 6,377 respondents returning the questionnaire, the overall response was 64.4%. Among those who participated before in the study, the response was 74.4%, while among those who were new in the study the response was 55.0%.

Among those who received the questionnaire, 48.2% were male and 51.8% were female. There appeared to be small selective non-response by sex (Chi-square 23.294, $p<0.01$), with a slightly lower percentage of men (46.4%) returning the questionnaire compared to those invited (Table 2). Respondents were also more likely to be older. Using data from Statistics Netherlands on the mean monthly taxable income of residents and the average value of houses, it appeared that non-response was slightly higher in the lower quartiles of neighbourhood income and housing values.

Postal survey: Methods

The study focused on three behaviours: 1) smoking, 2) physical activity and 3) fruit and vegetable intake. Current smoking and smoking history were asked for using similar questions as asked in previous waves of the study [19, 20]. The Short QUestionnaire to ASsess Health-enhancing physical activity (SQUASH) is a reliable and reasonably valid Dutch questionnaire to assess the level of physical activity among adults [21], which was included in the survey to obtain information on leisure-time physical activity, sports, work-related transport and occupational physical activity. Fruit and vegetable intake were measured by a validated food frequency questionnaire with a reference period of one month [22]. Two indicators of SEP were sought: highest attained educational level and monthly net household income. Level of education is considered a good indicator of SEP in the Netherlands, and therefore often applied [23]. Our study appeared to be among the few epidemiological studies in the Netherlands measuring income data in a postal survey. To avoid a high non-response we followed recommendations as described elsewhere [24], which included an introduction of the question by a short rationale for asking information on income, using broad response categories, and by including an answer category 'I do not know my household income, or I don't want to answer this question'. Table 3 presents the socio-demographic characteristics of the cross-sectional sample and some baseline characteristics of the health-related variables.

Table 2.2 Response and non-response by sociodemographic characteristics, GLOBE postal survey 2004

	Invited* N = 9.898	Response N = 6.395	Non-response N = 3.425
Age			
25-34	15.1	11.9	20.9
35-44	17.7	15.6	21.4
45-54	14.1	14.1	14.0
55-64	19.1	21.8	14.1
65-74	18.5	21.8	12.4
75- 84	10.5	10.8	9.9
85 >	1.9	1.2	2.8
Missing	3.2	2.9	3.7
Chi-Square (p-value)	413.406 (p>0.01)		
Sex[b]			
Males	48.2	46.4	51.5
Females	51.8	53.6	48.5
Chi-Square (p-value)	23.249 (p<0.01)		
Neighbourhood income quartiles[c]			
1 (low)	24.4	22.7	27.3
2	28.9	27.7	31.0
3	20.7	21.4	19.4
4 (high)	23.4	25.4	19.7
Missing	2.7	2.8	2.5
Chi-Square (p-value)	63.625 (p< 0.001)		
Average house value quartiles[d]			
1 (low)	24.3	21.7	29.0
2	23.5	23.5	23.4
3	23.2	24.0	21.8
4 (high)	23.9	26.1	19.8
Missing	5.2	4.8	5.9
Chi-Square (p-value)	98.005 (p< 0.001)		

a Eligible to return the questionnaire, 1 person with missing value for sex
b For one person, sex was missing
c Income quartiles based on average taxable monthly income (cut off points 1500, 1900 and 2300 euro's)

Table 2.3 Baseline information of participants in the cross sectional sample (n=4.785)[a]

	%		%
Age (in 2004)		*Perceived health*	
25 – 34	14.8	Excellent	7.7
35 – 44	17.8	Very good	20.7
45 – 54	17.1	Good	52.1
55 – 64	25.1	Moderate	15.1
65 – 74	23.9	Poor	1.6
Missing	1.0		
		Smoking	
Sex		Current smoker	21.4
Male	45.4	Former smoker	33.7
Female	53.5	Never smoker	38.2
Missing	1.1	Missing	
Marital status[b]		*BMI*[c]	
Married	67.7	15 - 19.9	2%
Registered partner	4.0	20 – 24,9	35%
Single, never married	13.9	25,9 – 29,9	46.2
Divorced	7.3	30 >	16.2
Widowed	5.4	Missing	
Missing			
		PA recommendations	
Net Household Income		Yes	61.5
0-1200 euro per months	13.5	No	38.5
1200 – 1800	22.4	Missing	
1800 – 2600	24.1		
2600 or higher	25.6	*Recommended fruit intake*	
Don't know / Don't want to tell	11.4	Yes	53.6
Missing	3.0	No	46.4
		Missing	
Education[d]			
1. Low	10.0	*Recommended vegetable intake*	
2	32.9	Yes	20.1
3	23.0	No	79.9
4. High	28.0	Missing	
Missing	6.0		

a 3 persons were below the age of 25, and 3 persons above the age of 75

b 5.9% of the total population is single, divorced or widowed, but cohabitates with a partner.

c persons with missing values for height and weight excluded; BMI values below 15 and above 50 considered as incorrect

Neighbourhood characteristics that were measured included perceptions of a) social neighbourhood characteristics (such as incivilities, safety and length of residence), and b) physical characteristics (attractiveness and absence of facilities) and prices. Household environmental characteristics asked for included material (e.g. meeting ends financially) and social deprivation (e.g. having friends or family over for dinner). Work-related environmental characteristics included physical working conditions and job control [25]. Individual-level characteristics included were predominantly measured for physical activity and included outcome expectancies, social norms, self-efficacy, barriers and the 'intention to change' in relation to physical activity. Environmental barriers were also assessed for fruit and vegetable consumption.

3 In-depth interviews

While the data from the postal survey can be used to quantitatively estimate the contribution of broad groups of environmental determinants to socioeconomic inequalities in health-behaviours, they do not allow a more specific investigation of the pathways through which specific environmental characteristics are linked to individual level characteristics and ultimately to health-related behaviours. For that purpose, in-depth interviews were conducted in November 2005. The aims of the interviews were 1) to measure perceptions of environmental factors extensively and 2) to explore the pathways between environmental factors and health-related behaviours via individual-level characteristics.

In-depth interviews: Study population

Participants for the in-depth interviews were recruited among the respondents of the postal survey 2004. We conducted interviews among 210 participants residing in seven socioeconomically disadvantaged neighbourhoods, and 217 participants living in seven advantaged neighbourhoods of the city of Eindhoven. Table 4 presents the recruitment of the participants. The overall response was 72,4% with a higher response among those in the more affluent areas (76,4%) compared to those in the more deprived areas (68,6%).

In-depth interviews: Methods

Generally, the interview asked about environmental characteristics and individual-level characteristics in more details than that covered by the postal survey. As an extension of the postal survey, important neighbourhood physical environmental perceptions asked for in more detail included a) the aesthetics of the environment, b) safety, and c) the availability of neighbourhood facilities (specifically shops, schools public transport and sports facilities). Perceived aesthetics of the environment were asked for by rating aesthetic elements of the environment (green, trash, maintenance). Indicators of safety included (fear of) crime, perceived safety in the evenings, and availability of streetlights). Further, the availability of a large variety of facilities within 10 minutes walking

from home was asked about, including shops, schools, and specific sports facilities. More questions elicited information about working conditions (full time or part time, shift work, job demands and perceived rewards). At the household level, more information on the financial situation was sought, including spending patterns and financial debts. Leisure-time activities were asked for to verify the existence of broader – that is not only restricted to health-related behaviours – cultural differences between socioeconomic groups. Individual-level characteristics (attitudes, social norms, self-efficacy and intentions to change behaviour) were asked in relation to fruit consumption and smoking. For the latter, questions were included to measure nicotine dependence. Information on knowledge of health-behaviour was obtained by asking participants to recall the current Dutch recommendations for physical activity and fruit consumption. Moreover, questions were asked about the big five personality characteristics (extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience), as they may moderate associations between environmental characteristics and health-related behaviours [26].

Table 2.4 Response to the in-depth interviews 2005

	Total	Area deprivation	
		low	high
Sample invited, participants to postal survey, residing in 14 neighbourhoods in Eindhoven	829	418	411
Total *not* in denominator	239	112	127
No phone number	119	52	67
Incorrect phone number	48	25	23
Not reached	44	18	26
Other (moved, died)	28	17	11
Total *in* denominator	590	306	284
Interview complete	410	204	206
Interview incomplete	17	6	11
Refused	163	96	67
Response Globe in-depth interview 2005			
Interview (complete + incomplete)/ total	72,4%	68,6%	76,4%
Interview complete/ total	69,5%	66,7%	72,5%

4 Objective environmental characteristics

The fourth step in the data collection was to assess objective environmental characteristics of the fourteen neighbourhoods of Eindhoven from which interview participants were recruited. To do so, we first developed an audit instrument, including items on environmental factors of potential importance for health-related behaviours, including the accessibility of sport facilities, prices,

accessibility and quality of fruit and vegetables, outlets for fast food and tobacco purchase, neighbourhood aesthetics (litter, graffiti, buildings, gardens, trees), safety (signs of neighbourhood surveillance, street lighting), traffic (speed limits, traffic control devices, crossing aids), and the presence and quality of walk/cycle paths and parks [27]. Each item asked for a rating of the specific neighbourhood characteristic. The audit instrument was pre-tested and refined during three pilot rounds. In these pilots, a selection of streets was rated by four observers and afterwards, answers given to the different items were discussed. Items with low interrater reliability were reformulated or removed from the instrument.

To obtain information on availability, quality and price of the fruits and vegetables, we selected the five most commons types of fruit and vegetables. The distance to the three closest shops selling fruit and vegetables was measured from each neighbourhood centroid. In these shops, prices of predefined quantities (1 kg) of and types of fruits and vegetables were recorded. A similar strategy was used to obtain information about the distance to and costs of the sports facilities closest to each neighbourhood centroid.

The final assessment of the items observed in the streets in the fourteen neighbourhoods of Eindhoven was conducted according to the following protocol. First, a list of all streets within each neighbourhood was created. As neighbourhoods and streets differed in size, the total number of streets per neighbourhood varied from 17 to 76. An assessment of 10% of the streets per neighbourhood, with a minimum of 5 streets, was thought to accurately represent neighbourhood characteristics. Within neighbourhoods, streets were randomly selected. Thirty of the total of 75 streets were assessed twice by two different observers, auditing the segments independently, in order to be able to calculate the interrater reliability of the audit (based on percent agreement). The 105 observations were carried out by four trained observers in one week in February 2006.

Interrater reliability of each item of the instrument was calculated using the percentage agreement between two observers (consensus score), as described by Stemler [28]. Percent agreement for each specific item was calculated by adding up the number of cases that received the same rating by both observers and dividing that number by the total number of cases rated by the two observers. Table 5 describes the interrater reliability, which in general was moderate to good. Five items had low reliability (i.e. <0.7) and will not be used in analyses. The average reliability over the 55 remaining items was 84%.

Table 2.5 Objective neighbourhood characteristics of advantaged and deprived areas in the city of Eindhoven – interrater reliability, and mean score (standard error (SE)) by neighbourhood deprivation

	Inter-rater reliability[a]	Advantaged areas (n=7)	Deprived areas (n=7)	p-value
Sum score functional/design features		2.40 (.23)	2.17 (.13)	0.412
Sidewalks present (0=no, 1=yes)	0.97	.90 (.07)	1.00 (.07)	0.192
Quality of sidewalks (0=bad-moderate, 1=good)	0.70[b]	.62 (.12)	.38 (.05)	0.084
Cycling track present (0=no, 1=yes)	0.93	.15 (.06)	.08 (.04)	0.345
Quality of cycling tracks (0=bad-moderate, 1=good)	0.93[b]	1.00 (.00)	.33 (.33)	0.062
Speed-limit zone (max. 30 km/h) (0=no, 1=yes)	0.77	.14 (.04)	.22 (.08)	0.404
Traffic control devices (0=no; 1=yes)	0.87	.47 (.13)	.46 (.12)	0.970
Sum score social unsafety		.87 (.11)	1.08 (.18)	0.337
Houses for sale (0=no, 1=yes)	0.80[b]	.23 (.07)	.35 (.08)	0.846
Empty houses (0=no, 1=yes)	0.70[b]	.06 (.03)	.30 (.10)	0.036
Height of fences (0= below eye level; 1= above eye level)	0.73	.12 (.06)	.16 (.06)	0.710
Visibility of the street from surrounding houses (0= >½ of the street is visible, 1= <1/2 of the street is visible)	0.73[b]	.26 (.08)	.11 (.04)	0.128
Vandalism (0=none, 1=some, 2= many)[c]	0.97[b]	.06 (.04)	.06 (.04)	1.000
Street lighting (0= on both sides, 1= on one side)	0.83	.19 (.04)	.11 (.04)	0.184
Youth hanging around in the streets (0=no, 1=yes)[c]	0.90	.03 (.03)	.06 (.04)	0.552
Signs of alcohol/drugs use (0=no; 1=yes)	0.83	.06 (.06)	.18 (.05)	0.136
Sum score traffic unsafety		.98 (.22)	1.16 (.31)	0.644
Traffic (0=bestemmingsverkeer only, 1= through traffic)	0.80	.18 (.07)	.36 (.13)	0.246
Crossovers present (0=no, 1=yes)	0.93	.06 (.04)	.11 (.04)	0.375
Traffic signs painted on the road (0=no, 1=yes)	0.67[b]	.21 (.07)	.16 (.05)	0.571
Traffic control devices (0=no, 1=yes)	0.87	.53 (.13)	.54 (.13)	0.970
Sum score aesthetics		4.84 (.71)	2.96 (.37)	0.038
Graffiti (0=yes, 1=no)	0.70[b]	.66 (.32)	.40 (.12)	0.073
Vandalism (0=none, 1=some, 2= many)[c]	0.97[b]	.06 (.04)	.06 (.04)	1.000
Litter on the streets (0=yes, quite some-a lot, 1=no, nothing much)	0.67[b]	.69 (.38)	.38 (.14)	0.066
Maintenance of best buildings (0=bad-moderate, 1=excellent)	0.67[b]	.90 (.19)	.65 (.25)	0.061
Maintenance of worst buildings (0=bad-moderate, 1=excellent)	0.67[b]	.69 (.29)	.24 (.27)	0.011
Gardens (0=not with all houses, 1=yes, with all houses)	0.87[b]	.71 (.38)	.42 (.28)	0.119
Maintenance of best-maintained gardens (0=bad-moderate, 1=excellent)	0.80[b]	.65 (.35)	.49 (.28)	0.343
Green diversity (0= <1 kind of green, 1= >2 kinds of green, e.g. trees, field, bushes)	0.83[b]	.36 (.09)	.51 (.06)	0.170
Maintenance of public green areas (0=bad-moderate, 1=excellent)	0.80	.31 (0.11)	.00 (.00)	0.016
Sum score destinations		.41 (.12)	.51 (.15)	0.590
Destinations (0=none, 1= one or more)	0.77[b]	.28 (.12)	.37 (.15)	0.617
Public transport (0=no; 1=yes)	0.73	.13 (.04)	.14 (.06)	0.876

a Interrater reliability is represented by the percentage agreement between two observers (consensus score). Percent agreement for each specific item was calculated by adding up the number of cases that received the same rating by both judges and dividing that number by the total number of cases rated by the two judges (Stemler & Steven, 2004).

b Originally, there were more than two response categories for this audit item. These categories were dichotomised in order to calculate meaningful sum scores. However, inter-rater reliability scores were calculated for the original items, and therefore, are actually higher for the dichotomised items.

c tem was not included in the sum score as the prevalence was very low, e.g. in all neighbourhoods the prevalence of signs of vandalism was close to zero.

Discussion

We have developed a study protocol to investigate the contribution of environmental characteristics to socioeconomic variation in health-related behaviours. A major strength of this study is its stepwise approach, including complementary research methodologies. When we started the study, research in the field of environmental determinants of health-behaviours was just emerging and a stepwise approach was considered necessary as a wide variety of environmental characteristics could be identified as potentially relevant, of which only a selection could be included in the study. It remains to be explored to what extent we indeed identified relevant environmental factors.

There are a number of methodological issues related to this study. Firstly, the environmental characteristics as measured in the audit instrument were not measured in previous waves of the GLOBE study, and therefore the study cannot explore changes in health related behaviours following changes in objective characteristics. On the other hand, data collected on health-behaviours in previous waves may help to establish as to whether they predict environmental characteristics, such as whether physical activity results in social networks and social cohesion. Secondly, selection bias may influence our results. Analyses confirmed that residents in neighbourhoods with a lower mean income returned the postal survey slightly less often than those living in higher income neighbourhoods. As a result of SES-heterogeneity in neighbourhoods, mean neighbourhood income cannot automatically be interpreted as income at the individual level. Consequently, it remains difficult to estimate to what extent differential response by neighbourhood income influences individual socioeconomic inequalities. In addition, it is possible that the lower educated who behave most unhealthy are less likely to respond than the lower and higher educated who behave more healthy. This may ultimately result in an underestimation of socioeconomic inequalities in health-related behaviours, and, if those with the poorest behaviours indeed live under the worst circumstances, in an underestimation of the contribution of environmental characteristics to these inequalities. Thirdly, despite the careful selection of characteristics, we were not able to include items on all potentially interesting characteristics in our postal survey and interviews, due to space constraints. For example, only limited information on individual social-cognitive factors in relation to vegetable intake was ascertained in the interviews. In the interviews, cognitive factors were asked with regard to behaviours in general, e.g. physical activity cognitions referred to "being physically active for 30 minutes per day", instead of measuring cognitions for walking, cycling, and sports participation specifically. With the growing recognition of the need to analyse associations between environmental and individual characteristics and health-related behaviours as specific as possible, this should be considered a limitation of the data collection [29, 30].

The cross-sectional sample will be used to explore the contribution of groups of environmental characteristics to socioeconomic inequalities in health-related behaviours. These data should be externally valid for the region of Eindhoven and surroundings and preferably for the Netherlands. About 50% of the study population in the postal survey is 55 and older, which needs to taken into account when interpreting the data, because this is more than in the Dutch population. Using a weighted procedure, which makes the sample representative for our source population, prevalence data can be assessed. Using such a procedure, the prevalence of 'current' smoking for example is 23,1%, which is lower than the prevalence of 28% among Dutch adults; the prevalence of overweight and obesity on the other hand is 45% (BMI > 25) and 14.6% (BMI >30), respectively and these rates are reasonably in line with similarly obtained data in the Dutch population [31]. Thus, it seems that the external validity of results obtained in our study needs to be examined for outcomes specifically.

In general, socioeconomic inequalities in health and health-related behaviours are still poorly understood. An unequal distribution of traditional risk factors among socioeconomic groups appears to only partially explain these inequalities. Therefore, new lines of research have been proposed. Our study fits in one of these new lines, i.e. the one in which characteristics more distal from the individual-level are included in explanatory analyses. Another rapidly developing line of research adopts the life-course approach. According to the life course approach, socioeconomic inequalities are the result of accumulated exposure to risk factors across the life-course. Repeated measurements of health-related behaviours allow us to perform such 'life-course-analyses'. For that purpose, a longitudinal sample can be constructed, including for example those persons who participated in the study in 1991 and 2004.

In this paper, we concentrated on the design and data collection of the GLOBE study between 2004 and 2006. In order to answer the third research question concerning entry-points for interventions and policies to reduce socioeconomic variations in health-related behaviour, we will develop a summary report based on the answers of the first and second research question. This summary report will be discussed at a national invitational conference with scientific experts, policy-makers, public health practitioners, and representatives from the local community.

The collected data are currently being analysed, and this will provide important information on the role of environmental characteristics to socioeconomic inequalities in health-related behaviours. The majority of research on environmental determinants of health-related behaviours, and on the contributions of environmental determinants to socioeconomic inequalities in health-related behaviours, is conducted in the U.S. and in Australia. It remains unknown to

what extent results from these countries can be translated to other countries. Therefore, it is important to extent studies in this area to other countries. We hope this overview of our approach may facilitate the development of similar studies across the world.

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3

Perceived environmental determinants of physical activity and fruit and vegetable consumption among low and high socio-economic groups in the Netherlands

Kamphuis CBM, Van Lenthe FJ, Giskes K, Brug J & Mackenbach JP (2007). Perceived environmental determinants of physical activity and fruit and vegetable consumption among low and high socioeconomic groups in the Netherlands. *Health & Place* 13(2), 493-503.

Abstract

A focus group study was conducted to explore how perceptions of environmental influences on health behaviours pattern across socioeconomic groups in the Netherlands. Participants perceived their spouse's and friends' health behaviour and support as highly important. People from lower socioeconomic backgrounds reported poor neighbourhood aesthetics, safety concerns and poor access to facilities as barriers for being physically active, while easy accessibility to sports facilities was mentioned by high socioeconomic participants. The availability of fruits and vegetables at home was perceived as good by all participants. Overall, lower socioeconomic groups expressed more price concerns. Possible pathways between socioeconomic status, environmental factors and health behaviours are represented in a framework, and they should be investigated further in longitudinal research.

Introduction

Poorer people experience worse health [1, 2] with higher rates of mortality and morbidity from cardiovascular diseases, obesity, type 2 diabetes and cancers [3-5]. Fruit and vegetable consumption and physical activity play a protective role in the onset of these chronic diseases [6-9]. Low socioeconomic groups consume less fruits and vegetables [10, 11] and do less physical activity [8, 12] than people from higher socioeconomic backgrounds, which is considered one of the explanations for socioeconomic inequalities in health. In view of the collective nature of health behaviours being less favourable for the disadvantaged, it is hypothesized in the literature that these socioeconomic variations may be due to common environmental exposures [13, 14].

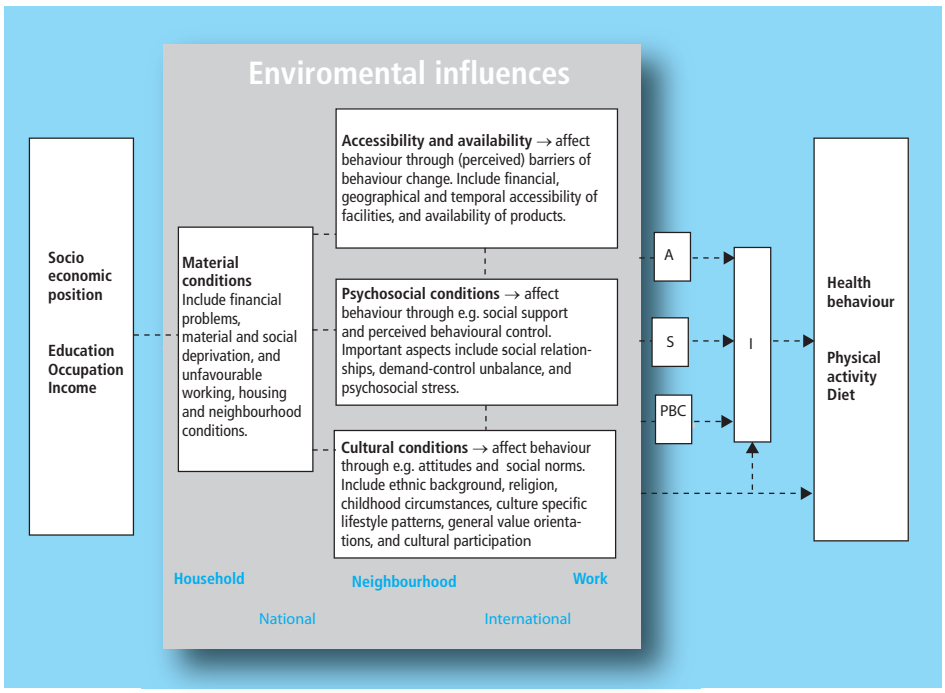
Research that has examined the patterning of environmental influences of health behaviours across socioeconomic groups is scarce and mainly carried out in the U.K. and U.S. In some studies examining the lower rates of physical activity in disadvantaged areas, the importance of neighbourhood attractiveness, the accessibility and proximity of neighbourhood facilities, and neighbourhood safety has been demonstrated [15-19]. Participation in social activities was a strong predictor of socioeconomic differences in low leisure-time physical activity, which may be mediated by a higher extent of encouragement or peer pressure to participate in physical activities experienced by persons with a high social participation [20]. In qualitative studies, lack of money, lack of access to transportation and inconvenient access to facilities are more often cited as barriers to physical activity among the less affluent [21, 22].

A range of possible mediating environmental factors between area deprivation and an unhealthy diet (again from studies performed in the U.S. and U.K.) includes a lower prevalence of supermarkets [15, 23], a higher prevalence of fast food restaurants [23] and a relatively higher premium on the price of healthy compared to less healthy food in deprived areas [24, 25]. Financial considerations were among the most frequently mentioned barriers for healthful eating among low-income women [26]. Social participation and social support may play a role in inequalities in fruit and vegetable consumption [27], as a lack of social participation might indicate a less extensive social network and less social support for adhering to a healthy diet. Also cultural influences, such as traditional beliefs about appropriate or healthy diets [28], may contribute to socioeconomic differences in fruit and vegetable consumption.

As previous research mostly investigated potentially relevant environmental factors based on the literature, we sought to investigate whether these factors are indeed perceived as potentially relevant across the socioeconomic spectrum, and whether additional environmental factors are perceived to play a role. This

is one of the first studies in Europe (outside the U.K.) to investigate how people from high and low socioeconomic backgrounds perceive how their living environment shapes their physical activity and fruit and vegetable consumption.

Figure 3.1 A framework of environmental determinants contributing to the explanation of socioeconomic inequalities in health behaviours



Notes: The grey panel incorporates four boxes of environmental determinants. The terms household, neighbourhood and work are examples of the different settings in which these determinants may influence health behaviours. The abbreviations in the right hand boxes represent the following constructs: A= attitude; S= social influences, like social support, subjective norms, and modelling; PBC= perceived behavioural control; I=intention. These constructs are derived from the Theory of Planned Behaviour; see (Ajzen, 1991) for more information.

A framework for explaining socioeconomic inequalities in health-behaviour

For this paper, we developed a framework that specifies the pathways between socioeconomic status (SES), environmental factors, personal level factors (constructs from the Theory of Planned Behaviour; see [29]) and health behaviours (Figure 1). Other models have the disadvantage that they can only be applied to one particular health behaviour [30], focus on personal and environmental factors related to health instead of health behaviour [31], or do not clearly visualise via which pathways socioeconomic status relates to health behaviour [13, 32]. In the development of our framework we reviewed the current state of knowledge on environmental determinants of health behaviours, and com-

bined this with the literature on explanations of socioeconomic inequalities in health-related behaviours. The four categories that form the framework are:

(a) Accessibility and availability. Including financial, geographical and temporal accessibility of products and facilities that are needed for (un)healthy behaviour, and interventions to support behaviour change.
(b) Psychosocial conditions. Including social relationships, social support, and psychosocial stress.
(c) Cultural conditions. Culture-specific lifestyle patterns, childhood circumstances, general value orientations, and cultural participation.
(d) Material conditions. Including financial problems, material and social deprivation, and unfavourable working, housing and neighbourhood conditions. These may affect behaviour through one of the previous environmental factors. For instance, a person's budgetary situation may partly determine one's access to products and facilities, or in what neighbourhood one can afford to live.

In this study, we will address the following research questions:

1) What environmental factors related to fruit and vegetable consumption and physical activity are important for all socioeconomic groups?
2) How do socioeconomic groups differ in their perception of important environmental factors related to fruit and vegetable consumption and physical activity?
3) Does the framework capture all relevant environmental influences for fruit and vegetable consumption and physical activity, or are additional factors perceived as influential?

Methods

A focus group study was carried out to explore perceptions of environmental influences on physical activity and fruit and vegetable consumption among socioeconomic groups. Four groups were held in spring 2004 among a total of 38 adult participants living in one city of the Netherlands (Eindhoven). This study has been subject to appropriate ethical review.

Participants

Participants were selected from an existing cohort study, the GLOBE study, based on their neighbourhood's deprivation level (as marker for neighbourhood SES) and highest educational attainment (as marker for individual SES) Objectives and design of the GLOBE study are presented in detail elsewhere [33]. Neighbourhood deprivation was based on the Dutch general practitioner deprivation score. This index for social and economic deprivation has shown to be a reliable and valid measure for area deprivation in the Netherlands in several other studies [19, 34]. Educational attainment is only one component

of the broad concept of SES, but is considered a good indicator for SES in the Netherlands [35]. GLOBE participants with a high educational attainment (i.e. either with a higher vocational training or an university degree) were randomly selected from the eight most advantaged neighbourhoods (these participants will be referred to as 'high SES'), while people with a low educational attainment (i.e. with no education, or with primary school or lower vocational training) were randomly selected from the eight most deprived neighbourhoods (these participants will be referred to as 'low SES'). Via letters and follow-up phone calls, ten to twelve people per focus group were recruited. For the two high SES focus groups all twelve people attended. Response rates for the low SES groups were somewhat lower, with six and eight people showing up (still respectable numbers for focus group discussions). Demographic data of participants are shown in Table 1.

Table 3.1 Characteristics of focus group participants

	High educated people residing in advantaged neighbourhoods		Low educated people residing in disadvantaged neighbourhoods	
	Group 1	**Group 2**	**Group 3**	**Group 4**
Participants (N)	12	12	6	8
women	5	3	3	6
men	7	9	3	2
Age, mean (age range)	57 (39-81)	62 (39-74)	64 (58-75)	62 (29-75)

Procedures

A semi-structured questioning route was developed to ensure consistency in questions asked across groups [36, 37]. Questions were pretested for understanding in a high and low SES pilot group. The questioning route covered three subjects: determinants of people's fruit and vegetable consumption, leisure time physical activity and smoking behaviour (results for the latter topic are not in the scope of this paper). Each topic was shortly introduced by the moderator and then discussed by the group, following this questioning route:

- Do you engage in this health behaviour? How often? Why or why not?
- Can you think of determinants in your living environment that might influence whether or not you engage in this behaviour?
- How do those environmental determinants influence behaviour?

Focus groups were led by an experienced moderator and group members consented to the discussion being taped. Group discussions lasted about 2 hours and incentives were given afterwards (i.e. a €15 gift voucher, and a €6,20 bus card as refund of travelling expenses).

Data analyes

The audio taped discussions were transcribed verbatim by the first author (CK). As environmental determinants are likely to differ for fruit and vegetable consumption and physical activity, the content analysis procedure as described below was carried out for both behaviours separately.

Data analyses were performed following the framework approach [38], in which our framework served as base. A preliminary list of labels was composed, relating to the four categories of environmental determinants in our framework. Next, all relevant phrases in the transcripts (i.e. where a participant addressed an influence), were identified and examined by constant comparison [38]: for each relevant quote a judgement was made whether it fitted into one of the existing labels or required a new label. Correspondingly, each quote was coded with one or more labels, to reflect as many of the nuances in the data as possible. The coding of the transcripts was done by CK and FvL independently. Differences in interpretations of the two researchers were minimal, and consensus between them was readily achieved. Data analysis software NVIVO (1.3) was used in the coding process.

After coding all four transcripts, the labels were reviewed. Most labels referred to a specific individual or environmental factor. The importance of each factor was assessed for high and low SES participants separately. More emphasis was given to comments that were discussed in great length, with great intensity, with great specificity, by different participants within one focus group, and/or by participants over different focus groups [37, 39].

Results

Whereas enjoyment, relaxation, habit, lack of time and health constraints were important individual-level factors for physical activity, taste, health, habit, weight maintenance, lack of time and disturbance of daily routines were individual factors often discussed with respect to fruit and vegetable consumption. Our findings of environmental-level factors, as presented in Tables 2 and 3, are described below, and illustrated with quotations. Quotations are followed by the participant's SES level, sex, and age in years between brackets.

Table 3.2 Factors related to physical activity (PA), as mentioned by focus group participants with either a high or low socioeconomic status (SES)

	High SES	Low SES
Individual level factors		
good for physical condition, fitness	++	++
good for my health	++	++
weight maintenance	++	+
enjoyment, relaxation	++	++
habit	+	++
lack of time	--	0
health constraints	-	--
Environmental level factors		
Accessibility and availability		
accessibility of facilities	++	-
neighbourhood safety	-	--
neighbourhood aesthetics	+	--
enjoyable nature in surroundings	+	+
availability of home equipment	+	+
Cultural conditions		
parental and own PA in childhood	+	+
Psychosocial conditions		
social support from relevant others	++	++
meeting people during PA	++	++
observed behaviour of relevant others	0	+
Material conditions		
cost considerations	-	--
Other influences		
nice weather, summer	+	++
bad weather, winter	-	-

Notes The plus and minus signs in the second and third column indicate that the factor either serves as promoter (+) or barrier (-) to being physically active, according to the predominant opinion of the focus group participants. Moreover, the number of symbols gives some indication of how important the factor is in relation to PA, according to the focus group participants. Importance is based on whether or not the factor is discussed in great length, with great intensity, on different points in time during the focus group, by different participants within one focus group, and/or by participants over different focus groups.

Range: 0 factor of no importance (not mentioned)
- or + factor of minor importance
-- or ++ factor of importance

Perceived environmental factors related to PA

Similarities between socioeconomic groups

Participants described the fact that their partner and friends are fairly active, and the support they receive from them to exercise as important influences for their own level of physical activity. Moreover, they enjoyed the opportunities to meet and chat with people during participation in group activities.

"If I would have to go all by myself, I think I would not go at all. Doing sports is a good opportunity to meet my friends" [high SES, man, 50].
"We always make long bike rides with the three of us. We like each other's company, and have lots of fun" [low SES, man, 59].

In both socioeconomic groups the enjoyment of the natural scenery during hikes and bike rides was reported frequently. Several participants had a home trainer, but low SES participants seemed more enthusiastic about using this home equipment. Some high SES participants considered their dog as an important motivator to walk every day. A number of participants believed that positive experiences with sports during their childhood, and their parents' enthusiasm for being active, contributed to their current interest in sports. Finally, exercising in bad weather and during winter was seen as a barrier to being active, as rain and low temperatures made it more difficult to leave the house and get started. The fewer daylight hours in winter reduced opportunities to exercise and increased participant's safety concerns.

Differences between socioeconomic groups
The majority of high SES participants perceived accessibility to sporting facilities being fairly good, referring both to the diversity and proximity of facilities. In general, low SES participants found accessibility to sports facilities more difficult.

"You can easily rent some tennis courts. In summers we do that every week" [high SES, man, 63].

"At work I have the possibility to do fitness. That's an ideal opportunity for me. It saves me quite some time travelling to and from facilities located elsewhere." [high SES, man, 39].
"The swimming pool is not close to my house. My husband always has to drive me there" [low SES, woman, 75].

High SES participants considered their neighbourhoods to be well-designed, green and spacious. They found this inviting to do outdoor sports. Poor neighbourhood aesthetics were extensively discussed as a barrier by low socioeconomic groups. Furthermore, some low SES participants expressed that they sometimes feel unsafe in their neighbourhood, and how this refrains them from walking during evening hours.

"The neighbourhood I live in is not a neighbourhood where one would say: let's go for a walk here. It used to be quite a green area. Ten years ago it was. But now it's really declined. It's not inviting to go for a walk, there's just nothing to see or do" [low SES, man, 59].
"Unreliable people walk around the streets at night, you know" [low SES, man, 61]

> "Sometimes, in the evening, I do feel a bit unsafe, especially when I walk close by the park. It's pretty dark there" (low SES, woman, 58]

High SES participants mentioned cost considerations as a plausible barrier for their less advantaged counterparts, but did not consider this a factor important for themselves. Low SES participants explained that rather high expenditures for equipment and sports club contributions are likely to be an important barrier to less fortunate people, like single-mothers and people living on social payments. They discussed this subject in greater detail and with more intensity than the high SES groups.

> "I know people at my swimming club who cannot afford to swim every week. We just do that, and do not even think about the contribution we have to pay" [high SES, woman, 40].
> "I do think that the rather high charges of sports clubs refrain some people from doing sports. Find out for yourself what you have to pay when you want to join a fitness club. If you want that for both yourself and your husband… [concerned facial expression]" [low SES, woman, 60].

Perceived environmental factors related to fruit and vegetable consumption

Similarities between high and low socioeconomic groups
All participants reported that adequate amounts of fruits and vegetables were readily available at home. Men admitted that their wives took care of this. A few participants explained that their own vegetable garden was an extra motivator to eat large varieties of fruits and vegetables.

> "My wife always makes sure there is enough fruit at home. She goes to the market every week to buy kilos of fruits and vegetables" [high SES, man, 44].

Social support, especially from one's partner, was mentioned as an important influence by high as well as low SES participants. Some men emphasized the central role their wife's play in what and how often they eat fruits and vegetables, by choosing, buying, preparing and serving the fruits and vegetables that are eaten within the household. Furthermore, having company from people eating fruits regularly, like a friend or household member, encouraged participants to eat fruit themselves. Having eaten fruits and vegetables regularly in childhood was reported as a habit that some participants carried into their adulthood. Moreover, some participants indicated that media attention for fruits and vegetables has made them more aware of their health benefits. Educational campaigns, TV-series and talk shows on health-related topics make participants reflect on their own health behaviour, including their fruit and vegetable consumption.

Table 3.3 Factors related to fruit and vegetable (FV) consumption, as mentioned by focus group participants with either a high or low socioeconomic status (SES)

	High SES	Low SES
Individual level factors		
taste preferences	++	++
health considerations	++	++
habit	++	++
weight maintenance	++	0
pleasure of cooking and preparing FV	0	+
lack of time	--	--
disturbance of daily routine (weekends, holidays)	-	--
recommended amounts are too high	-	-
Environmental level factors		
Accessibility and availability		
accessibility of shops	0	--
availability of FV in shops	++	+
presentation of FV in shops	+	0
availability of FV at home	++	++
have my own garden	+	+
availability of convenience foods	-	-
Cultural conditions		
parental and own behaviour in childhood	+	+
Psychosocial conditions		
social support from relevant others	++	++
observed behaviour of relevant others	+	+
Material conditions		
cost considerations	-	--
Other influences		
media attention for health and FV	+	+

Notes The plus and minus signs in the second and third column indicate that the factor either serves as promoter (+) or barrier (-) to FV consumption, according to the predominant opinion of the focus group participants.
Moreover, the number of symbols gives some indication of how important the factor is in relation to FV, according to the focus group participants. Importance is based on whether or not the factor is discussed in great length, with great intensity, on different points in time during the focus group, by different participants within one focus group, and/or by different participants over different focus groups.

Range: 0 factor of no importance (not mentioned)
- or + factor of minor importance
-- or ++ factor of importance

The consumption of convenience foods influenced the vegetable consumption of high as well as low SES participants in a negative way. Participants reported that the proximity to fast food outlets in their neighbourhood and the easy availability of convenience foods in shops, lead them to eat these foods more frequently, and with that, consume less vegetables than during a self-prepared meal.

> "Those microwave meals are easily available in every supermarket…" [low SES, women, 60]
> ".. Indeed, you just put them in the microwave and your meal is ready in a sec!" [low SES, woman, 67]
> "The pizzeria is close by, just around the corner. My children -always busy- get pizzas there every now and then" [high SES, man, 74].

Differences between high and low socioeconomic groups

High SES participants talked about the many different kinds of fruits and vegetables that are available in the shops the whole year round. Moreover, some high SES participants indicated that the attractive way fruits and vegetables are presented in shops tempts them to buy fruits and vegetables.

> "You can get everything you want. We used to be dependent on the fruits and vegetables of the season, but now you can easily get everything, every day of the year, and of the most excellent quality" [high SES, man, 58].

Poor accessibility to shops was raised several times by low SES participants. Some indicated that there were shops to buy fruits and vegetables in surrounding neighbourhoods, but among participants of advancing age who were less mobile, accessibility to these shops was a problem. They described that in former times, a mobile grocery shop would go from door-to-door, but that this was no longer the case. Also, they explained that there are fewer green grocers in their neighbourhoods than some years ago.

> "Where did the shop around the corner go? It's a pity, but those little shops all moved out of my neighbourhood. For me, that makes it harder to do my own shopping" [low SES, woman, 75].

Finally, relative high prices of fruits and vegetables were reported in both SES groups, though criticized more often and in more detail by low SES groups. These participants stated that price was often a deciding factor for whether or not to buy a certain product. If prices of fresh vegetables were judged as too high, they would rather choose canned or frozen products.

> "I think that fruits and vegetables are pretty expensive. Even if you buy fruits and vegetables at the market, you still have to pay a lot of money, I can tell you that" [low SES, woman, 60].

Factors in the framework compared to factors discussed by participants

The main environmental factors, as identified in the focus groups, were included in the framework. Of the four categories that are distinguished in the

framework, accessibility- and availability-factors and psychosocial conditions were discussed most often, in greatest length and in the most detail. For physical activity, determinants that were not included in the framework beforehand, were weather and seasonal influences. For fruit and vegetable consumption, additional environmental determinants were the easy availability of convenience foods (like take-away and microwave meals) and having a vegetable garden. Those factors were mentioned by high as well as low socioeconomic participants, though weather influences on physical activity were more salient to the low SES groups.

Discusssion

Focus group discussions with high and low SES participants revealed a rich variety of environmental factors they perceived as associated with their physical activity and fruit and vegetable consumption. Participants from both socioeconomic groups indicated that their physical activity and fruit and vegetable consumption benefited from social support to perform these behaviours. However, low SES groups perceived more barriers for behaving healthy, specifically barriers related to accessibility, availability, neighbourhood characteristics, and cost considerations. All factors perceived as important have been included in our framework.

Most of our findings are supported by conclusions that have been reached in previous research, which verifies the validity of our results [40]. Low SES participants had a more negative view of their neighbourhood's aesthetics, attractiveness, and safety [18, 41]. Cost considerations are an established barrier for health behaviours [26, 42, 43] and were perceived as a more important influence among low SES participants. We found that social influences for physical activity and fruit and vegetable consumption, like social support and social networks, were of equal importance and equally positive for both socioeconomic groups. However, studies in Australia and Sweden found the disadvantaged groups more likely to indicate a lack of encouragement and companionship [22] and lack of social participation (which might indicate a less extensive social network and less social support) [20]. In a densely populated country such as the Netherlands, it may be less difficult to arrange company for exercising, also for people with less developed social networks.

Poor accessibility to products and facilities were reported as barriers by people from low SES backgrounds, as has been found in studies from the U.S., U.K. and Australia [15, 17, 18, 22]. We expected that differences in accessibility and availability of products and facilities, just like for social support, would be less pronounced in a country as the Netherlands, which is geographically compact.

Nevertheless, relative differences between socioeconomic groups still seem to be apparent in the Netherlands.

All environmental factors that were perceived as important by participants were already included in our framework. Weather and seasonal influences were perceived to be of some importance but not incorporated in our framework beforehand, as research had shown no significant associations with physical activity [44]. Although weather cannot directly be influenced by policy or interventions, levels of physical activity can be promoted by providing indoor facilities in places where climatic extremes are experienced. Both factors will be included in the framework. Regarding fruit and vegetable consumption, we will include two factors that emerged from the focus groups as being important, i.e. availability of convenience foods (like take-away and microwave meals; also found as influential on fruit and vegetable consumption by Cox and colleagues [45]) and possessing one's own vegetable garden (also reported by Eikenberry and colleagues [26]). Though not graded with SES, these factors may be important for the understanding of fruit and vegetable consumption patterns, and are susceptible to change.

Some categories of factors within our framework were hardly discussed. Arguments for influences not being raised, could be that they are so ingrained or distal from people's behaviour, that individuals do not even think of them as influential (e.g. cultural and material conditions). Material deprivation and financial problems were perceived as possible determinants for 'less fortunate others', but not for the participants themselves. Although these determinants may have been important to participants too, this may have been too sensitive to bring up in the group context [46]. Future longitudinal research needs to confirm whether or not these factors contribute to socioeconomic differences in physical activity and fruit and vegetable consumption.

Study strengths and limitations

An important strength of this study was the comparison made between views of environmental influences among high and low socioeconomic groups, as this has received little attention in the literature to date [22]. An advantage above the study of Burton and colleagues (2003) was that participants of the focus groups where not only selected on individual level SES, but also on neighbourhood SES. As physical and social characteristics often differ for affluent and deprived neighbourhoods, this sampling approach made it more likely that, as far as these environmental influences are salient to the participants' health behaviours, differences between high and low SES groups would be detected.

Another strength of our study was the use of a conceptual framework. First, we incorporated determinants in the framework that emerged from an extensive

review of the current body of literature ('top down'). Then, the focus group study confirmed that most determinants were also *perceived* as influential by people from different socioeconomic groups, and yielded some additional determinants ('bottom up'). This gives us firm grounds to believe that the framework incorporates all possibly important determinants for socioeconomic differences in health behaviours, which makes it a suitable framework to build upon in future research.

Furthermore, this study adds a new dimension to this existing body of research, since our study was carried out in a geographically and socially more compact context then most previous studies, which mainly have been carried out in the U.S. and U.K. Methodological strengths include the semi-structured, pretested questioning route, and independent analyses of the first and second author to optimise the reliability of the outcomes [40].

A limitation of our study was the relatively small and selective sample recruited through a purposive sampling strategy. However, issues of representativeness were considered less important than our objective of obtaining views from people that were on the opposite ends of the socioeconomic spectrum. During the participant recruitment procedure our focus was on their educational level and neighbourhood deprivation score, with age and gender as selection criteria of minor importance. This resulted in some small differences in age and sex distributions between groups. However, apparent gender and age differences in perceptions were not found, which makes it unlikely that these small group differences affected the results.

Another issue is to what extent separate focus groups can be compared with each other. Sim (1998) argues that the fact that some members of a group may or may not voice a viewpoint, may be a reflection of the specific pattern of interaction occurring at the time [47]. However, it is generally accepted that the importance of a certain theme can based on the frequency, specificity, extensiveness and emotion with which a view is expressed [39]. As we have sensed the openness and integrity with which participants in different focus groups expressed their views, we believe that everyone could say and has said what he/she thought.

Conclusion

This focus group study provided a rich variety of environmental factors perceived by low and high SES groups in the Netherlands, to be associated with their health behaviours. Participants from both socioeconomic groups indicated to benefit from social support, but the low SES groups perceived more barriers for behaving healthy, related to accessibility, availability, neighbour-

hood characteristics, and cost considerations. The proposed framework provides a good overview of important environmental influences associated with health behaviour of different socioeconomic groups. As qualitative research cannot tell to what extent the perceived factors truly inhibit or facilitate people's behaviour, results should be verified in longitudinal studies to give more insight in the associations between SES, environment and health behaviours. Ultimately, when policy makers and health workers act upon these insights, it seems achievable to exert a positive influence on health behaviours -especially the behaviour of the socioeconomic disadvantaged- and, as ultimate goal, to contribute to a reduction in health inequalities.

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Part 2

Socioeconomic status, environmental factors and physical activity

4

The relative importance of neighbourhood factors for different levels of sports activity

Kamphuis CBM, Van Lenthe FJ, Giskes K, Huisman M, Brug J, Mackenbach JP. Short report - The relative importance of neighbourhood factors for different levels of sports activity (under review with *Br J Sports Med*)

Abstract

Background It is suggested that increased specificity in outcomes is needed in studies of environmental determinants of physical activity. The objective of this study is to examine the relative importance of neighbourhood perceptions and individual cognitions for two specific cut-off points of sports activity.

Methods Self-reported data from the GLOBE postal survey in 2004 were used, comprising a stratified sample of 4785 adults, aged 25-75 years. Multilevel logistic regression models examined physical (e.g. neighbourhood attractiveness, safety) and social neighbourhood perceptions (e.g. social disorder, community engagement), and individual cognitions with regard to doing regular physical activity (attitude, social influences, self-efficacy) in their associations with the probability of (a) doing any vs. no sports, and (b) meeting vs. not meeting recommendations for sports activity.

Results In the full model, physical and social neighbourhood factors as well as all individual cognitions showed independent associations with doing any sports. No neighbourhood factors were significantly associated with meeting recommended sports activity levels, but attitude and self-efficacy showed strong associations with this outcome.

Conclusions Neighbourhood factors were associated with doing any sports, but not with meeting recommended levels of sports activity. Interventions aimed at facilitating the take up of sports among those who do not engage in any sports activity may be most successful if based on neighbourhood factors as well as individual cognitions. However, in interventions aimed at increasing sports activity among those who are active already, it may be particularly important to focus on individual-level cognitions.

Introduction

Regular vigorous activity, like sports activity, promotes cardio respiratory fitness, and reduces the risk of mortality from coronary heart disease and cancer [1]. Current guidelines recommend vigorous physical activity on ≥ 3 days per week for ≥ 20 minutes per occasion [2]. However, a large group of the population does not engage in any sports activities at all, and therefore, meeting recommended levels might be a bridge too far for many people. A first step for public health action therefore may be to facilitate the take up of sports, before increasing sports activity to recommended levels (as doing at least some compared to no sports is associated with health benefits as well, e.g. reduced mortality [3]). But what are the determinants for public health action to focus on regarding those two outcomes of sports activity?

Over the past decade, the field of physical activity research has shifted its focus on a completely new area: identifying and measuring attributes of the physical environment in relation to physical activity [4]. Although evidence is still emerging, neighbourhood factors, such as the availability of facilities and neighbourhood safety, have shown associations with a range of physical activity behaviours. Researchers have become increasingly aware of the importance of studying neighbourhood factors in associations with specific physical activity outcomes [4]. Similarly, neighbourhood factors may also differ for different *levels* of a specific activity, however, this topic has rarely been addressed yet [5, 6]. To our knowledge, no study has investigated the relative importance of neighbourhood factors for specific levels of sports activity.

We hypothesize that neighbourhood factors may be more important for the adoption of sports activity, than for increasing sports activity to recommended levels. Persons participating already once or twice per week in sports activities may, for example, have a social network including company for doing sports, and may not consider distances to facilities or safety as barriers for sports participation. To increase the level of sports activity of this specific group to the recommended level, individual cognitions such as a positive attitude and high self-efficacy may be more important than environmental issues. However, for those not doing any sports, neighbourhood factors, such as a small social network or the absence of facilities in the neighbourhood may be important barriers to take up sports activity, independent of their individual cognitions. Accordingly, we hypothesize that neighbourhood perceptions will be more strongly associated with (a) doing any vs. no sports, than with (b) meeting vs. not meeting recommendations for sports activity.

Methods

Sample

Self-reported data were obtained by a large-scale postal survey (as part of the longitudinal GLOBE study) among a stratified sample of the adult population (age 25-75 years) in the Southeast of the Netherlands in October 2004 (N=4785; response rate 64.4%). Participants eligible for the analyses (N=3839) resided in 177 neighbourhoods in the study area (participants with missing values on the outcome, confounding variables or neighbourhood indicator (n=639), and those who reported that poor health is often a barrier to be physically active (n=307) were excluded). Information about the objectives, design and results of the GLOBE study can be found elsewhere [7-9].

Sports activity

Sports activity was measured with the SQUASH questionnaire - a validated Dutch physical activity questionnaire which has shown reasonable reliability among Dutch adults [10]. Participants wrote done up to four sports they did on a weekly basis during previous month (open question). For these sports, they reported frequency (times per week), average duration (minutes per day), and intensity (low, average, high). Self-reported intensity, in combination with participant's age, and activity-specific MET-values, were used to calculate intensity scores. Two binary outcomes were constructed, i.e. (a) doing any vs. no sports with at least moderate intensity (moderate intensity= 4-6 MET for 18-55 yrs-old; 3-5 MET for 55+ yrs-old), and (b) meeting vs. not meeting recommendations for sports activity (i.e. >3 times/week, >20 minutes per occasion, with moderate-high intensity) [2].

Neighbourhood perceptions

Perceived physical neighbourhood factors measured in the survey were: neighbourhood aesthetics, neighbourhood safety, and the availability of sport facilities. Perceived social neighbourhood factors were: social disorder (factor derived from factor analyses with 11 items, Cronbach's α = .94); social cohesion, social network and feeling at home in one's neighbourhood (factors were derived from a factor analysis including 13 items on social relationships (Cronbach's α = .86). More about the construction of these variables can be found in Chapter 5 (Table 5.2) [9].

Individual cognitions

The Theory of Planned Behaviour was used as framework to measure individual cognitions, i.e. attitude, social influences, self-efficacy, and intention to be regularly physically active. Regular physical activity was defined in the questionnaire as "being physically active for at least 30 minutes/day, e.g. doing sports, cycling, and gardening". Items for all constructs were formulated according

to instructions given by Conner & Norman [11]. Individual cognitions in the analyses were: attitude (positive, negative; dichotomized sum score of 12 items for outcome expectancies of regular physical activity (Cronbach's (α = .77)), social influences (positive, negative; dichotomized sum score of three items regarding subjective norm, social support, and modelling of significant others for regular physical activity (Cronbach's α = .85)); self-efficacy (unsure, not sure/unsure, sure), and intention (unsure, not sure/unsure, sure).

Demographic variables

Participants reported their highest attained educational level (categorized in high, medium-high, medium-low, and low). Other possible confounding factors that were measured were age (in ten-year categories), sex, and country of origin (Netherlands, other country).

Statistical analyses

We tested bivariate associations between outcomes and neighbourhood and individual factors (adjusting for educational level, age, sex, country of origin) in SPSS version 11.0 [12]. Factors associated with the outcome were included in a 3-step multilevel logistic regression modelling sequence in MlwiN version 2.02 (to take into account the hierarchical structure of the data) [13]. We included neighbourhood perceptions (model 1) and individual cognitions (model 2) separately, and then tested all factors simultaneously (model 3). Analyses were carried out in 2007.

Results

Half of the study sample (49.7%) indicated to do at least some sports, whereas 16.9% of the sample reported sports activity according to recommended levels. Mean age of the sample was 47.7 years (range 25-75 years), 52.5% of the sample were women, and 90.3% were born in the Netherlands [9].

Outcome (a): any sports activity

Perceived neighbourhood attractiveness, safety, social cohesion, social network and feeling at home in one's neighbourhood were associated with doing any sports in bivariate associations (results not shown). As presented in Table 1, four neighbourhood factors remained significant when including all neighbourhood factors in one model (model 1a). In the full model, two neighbourhood factors (safety and social cohesion) remained significantly associated with doing any sports in addition to all individual cognitions.

Table 4.1 Adjusted odds ratios (OR) and 95% confidence intervals (95% CI)[a] for neighbourhood perceptions and individual cognitions[b] with a) any sports activity, and (b) meeting recommended levels of sports activity

	Outcome (a): any sports activity			Outcome (b): meeting recommended levels of sports activity		
	Model 1a: neighbourhood perceptions	Model 2a: individual cognitions	Model 3a: neighbourhood + individual	Model 1b: neighbourhood perceptions	Model 2b: individual cognitions	Model 3b: base neighbourhood + individual
Neighbourhood perceptions	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
My neighbourhood is unattractive						
agree	1.00		1.00			
disagree	1.27 (1.05-1.54)		1.14 (0.93-1.39)			
My neighbourhood is unsafe						
agree	1.00		1.00			
disagree	1.47 (1.00-2.19)		1.44 (1.04-2.00)			
There are insufficient places to do physical activity						
agree				1.00		1.00
disagree				1.16 (0.92-1.46)		1.08 (0.81-1.43)
Neighbourhood social cohesion						
small	1.00		1.00			
medium	1.45 (1.22-1.72)		1.39 (1.17-1.66)			
large	1.22 (1.03-1.44)		1.13 (0.95-1.34)			
Neighbourhood social network						
small	1.00		1.00			
medium	0.99 (0.84-1.17)		0.95 (0.79-1.13)			
large	1.20 (1.01-1.42)		1.08 (0.92-1.29)			

Table 4.1 (Continued)

	Outcome (a): any sports activity			Outcome (b): meeting recommended levels of sports activity		
Individual cognitions						
	Model 1a: neighbourhood perceptions	Model 2a: individual cognitions	Model 3a: neighbourhood + individual	Model 1b: neighbourhood perceptions	Model 2b: individual cognitions	Model 3b: base neighbourhood + individual
Attitude						
negative		1.00	1.00		1.00	1.00
positive		1.79 (1.54-2.08)	1.76 (1.51-2.06)		3.22 (2.64-3.91)	3.19 (2.61-3.90)
Social influences						
negative		1.00	1.00			
positive		1.23 (1.07-1.43)	1.21 (1.04-1.41)			
Self-efficacy for being regularly active						
(very) unsure		1.00	1.00		1.00	1.00
not sure/unsure		1.25 (0.84-1.87)	1.26 (0.91-1.75)		5.42 (1.03-28.62)	1.96 (0.85-4.49)
(very) sure		1.70 (1.15-2.51)	1.71 (1.24-2.36)		16.46 (3.23-83.91)	6.00 (2.73-13.20)
Intention to be regularly active						
(very) unsure		1.00	1.00			
not sure/unsure		1.52 (1.07-2.14)	1.47 (1.03-2.10)			
(very) sure		2.70 (1.91-3.83)	2.62 (1.85-3.71)			
Random effects [c]						
Level-2 variance (SE)	0.049 (0.035)	0.064 (0.033)	0.066 (0.031)	0.005 (0.005)	0.033 (0.028)	0.029 (0.037)
MOR (95% CrI) [c]	1.23 (1.04-1.39)	1.27 (1.10-1.42)	1.28 (1.15-1.43)	1.07 (1.00-1.14)	1.19 (1.03-1.36)	1.18 (1.03-1.42)

a All models are adjusted for age, sex, education and country of origin.

b Only neighbourhood perceptions and individual cognitions with significant associations are presented in this table.

c Multilevel models were estimated with the Markov Chain Monte Carlo method implemented in MlwiN version 2.02 (CrI = credible interval; MOR = median odds ratio; SE = standard error). The MOR represents the level-2 variance, translated into the odds ratio scale. If the MOR is equal to 1.00, there are no differences between areas in the probability that residents do sports activity. If the MOR >>1.00, this indicates that the area of residence is relevant for understanding variations of the individual probability of sports activity [16].

Outcome (b): meeting recommended levels of sports activity

Availability of facilities and feeling at home in one's neighbourhood were associated with meeting recommended levels of sports activity in bivariate associations (results not shown), however, only the first remained borderline associated when taking both into account (model 1b). Where social influences for physical activity and intention to be regularly active fell short of significance in the model containing all individual factors (model 2b), attitude and self-efficacy showed high odds ratios. In the full model (model 3b), no neighbourhood factors but only attitude and self-efficacy remained significant.

Discussion

In this paper, we showed that perceived physical and social neighbourhood factors were associated with doing any sports activity, in addition to individual cognitions. However, no neighbourhood factors were associated with meeting recommended levels of sports activity, though two individual cognitions, i.e. attitude and self-efficacy, showed strong associations.

Our findings are consistent with previous research, which showed that associations of neighbourhood factors with physical activity differed for specific outcomes in terms of purpose of the activity (transport or recreation) [14, 15], and for different cut-off points regarding one specific activity [5, 6]. Study limitations to be kept in mind are the cross-sectional design, the fact that perceptions do not necessarily reflect objective neighbourhood characteristics, the relatively old-aged sample which explains the rather low prevalence of sports activity, and that individual cognitions and neighbourhood perceptions were not specifically asked in the context of sports activity.

An important implication of the study is that, in order to increase sports activity among the inactive, interventions may fall short if they focus on individual factors only, disregarding a person's social and physical environment. However, when aiming to increase sports activity among those active already, individual-level factors, such as attitudes and self-efficacy with regard to regular physical activity, may be particularly important to focus on. The relative importance of neighbourhood factors for different levels of specific physical activity behaviours deserves attention in future research, to further increase our understanding of the mechanisms underlying differences in physical activity.

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5

Socioeconomic status, environmental and individual factors, and sports participation

Kamphuis CBM, Van Lenthe FJ, Giskes K, Huisman M, Brug J, Mackenbach JP (2008) Socioeconomic status, environmental and individual factors, and sports participation. *Med Sci Sports Exerc* 40(1): 71-81

Abstract

Background The objective of this study is to examine the contribution of neighbourhood, household and individual factors to socioeconomic inequalities in sports participation in a multilevel design.

Methods Data were obtained by a large-scale postal survey among a stratified sample of the adult population (age 25-75 years) of Eindhoven (the fifth largest city of the Netherlands) and surrounding cities, residing in 213 neighbourhoods (N=4785; response rate 64.4%). Multilevel logistic regression analyses were done with sports participation as binary outcome (no, vs. yes), i.e. respondents not doing any moderate or high intensity sports at least once a week were classified as nonparticipants.

Results Unfavourable perceived neighbourhood factors (e.g. feeling unsafe, small social network), household factors (material and social deprivation), and individual physical activity cognitions (e.g. negative outcome expectancies, low self-efficacy) were significantly associated with doing no sports, and reported more frequently among lower socioeconomic groups. Taking these factors into account reduced the odds ratios of doing no sports of the lowest educational group by 57%, from 3.99 (95% CI, 2.99-5.31) to 2.29 (95% CI 1.70-3.07), and among the lowest income group by 67%, from 3.02 (95% CI, 2.36-3.86) to 1.66 (95% CI 1.22-2.27).

Conclusions A combination of neighbourhood, household, and individual factors can explain socioeconomic inequalities in sports participation to a large extent. Interventions and policies should focus on all three groups of factors simultaneously, to yield a maximal reduction of socioeconomic inequalities in sports participation.

Introduction

Regular physical activity can reduce the risk of several chronic diseases, such as coronary heart disease and type-2 diabetes [1], however, physical activity is among several health behaviours (e.g. smoking, diet) known to be less favourable for people with a low socioeconomic status (SES), compared to their higher status counterparts [2-5]. In the literature, differences in physical and social environmental exposures have been hypothesized as the ultimate explanations for the differential distribution of physical activity and other health behaviours across socioeconomic groups [5-7]. Presently, little is known about the contribution of possible environmental influences to socioeconomic inequalities in physical activity.

A considerable number of studies have shown relationships of physical and social environmental factors with physical activity [8-11], however, with little reference to their patterning across socioeconomic groups. Some studies have examined the lower rates of physical activity in disadvantaged areas, and have demonstrated the importance of neighbourhood attractiveness, the accessibility and proximity of neighbourhood facilities, and neighbourhood safety [12-17]. Educational differences in leisure-time walking were explained by a range of personal, physical and social environmental factors, whereas few variables explained educational variations in walking for transport [18]. Social participation (i.e. how actively a person takes part in group activities in society, e.g. courses, events, church) has shown to contribute to socioeconomic differences in leisure-time physical activity [19].

As environmental influences should be investigated for specific behaviours [11, 20], this paper focuses on one aspect of one's overall physical activity, i.e. sports participation. Participation in vigorous activities like sports is low among the socioeconomically disadvantaged [21], however, regular vigorous activity can have an important positive health effect. Life expectancy for sedentary people and moderately active people at age 50 years was found to be 3.8 years and 1.4 years shorter, respectively, compared to people with high physical activity levels [22]. More specifically, within the moderately and highly active persons, sports participants experienced only half the mortality of nonparticipants [21].

Studies that have investigated environmental factors in relation to socioeconomic inequalities in PA mainly focused on neighbourhood factors. However, an ecological approach requires the investigation of environmental factors from different settings, as well as individual factors [8, 23]. In recent multilevel studies, the household has shown to have an important effect on health, independent of individual and neighbourhood-level effects [24, 25]. Therefore, in this paper, we examine the contribution of perceived neighbourhood, household,

and individual factors to socioeconomic inequalities in sports participation in a multilevel design (to be able to examine and account for possible clustering of sports participation within neighbourhoods) [26].

Methods

Study population

Data were obtained by a large-scale postal survey, a component of the new wave of data collection for the longitudinal GLOBE study, among a stratified sample of the adult population (age 25-75 years) of Eindhoven (the fifth largest city in the Netherlands) and surrounding cities in October 2004 (N=4785; response rate 64.4%). Participants resided in 213 neighbourhoods, which are the smallest geographical units in the Netherlands created for statistical and administrative purposes. More about the objectives, design and results of the GLOBE study can be found elsewhere [27, 28]. The use of personal data in the GLOBE study is in compliance with the Dutch Personal Data Protection Act and the Municipal Database Act, and has been registered with the Dutch Data Protection Authority (number 1248943).

Participants with missing values for sports participation, education, income or one of the confounding variables, i.e. age, sex, country of origin or marital status, were excluded from the analyses (n=557). Also, we excluded participants who reported that poor health or pain was often a barrier for being physically active (n=307). Furthermore, we excluded participants with missing values for the level-2 indicator (neighbourhood) (n=48), and participants residing in neighbourhoods with only one or two participants (n=34). Therefore, the analytic sample comprised of 3839 participants, who resided in 177 neighbourhoods (mean number of participants per neighbourhood: n= 21, range 3-70).

Measurements

All factors were measured in the GLOBE postal survey 2004. Selection of items for the questionnaire was based on an extensive literature review [29-31], expert meetings, and focus groups conducted with residents living in the city of Eindhoven [32]. Items that measured neighbourhood, household, and individual factors, as described in Table 2, were mostly derived from existing scales. For physical activity cognitions, we assessed key factors that recur in models commonly employed to predict health behaviours, i.e. Social Cognitive Theory and the Theory of Planned Behaviour [33]. Missing values for neighbourhood, household, individual factors were imputed by drawing randomly from the distribution of answering categories, using observed prevalences per educational group as probabilities. Possible confounding factors were age (in ten-year categories), sex, country of origin (Netherlands, other country), and marital status (married/registered partnership, not married).

Socioeconomic status

Educational attainment is only one component of the broad concept of SES, but is considered a good indicator of SES in the Netherlands [34], and therefore was our main SES-indicator. Four levels of education were distinguished ((1) no education or primary education; (2) lower professional and intermediate general education; (3) intermediate professional and higher general education; (4) higher professional education and university). We also used household income as SES-indicator, asking participants to report their net monthly household income (0-1200 euro, 1200-1800 euro, 1800-2600 euro, 2600 euro or more, and 'don't want to say / don't know').

Table 5.1 Characteristics of the GLOBE study – a stratified sample from the city of Eindhoven, Netherlands (2004)- by educational level[a]

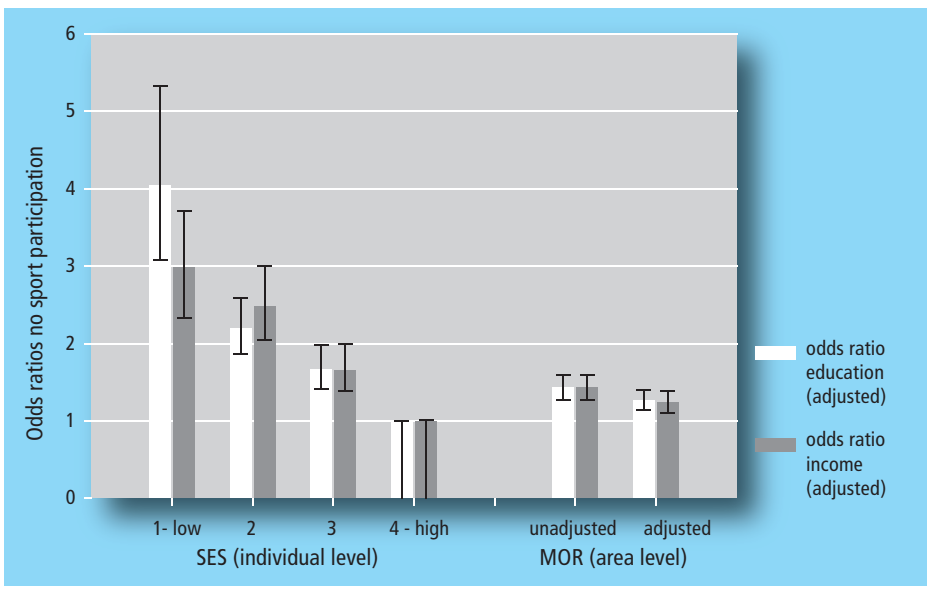
	Total		Educational level[a]			
			1–low (N=337)[b]	2 (N=1328)	3 (N=965)	4–high (N=1215)
	N[b]	%[c]	%[c]	%[c]	%[c]	%[c]
Total sample	3839	100	6.9	31.1	28.3	33.7
Sports participation						
Yes	1851	50.3	23.5	41.1	52.3	62.5
No	1988	49.7	76.5	58.9	47.7	37.5
Sex						
Male	1836	47.5	43.5	37.0	47.7	57.8
Female	2003	52.5	56.5	63.0	52.3	42.2
Age group						
25-34	603	19.8	8.6	8.8	24.3	28.4
35-44	728	24.0	12.3	18.8	31.0	25.3
45-54	675	21.8	19.0	24.0	20.9	21.1
55-64	976	22.0	31.6	31.4	16.1	16.3
65-74	857	12.4	28.6	17.0	7.7	8.9
Country of birth						
Netherlands	3505	90.3	78.7	91.6	91.8	90.1
Other	334	9.7	21.3	8.5	8.2	9.9
Monthly net household income						
Less than 1200 euro	443	10.6	32.6	14.5	7.6	5.0
1200-1800 euro	872	20.7	33.3	30.4	20.0	9.7
1800-2600 euro	1008	26.1	10.7	25.9	34.7	22.1
More than 2600 euro	1084	31.3	3.3	14.6	27.9	55.5
Don't want to say/don't know	432	11.3	20.0	14.6	9.8	7.7
Marital status						
Married	2853	73.9	76.6	78.4	74.6	68.7
Unmarried/divorced/ widowed	986	26.1	23.4	21.6	25.4	31.1

a Educational level with 1= primary education, 2= lower secondary, 3= higher secondary, and 4= tertiary education.
b The numbers (N) are unweighted, and reflect the actual numbers of participants in our dataset.

Sports participation

Sports participation was measured with the SQUASH questionnaire - a validated Dutch questionnaire to measure various types of physical activity among an adult population: commuting, leisure time, sports, occupational, and housekeeping activities [35]. Participants wrote done up to four sports they did on a weekly basis during previous month (open question). For these sports they reported frequency (times per week), average duration (minutes per day), and intensity (low, average, high). Self-reported intensity, in combination with participant's age, and activity-specific MET-values, were used to calculate intensity scores. As almost half of the sample did not do any sport, sports participation was dichotomised, with 'no': not doing any sports weekly with at least moderate intensity (moderate intensity= 4-6 MET for 18-55 yrs-old; 3-5 MET for 55+ yrs-old) versus 'yes': doing sports at least once a week with moderate or high intensity.

Figure 5.1 Adjusted odds ratios (ORs) for no sports participation by education and household income, and median odds ratios (MORs) (indicating clustering of sports participation within neighbourhoods)



Note:
Models for education were adjusted for age, sex, and country of origin.
Models for income were adjusted for age, sex, country of origin, and marital status.

Statistical analyses

'No sports participation' was modelled as a binary outcome variable in weighted multilevel logistic regression models of participants (level 1) nested within neighbourhoods (level 2). To take into account the hierarchical nature of the

data, analyses were done in MLwiN (version 2.02) using the logit-link function and 2nd order PQL estimation methods [36], unless specified otherwise. Clustering of sports participation within neighbourhoods was determined by calculating the median odds ratio (MOR) with 95% credible intervals (CrL), using the posterior distribution of the area variance as provided by the Markov Chain Monte Carlo (MCMC) procedure in MlwiN [37]. The MOR was computed with the following formula [26]:

$$\begin{aligned} MOR &= \exp[\sqrt{(2 \times \text{area variance})}] \times 0.6745 \\ &\approx \exp(0.95\sqrt{\text{area variance}}) \end{aligned}$$

All analyses were conducted separately for education and income as SES-indicators, as they are likely to relate to different causal processes [38]. Analyses were weighted to reflect our source population (i.e. the adult population of the region of Eindhoven in October 2004) in terms of sex, age and educational level.

Firstly, we tested the association of SES with no sports participation (adjusted for age, sex, and country of origin). Then, we examined which neighbourhood, household, and individual factors were significantly associated with doing no sports in univariate analyses ($p<0.05$), and whether these factors were unequally distributed across SES-groups (using SPSS version 11.0) [39]. Factors that were significantly associated with both sports participation and SES, were then analysed in multivariate analyses for neighbourhood, household and individual factors separately, using the Backward Stepwise procedure in SPSS (i.e. at each step, the least significant factor was removed from the model, until all factors in the model were significant ($p<0.100$)). Neighbourhood, household, and individual factors that remained significant in these multivariate models were included in the following six-step modelling sequence in MLWIN.

Firstly, we examined neighbourhood level variance and the MOR for the empty model (model 0). Secondly, we calculated the odds ratios (ORs) of no sports participation by socioeconomic groups adjusted for age, sex, and country of origin (model 1). Then, we included neighbourhood factors only (model 2), household factors only (model 3), and individual factors only (model 4). Finally, we tested the full model (model 5), in which we included neighbourhood, household, and individual factors simultaneously that had been significant in models 2 to 4. For each of the models 2 to 5, we calculated the percentage change in ORs compared to ORs for model 1 ([ORmodel1 - ORmodelx]/ [ORmodel1 - 1] * 100). This reduction in ORs was interpreted as the contribution of the specific factors included in the model to the explanation of socioeconomic inequalities in sports participation.

Table 5.2 Neighbourhood, household, and individual factors as measured in the GLOBE postal survey 2004

Factors in logistic regression models	Measurement of factors in GLOBE postal survey 2004	Answering categories in the analyses
NEIGHBOURHOOD		
Neighbourhood physical factors		
Neighbourhood safety	"My neighbourhood is unsafe"	Agree, disagree
Neighbourhood attractiveness	"My neighbourhood is unattractive"	Agree, disagree
Availability of facilities	"There are insufficient places for physical activity in my neighbourhood"	Agree, disagree
Poor weather	"It is often poor weather"	Agree, disagree
Neighbourhood social factors		
Social network (the extent to which one is interconnected and embedded in a community [26])	The first factor constructed by a factor analysis with 13 items concerning aspects of social relationships, which we referred to as 'social network'. Items that loaded on this factor were e.g. "I borrow stuff from my neighbours", "I visit my neighbours in their house", and "I ask my neighbours for advice" (five-point scale: totally agree - totally disagree).	Large, medium, small
Social capital in the neighbourhood (the extent of connectedness and solidarity among groups [26])	Second factor constructed by a factor analysis with 13 items concerning aspects of social relationships, which we referred to as 'social capital'. Items that loaded on this factor were e.g. "People in this neighbourhood agree on norms and values", "People in this neighbourhood are willing to help each other", and "People in this neighbourhood can be trusted" (five-point scale: totally agree - totally disagree).	High, medium, low
Feeling at home in one's neighbourhood	Third factor constructed by a factor analysis with 13 items concerning aspects of social relationships, which we referred to as 'feeling at home in one's neighbourhood'. Items that loaded on this factor were e.g. "I feel alone in this neighbourhood", "(f) I feel at home in this neighbourhood", (g) "I want to move out of this neighbourhood" (five-point scale: totally agree - totally disagree).	High, medium, low
Social disorganisation (the inability of residents of an area to regulate everyday public behaviours and physical conditions [25])	One factor constructed by a factor analysis with 11 items concerning the frequency with which adverse neighbourhood events occurred (often, sometimes, (almost) never). Items referred to e.g. litter, graffiti, vandalism, people being hassled on the streets, drunken people in the streets.	High, medium, low
Length of residence	"For how long have you lived in this neighbourhood?"	0-2 ; 2-5 ; 5-15 ; 15 > years

Table 5.2 (Continued)

Factors in logistic regression models	Measurement of factors in GLOBE postal survey 2004	Answering categories in the analyses
HOUSEHOLD		
Indicators for material deprivation		
Indicator 1: financial problems	"Did you have financial problems last year, e.g. problems paying bills, food or rent?"	None, some, many
Indicator 2: car possession	"Is there a car available in your household?"	Yes, no
Indicator 3: crowding	Crowding was calculated from 2 items, i.e. "With how many people do you live together in your household? (including yourself)", and "How many rooms has the house you live in?" (excluding kitchen, corridor, cellar, bathroom, toilet, garage, attic)	1< person per room, 1> persons per room,
Indicators for social deprivation		
Indicator 1: friends/family for dinner monthly	"Do you have friends/family over for dinner at least monthly?"	Yes; no, for financial reasons; no, for other reasons;
Indicator 2: going out fortnightly	"Do you go for a night out with friends/family at least fortnightly?"	Yes; no, for financial reasons; no, for other reasons;
Indicator 3: going on holiday yearly	"Do you go on holiday for at least one week per year?"	Yes; no, for financial reasons; no, for other reasons;
INDIVIDUAL		
Positive outcome expectancies of recommended PA [a]	Measured with six items on a five-point scale (very important – very unimportant) [b]: "It makes me feel less stressed", "I get in a good mood", "I enjoy being active", "I'm more confident with my body", "It is good for my fitness", and "I feel energized".	(Very) important, not important/ unimportant, (very) unimportant,
Negative outcome expectancies of recommended PA	Measured with six items on a five-point scale (very important – very unimportant) [b]: "It requires too much time", "It requires too much discipline", "It requires too much energy", "I'm afraid of injuries", "I feel uncomfortable when others see me exercising", and "Doing sports is expensive".	(Very) important, not important/ unimportant, (very) unimportant,
Subjective norm	"Significant others think that I should be physically active for at least 30 minutes/day"	Agree, partly agree/disagree, disagree,
Social support	"Significant others support me to be physically active for at least 30 minutes/day"	Agree, partly agree/disagree, disagree,
Modelling	"Significant others are physically active for at least 30 minutes/day themselves"	Agree, partly agree/disagree, disagree,
Self-efficacy	"How sure are you that you can be physically active for at least 30 minutes/day?" (measured on a five-point scale (very sure – very unsure) [b]	(Very) sure, not sure/unsure, (very) unsure,
Intention	"Do you plan to be physically active for at least 30 minutes/day?" (measured on a five-point scale (surely yes – surely no) [b]	(Surely) yes, maybe, (surely) no,

a All items regarding individual factors were asked in relation to the following definition of recommended physical activity (PA): "being physically active with at least moderate intensity on at least 30 minutes per day".

Results

Demographic characteristics of our sample are provided in Table 1. All characteristics were significantly associated with sports participation (not shown). Compared to higher educational groups, people in the lowest educational group were more likely than higher educated to be female, to be of older age, to have a low household income, and to be born in a country other than the Netherlands (Table 1). Marital status differed by income group (not shown), but not by educational group. Therefore, marital status was taken into account as confounder in analyses with income as SES-indicator.

SES and sports participation

As presented in Figure 1, a gradient was found between SES and no sports participation, with the lowest educated (OR=3.99; 95% CI: 2.99-5.31) and lowest income group (OR=3.02; 95% CI: 2.36-2.86) most likely to report no sports participation. Moreover, we found significant clustering of no sports participation within neighbourhoods, as indicated by the MOR. Possible explanatory factors that could mediate the association between SES and sports participation are discussed below.

Associations of neighbourhood, household, and individual factors with SES and sports participation

Compared to higher groups, participants from lower socioeconomic groups were more likely to report that their neighbourhood was unsafe, unattractive, and had insufficient places for physical activity (Table 3). Also, they were more likely to report that 'it is often poor weather', and to report a small social network and low social cohesion. All of these characteristics increased the likelihood of doing no sports. People indicating not feeling at home in their neighbourhood were also more likely to do no sports, but this was not significantly more prevalent among any of the educational groups (p=.093). Social disorganisation and length of residence were not significantly associated with doing no sports.

Two out of three indicators of material deprivation (crowding, and having financial problems) and all three indicators of social deprivation increased the likelihood of doing no sports. Also, these factors showed higher prevalence among lower socioeconomic groups.

Furthermore, all individual cognitions of recommended physical activity were significantly related to sports participation, and unfavourable cognitions were more prevalent among lower socioeconomic groups. As an exception, the negative outcome expectancy 'physical activity requires too much time' was more frequently reported by people from higher than lower socioeconomic groups. Of all factors examined, self-efficacy and intention showed the strongest associ-

ations with sports participation. Factors that were either not significantly associated with sports participation nor/or with SES, were not included in further explanatory analyses.

Explanatory models

Compared to the basic model (including education, age, sex and country of origin), the increased ORs for doing no sports seen among lower educated groups decreased by 0-7% when neighbourhood factors were added (model 2, Table 4). Adjustment for household factors (model 3) lowered ORs by 17-28% compared to the basic model. Adding individual factors to the basic model showed the largest percentages reduction in ORs, i.e. 19-42% (model 4). In the full model, two neighbourhood factors (safety and social cohesion), three household factors (material deprivation (indicator 3) and social deprivation (indicator 2 and 3)), and nine individual factors (six outcome expectancies, social support, modelling, self-efficacy, and intention) remained statistically significant. All factors together reduced the ORs of doing no sports among the lowest educational group by 57%, for the second-lowest by 48%, and for the second-highest by 26%. As presented in Table 5, results of the explanatory analyses for income as SES-indicator were comparable to those for education, however, adjustment for neighbourhood factors, household factors and all factors showed larger reductions in ORs.

Compared to the empty model, the MOR reduced substantially in model 1 (taking compositional characteristics into account), and further reduced somewhat after inclusion of neighbourhood factors (in models with income as SES indicator) or household factors (in models with education as SES indicator).

Discussion

We examined the contributions of neighbourhood, household and individual factors to the explanation of socioeconomic variation in sports participation using a multilevel design. Unfavourable neighbourhood (e.g. feeling unsafe, low social network), household (e.g. material and social deprivation), and individual factors (e.g. low self-efficacy, perceived negative outcome expectancies) were associated with doing no sports, and were reported among lower socioeconomic groups more frequently. Together, these factors explained socioeconomic inequalities in sports participation to a large extent. Interventions and policies should focus on all three groups of factors simultaneously, to yield a maximal reduction of socioeconomic inequalities in sports participation.

Table 5.3 Adjusted odds ratios (OR)[a] for doing no sports, and prevalence rates of response categories of neighbourhood, household, and individual factors by educational level

Independent factors	OR[a] for doing no sports	95% CI	p[b]	Educational level 1 (low)	2	3	4 (high)	p[b]
NEIGHBOURHOOD								
Neighbourhood physical factors								
Neighbourhood is unsafe								
disagree	1.00		.005	92.9[c]	96.4	97.7	97.8	.000
agree	1.77	(1.18-2.65)		7.1	3.6	2.3	2.2	
Neighbourhood is unattractive								
disagree	1.00		.000	72.4	83.9	88.4	87.2	.000
agree	1.45	(1.20-1.75)		27.6	16.1	11.6	12.8	
Insufficient places for physical activity								
disagree	1.00		.106	68.7	80.1	84.7	89.4	.000
agree	1.16	(0.97-1.37)		31.1	19.9	15.3	10.6	
Often poor weather								
disagree	1.00		.051	72.8	82.0	84.0	82.1	.000
agree	1.19	(1.00-1.41)		27.2	18.0	16.0	17.9	
Neighbourhood social factors								
Social network								
large	1.00		.006	32.8	39.5	36.5	29.1	.000
medium	1.27	(1.09-1.49)		35.8	31.4	34.2	33.3	
small	1.23	(1.05-1.45)		31.3	29.1	29.3	37.6	
Social cohesion								
high	1.00		.000	30.9	36.1	36.1	36.9	.028
medium	0.85	(0.72-0.99)		30.5	32.9	33.5	35.5	
low	1.17	(1.00-1.38)		38.7	31.0	30.4	27.6	
Feeling at home in neighbourhood								
high	1.00		.018	30.1	37.0	36.6	35.3	.093
medium	1.16	(0.99-1.35)		31.2	34.2	33.5	34.2	
low	1.26	(1.07-1.48)		38.7	28.9	29.9	30.5	
Social disorganisation								
low	1.00		.552	43.9	52.1	51.2	54.5	.058
medium	1.16	(0.89-1.50)		8.9	6.7	6.8	7.2	
high	1.02	(0.89-1.17)		47.2	41.2	42.1	38.3	
Length of residence								
0-2 years	1.08	(0.85-1.36)	.681	12.5	8.7	14.5	19.0	.000
2-5 years	0.95	(0.77-1.17)		12.1	13.6	22.0	22.9	
5-15 years	1.05	(0.88-1.24)		28.7	32.2	34.0	35.0	
15> years	1.00			46.8	45.5	29.5	23.2	
HOUSEHOLD								
Indicators of material deprivation								
1) Financial problems								
no	1.00		.000	53.0	61.8	63.4	79.7	.000
some	1.36	(1.17-1.59)		34.3	30.2	30.8	17.3	
many	2.13	(1.59-2.87)		12.7	8.0	5.8	3.0	

Table 5.3 (continued)

Independent factors	OR[a] for doing no sports	95% CI	p	Educational level 1 (low)	2	3	4 (high)	p
2) Car possession								
yes	1.00		.105	79.9	91.9	94.4	95.0	.000
no	1.27	(0.96-1.62)		20.1	8.1	5.6	5.0	
3) Crowding								
<1 per room	1.00		.001	78.4	82.0	80.1	85.8	.000
>1 person per room	1.37	(1.14-1.64)		21.6	18.0	19.9	14.2	
Indicators of social deprivation								
1) Friends/family for dinner monthly								
yes	1.00		.052	43.7	50.7	55.2	67.7	.000
no, for financial reasons	1.31	(1.02-1.69)		18.7	10.9	8.0	2.8	
no, for other reasons	1.13	(0.98-1.30)		37.7	38.4	36.8	29.5	
2) Going out fortnightly								
yes	1.00		.000	27.7	29.4	40.3	46.2	.000
no, for financial reasons	1.57	(1.30-1.91)		35.4	22.8	19.0	9.3	
no, for other reasons	1.31	(1.13-1.51)		37.7	47.8	40.8	44.5	
3) Going on holiday yearly								
yes	1.00		.000	50.2	76.1	81.6	90.1	.000
no, for financial reasons	1.68	(1.35-2.10)		31.6	13.4	11.7	5.0	
no, for other reasons	1.33	(1.04-1.77)		18.2	10.5	6.7	4.9	
INDIVIDUAL								
Positive outcome expectancies of PA								
Makes me feel less stressed								
important	1.00		.000	59.7	63.2	70.5	69.3	.000
unimportant	2.13	(1.85-2.46)		40.3	36.8	29.5	30.7	
Get in good mood								
important	1.00		.000	59.9	67.4	71.4	68.6	.003
unimportant	2.17	(1.87-2.50)		40.1	32.6	28.6	31.4	
Like being active								
important	1.00		.000	64.7	64.8	64.2	65.2	.966
unimportant	2.61	(2.27-3.00)		35.3	35.2	35.8	34.8	
More confident with body								
important	1.00		.000	61.9	67.9	68.3	67.4	.257
unimportant	1.89	(1.64-2.18)		38.1	32.4	31.7	32.6	
Good for fitness/condition								
important	1.00		.000	80.3	87.0	91.5	92.0	.000
unimportant	2.45	(1.94-3.08)		19.7	13.0	8.5	8.0	
Feel energized								
important	1.00		.000	71.6	80.4	85.1	84.4	.000
unimportant	2.23	(1.86-2.67)		28.4	19.6	14.9	15.6	
Negative outcome expectancies of PA								
Requires too much time								
unimportant	1.00		.000	47.4	53.1	45.3	37.7	.000
important	1.43	(1.25-1.64)		52.6	46.9	54.7	62.3	

Table 5.3 (continued)

Independent factors	OR[a] for doing no sports			Educational level				
		95% CI	p	1 (low)	2	3	4 (high)	p
Requires too much discipline								
unimportant	1.00		.000	49.1	51.4	45.6	44.8	.005
important	1.55	(1.36-1.77)		50.9	48.6	54.4	55.2	
Requires too much energy								
unimportant	1.00		.000	47.7	58.5	65.3	74.1	.000
important	1.85	(1.61-2.13)		52.3	41.5	34.7	25.9	
Afraid to get injured								
unimportant	1.00		.000	55.0	67.2	75.1	81.9	.000
important	1.31	(1.13-1.53)		45.0	32.8	24.9	18.1	
Feel uncomfortable when exercising								
unimportant	1.00		.000	65.3	78.9	84.4	90.0	.000
important	1.89	(1.57-2.26)		34.7	21.1	15.6	10.0	
Doing sports is expensive								
unimportant	1.00		.000	48.5	68.2	76.7	82.4	.000
important	1.81	(1.55-2.12)		51.5	31.8	23.3	17.6	
Social influences								
Subj. norm: other think I should do PA								
true	1.00		.000	54.1	57.5	58.6	65.0	.000
not true/false	1.31	(1.12-1.53)		19.8	24.3	25.0	22.5	
false	1.48	(1.23-1.78)		26.1	18.2	16.4	12.5	
Soc. support: others support me in PA								
true	1.00		.000	46.3	41.2	37.7	40.2	.000
not true/false	1.40	(1.20-1.62)		25.7	34.4	36.7	39.2	
false	1.87	(1.59-2.22)		28.0	24.4	25.7	20.6	
Modelling: others do PA								
true	1.00		.000	51.3	48.6	44.4	46.9	.175
not true/false	1.32	(1.15-1.52)		37.9	39.2	44.6	41.6	
false	1.30	(1.05-1.61)		10.8	12.2	11.0	11.5	
Self-efficacy								
How sure to get sufficient PA?								
(very) sure	1.00		.000	57.5	70.6	73.6	79.0	.000
not sure/unsure	2.25	(1.91-2.66)		33.2	24.9	20.8	15.2	
(very) unsure	2.81	(2.08-3.81)		9.3	4.5	5.6	5.8	
Intention: Plan to get sufficient PA?								
yes	1.00		.000	46.3	60.4	65.9	75.3	.000
maybe	2.73	(2.35-3.57)		44.0	34.6	30.7	21.4	
no	3.39	(2.36-4.87)		9.7	5.0	3.4	3.3	

a Models were adjusted for age, sex, educational level, and country of origin.
n.s. = not significant; *= p<0.050; **= p<0.010; ***= p<0.001.

b This is the percentage of respondents that agreed on the statement per socioeconomic group; for example, 92.9% of those in the lowest group disagreed with the statement "My neighbourhood is unsafe".

The main strength of our study is that we incorporated neighbourhood, household as well as individual factors in our analyses to explain socioeconomic variations in sports participation, using a multilevel design to correct for possible area variance. Although not the focus of this paper, we also showed that the individual probability to do no sports was statistically dependent on the neighbourhood of residence (indicated by the MOR>>1), which could be mainly explained by compositional differences between neighbourhoods (in terms of age, education, sex) and slightly by differences in neighbourhood perceptions and household factors.

Another strength is our well-considered selection of factors, which was preceded by an extensive literature review [29-31], expert meetings, and focus groups [32]. Moreover, we could quantify the contributions of groups of factors, by interpreting the reduction in ORs after introduction of explanatory factors to the basic model as the mediating role of these factors to socioeconomic inequalities in sports participation.

Our study was cross-sectional, and therefore could not disentangle causal pathways between SES, explanatory factors, and sports participation. Although we made a well-considered selection of explanatory factors, results are likely to depend on the specific factors used in this study. The classification of factors in the three domains (neighbourhood, household, and individual) has been done through informed discussion among the research team and in close consultation with the literature. However, we acknowledge that this classification is debatable, as different researchers may classify items differently.

Items to measure individual-level cognitions were not behaviour-specific for sports participation, but referred to recommended physical activity ("being physically active with moderate intensity for at least 30 minutes per day"). We suspect that associations of individual factors with the outcome measure sports participation would have been even stronger if those variables would have been behaviour-specific for the outcome [20].

For many of the neighbourhood and household factors, participants with missing values had increased ORs to do no sports, and the prevalence of missing values was highest among participants from the lowest SES group. When we took missing values into account by treating them as separate answering categories, the contribution of certain factors to the explanation of socioeconomic inequalities in sports participation was overestimated, as it was actually the high OR for the missing value category (and its higher prevalence in low SES groups) that was driving the explanatory power. Therefore, missing values for explanatory factors were imputed by drawing randomly from the distribution of answering categories, using observed prevalences per educational group as probabilities.

We could not include objectively measured neighbourhood characteristics in our analyses. Therefore, it remains uncertain to what extent differences in perceived neighbourhood safety and attractiveness reflect objective differences in neighbourhood characteristics. On the one hand, as the lowest socioeconomic group more frequently reported bad weather (although weather differences between neighbourhoods are very unlikely) this might suggest that lower socioeconomic groups have an overall negative perception of life, including the perception of their living environment. On the other hand, we found that neighbourhood factors could explain some of the neighbourhood variance in sports participation. Also, in additional multilevel analyses we found significant clustering of perceived safety, attractiveness and availability of facilities within neighbourhoods (results available on request). Both findings may indicate the existence of true neighbourhood differences.

Our findings are in line with two studies from Australia, which concluded that personal, social, and physical environmental factors could explain educational inequalities in leisure-time walking [18], and variations in recommended levels of exercising [40]. Also similar to our study, these two studies found that distal (environmental) factors could explain less of the (socioeconomic) variations in physical activity than more proximal (household and individual) factors. This does not mean that neighbourhood factors require less attention in policy and intervention development. From a population perspective, even small odds ratios for neighbourhood characteristics may imply that changes to (perceptions of) the neighbourhood context may have a significant effect on physical activity levels. Especially since we found that most perceptions of unfavourable neighbourhood factors were more prevalent among lower socioeconomic groups, these may offer important opportunities to reduce socioeconomic inequalities in physical activity.

All analyses were done for two different SES-indicators separately, as education and income may be related to sports participation through different processes [38]. In our study, education showed a larger gradient with sports participation than income, but on the other hand, neighbourhood and household factors could explain more of the income than educational inequalities in sports participation. Future research should further disentangle which aetiological mechanisms can explain educational and income inequalities in sports participation.

Table 5.4 Effect of adjustment for neighbourhood, household, and individual level factors on clustering of sports participation in neighbourhoods (random effects), and on the association between educational level and no sports participation[a] (fixed effect)[b]

	Factors included in the model (significant)	Area (random effects)		Educational level[c] (fixed effect)						
				1- low		2		3		4- high
		Area level variance (SE)	MOR (95% CrI)	(N=347)		(N=1346)		(N=984)		(N=1244)
Model 0 (empty)	--	0.157 (0.047)	1.46 (1.30-1.63)							
Model 1: BASIC	education + age + sex + country of origin	0.067 (0.032)	1.28 (1.15-1.43)	3.99	(2.99-5.31)	2.19	(1.86-2.59)	1.65	(1.39-1.96)	1.00
Model 2: BASIC + NEIGHBOURHOOD	neighbourhood attractiveness + neighbourhood safety + social network + social cohesion	0.060 (0.031)	1.26 (1.10-1.40)	3.77 *7%*[d]	(2.83-5.02)	2.18 *1%*	(1.84-2.59)	1.71 *0%*	(1.45-2.02)	1.00
Model 3: BASIC + HOUSEHOLD	material deprivation (ind. 1+3) + social deprivation (ind. 2+3)	0.049 (0.024)	1.23 (1.12-1.36)	3.16 *28%*	(2.34-4.26)	1.89 *25%*	(1.58-2.26)	1.54 *17%*	(1.29-1.84)	1.00
Model 4: BASIC + INDIVIDUAL	PA makes me feel less stressed + I get in a good mood + PA is good for my fitness + PA costs too much energy + I feel uncomfortable during PA + PA is too expensive + social support + modelling + self-efficacy + intention	0.052 (0.036)	1.24 (1.05-1.40)	2.67 *44%*	(1.96-3.63)	1.75 *37%*	(1.45-2.12)	1.54 *17%*	(1.27-1.87)	1.00
Model 5: BASIC + NEIGHBOURHOOD + HOUSEHOLD + INDIVIDUAL	neighbourhood safety + social cohesion + material deprivation (ind. 3) + social deprivation (ind. 2+3) + PA makes me feel less stressed + I get in a good mood + PA is good for my fitness + PA costs too much energy + I feel uncomfortable during PA + PA is too expensive + social support + modelling + self-efficacy + intention	0.046 (0.024)	1.22 (1.12-1.36)	2.29 *57%*	(1.70-3.07)	1.62 *48%*	(1.34-1.96)	1.48 *26%*	(1.23-1.78)	1.00

a Doing sports (no vs. yes), with 'no': not doing any sports, with at least moderate intensity (i.e. 3-5 MET for 55+ yrs-old, and 4-6.5 MET for 18-55 yrs-old).

b Multilevel models were estimated with the Markov Chain Monte Carlo method implemented in MlwiN (version 2.02) ; CrI, credible interval; MOR, median odds ratio; OR, odds ratio; SE, standard error.

c Education: highest attained education, with 1= no education or primary education; 2= lower secondary; 3= higher secondary; 4= tertiary.

d Percentages in italic show the percentages reduction in odds ratio's compared to the basic model, per educational group. For instance, the reduction in the OR for the lowest educational group when adding neighbourhood factors into the basic model, is [(3.99-3.77)/(3.99-1.00)] * 100 = 7%.

Table 5.5 Effect of adjustment for neighbourhood, household, and individual level factors on clustering of sports participation in neighbourhoods (random effects), and on the association between household income and no sports participation[a] (fixed effect)[b]

	Factors included in the model (significant)	Area (random effects)		Household income[c] (fixed effect)						
				1- low		2		3		4- high
		Area level variance (SE)	MOR (95% CrI)	OR	(N=461) 95% C.I.	OR	(N=887) 95% C.I.	OR	(N=1022) 95% C.I.	(N=1107) OR
Model 0 (empty)	--	0.157(0.047)	1.46 (1.30-1.63)							
Model 1: BASIC	income + age + sex + country of origin + marital status	0.050 (0.032)	1.23 (1.08-1.39)	3.02	(2.36-3.86)	2.47	(2.05-2.98)	1.67	(1.40-1.99)	1.00
Model 2: BASIC + NEIGHBOURHOOD	neighbourhood attractiveness + neighbourhood safety + social network + social cohesion	0.029 (0.030)	1.18 (1.04-1.36)	2.77 *12%*[d]	(2.14-3.59)	2.38 *6%*	(1.97-2.88)	1.68 *0%*	(1.40-2.01)	1.00
Model 3: BASIC + HOUSEHOLD	material deprivation (ind. 1+3) + social deprivation (ind. 2+3)	0.042 (0.031)	1.21 (1.05-1.38)	1.97 *52%*	(1.48-2.64)	2.01 *31%*	(1.64-2.47)	1.49 *27%*	(1.25-1.79)	1.00
Model 4: BASIC + INDIVIDUAL	PA makes me feel less stressed + I get in a good mood + PA is good for my fitness + PA costs too much energy + I feel uncomfortable during PA + PA is too expensive + social support + self-efficacy + intention	0.056 (0.034)	1.25 (1.08-1.41)	2.06 *48%*	(1.58-2.70)	2.00 *32%*	(1.62-2.46)	1.47 *30%*	(1.21-1.78)	1.00
Model 5: BASIC + NEIGHBOURHOOD + HOUSEHOLD + INDIVIDUAL	neighbourhood safety + social cohesion + material deprivation (ind. 3) + social deprivation (ind. 3) + PA makes me feel less stressed + I get in a good mood + PA is good for my fitness + PA costs too much energy + I feel uncomfortable during PA + PA is too expensive + social support + self-efficacy + intention	0.044 (0.033)	1.22 (1.08-1.38)	1.66 *67%*	(1.22-2.27)	1.80 *46%*	(1.44-2.26)	1.40 *40%*	(1.14-1.71)	1.00

a Doing sports (no vs. yes), with 'no': not doing any sports, with at least moderate intensity (i.e. 3-5 MET for 55+ yrs-old, and 4-6.5 MET for 18-55 yrs-old).

b Multilevel models were estimated with the Markov Chain Monte Carlo method implemented in MlwiN (version 2.02) ; CrI, credible interval; MOR, median odds ratio; OR, odds ratio; SE, standard error.

c Income level in four groups: 1= <1200 euro; 2=1200-1800 euro; 3=1800-2600 euro; 4=> 2600 euro.

d Percentages in italic show the percentages reduction in odds ratio's compared to the basic model, per income group. For instance, the reduction in the OR for the lowest income group when adding neighbourhood factors into the basic model, is [(3.02-2.77)/(3.02-1.00)] * 100 = 12%.

Conclusions and implications

This study is among the first to show that neighbourhood and household factors in addition to individual factors contribute to the explanation of socioeconomic inequalities in sports participation. More research into specific pathways between (objective and perceived) neighbourhood, household, and individual factors is needed to better understand how socioeconomic disadvantage leads to physical inactivity. Our results suggest that intervention and policy strategies targeted towards lower socioeconomic groups would need to intervene on neighbourhood, household, as well as individual factors, to yield a maximal increase in sports participation among lower socioeconomic groups, and, ultimately, reduce socioeconomic inequalities in health.

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6

Socioeconomic variations in recreational walking among older adults: mediation of neighbourhood perceptions and individual cognitions

Kamphuis CBM, Van Lenthe FJ, Giskes K, Huisman M, Brug J, Mackenbach JP. Socioeconomic variations in recreational walking among older adults: mediation of neighbourhood perceptions and individual cognitions *(*under review with *IJBNPA)*

Abstract

Background People with a low socioeconomic status (SES) are more likely to be physically inactive than their higher status counterparts, however, the mechanisms underlying this socioeconomic gradient in physical inactivity remain largely unknown. Our aims were (1) to investigate socioeconomic differences in recreational walking among older adults and (2) to examine whether neighbourhood perceptions and individual cognitions regarding regular physical activity mediate these differences.

Methods Data were obtained by a large-scale postal survey among a stratified sample of older adults (age 55-75 years) (N=1994), residing in 147 neighbourhoods of Eindhoven and surrounding areas, in the Netherlands. Multilevel logistic regression analyses assessed associations between SES (i.e. education and income), perceptions of the social and physical neighbourhood environment, measures of individual cognitions derived from the Theory of Planned Behaviour (e.g. attitude, perceived behaviour control), and recreational walking for >10 minutes/week (no vs. yes).

Results Participants in the lowest educational group (OR 1.67 (95% CI, 1.18-2.35)) and lowest income group (OR 1.40 (95% CI, 0.98-2.01)) were more likely to report no recreational walking than their higher status counterparts. The association between SES and recreational walking attenuated when neighbourhood aesthetics was included in the model, and largely reduced when individual cognitions were added to the model (with largest effects of attitude, and intention regarding regular physical activity). The association between poor neighbourhood aesthetics and no recreational walking attenuated to (borderline) insignificance when individual cognitions were taken into account.

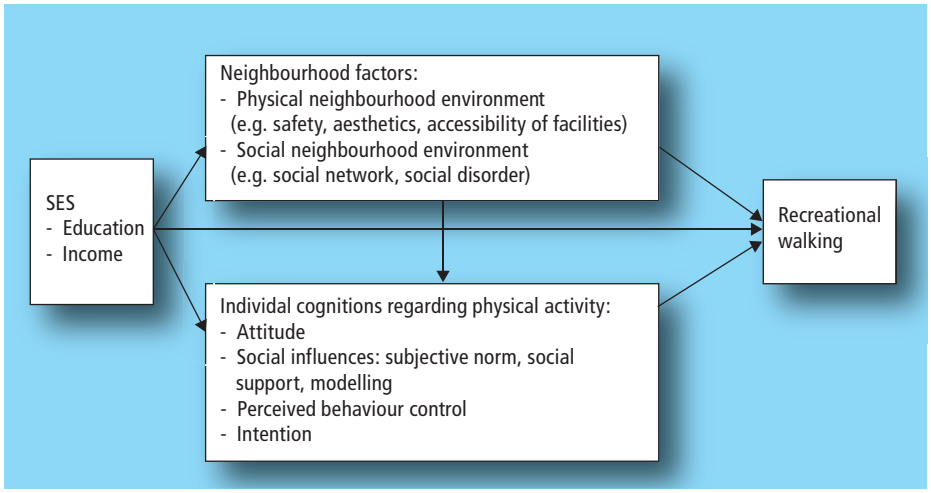
Conclusions Both neighbourhood aesthetics and individual cognitions regarding physical activity contributed to the explanation of socioeconomic differences in no recreational walking. Neighbourhood aesthetics mediated the association between SES and recreational walking largely *via* individual cognitions towards physical activity. Intervention and policy strategies to reduce socioeconomic differences in lack of recreational walking among older adults would be most effective if they intervene on both neighbourhood perceptions as well as individual cognitions.

Introduction

Socioeconomic status (SES) is an important determinant of all cause mortality, mortality from coronary heart diseases and morbidity in many countries [1, 2]. Several studies have shown that a higher prevalence of unhealthy behaviours among lower socioeconomic groups contribute to the explanation of socioeconomic inequalities in health [3-5]. Among those behaviours is physical activity, as people with a low SES are more likely to be physically inactive than their higher status counterparts [6, 7]. To be able to change unhealthy behaviours in order to improve health among low SES groups, one should understand which determinants to focus on, or in other words, to understand *why poor people behave poorly* [8]. However, the mechanisms underlying the socioeconomic gradient in physical inactivity remain largely unknown. In the few studies that have attempted to explain socioeconomic differences in physical inactivity, physical environmental factors (e.g. poor neighbourhood aesthetics, safety issues, access to facilities [9, 10]), social environmental factors (e.g. social participation [11]), and individual cognitions (e.g. self-efficacy or perceived behaviour control [9]) have been identified as potential mediators.

Few studies have simultaneously examined influences from both the environmental and individual domains, and therefore, little is known on the interplay between environmental and individual factors in the SES-inactivity relationship. As suggested in ecological models of physical activity, environmental factors may influence physical activity both directly and indirectly [12, 13]. The Theory of Planned Behaviour (TPB) [14] more specifically hypothesizes how environmental factors may indirectly influence behaviours, namely via individual cognitions such as attitude, social norms and perceived behaviour control. Similarly, as shown in Figure 1, we hypothesize that environmental factors and/or individual cognitions may mediate the relationship between SES and physical activity, and that environmental factors may mediate the association between SES and physical activity directly (as stated in ecological models) or *through* individual cognitions (as stated in the TPB). For instance, people with a low SES may experience worse neighbourhood safety, and these safety concerns may reduce their perceived behavioural control expectations or have a negative impact on their attitude towards physical activity. Thus, unfavourable neighbourhood perceptions may mediate the SES-inactivity relationship via low perceived behavioural control or negative attitudes, but could also have a direct effect on behaviour, e.g. when safety is perceived as barrier for doing physical activity.

Figure 6.1 Conceptual model of associations between socioeconomic status (SES), neighbourhood factors, individual cognitions regarding physical activity, and recreational walking



Environmental determinants are likely to differ for specific physical activity behaviours, and environmental and individual mediators of the SES-inactivity relationship may differ for population subgroups [15]. Therefore, in this paper we will focus on one specific behaviour, i.e. recreational walking, and one subgroup: older adults. Walking is the most common leisure-time physical activity among the general population in developed countries (e.g. the U.S. [16], Australia [17], and the Netherlands [18]). Walking is promising as a focus of public health interventions, due to its acceptability and accessibility (e.g. in terms of skills, equipment, and costs), especially among subpopulations who are known to be sedentary and whose activity should be increased, e.g. older people and people from a socioeconomically disadvantaged background. Older adults are an important subpopulation for public health interventions, as they represent a rapidly increasing share of the general population, and physical activity is important to preserve their health and functioning, and consequently avoid functional limitations and disability [19]. Little is known about socioeconomic differences in walking (and the determinants of these) among older adults.

In this paper we will integrate perceptions of the physical (i.e. perceived neighbourhood safety, aesthetics, and availability of facilities) and social neighbourhood environment (i.e. perceived social cohesion, social network, feeling at home in the neighbourhood, social disorganisation), with individual's cognitions regarding physical activity (e.g. attitude, perceived behavioural control), to determine to what extent socioeconomic differences in recreational walking

among older adults are mediated by neighbourhood perceptions and individual cognitions.

Methods

Study population

Data were obtained by a large-scale postal survey, a component of the new wave of data collection for the longitudinal GLOBE study, among a stratified sample of the adult population (age 25-75 years) of Eindhoven (the fifth largest city in the Netherlands) and surrounding cities in October 2004 (N=4785; response rate 62%). Participants resided in 213 neighbourhoods, which are the smallest geographical units in the Netherlands created for statistical and administrative purposes (with an average population of about 2000 inhabitants). More about the objectives, design and results of the GLOBE study can be found in detail elsewhere [20, 21]. The use of personal data in this study is in compliance with the Dutch Personal Data Protection Act and the Municipal Database Act, and has been registered with the Dutch Data Protection Authority (number 1248943).

Participants aged 55-75 years (N=2345) were selected for the current study. Those with missing values for recreational walking, education, household income, or sex were excluded from analyses (n=265). Furthermore, we removed participants with missing values for the level-2 indicator (neighbourhood) (n=26), and participants residing in neighbourhoods with only one or two participants (n=60). Therefore, the analytic sample comprised of 1994 participants, residing in 147 neighbourhoods (mean number of participants per neighbourhood: n= 14, range 3-80). Demographic characteristics of our sample are provided in Table 1.

Measures

All factors were measured in the GLOBE postal survey in 2004. Selection of items to measure salient environmental factors was based on an extensive literature review [22-25], expert meetings, and focus groups [26].

Neighbourhood perceptions

Three perceptions of physical neighbourhood factors were measured with single items, assessing whether participants agreed or disagreed with the following statements: “My neighbourhood is unsafe” (safety), “My neighbourhood is unattractive for physical activity” (aesthetics), and “There are insufficient facilities for physical activity in my neighbourhood” (availability of facilities).

Thirteen items asked about social relationships within the neighbourhood (on a five-point scale: totally agree - totally disagree) (α = .86), and these items

Table 6.1 Sample characteristics (N=1994; aged 55-75 years) by educational level[a], and univariate associations with no recreational walking (unadjusted)

	TOTAL		Educational level[a]				Unadjusted ORs for no recreational walking
	N[b]	%[c]	1–low %[c]	2 %[c]	3 %[c]	4–high %[c]	
Total sample	1994	100					
Recreational walking							
Yes	1356	68.7	61.5	65.3	77.9	70.8	
No	638	31.3	38.5	34.7	22.1	29.2	
Education							
1 Primary education	281	12.5	-	-	-	-	1.51 (1.09-2.09)
2 Lower secondary	908	43.7					1.29 (1.01-1.64)
3 Higher secondary	366	19.8					0.69 (0.50-0.94)
4 Tertiary education	439	24.1					1.00
Monthly net household income							
Less than 1200 euro	294	13.8	37.4	15.6	6.2	4.5	1.33 (0.97-1.83)
1200-1800 euro	533	23.6	32.1	30.3	21.8	8.3	1.04 (0.79-1.38)
1800-2600 euro	503	25.1	11.5	26.2	32.5	24.1	0.93 (0.70-1.23)
More than 2600 euro	421	24.5	1.2	13.3	26.8	55.2	1.00
Don't want to say/don't know	243	13.0	17.7	14.7	12.7	7.9	1.57 (1.14-2.16)
Sex							
Male	958	47.7	42.6	32.0	59.2	69.1	1.00
Female	1036	52.3	57.4	68.0	40.8	30.9	1.06 (0.87-1.28)
Age group							
55-64	1053	63.5	52.5	64.4	67.4	64.2	1.00
65-74	941	36.5	47.5	35.6	32.6	35.8	0.87 (0.71-1.07)
Country of birth							
Netherlands	1872	93.7	87.5	97.5	95.0	89.0	1.00
Other	106	6.3	12.5	2.5	5.0	11.0	0.88 (0.59-1.32)
Marital status							
Married	1589	82.3	78.9	82.2	84.4	82.3	1.00
Unmarried/divorced/widowed	390	17.7	21.1	17.8	15.6	17.7	1.20 (0.94-1.53)
General health status							
Excellent	93	5.3	4.1	6.1	4.2	5.5	1.00
Very good	314	18.6	8.2	15.4	23.4	26.0	1.06 (0.65-1.71)
Good	1133	57.0	55.1	58.9	57.1	54.4	1.18 (0.76-1.85)
Moderate	378	15.9	26.3	16.0	13.2	12.4	1.03 (0.63-1.69)
Poor	27	0.9	2.1	0.8	0.5	0.9	0.86 (0.28-2.62)
Missing	49	2.2	4.1	2.7	1.6	0.9	2.17 (1.04-4.52)

a Educational level with 1= primary education, 2= lower secondary, 3= higher secondary, and 4= tertiary education.
b The numbers (N) are unweighted, and reflect the actual numbers of participants in the dataset.
c The percentages (%) are weighted and represent the prevalence rates as they existed in the population of Eindhoven by October 2004, which is the source population. The weight factors are calculated from the distribution of the characteristics in a random sample drawn from the municipal registry in Eindhoven, October 2004.

were represented by three factors, as derived from a factor analysis, e.g. a principal component analysis with varimax rotation and kaiser normalization. We labelled the first factor 'social cohesion', i.e. "the extent of connectedness and solidarity among groups in society" [27]. Items that loaded on this factor were e.g. 'People in this neighbourhood agree on norms and values', 'People in this neighbourhood are willing to help each other', and 'People in this neighbourhood can be trusted'. The second factor was labelled 'social network' (i.e. "the presence and nature of interpersonal relationships and interactions; extent to which one is interconnected and embedded in a community" [28]), representing items such as 'I borrow things from my neighbours', 'I visit my neighbours in their home', and 'I can ask my neighbours for advice'. The third factor was labelled 'feeling at home in one's neighbourhood', representing items such as "I feel at home in this neighbourhood", and "I would like to move out of this neighbourhood". Each factor score was classed into tertiles for analytical purposes.

The fourth social neighbourhood factor was derived from a factor analysis that grouped eleven items ($\alpha = .94$) together in one factor, which we labelled as 'social disorder', i.e. "a lack of physical and social order in the community" [29]. These eleven items covered both social and physical indicators of social disorganization, and asked for the frequency with which adverse neighbourhood events occurred (often, sometimes, (almost) never). Items referred to, for instance, litter on the streets, graffiti, vandalism, and the presence of people hanging around on the streets and drinking alcohol. The factor score was classed into tertiles (high, medium, low).

Individual physical activity cognitions

We used an adapted version of the Theory of Planned Behaviour as a framework to measure individual cognitions of regular physical activity. This expanded model incorporated the constructs of attitude, subjective norm, perceived behaviour control, and intention. Two additional social influences of physical activity were added to the model, i.e. social support, and modelling by significant others [24, 28]. Items for all constructs were derived from existing scales, or formulated according to the algorithms of Conner & Norman [30]. All items were asked with regard to the behaviour "regular physical activity", which was defined in the questionnaire as "being physically active for at least 30 minutes, every day, e.g. cycling, doing sports, gardening".

Attitude was measured with outcome expectancies of regular physical activity, and responses were measured on a 5-point Likert-scale from (1) "very important" to (5) "not important at all". Participants reported on six items regarding negative outcome expectations (e.g. "Regular physical activity cost too much time", "Regular physical activity costs too much energy") and six items for pos-

itive outcome expectations (e.g. "Regular physical activity reduces my stress levels", "Regular physical activity is good for my fitness") (α = .77). Items were summed and, based on their specific sum scores, participants were divided in three groups: (very) positive attitude, positive-neutral, and neutral-negative attitude.

Social influences for regular physical activity were assessed with three separate items (α = .85) on a three-point scale (true, not true/not false, false): "Most important others (e.g. partner, children, parents, friends) think that I should be regularly active" (subjective norm), "Most important others support me to be regularly active" (social support), and "Most important others are regularly active themselves" (modelling). Items were combined into a sum score, and three groups were distinguished based on their sum scores: positive social influences, neutral, and negative social influences.

Perceived behaviour control was measured by one item that asked: "How sure are you that you can be regularly active?" (five-point scale, very sure - very unsure). Intention was measured with one item: "Do you plan to be regularly physical active?" (five-point scale, very likely - very unlikely).

Socioeconomic status and other demographic characteristics
Educational attainment is only one component of the broad concept of SES, but is considered a good indicator for SES in the Netherlands [31]. Four levels of education were distinguished ((1) no education or primary education; (2) lower professional and intermediate general education; (3) intermediate professional and higher general education; (4) higher professional education and university). We also measured household income as SES-indicator, asking participants to report their net monthly household income (0-1200 euro, 1200-1800 euro, 1800-2600 euro, 2600 euro or more, and 'don't want to say / don't know'). Other demographic characteristics we measured were age (55-65, 65-75 years), sex, country of origin (Netherlands, other country), marital status (married/ registered partnership, not married), and perceived general health (excellent, very good, good, moderate, poor).

Recreational walking
Walking in leisure time was measured with the SQUASH questionnaire - a validated Dutch questionnaire to measure physical activity among an adult population [32]. Participants reported frequency (times per week), average duration (minutes per day), and intensity (low, average, high) for recreational walking over the last couple of months. However, as the distribution of the sample was highly skewed with almost one third not reporting any recreational walking (and a mean (se) of 231 (5,8) minutes recreational walking per week among those who did any recreational walking), *in*activity rather than a continuous

outcome measure the focus of the current paper. The dichotomised outcome we examined was 'no recreational walking' (<10 minutes per week) vs. 'any recreational walking' (>10 minutes per week).

Statistical analyses

'No recreational walking' was modelled as a binary outcome variable in weighted multilevel logistic regression models of participants nested within neighbourhoods. To take into account the hierarchical nature of the data, explanatory models were run in MlwiN (version 2.02) using the logit-link function and 2nd order PQL estimation methods [33] [34]. All analyses were conducted separately for education and income as SES-indicators, as they are likely to relate to different causal processes [35]. The missing value category of many explanatory factors showed high odds ratios for no recreational walking, and the prevalence of missing values was highest among participants from the lowest SES group. Therefore, to prevent overestimation of the explanatory power of these factors to SES differences in recreational walking, missing values for explanatory factors were imputed by drawing randomly from the distribution of answering categories, using observed prevalences per educational group as probabilities (analyses with non-imputed data show approximately the same results – available upon request). All bivariate and multivariate analyses were adjusted for age and sex (unless specified otherwise) and weighted (level-1 weight) to reflect our source population (i.e. older adults in the region of Eindhoven in October 2004) in terms of sex, age and educational level. This type of (single) imputation was chosen on the assumption of missing at random, dependent on SES only, i.e. Conditional Mean Imputation [36].

Firstly, we tested univariate associations of education and income with no recreational walking. Then, we examined which possible explanatory factors were significantly associated with no recreational walking ($p<0.05$), and whether these factors were unequally distributed across SES-groups (calculated in SPSS version 11.0) [37]. Factors associated with no recreational walking and with risk categories more prevalent in low than high SES-groups were included in the following modelling sequence in MlwiN.

We examined mediation of neighbourhood perceptions and individual cognitions in the association between SES and no recreational walking. Therefore, we firstly calculated the odds ratios of no recreational walking by socioeconomic groups adjusted for age, and sex (model 1). Then, we added neighbourhood perceptions separately (model 2); individual cognitions separately (model 3); and finally neighbourhood perceptions and individual cognitions simultaneously (model 4). When odds ratios for the SES-indicator in model 2-4 reduced (compared to model 1), this was interpreted as mediation of the explanatory factors included in the model between SES and no recreational walking [38].

Table 6.2 Adjusted odds ratios (OR)[a] for no recreational walking, and prevalence rates for response categories of neighbourhood perceptions and individual cognitions by educational level

				Educational level				
Independent factors	OR	95% CI	p	1 (low)	2	3	4 (high)	p
NEIGHBOURHOOD								
Physical neighbourhood factors								
Neighbourhood is unsafe								
disagree	1.00		.636	95.5[b]	95.9	98.2	98.9	.004
agree	0.87	(0.49-1.55)		4.5	4.1	1.8	1.1	
Neighbourhood is unattractive								
disagree	1.00		.008	72.5	84.3	88.6	86.0	.000
agree	1.41	(1.09-1.82)		27.5	15.7	11.4	14.0	
Insufficient places for physical activity								
disagree	1.00		.256	64.3	75.2	77.5	88.7	.000
agree	1.14	(0.91-1.44)		35.7	24.8	22.5	11.3	
Social neighbourhood factors								
Social cohesion								
high	1.00		.000	38.1	36.3	41.3	40.9	.001
medium	0.62	(0.50-0.78)		30.3	37.1	38.2	34.9	
low	0.82	(0.64-1.05)		31.6	26.6	20.5	24.3	
Social network								
large	1.00		.000	34.4	37.4	37.6	29.4	.034
medium	1.56	(1.23-1.98)		33.2	32.9	40.9	37.0	
small	1.59	(1.25-2.04)		32.4	29.7	21.5	33.6	
Feeling at home in neighbourhood								
high	1.00		.120	32.4	35.3	36.4	42.3	.020
moderate	0.80	(0.64-1.01)		33.2	38.0	36.6	31.1	
low	0.99	(0.78-1.26)		34.4	26.7	27.0	26.6	
Social disorganisation								
low	1.00		.540	45.3	48.4	50.6	54.0	.000
medium	0.96	(0.75-1.22)		18.6	24.3	23.5	24.5	
high	0.86	(0.67-1.12)		36.1	27.3	25.9	21.5	
INDIVIDUAL								
Attitude towards regular physical activity								
positive	1.00		.000	25.8	32.8	36.0	32.8	.002
neutral	1.34	(1.07-1.67)		61.9	54.9	58.5	58.4	
negative	4.16	(2.96-5.84)		12.3	12.3	5.4	8.7	

Table 6.2 (Continued)

Independent factors	OR	95% CI	p	Educational level 1 (low)	2	3	4 (high)	p
Social influences for regular physical activity								
positive	1.00		.000	54.9	50.1	49.6	53.2	.003
neutral	1.62	(1.32-1.99)		30.3	40.3	43.9	38.3	
negative	1.76	(1.26-2.45)		14.8	9.6	6.5	8.5	
Perceived behaviour control to be regularly active								
(very) sure	1.00		.000	59.2	67.0	70.7	74.2	.001
not sure/unsure	1.65	(1.32-2.07)		31.0	25.7	20.5	19.0	
(very) unsure	2.10	(1.48-2.97)		9.8	7.3	8.8	6.8	
Intention to be regularly active								
yes	1.00		.000	45.9	55.0	57.3	67.0	.000
maybe	1.84	(1.49-2.27)		38.9	38.1	35.2	26.7	
no	4.41	(3.09-6.29)		15.2	6.9	7.5	6.4	

a Weighted models were adjusted for age, sex, and educational level.
b This is the percentage of respondents in a certain response category per socioeconomic group; for example, 95.5% of those in the lowest group disagreed with the statement "My neighbourhood is unsafe".

Also, we examined whether individual cognitions mediated the association between neighbourhood perceptions and no recreational walking. Therefore, we compared ORs for neighbourhood perceptions with and without controlling for attitude, social influences, perceived behaviour control, and intention. When the association between neighbourhood perceptions and no recreational walking attenuated after inclusion of individual cognitions in the model, we interpreted this as the mediating role of individual cognitions in the association between neighbourhood perceptions and no recreational walking.

Results

Socioeconomic differences in no recreational walking

As presented in Table 1, participants in the lowest educational group (OR 1.51 (95% CI, 1.09-2.09)) and lowest income group (OR 1.33 (95% CI, 0.97-1.83)) were more likely to do no recreational walking than their higher status counterparts (unadjusted ORs). Other demographic characteristics were not associated with no recreational walking.

Selection of explanatory factors

Three out of seven neighbourhood perceptions were significantly associated with no recreational walking, i.e. poor neighbourhood aesthetics, high social cohesion, and a small social network (see Table 2). As the latter two risk factors were more prevalent among *high* SES groups, these factors could not serve as possible explanatory factors for the raised odds for no recreational walking among *low* SES groups. All four individual cognitions were significantly associated with no recreational walking, and risk categories (i.e. negative attitude, negative social influences, low perceived behaviour control and no intention to be regularly physically active) were most prevalent among the lowest SES groups. Therefore, all individual cognitions and one neighbourhood perception (neighbourhood aesthetics) were taken into account in further explanatory models.

Explaining the 'SES – no recreational walking' association

As presented in Table 3, the sex- and age-adjusted OR to do no recreational walking for the lowest educational group (OR 1.67 (95% CI, 1.18-2.35) attenuated when neighbourhood aesthetics was included in the model (model 2), or when individual cognitions were included (model 3), and further reduced when all these factors together (model 4) were taken into account (OR 1.30 (95% CI, 0.91-1.87). Attitude and intention regarding regular physical activity had the largest effect on the reduction of SES inequalities in recreational walking. The odds to do no recreational walking were lowest for the second-highest educational group in all models.

Results of the analyses with income as SES-indicator showed the same pattern as those for education. However, there was a smaller socioeconomic gradient for income (see model 1, Table 4), and the socioeconomic differences were fully explained when all explanatory factors were taken into account (model 4, Table 4). People who ticked the answer category "I do not want to report my income, or I do not know" were most likely not to engage in any recreational walking.

Explaining the 'neighbourhood aesthetics– no recreational walking' association

The association between neighbourhood aesthetics and no recreational walking reduced to non-significance when individual cognitions were taken into account (model 4, Table 3 and Table 4), although the OR for no recreational walking among those finding their neighbourhood unattractive remained elevated (OR 1.19 (95% CI, 0.95-1.50).

Discussion

This study is among the first to investigate how neighbourhood perceptions and individual cognitions mediate socioeconomic differences in recreational walking among older adults using a multilevel design. We found the lowest

Table 6.3 Odds ratios with 95% confidence intervals (OR, 95% CI) for no recreational walking by education, mediated by neighbourhood perceptions and individual cognitions

		Model 1 (base model): education + age + sex	Model 2: base + neighbourhood	Model 3: base + individual	Model 4: base + neighbourhood + individual
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education	% no walking				
1 - low	38.5	1.67 (1.18-2.35)	1.60 (1.13-2.27)	1.33 (0.93-1.90)	1.30 (0.91-1.87)
2	34.7	1.49 (1.17-1.90)	1.48 (1.16-1.89)	1.35 (1.04-1.75)	1.29 (0.99-1.68)
3	22.1	0.84 (0.60-1.18)	0.84 (0.60-1.19)	0.80 (0.57-1.13)	0.75 (0.53-1.06)
4 - high	29.2	1.00	1.00	1.00	1.00
Neighbourhood perceptions					
My neighbourhood is unattractive					
disagree			1.00		1.00
agree			1.32 (1.06-1.65)		1.19 (0.95-1.50)
Individual cognitions					
Attitude towards regular physical activity					
positive				1.00	1.00
neutral				1.12 (0.87-1.45)	1.11 (0.86-1.43)
negative				2.30 (1.59-3.32)	2.26 (1.57-3.26)
Social influences for regular physical activity					
positive				1.00	1.00
neutral				1.24 (1.01-1.52)	1.24 (1.02-1.532)
negative				1.54 (1.11-2.14)	1.54 (1.11-2.14)
Perceived behaviour control to be regularly active					
(very) sure				1.00	1.00
not sure/unsure				1.21 (0.95-1.55)	1.20 (0.94-1.54)
(very) unsure				1.57 (1.11-2.22)	1.56 (1.10-2.21)
Intention to be regularly active					
(very) likely				1.00	1.00
maybe				1.31 (0.99-1.73)	1.30 (0.98-1.72)
(very) unlikely				2.38 (1.59-3.57)	2.38 (1.59-3.57)
Random effects [a]					
Level-2 variance (SE)		0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

a Weighted multilevel models were estimated with the iterative generalized least squares procedure implemented in MlwiN version 2.02.

socioeconomic group most likely to be inactive regarding recreational walking, which is consistent with previous studies on walking [9, 10] and other physical activity outcomes [39-43]. Also consistent with other findings, we found

that neighbourhood perceptions (i.e. neighbourhood aesthetics [9, 10, 43]) and individual cognitions (i.e. attitude, social influences, perceived behaviour control, and intention [9, 43]) were important in the explanation of socioeconomic differences in recreational walking. Associations of neighbourhood factors with recreational walking, and their contribution to socioeconomic differences in recreational walking were smaller than the effect and contribution of individual factors (similar to findings for sports participation [43]). Still, as small odds ratios for neighbourhood characteristics may imply that changes to (perceptions of) the neighbourhood context may have a significant effect on physical activity levels, these may offer important opportunities to reduce socioeconomic differences in physical activity.

Going beyond previous studies, our findings suggested that perceived unfavourable neighbourhood aesthetics mediated the SES-inactivity relationship *via* individual physical activity cognitions (since the OR for neighbourhood aesthetics reduced to non-significance when individual cognitions were taken into account, OR= 1.19 (95% CI: 0.95-1.50)). As the OR for neighbourhood aesthetics remained rather elevated, a direct effect of neighbourhood aesthetics may also play a role. These results support the hypothesis of ecological models of physical activity [12, 13], which suggest that environmental factors show both direct and indirect effects with physical activity. Findings indicated that older adults from socioeconomically disadvantaged backgrounds were more likely to perceive poor neighbourhood aesthetics, which in turn may have reduced their perceived behavioural control expectations and may have had a negative impact on their attitudes toward regular physical activity, explaining their lower levels of recreational walking. Previous studies also reported (small) mediating effects of attitude and perceived behaviour control/self-efficacy in the association between environmental influences and physical activity [45-47].

The main strength of our study is that we could estimate mediating effects of a wide range of physical and social neighbourhood perceptions and individual cognitions in the explanation of socioeconomic differences in recreational walking among older adults, using multilevel analysis techniques to correct for possible area effects. However, there were several limitations of our study. First, the cross-sectional design precluded any causal inferences from being drawn. Due to the exclusion of participants with missing values for recreational walking, education, and household income, this study may have underestimated SES-walking associations, as lower SES groups may have been more inclined towards selective non-response. Mediation effects only indicated that causal pathways may exist, however, selection may also play a role, i.e. people that find regular physical activity important may choose to live in a pleasant environment. Also, as neighbourhood attractiveness and individual cognitions were both self-reported, other characteristics (e.g. personality, depressiveness) may

have influenced both factors in the same (positive/negative) way. Secondly, we could not examine objective, level-2 measures of neighbourhood influences, and therefore, it remains uncertain to what extent SES differences in neighbourhood perceptions reflect objective differences between neighbourhoods.

Table 6.4 Odds ratios with 95% confidence intervals (OR, 95% CI) for doing no recreational walking by income, adjusted for neighbourhood perceptions and individual cognitions

		Model 1 (base model): income + age + sex	Model 2: base + neighbourhood	Model 3: base + individual	Model 4: base + neighbourhood + individual
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Income	% no walking				
1 - low	35.7	1.40 (0.98-2.01)	1.34 (0.94-1.91)	1.03 (0.73-1.47)	1.01 (0.71-1.42)
2	30.3	1.10 (0.81-1.49)	1.09 (0.80-1.48)	0.94 (0.70-1.27)	0.93 (0.69-1.26)
3	27.8	0.81 (0.60-1.10)	0.81 (0.60-1.10)	0.77 (0.57-1.05)	0.77 (0.57-1.05)
4 - high	29.4	1.00	1.00	1.00	1.00
5 - don't want to say/ don't know	36.6	1.32 (0.97-1.81)	1.31 (1.05-1.63)	1.16 (0.85-1.58)	1.15 (0.84-1.56)
Neighbourhood perceptions					
My neighbourhood is unattractive					
disagree			1.00		1.00
agree			1.31 (1.05-1.63)		1.19 (0.95-1.50)
Individual cognitions					
Attitude towards regular physical activity					
positive				1.00	1.00
neutral				1.11 (0.86-1.43)	1.10 (0.85-1.42)
negative				2.32 (1.61-3.34)	2.28 (1.59-3.28)
Social influences for regular physical activity					
positive				1.00	1.00
neutral				1.22 (0.99-1.51)	1.23 (1.001.51)
negative				1.53 (1.10-2.11)	1.53 (1.10-2.12)
Perceived behaviour control to be regularly active					
(very) sure				1.00	1.00
not sure/unsure				1.25 (0.98-1.59)	1.24 (0.97-1.57)
(very) unsure				1.55 (1.09-2.20)	1.55 (1.09-2.19)
Intention to be regularly active					
(very) likely				1.00	1.00
maybe				1.32 (1.00-1.75)	1.31 (0.99-1.74)
(very) unlikely				2.43 (1.65-3.57)	2.43 (1.65-3.57)
Random effects [a]					
Level-2 variance (SE)		0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

a Weighted multilevel models were estimated with the iterative generalized least squares procedure implemented in MlwiN version 2.02.

However, in additional multilevel analyses we found significant clustering of perceived safety, attractiveness and availability of facilities within neighbourhoods, even when adjusting for resident's age, sex, and education. This clustering of perceptions might indicate true neighbourhood differences (results available on request). Individual cognitions were not measured specific-specific for recreational walking, but referred to regular physical activity ("being physically active with moderate intensity for at least 30 minutes per day"). In addition, neighbourhood perceptions were not specifically asked in the context of recreational walking. Increased specificity in and correspondence between outcome, and individual and neighbourhood variables, may lead to stronger associations and increased explanation of socioeconomic differences in recreational walking [15].

Simple cross tabulations indicated that the proportion of residents engaging in recreational walking does significantly vary by neighbourhood (results available upon request). Unexpectedly, we did not find any neighbourhood variance in recreational walking within our multilevel models (see Table 3 en Table 4), which is difficult to explain. However, the fact that we did not find clustering of the outcome variable entailed no need for the multilevel mediational analysis procedure, as specified by Krull and MacKinnon [48], which should have been applied in case of strong clustering. The multilevel statistical package MlwiN (version 2.02) was used nonetheless, as explanatory factors did cluster within neighbourhood.

We found opposite associations of social cohesion and social network with recreational walking: both *high* social cohesion and a *small* social neighbourhood network were associated with a lower likelihood of recreational walking. The latter association was expected and in line with the literature [28, 40]: participants with a small social neighbourhood network may find it more difficult to find company for recreational walking, or may experience less social support/peer encouragement for physical activity. However, one can only speculate why people who experience high social cohesion (i.e. those who reported that people in the neighbourhood are willing to help each other, and that people in the neighbourhood agree on norms and values) are more likely to do no recreational walking. Maybe neighbourhoods with high social cohesion organized other neighbourhood activities in which these participants engaged rather than walking. Or, if social cohesion is high but the social norm is *not* to engage in recreational walking, people may find it more difficult to go walking than those living in neighbourhoods with low social cohesion and no norm regarding walking.

This study is among the first to show that unfavourable neighbourhood perceptions contribute to the explanation of socioeconomic differences in no recreational walking among older adults mainly indirectly, i.e. via unfavourable individual cognitions towards regular physical activity. More research into causal pathways between (objective and perceived) neighbourhood influences and individual cognitions is needed to better understand how socioeconomic disadvantage leads to physical inactivity. Our results suggest that intervention and policy strategies to reduce socioeconomic differences in lack of recreational walking among older adults would need to intervene on both neighbourhood perceptions as well as individual cognitions.

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7

Why do poor people perceive poor neighbourhoods? Explaining socioeconomic differences in neighbourhood perceptions with objective neighbourhood features and psychosocial characteristics

Kamphuis CBM, Mackenbach JP, Giskes K, Huisman M, Brug J, Van Lenthe FJ. Why do poor people perceive poor neighbourhoods? Explaining socioeconomic differences in neighbourhood perceptions with objective neighbourhood features and psychosocial characteristics (submitted to *Health & Place*)

Abstract

Background People with a lower socioeconomic status (SES) are more likely to perceive their neighbourhood as unattractive or unsafe, which is associated with lower levels of physical activity. This study investigates to what extent socioeconomic differences in neighbourhood perceptions can be explained by objective neighbourhood characteristics, and to what extent neighbourhood social factors and psychosocial characteristics play a role in these perceptions.

Methods Two outcome variables are studied: perceived neighbourhood safety and perceived neighbourhood attractiveness. In a postal survey, residents (N=814) of fourteen neighbourhoods in the city of Eindhoven (the Netherlands) reported their socioeconomic characteristics (household income and education), social neighbourhood factors (social network, social cohesion), psychosocial factors (depressed/nervousness, negative life events, self-assessed health) as well as perceptions of neighbourhood attractiveness and safety. Neighbourhood audits objectively assessed aesthetic, design, traffic safety, social safety, and destination features of neighbourhoods.

Results Compared to higher income groups, those with the lowest incomes were most likely to perceive their neighbourhood as unattractive (OR 1.75 (95% CI, 0.85-3.58)) and unsafe (OR 2.97 (95% CI, 1.55-5.67)). These socioeconomic gradients were partly explained by objective neighbourhood characteristics, and partly by self-reported social neighbourhood cohesion and psychosocial factors.

Conclusions Unfavourable neighbourhood perceptions of low SES-groups partly reflect their actual less appealing and less safe neighbourhoods, and partly their perceptions of low social cohesion and a depressed mood. To yield a maximal improvement of neighbourhood perceptions among lower socioeconomic groups, environmental change strategies, for instance, improving neighbourhood aesthetics and traffic safety, would need to be combined with social community interventions, and individual level interventions. Ultimately, improved neighbourhood perceptions and truly 'better' neighbourhoods may increase residents' physical activity.

Introduction

An increasing number of studies confirms that elements of the physical environment are important for physical activity. Residents' perceptions of their local area, such as perceived neighbourhood aesthetics and perceived safety, are associated with a wide range of physical activities [1-3], and contribute to the explanation of socioeconomic inequalities in physical inactivity [4-7]. These findings imply that effectively changing these perceptions especially among lower socioeconomic groups, may contribute to an increase of physical activity and/or a reduction in socioeconomic inequalities in physical inactivity. However, little is known about the determinants of environmental perceptions relevant for physical activity.

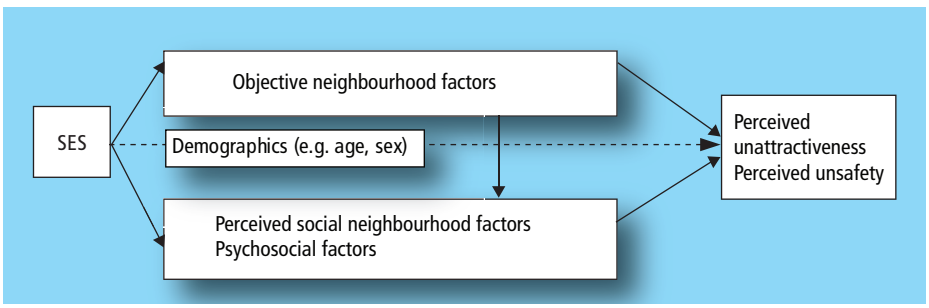
Studies that have investigated neighbourhood perceptions in association with physical activity often assume – either implicitly or explicitly- that these perceptions reflect actual, objective neighbourhood circumstances. Indeed, objective neighbourhood factors have found to be associated with physical activity [8-11], and to contribute to socioeconomic variations in physical activity [6, 12]. However, other studies that have investigated the level of agreement between objective and perceived environmental factors, found this agreement to be moderate or low [13-18]. This suggests that factors other than the objective neighbourhood environment may play a role in the formation of residents' perceptions.

The scarce evidence of the determinants of these perceptions mainly relates to (1) demographic factors, (2) perceptions of the social neighbourhood environment, (3) self-assessed health, and (4) depressed mood. Women, older people, and people with a lower socioeconomic status express feelings of unsafety, disorder, and neighbourhood problems more so than their male, younger and higher status counterparts [19-23]. Indicators of the social neighbourhood environment, such as social capital (i.e. taking part in activities of formal and informal groups in society) and social/community involvement, have shown strong inverse associations with fear of crime, sense of insecurity and perceived disorder [20-23]. Also, poor self-assessed health has shown associations with increased feelings of unsafety [20, 21, 24], as people with poorer health experience increased physical vulnerability, or may be more likely to be negative about life in general [19]. Similarly, people with a pessimistic world view or depressed mood may be more likely to report their neighbourhoods as being poor [19] [20]. As low social capital [25], poor health, and a pessimistic world view [26] and have been found more prevalent in lower than higher socioeconomic groups, these factors may play a role in socioeconomically disadvantaged groups perceiving their neighbourhood as less attractive and less safe.

Thus, up till now, there is little empirical evidence on correlates of neighbourhood perceptions, and even less on the relative contribution of objective neighbourhood and other factors to the explanation of socioeconomic differences in these neighbourhood perceptions. Since perceived neighbourhood aesthetics and perceived safety have shown rather consistent associations with several physical activity outcomes [2, 27], and also to contribute to socioeconomic inequalities in physical inactivity [4-6], we selected these two neighbourhood perceptions to investigate which factors should be targeted to change perceptions. In this present paper, our main aim is to examine to what extent socioeconomic variations in perceived neighbourhood unattractiveness and perceived unsafety can be explained by five domains of objective features (i.e. design, traffic safety, social safety, aesthetics, and destinations), and to what extent other factors, such as the social neighbourhood environment and psychosocial factors, contribute to this explanation (see Figure 1). Secondly, as the design of this study demands a multilevel analysis, we will also consider neighbourhood variance in perceptions and investigate whether these neighbourhood differences can be explained by objective characteristics or other factors. Research questions that will be addressed are:

1. Are lower socioeconomic groups more likely to perceive their neighbourhood as unattractive and unsafe?
2. Which objective neighbourhood characteristics, neighbourhood social characteristics and residents' psychosocial characteristics are associated with perceptions of neighbourhood unattractiveness and unsafety?
3. Which factors can explain socioeconomic differences and neighbourhood differences in perceived neighbourhood attractiveness and safety?

Figure 7.1 Conceptual framework



Methods

Study population

Data were obtained by a large-scale postal survey, a component of the new wave of data collection for the longitudinal GLOBE study, among a stratified sample of the adult population (age 25-75 years) of Eindhoven (the fifth largest city in the Netherlands) and surrounding cities in October 2004 (N=6377; response rate 62%). More about the objectives, design and results of the GLOBE study can be found in detail elsewhere [28, 29]. We selected postal survey participants residing in seven of the most deprived and seven of the most advantaged neighbourhoods of the city of Eindhoven (N=814). Participants with missing values for education, household income, age or sex were excluded from the analyses (n=81), which resulted in an analytic sample of 733 participants (mean number of participants per neighbourhood: n= 53, range 16-85). Demographic characteristics of the total GLOBE sample of 2004 and the analytic sample are provided in Table 1. This table shows that the demographic structure of the total sample and selected sample are comparable.

Measurements

Socioeconomic status (SES), demographic characteristics, possible explanatory factors (psychosocial factors and social neighbourhood factors), and perceived neighbourhood attractiveness and safety were measured in the GLOBE postal survey in October 2004. Objective neighbourhood characteristics were measured during field observations in February 2006. The measures are described below, in order of appearance in Figure 1 (from left to right).

Socioeconomic status and demographic factors

Educational attainment is only one component of the broad concept of SES, but is considered a good indicator for SES in the Netherlands [30]. Four levels of education were distinguished: (1) no education or primary education; (2) lower professional and intermediate general education; (3) intermediate professional and higher general education; (4) higher professional education and university. We also measured household income as SES-indicator, asking participants to report their net monthly household income by selecting one out of five response categories: 0-1200 euro, 1200-1800 euro, 1800-2600 euro, 2600 euro or more, and 'don't want to say / don't know'. Analyses were controlled for demographic factors that may act as confounders in the association between SES and neighbourhood perceptions, i.e. age (categorised in ten-years age groups), sex, country of origin (Netherlands, other country), marital status (married, unmarried/divorced/widowed), and employment status (employed, unemployed/non-active).

Table 7.1 Characteristics of all respondents to the GLOBE postal survey 2004[a] and of the respondents residing in fourteen selected neighbourhoods of the city of Eindhoven

	Total sample[a] (N=6377)	Selected sample[b] (N=733)
Mean age (SE)	55.6 (0.20)	55.6 (0.58)
[age range]	[25-90]	[25-87]
Age categories (%)		
25-34	12.4	10.9
35-44	16.5	19.0
45-54	14.8	16.0
55-64	22.6	20.9
65-74	21.9	21.0
75>	11.8	12.3
Sex (%)		
men	46.3	45.8
women	53.7	54.2
Income (%)		
1 low	14.6	11.5
2	22.8	24.0
3	24.6	27.8
4 high	26.1	25.6
5 don't want to tell/ don't know	11.9	11.1
Education (%)		
1 low	12.2	12.0
2	35.4	38.2
3	23.1	23.2
4 high	29.3	26.6
Perceived neighbourhood unattractiveness (%)		
unattractive	17.2	18.6
attractive	82.8	81.4
Perceived neighbourhood unsafety (%)		
unsafe sometimes	39.2	44.1
safe	60.8	55.9

a Total sample of the postal survey, i.e. participants living in the city of Eindhoven and other parts of the Netherlands (N=6377).

b Postal survey participants living in seven deprived and seven advantaged neighbourhoods in the city of Eindhoven (N=733).

c Mean scores and standard errors (SE) for objective neighbourhood characteristics were calculated in a dataset with N=14 neighbourhoods (see Table 2 for more information on the composition of the five sum scores and ranges).

Objective neighbourhood characteristics

Neighbourhood characteristics with respect to aesthetic, design, traffic unsafety, social unsafety, and destination features were collected for each of the fourteen neighbourhoods by environmental audits. The audit instrument was developed based on other audit instruments [31-35], and its development has been

described in more detail elsewhere [36]. For each neighbourhood, 10% of the total number of streets in the neighbourhood was randomly selected, resulting in 75 streets to be audited. Thirty of the 75 selected streets were audited by two observers independently, in order to estimate inter-rater reliability afterwards (observers did not know which streets would be audited twice). The 105 street observations were conducted by four trained observers.

Inter-rater reliability of each item of the instrument was calculated by using the percentage agreement between two observers (consensus score), as described by Stemler [37]. Percent agreement for each specific item was calculated by adding up the number of cases that received the same rating by both observers and dividing that number by the total number of cases rated by the two observers. Inter-rater reliability was moderate to good, with only five items with a low reliability (i.e. <0.7), and these were excluded from the analyses. The average reliability over the fifty-five remaining items was 84% [36].

Specific audit items measured five domains of objective neighbourhood characteristics that are hypothesized to influence physical activity (based on the framework of Pikora and colleagues [38, 39]), i.e. aesthetics, design, traffic unsafety, social unsafety, and destinations. Audit scores of all items belonging to a specific domain were summed, and the mean street-level sum scores for each of the five domains were aggregated to the neighbourhood-level, resulting in a database with scores for N=14 neighbourhoods. Table 2 shows the specific items that were summed in each sum score, the reliability of the items and whether the mean sum scores for each domain differed significantly between the fourteen neighbourhoods. Sum scores were dichotomised for analytic purposes. Dichotomised sum scores for each neighbourhood were merged with the resident-level (postal survey) data.

Neighbourhood social environment

Ten items asked about neighbourhood social relationships (on a five-point Likert scale: totally agree - totally disagree) (α = .85), and factor analyses showed two factors underlying these items. We labelled the first factor 'social cohesion', i.e. "the extent of connectedness and solidarity among groups in society" [40]. Items that loaded on this factor were e.g. 'People in this neighbourhood agree on norms and values', 'People in this neighbourhood are willing to help each other', and 'People in this neighbourhood can be trusted'. The second factor was labelled 'social network' (i.e. "the presence and nature of interpersonal relationships and interactions; extent to which one is interconnected and embedded in a community" [41]), representing items such as 'I borrow things from my neighbours', 'I visit my neighbours in their home', and 'I can ask my neighbours for advice'. For analytical purposes, each factor score was classed into tertiles.

Table 7.2 Descriptives of objective neighbourhood characteristics measured in fourteen neighbourhoods in the city of Eindhoven – inter-rater reliability, mean score, range [minimum, maximum score], p-value[d]

	Inter-rater reliability[a]	Mean score	[range]	p [d]
Sum score design (functional) features		2.28	[1.60-3.38]	*
Sidewalks present (0=no, 1=yes)	0.97	0.95	[0.50-1.00]	**
Quality of sidewalks (0=bad-moderate, 1=good)	0.70[b]	0.50	[0.00-1.00]	n.s.
Cycling track present (0=no, 1=yes)	0.93	0.12	[0.00-0.40]	n.s.
Quality of cycling tracks (0=bad-moderate, 1=good)	0.93[b]	0.71	[0.00-1.00]	n.s.
Speed-limit zone (max. 30 km/h) (0=no, 1=yes)	0.77	0.18	[0.00-0.60]	n.s.
Traffic control devices (0=no; 1=yes)	0.87	0.46	[0.00-1.00]	**
Sum score social unsafety		0.98	[0.50-1.80]	n.s.
Houses for sale (0=no, 1=yes)	0.80[b]	0.26	[0.00-0.57]	n.s.
Empty houses (0=no, 1=yes)	0.70[b]	0.18	[0.00-0.60]	*
Height of fences (0= below eye level; 1= above eye level)	0.73	0.13	[0.00-0.40]	n.s.
Visibility of the street from surrounding houses (0= >½ of the street is visible, 1= <1/2 of the street is visible)	0.73[b]	0.17	[0.00-0.60]	n.s.
Vandalism (0=none, 1=some, 2= many)[c]	0.97[b]	[c] -	-	-
Street lighting (0= on both sides, 1= on one side)	0.83	0.15	[0.00-0.40]	n.s.
Youth hanging around in the streets (0=no, 1=yes)[c]	0.90	[c] -	-	-
Signs of alcohol/drugs use (0=no; 1=yes)	0.83	0.12	[0.00-0.40]	n.s.
Sum score traffic unsafety		1.07	[0.00-2.60]	*
Traffic (0=bestemmingsverkeer only, 1= through traffic)	0.80	0.27	[0.00-1.00]	*
Crossovers present (0=no, 1=yes)	0.93	0.08	[0.00-0.20]	n.s.
Traffic signs painted on the road (0=no, 1=yes)	0.67[b]	0.20	[0.00-0.50]	n.s.
Traffic control devices (0=yes, 1=no)	0.87	0.52	[0.00-1.00]	**
Sum score aesthetics		3.90	[1.20-7.25]	***
Graffiti (0=yes, 1=no)	0.70[b]	0.55	[0.20-1.00]	n.s.
Vandalism (0=none, 1=some, 2= many)[c]	0.97[b]	[c] -	-	-
Litter on the streets (0=yes, some or a lot, 1=no, nothing much)	0.67[b]	0.55	[0.00-1.00]	**
Maintenance of best buildings (0=bad-moderate, 1=excellent)	0.67[b]	0.78	[0.40-1.00]	*
Maintenance of worst buildings (0=bad-moderate, 1=excellent)	0.67[b]	0.48	[0.00-1.00]	***
Gardens (0=not with all houses, 1= with all houses)	0.87[b]	0.59	[0.00-1.00]	***
Maintenance of best-maintained gardens (0=bad-moderate, 1=excellent)	0.80[b]	0.61	[0.20-1.00]	*
Green diversity (0= <1 kind of green, 1= >2 kinds of green, e.g. trees, field, bushes)	0.83[b]	0.44	[0.00-0.60]	n.s.
Maintenance of public green areas (0=bad-moderate, 1=excellent)	0.80	0.18	[0.00-0.75]	***
Sum score destinations		0.46	[0.00-1.20]	**
Destinations (0=none, 1= one or more)	0.77[b]	0.31	[0.00-1.00]	n.s.
Public transport (0=no; 1=yes)	0.73	0.13	[0.00-0.40]	***

a Inter-rater reliability is represented by the percentage agreement between two observers (consensus score). Percent agreement for each specific item was calculated by adding up the number of cases that received the same rating by both judges and dividing that number by the total number of cases rated by the two judges (Stemler & Steven, 2004).

b Originally, there were more than two response categories for this audit item. However, categories were dichotomized in order to calculate meaningful sum scores. Inter-rater reliability scores were calculated for the original items, and therefore, are actually higher for the dichotomised items.

c Item has not been included in the sum score as the prevalence was very low, i.e. in all neighbourhoods the prevalence of signs of vandalism and youth in the streets was close to zero.

d p-value indicates whether mean score for the item or sum score differed significantly between the fourteen neighbourhoods, with ***= p<0.001, **= p<0.010, *= p<0.050, n.s.= not significant (analysed by ANOVA in SPSS 15.0).

Psychosocial factors

Self-assessed health was measured with the question "How is your health in general?" (excellent, very good, good, moderate, poor). Response categories were taken together in two groups: excellent-good, vs. less than good. The SF-12 Mental Health index was used as a measure of depressiveness and nervousness, consisting of five items such as "Did you feel down and depressed?" and "Did you feel nervous?", with six response categories ranging from constantly till never. The five items were summarised in a sum score, and the sum score was dichotomised in low and high depressed mood. For a list of nine stressful life events (e.g. job loss, divorce, significant other deceased), each respondent reported whether he/she had experienced this life event in the last year (yes/no). Responses were summed, and the sum score was divided in three groups: no life events, one life event, two or more life events.

Outcome measures: perceived neighbourhood unattractiveness and unsafety

We investigated two outcome measures: perceived neighbourhood unattractiveness and perceived unsafety. Perceived neighbourhood unattractiveness was measured by one item: "My neighbourhood is unattractive for physical activity" (yes, no). Perceived neighbourhood unsafety was measured with three items: "Sometimes I'm afraid to go out on the streets in my neighbourhood at night time", "Sometimes I'm afraid to go out on the streets in my neighbourhood in the daytime", "Sometimes I'm afraid to be home alone at night time" (0=disagree, 1=don't agree/don't disagree, 2=agree). Scores on these three items were summed, and a sum score of 0 was labelled "feeling safe", a sum score of 1> was labelled "sometimes feeling unsafe".

Statistical analyses

Exploratory analyses were conducted in SPSS version 11.0 [42]. Firstly, we tested bivariate and multivariate associations of SES-indicators and demographic characteristics with perceived neighbourhood unattractiveness and perceived neighbourhood unsafety. Then, we examined bivariate and multivariate associations of the explanatory factors (objective neighbourhood characteristics, social neighbourhood factors, and psychosocial factors) with both of the outcome variables. Factors that remained significant in the multivariate models were included in the following multilevel modelling sequence.

Perceived neighbourhood unattractiveness was modelled as a binary outcome variable in logistic regression models of participants (level 1) nested within neighbourhoods (level 2). To take into account the hierarchical nature of the data, multilevel analyses were done in MLwiN version 2.02 (using the logit-link function and 2nd order PQL estimation methods) [43]. Firstly, we calculated the odds ratios (ORs) for perceived neighbourhood unattractiveness by SES group, adjusted for demographics only (model 1). Secondly, we included objective neighbourhood factors (model 2), and thirdly, we added social neigh-

bourhood and psychosocial factors to the model (model 3). The reduction in ORs for perceived neighbourhood unattractiveness was interpreted as the contribution of the specific factors included in the model to the explanation of socioeconomic inequalities in perceived neighbourhood unattractiveness. The modelling sequence was then repeated with perceived neighbourhood unsafety as binary outcome variable.

Multilevel models not only account for the structure of data, with participants residing in neighbourhoods, but also provide a measure of the importance of the neighbourhood-level influence on the outcome of interest. This measure is referred to as neighbourhood-level variance or between-neighbourhood variance, which can be used to calculate measures of clustering [44]. Clustering of perceived unattractiveness and perceived unsafety within neighbourhoods was determined by calculating the median odds ratio (MOR) with 95% credible intervals (CrL), using the posterior distribution of the neighbourhood variance as provided by the Markov Chain Monte Carlo (MCMC) procedure in MlwiN [45]. The MOR was computed with the following formula [44]:

$$\begin{aligned} \text{MOR} &= \exp[\sqrt{(2 \times \text{neighbourhood variance})} \times 0.6745 \\ &\approx \exp(0.95\sqrt{\text{neighbourhood variance}}) \end{aligned}$$

An MOR of 1.50, for instance, can be interpreted as follows: if a person moves to another neighbourhood where residents have a higher probability to perceive their neighbourhood as unsafe, his individual odds to perceive the neighbourhood as unsafe will have a median increase of 1.5 times [44].

We examined neighbourhood level variance and the MOR for the so called "empty" model or null model, i.e. including no explanatory factors, and then for subsequent models, including explanatory factors. The contribution of explanatory factors to neighbourhood level variance in perceived neighbourhood unattractiveness and perceived unsafety was assessed by reductions in the MOR in the models 1 to 3. When differences between neighbourhoods are seen to diminish when objective neighbourhood characteristics are included in the model (i.e. shown by a reduction of the neighbourhood level variance and MOR), it can be concluded that objective characteristics contribute to the explanation of neighbourhood differences in perceived unattractiveness and unsafety.

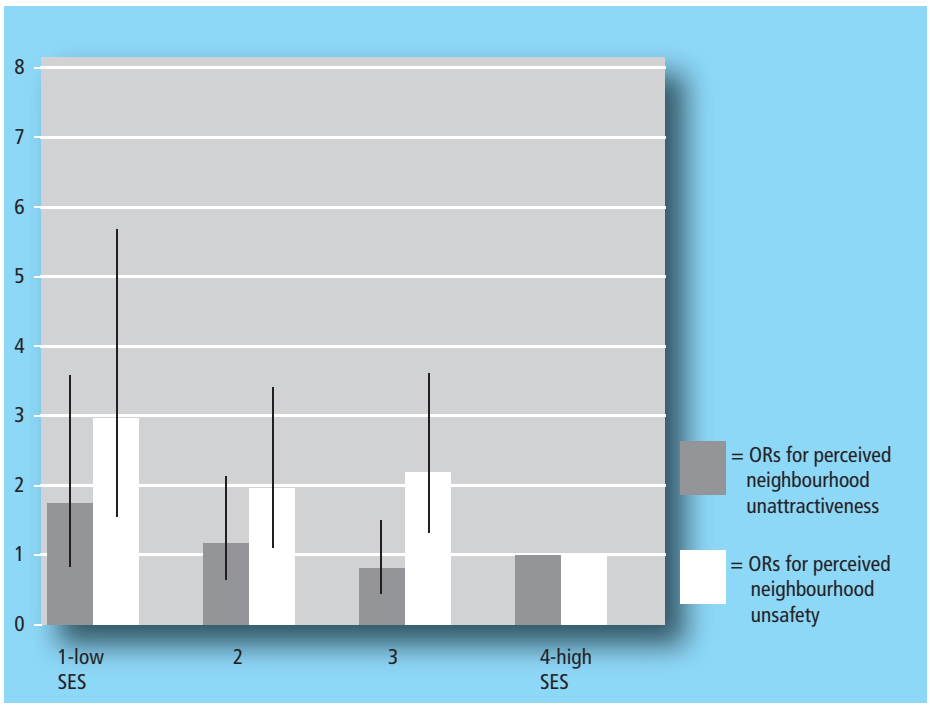
Results

Associations of neighbourhood perceptions with SES and demographic characteristics

In bivariate analyses (results not shown), age, employment status, and country of origin were not related to perceptions of neighbourhood unattractiveness. Being male, unmarried, having a lower household income, and having

a lower education were associated with an increased likelihood of perceiving the neighbourhood as unattractive. When these four demographic characteristics were taken into account in a multilevel model, only household income and sex remained significantly associated with neighbourhood unattractiveness (therefore, all subsequent models were sex-adjusted, and household income was chosen as SES-indicator). As presented in Figure 2, the lowest income group had an odds of 1.75 (95% CI: 0.85-3.58) to perceive their neighbourhood as unattractive, compared to the highest income group (although differences between income groups fell short of significance).

Figure 7.2 Odds ratios (ORs) for perceived neighbourhood unattractiveness and unsafety by SES (i.e. household income) (adjusted for demographic characteristics)



Country of origin and marital status were not associated with perceived neighbourhood unsafety, whereas women, elderly, unemployed, those with lower incomes, and lower levels of education were significantly more likely to perceive their neighbourhood as unsafe in bivariate analyses (results not shown). Only household income, age, and sex remained significant in the multivariate model (therefore age and sex were taken into account in subsequent models, and household income was chosen as SES-indicator). Low income residents were more likely to perceive their neighbourhoods as unsafe (OR=2.97 (95% CI: 1.55-5.67) (see Figure 2).

Table 7.3 Adjusted odds ratios (OR) for perceptions of neighbourhood unattractiveness and neighbourhood unsafety by objective neighbourhood characteristics, social neighbourhood factors, and psychosocial factors

	Perception that neighbourhood is unattractive (vs. attractive)			Perception that neighbourhood is unsafe (vs. safe)		
	Adjusted OR[a]	(95% CI)	p	Adjusted OR[c]	(95% CI)	p
Objective neighbourhood characteristics						
Neighbourhood design score						
high	1.00		.385	1.00		.090
low	1.19 (0.81-1.76)			1.33 (0.96-1.86)		
Social unsafety score						
low	1.00		.217	1.00		.594
high	0.79 (0.54-1.15)			1.10 (0.78-1.53)		
Traffic unsafety score						
low	1.00		.003	1.00		.005
high	1.83 (1.24-2.71)			1.55 (1.10-2.17)		
Aesthetics score						
high	1.00		.000	1.00		.000
low	3.17 (2.05-4.91)			1.94 (1.38-2.73)		
Destination score						
low	1.00		.001	1.00		.217
high	1.96 (1.33-2.92)			1.23 (0.88-1.72)		
Social neighbourhood factors						
Social network (visiting neighbours in home, asking neighbours advice)						
large	1.00		.295	1.00		.231
moderate	1.18 (0.72-1.93)			1.40 (0.93-2.10)		
small	1.46 (0.90-2.35)			1.32 (0.88-1.98)		
Social cohesion (trust in neighbours, neighbours share norms & values)						
high	1.00		.004	1.00		.000
medium	1.29 (0.75-2.19)			1.21 (0.79-1.85)		
low	2.17 (1.32-3.57)			2.66 (1.74-4.06)		
Psychosocial factors						
Self-assessed health						
Excellent - good	1.00		.168	1.00		.029
Moderate - poor	1.40 (0.87-2.28)			1.66 (1.07-2.58)		
Depressed mood score						
Low	1.00		.004	1.00		.000
High	1.80 (1.21-2.67)			2.45 (1.75-3.42)		
Negative life events in the last year						
none	1.00		.412	1.00		.014
1 life event	1.14 (0.73-1.81)			0.76 (0.51-1.12)		
2> life events	1.38 (0.86-2.21)			1.52 (0.99-2.32)		

a Odds ratios were adjusted for household income and sex [b] Odds ratios were adjusted for household income, age, and sex

Associations of objective neighbourhood characteristics with neighbourhood perceptions

Low scores for objective aesthetics and high scores for objective traffic unsafety and destinations were associated with perceptions of the neighbourhood as unattractive – objective aesthetics and objective traffic unsafety were also associated with an increased likelihood to perceive the neighbourhood as unsafe (Table 3). Compared to the highest SES group, participants from lower SES groups were more likely to reside in neighbourhoods with higher scores for traffic unsafety, lower scores for neighbourhood aesthetics, and more destinations (not shown). The other objective characteristics, design and social unsafety, were not associated with perceived unattractiveness or with perceived unsafety. Taking all objective neighbourhood characteristics into account, traffic unsafety, aesthetics and destination scores remained independently associated with perceived unattractiveness (adjusted for SES and sex), and only aesthetics remained significant in the multivariate model for perceived unsafety (adjusted for SES, sex and age).

Associations of social neighbourhood and psychosocial factors with neighbourhood perceptions

Participants experiencing low social cohesion in their neighbourhood were also more likely to perceive their neighbourhoods as unattractive and unsafe (Table 3), and this was most often reported by the lowest SES group (not shown). Perceived social network was not associated with neighbourhood perceptions, nor with SES. Depressed mood was the only psychosocial factor significantly associated with perceived neighbourhood unattractiveness (Table 3).

All three psychosocial factors showed significant associations with perceived unsafety, with those in moderate-poor health, those with a depressed mood, and those having experienced two or more negative life events in the last year, more likely to perceive their neighbourhood as unsafe. Unfavourable psychosocial factors were more prevalent among low than high SES groups (not shown). When all psychosocial factors were entered in a model for explaining perceived unsafety, only depressed mood and stressful life events remained significant.

Table 7.4 Multilevel logistic regression models[a], with odds ratios and 95% confidence intervals (OR, 95% CI) for perceived neighbourhood unattractiveness, by household income

		Model 0 (empty model)	Model 1: income + sex	Model 2: income + sex + objective neighbourhood factors	Model 3: income + sex + objective neighbourhood + social neighbourhood + psychosocial factors
			OR (95% CI)	OR (95% CI)	OR (95% CI)
Income	% perceived neighbourhood as unattractive				
1 - low (n= 82)	29.8		1.75 (0.85-3.58)	1.50 (0.77-2.93) *33%*[b]	1.14 (0.57-2.25) *81%*
2 - (n=176)	20.5		1.17 (0.65-2.12)	1.00 (0.56-1.81) *100%*	0.88 (0.47-1.62)
3 - (n=204)	14.2		0.82 (0.45-1.49)	0.78 (0.43-1.44)	0.69 (0.37-1.30)
4 - high (n=188)	15.4		1.00	1.00	1.00
Objective					
Traffic unsafety score					
Low				1.00	1.00
High				1.65 (0.97-2.78)	1.59 (0.92-2.76)
Aesthetics score					
High				1.00	1.00
Low				2.43 (1.49-3.96)	2.53 (1.48-4.31)
Destination score					
Low				1.00	1.00
High				1.96 (1.15-3.35)	1.89 (1.03-3.46)
Self-reported					
Social neighbourhood cohesion					
High					1.00
Medium					1.24 (0.72-2.16)
Low					2.18 (1.29-3.69)
Depressed mood score					
Low					1.00
High					1.65 (1.08-2.53)
Random effects [a]					
Level-2 variance (SE)		0.556 (0.342)	0.490 (0.309)	0.049 (0.080)	0.056 (0.086)
MOR (95%CrI)		2.03 (1.45-3.12)	1.94 (1.42-2.94)	1.23 (1.03-1.65)	1.25 (1.03-1.67)

a Multilevel models were estimated the Markov Chain Monte Carlo method implemented in MlwiN version 2.02 (CrI = credible interval; MOR = median odds ratio; SE = standard error).

b The percentages in blue show the reduction in odds ratio (OR) compared to the basic model, per income group. For instance, the reduction in the OR for the lowest income group when adding neighbourhood factors to the first model, is [(1.75-1.50)/(1.75-1.00)] * 100 = 33%.

Explaining socioeconomic and neighbourhood variations in perceived neighbourhood unattractiveness

Compared to model 1 (including income and sex only), the elevated ORs for neighbourhood unattractiveness observed among the lowest income group decreased by 33% when objective neighbourhood factors were added (model 2, Table 4). Adding self-reported social neighbourhood and psychosocial factors (model 3) reduced the ORs for perceived neighbourhood unattractiveness among the lowest income group by 81% to 1.14 (95% CI: 0.57-2.25). In the full model, two objective neighbourhood factors (aesthetics and destinations), and social cohesion and depressed mood remained statistically significant.

Between-neighbourhood variance in perceived neighbourhood unattractiveness was 0.556 (SE=0.342) (MOR: 2.03 (95%CrI 1.45-3.12)) for model 0 (presented in Table 4), and reduced to 0.490 (SE=0.309) (MOR: 1.94 (95%CrI 1.42-2.94)) when income and sex were added (model 1), showing that only a small part of the neighbourhood differences in perceived unattractiveness could be attributed to differences in the demographic composition of neighbourhoods. Conversely, neighbourhood variations were almost completely explained by differences between neighbourhoods in their objective traffic unsafety, aesthetics, and destination scores, as indicated by the vast reduction in between-neighbourhood variance (to 0.049 (SE=0.080); MOR: 1.23 (95% CrI 1.03-1.65)) when these characteristics were taken into account (model 2). Neighbourhood social cohesion and psychosocial factors did not contribute to the explanation of neighbourhood differences in perceived neighbourhood unattractiveness (model 3).

Explaining socioeconomic and neighbourhood variations in perceived neighbourhood unsafety

As presented in Table 5, the odds for perceived neighbourhood unsafety among the lowest compared to the highest income group was attenuated by 11% when objective neighbourhood aesthetics was included in the model (model 2), and with 66% when self-reported social neighbourhood and psychosocial factors were added (model 3). In this full model, one objective neighbourhood factor (aesthetics), and social cohesion and depressed mood remained statistically significant.

Between-neighbourhood variance in perceived neighbourhood unsafety was 0.342 (SE: 0.215) for the null model, corresponding with an MOR of 1.74 (95%CrI 1.34-2.46) (Table 5), and reduced half to 0.160 (SE: 0.128) (MOR: 1.46 (95%CrI 1.07-1.94) when income, sex, and age were added (see model 1). The remaining between-neighbourhood variance was largely explained by objective neighbourhood characteristics, as between-neighbourhood variance reduced to 0.043 (SE=0.061)) (MOR: 1.22 (1.03-1.55) when these characteris-

Table 7.5 Multilevel logistic regression models[a], with odds ratios and 95% confidence intervals (OR, 95% CI) for perceived neighbourhood unsafety, by household income

		Model 0 (empty model)	Model 1: income + sex + age	Model 2: income + sex + age + objective neighbourhood	Model 3: income + sex + age + objective neighbourhood + social neighbourhood + psychosocial factors
			OR (95% CI)	OR (95% CI)	OR (95% CI)
Income	% perceived neighbourhood as unsafe sometimes				
1 - low (n= 82)	64.3		2.97 (1.55-5.67)	2.76 (1.47-5.18) *11%*[b]	1.67 (0.85-3.30) *66%*[c]
2 - (n=176)	47.2		1.96 (1.12-3.41)	1.82 (1.08-3.08) *15%*	1.48 (0.87-2.50) *50%*
3 - (n=204)	46.1		2.19 (1.33-3.61)	2.11 (1.31-3.41) *7%*	1.83 (1.11-3.01) *30%*
4 - high (n=188)	24.5		1.00	1.00	1.00
Objective					
Aesthetics score					
High				1.00	1.00
Low				1.94 (1.30-2.91)	1.91 (1.26-2.90)
Self-reported					
Social neighbourhood cohesion					
High					1.00
Medium					1.23 (0.80-1.91)
Low					2.81 (1.80-4.38)
Depressed mood score					
Low					1.00
High					2.50 (1.76-3.56)
Stressful life events					
None					1.00
1 life event					0.68 (0.44-1.05)
2> life events					1.31 (0.85-2.03)
Random effects [a]					
Level-2 variance (SE)		0.342 (0.215)	0.160 (0.128)	0.043 (0.061)	0.042 (0.055)
MOR (95%CrI)		1.74 (1.34-2.46)	1.46 (1.07-1.94)	1.22 (1.03-1.55)	1.21 (1.03-1.53)

a Multilevel models were estimated the Markov Chain Monte Carlo method implemented in MlwiN version 2.02 (CrI = credible interval; MOR = median odds ratio; SE = standard error).

b The blue percentages show the reduction in odds ratio (OR) compared to the basic model, per income group. For instance, the reduction in the OR for the lowest income group when adding objective neighbourhood factors to the first model, is [(2.97-2.76)/(2.99-1.00)] * 100 = 11%.

tics were added to the model (model 2). This shows that neighbourhood variations in perceived unsafety were partly due to differences in neighbourhood composition, and partly to objective differences in neighbourhood aesthetics. Neighbourhood social factors and psychosocial factors did not contribute to the explanation of neighbourhood differences in perceived unsafety (model 3).

Discussion

Our multilevel study among residents of fourteen neighbourhoods in the city of Eindhoven, the Netherlands, showed that low income groups were more likely than high income groups to perceive their neighbourhoods as unattractive and unsafe. These socioeconomic gradients could be partly explained by less favourable objective neighbourhood characteristics, and partly by self-reported social neighbourhood cohesion and psychosocial factors. Between-neighbourhood variance in perceived unsafety was partly due to compositional and contextual effects, whereas between-neighbourhood variance in perceived neighbourhood unattractiveness was mainly explained by contextual characteristics. Our findings suggest that improvements in unfavourable neighbourhood perceptions among lower socioeconomic groups are most likely to be achieved if environmental change strategies (e.g. improving neighbourhood aesthetics and traffic safety), would be combined with community interventions to increase residents' involvement in social processes, and in acknowledgement of residents' psychosocial circumstances.

Strengths and limitations of the current study

The relatively large number of neighbourhoods considered in this study and the rather large sample of participants residing in these neighbourhoods (compared to similar studies [46, 47]) are two important strengths of this study. It enabled us to apply multilevel modelling techniques, which allows quantifying the importance of the context for forming neighbourhood perceptions. The purposive neighbourhood selection strategy, which increased the likelihood to select neighbourhoods with a contrasting physical lay-out, and the relatively high response rate of participants to the postal survey, are additional strengths of this study.

Although the number of participants residing in the selected fourteen neighbourhoods was relatively high compared to similar studies, a limitation of the data was that the socioeconomic differences in perceived neighbourhood unattractiveness were no longer significant, whereas they were when we analysed the total sample of participants (see [5, 7]). The low number of respondents in the lowest income group (n=82) may be responsible for the wide confidence interval of the OR for neighbourhood unattractiveness (including the value of 1.00). Because this OR was still rather elevated compared to higher income

groups, and because previous analyses of the total sample demonstrated that there were significant income inequalities in neighbourhood unattractiveness, we decided to perform the explanatory analyses nonetheless.

Another study limitation was the 1,3 years time period between measurement of neighbourhood perceptions (in the postal survey) and collection of objective neighbourhood characteristics. If results of this study would have shown no contribution of objective neighbourhood data to the explanation of socioeconomic and neighbourhood variations in perceptions, we could have argued that this may have been due to different neighbourhood circumstances by the time of the postal survey and the environmental audit. Although this is not the case, and we have no indications that major changes on relevant neighbourhood characteristics occurred over the time period, this limitation still may have underestimated the contribution of objective neighbourhood characteristics to socioeconomic differences in neighbourhood perceptions.

We developed our own environmental audit tool based on existing audit instruments. Existing instruments could not simply be applied in our study as they were developed for other purposes and for other countries [31-35]. Inter-rater reliability of the audit instrument was good [36]. However, we are less sure about the construct validity: it is unknown to what extent specific area characteristics, i.e. the specific items in the instrument, when taken together in a sum score truly reflected broader constructs of social unsafety, traffic unsafety, design, etc. The selection of specific items for each construct was a well-deliberated choice, based on an existing theoretical framework [33, 38]. The result that objective neighbourhood aesthetics could partly explain socioeconomic variations in perceived neighbourhood unattractiveness, suggests that, at least for this concept, objective characteristics have been measured that people take into account in perceptions of neighbourhood aesthetics. The finding that objective measures of aesthetics (rather than objective measures of unsafety) explained perceptions of unsafety showed that the objective sum scores for traffic unsafety and social unsafety did not include all neighbourhood characteristics that people take into account when forming perceptions of unsafety.

Obviously, the cross-sectional nature of the evidence presented does not permit causal inferences to be drawn. Associations between social neighbourhood cohesion and perceived unsafety, for instance, may include pathways in both directions, as perceived unsafety may be a contributor to the detoriation of the social cohesion of a neighbourhood as well [48]. Another limitation was the measurement of perceived neighbourhood unattractiveness with a single item, although this concept may be multidimensional.

Interpretation of findings

We are aware of only one study which tested other factors in addition to objective environmental characteristics in their explanations of neighbourhood perceptions. Sampson and Raudenbusch (2004) showed that objectively rated neighbourhood disorder predicted perceived disorder, but that being part of a strong social neighbourhood network and the neighbourhoods' racial composition were stronger predictors [23]. This is comparable to our finding that social neighbourhood cohesion was a strong predictor of perceived neighbourhood unsafety, in addition to objective neighbourhood aesthetics. A study testing the association between a range of indicators for community involvement and perceived neighbourhood safety, found that only two indicators showed significant associations with perceived safety: trust in neighbours and length of residence [24].

A handful of studies have investigated the level of agreement between perceived and objective neighbourhood factors. A study among 2053 adults found no association between objectively measured density of facilities and self-reported convenience of exercise facilities [8], whereas a more recent study among adolescent girls found that the number and proximity of objectively measured facilities could predict their perceived access to recreational facilities [49]. Troped and colleagues (2001) found moderate to strong correlations between objective and self-reported measures of respondents' distance to a particular bikeway, whether they had to cross a busy street to access the bikeway, and whether there was a steep hill on their road to the bikeway [17]. However, results suggested that only the two distance-variables measured similar environmental phenomena, whereas the perceived and objective versions of the busy-street- and steep-hill-variables were not measuring the same constructs. Lastly, Kirtland and colleagues (2003) found moderate to low agreement between objective and self-reported neighbourhood factors (Cohens' kappa ranging from 0.19 to 0.37 for seven of the twenty-one environmental items considered, the remaining kappa's were lower) [14]. Most of these results imply that there must be other factors in addition to objective characteristics involved in forming neighbourhood perceptions, and our study provides an indication of some factors that may be important.

A noteworthy study finding is that a higher destination score (=more destinations in the neighbourhood) was associated with negative perceptions of neighbourhood attractiveness. One explanation could be that particularly the more inner-city neighbourhoods have many destinations, but that these neighbourhoods also experience more graffiti, more litter on the street, and less green areas, which would make them less attractive.

In additional analyses, we compared mean objective neighbourhood scores by neighbourhood deprivation level and found significant differences between advantaged and deprived neighbourhoods for only the aesthetic sum score ($p=0.038$); objective scores for the other four domains did not differ significantly between deprived and advantaged neighbourhoods (results not shown). However, as presented in Table 2, when comparing mean sum scores for the five domains of objective characteristics between all fourteen neighbourhoods, scores for four domains *did* differ significantly between the neighbourhoods, and only the social unsafety sum score did not. This shows that deprived neighbourhoods did not necessarily always had worse scores on specific domains, neither had advantaged neighbourhood always most favourable scores. However, overall, the fourteen neighbourhoods in our selection had a contrasting physical lay-out, which could explain a large part of the clustering in neighbourhood perceptions (as shown in Table 4 and 5).

Recommendations for future research and policy & practice

Recommendations for future research include the development and validation of environmental audit instruments for the objective assessment of neighbourhood characteristics. Future research aiming to increase our understanding of how perceptions and objective measures of the environment are related need to take into account how much time people spend in their neighbourhood, and to what extent people 'use' their neighbourhood's facilities (i.e. footpaths, bike paths, green spaces, recreational facilities, shops). People who spend many hours a day in their own neighbourhood, or people that walk to the neighbourhood's shop everyday, may have perceptions of their neighbourhood that better reflect actual circumstances [19].

Non-health interventions can play an important role in improving health-related behaviours. Our results suggest that perceived neighbourhood social cohesion is an important predictor of both perceived neighbourhood unattractiveness and unsafety, in combination with objective neighbourhood aesthetics. Therefore, interventions that encourage community participation and, for instance, stimulate residents to take some responsibility for the general up-keep of the neighbourhood may improve neighbourhood perceptions. These kind of non-health interventions may act upon health, for example via increasing neighbourhood walking, and may have a longer lasting positive effect on health and health-related behaviours than individual-level interventions stressing that people should become more physically active. On the other hand, our results show that individual psychosocial characteristics may influence neighbourhood perceptions as well, implying that individual level (psychosocial) support should accompany neighbourhood level strategies.

Conclusion

It is important to understand to what extent environmental perceptions, which have been found to be related to physical activity [2, 27] and socioeconomic inequalities in physical inactivity [4-6], would improve when the actual environment would be improved. This study showed that unfavourable neighbourhood perceptions of low SES-groups partly reflected their objectively less attractive and less safe neighbourhoods, and partly their perceptions of lower social neighbourhood cohesion and more often having a depressed mood. To yield a maximal improvement of neighbourhood perceptions, among lower socioeconomic groups in particular, environmental change strategies, for instance, improving neighbourhood aesthetics and traffic safety, would need to be combined with community interventions to increase residents' involvement in social processes, and individual level interventions. Ultimately, improved neighbourhood perceptions and objectively truly 'better' neighbourhoods may result in an increase of residents' physical activity.

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8

Area variations in recreational cycling in Melbourne, Australia: a composition or contextual effect?

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Abstract

Background The objective of this study is to examine whether compositional and/or contextual area characteristics are associated with area socioeconomic inequalities and between-area differences in recreational cycling.

Methods In a cross-sectional survey in the city of Melbourne, Australia, 2349 men and women residing in 50 areas reported their frequency of recreational cycling (58.7% response rate). Objective area characteristics were collected for their residential area by environmental audits or calculated with Geographic Information Systems software. Multilevel logistic regression models with cycling for recreational purposes (at least once a month vs. never) as outcome measure, were performed to examine associations between recreational cycling, area socioeconomic level, compositional characteristics (age, sex, education, occupation), and area characteristics (design, safety, destinations, or aesthetics).

Results After adjustment for compositional characteristics, residents of deprived areas were less likely to cycle for recreation (OR=0.66; 95% CI: 0.43-1.00), and significant between-area differences in recreational cycling were found (median odds ratio: 1.48 (95% CrI: 1.24-1.78). Aesthetic characteristics tended to be worse in deprived areas and were the only group of area characteristics that explained some of the area deprivation differences. Safety characteristics explained the largest proportion of between-area variation in recreational cycling.

Conclusion Creating supportive environments with respect to safety and aesthetic area characteristics may decrease between-area differences and area deprivation inequalities in recreational cycling, respectively.

Introduction

People with a lower socioeconomic status (SES) are less physically active than their higher status counterparts,[1-3] and this has been suggested as one of the explanations for their poorer health and higher mortality rates.[4] Multilevel studies have documented that disparities in physical activity also exist according to area socioeconomic deprivation (area SES), even after adjustment for individual SES.[2, 5-7] These findings suggest that deprived areas may be disadvantaged with respect to area characteristics that influence physical activity, independently of the characteristics of the people living in these areas (i.e. contextual vs. compositional effects).[8-9]

The mechanisms underlying area effects on physical activity are not well understood. Often, multilevel studies have been criticized because they tend to be driven by what data are available (i.e. routinely collected data, or individual-level data aggregated to the area level) rather than objectively and systematically collected environmental characteristics. More theory-driven analyses are needed that link environmental features to specific types of physical activity (e.g. presence of cycle paths with cycling for transport).[10, 11]

Cycling is a moderately intense type of physical activity that, compared to more vigorous forms of exercise, can be incorporated into one's daily routine relatively easy, for multiple purposes (i.e. recreation, transportation), and at relatively low cost.[12] However, in most developed countries the prevalence of cycling is low – e.g. only 8% and 3% of Australian adults cycle at least once a week for recreation and transport, respectively.[13] Meanwhile, in some European countries, cycling levels are much higher (in the Netherlands, for instance, 13% and 69% of adults cycle for recreation and transport at least once a week, respectively (Kamphuis and Van den Broek (in preparation). Time use of the Dutch in a European perspective (working title). Den Haag: SCP), suggesting there are significant opportunities to increase cycling. As small environmental changes may have the potential to lead to substantial and sustainable increases in cycling rates, it is important to understand which area level factors should be the target of public health action.

Current evidence of area influences on cycling mainly comes from the planning and transportation literature and therefore concentrates on cycling for transport.[12, 14-16] A review study of area influences on cycling for transport concluded that bike-friendly neighbourhoods are characterized by high population density, a good mixture of land use (i.e., providing different types of destinations to cycle to, including residential, office, retail/commercial, and public space), high connectivity of streets (i.e., providing different cycling routes), and adequate design (e.g. continuous bike tracks/lanes).[17] However, evidence about how these factors relate to between-area variation in recreational cycling or to area deprivation inequalities in cycling is limited.[7, 18]

Pikora and colleagues have previously postulated a framework that includes specific design, safety, destinations and aesthetic characteristics which may influence walking and cycling levels.[19] We examine the extent to which these characteristics explain area deprivation inequalities and between-area variation in recreational cycling, beyond compositional characteristics (i.e. age, sex, education, and occupation).

Methods

This study used data from the Victorian Lifestyle and Neighbourhood Environments Study (VicLANES), conducted in Melbourne, Australia, in 2003. The aim of VicLANES is to examine associations between environmental factors and socioeconomic inequalities in physical activity, dietary behaviour and alcohol consumption. The study sample included 2349 people residing in 50 census collector districts (CCDs), with a median of 47 respondents per CCD (range 12–92). Further details of the study design and methodology have been reported elsewhere. [6]

Sample areas and population

The study was conducted in an area extending about 20 kilometres from the central business district in Melbourne. A CCD is the basic geographical unit used by the Australian Bureau of Statistics to collect population census data, with a mean size of 0.34 km2 for the CCDs in our study area. All CCDs in the study area (n= 4170) were ranked according to the percentage of households with incomes of less than $400 per week (this income band includes about 15% of Australian households [6]), and then stratified into septiles. Fifty CCDs were randomly selected from this list, i.e. 17 from the highest, 16 from the middle, and 17 from the lowest septile (stage 1). Using the electoral roll (voting is compulsory for Australian adults aged > 18 years), 4005 households were randomly selected and one adult, aged 18 to 74 years, was randomly selected from each of these households (stage 2). Approximately equal numbers of participants were selected per strata. Selected participants were sent a postal survey. Valid responses were obtained from 2349 persons, giving an overall response rate of 58.7% (54.6% in the most disadvantaged septile, 59.0% in the middle septile and 62.1% in the most advantaged septile). Participants with missing values for cycling, education and/or occupation (n=146) were excluded, resulting in N=2203 participants eligible for the analyses.

Outcome measure: recreational cycling

Two closed-response items assessed participation in cycling and cycling purpose. The first item asked: "How often in the last month did you go cycling for 10 minutes or more?" We asked for cycling for more than 10 minutes, as we wanted respondents to recall substantial cycling episodes during the last

month. Participants were asked to nominate one of the following six responses: never, about once or twice, about once a week, 2-3 times a week, 4-5 times a week or every day. The second item asked: "For what purpose do you usually cycle?" with three responses listed: for transport (e.g. to get to work, shops), for recreation or exercise or for both transport and recreation. A test-retest of both items over a two-week interval on 67 participants showed good reliability (i.e. weighted kappa's: k=0.85 and k=0.72 respectively). The outcome under investigation in the present study was 'cycling for recreation', coded: 0='never'; and 1='at least once a month'.

Area socioeconomic characteristics

Area socioeconomic level was categorized as high, medium, or low, according to the septile from which the CCD was sampled. The mean proportion of households on low income (i.e. less than $400 per week) ranged from 7.0% in the high socioeconomic areas to 31.4% in the low socioeconomic areas.

Objectively-measured area characteristics

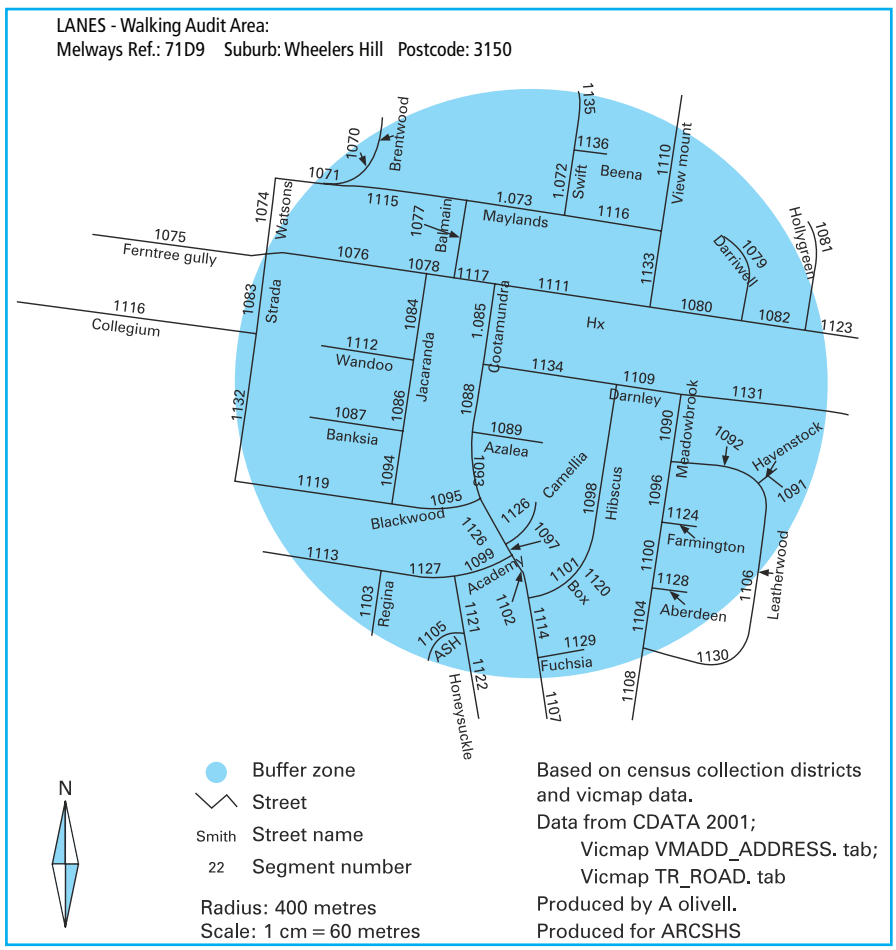
All area characteristics and environmental audits were measured at the same time the postal questionnaire was distributed (between September and December- spring/summer in Melbourne). Based on the framework of Pikora and colleagues [19] we assessed four domains of objective area characteristics, i.e. design (cycling paths/lanes, streets, street width, alternative routes), safety (lighting, traffic control), destination features (bike parking facilities and destinations such as: education institutions, shops [all types], post offices, sport facilities and public transport stops/stations), and aesthetics (streetscape, views, maintenance). These features have been suggested to be related to cycling for recreation by key-experts in in-depth interviews, and by a Delphi study. [19]

To measure area characteristics, first, we randomly selected a household within each CCD and drew a 400m radius around that house, resulting in a 0.50 km2 assessment area. The assessment areas were created using data from CDATA (a census data product from the Australian Bureau of Statistics) [20] and VicMap datasets [21], and MapInfo software [22]. A cosmetic (picture) layer using electronic street directory of greater Melbourne ('Melways', provided by MapInfo) [23] was overlaid to facilitate street recognition. All streets within each assessment area were divided into segments, with a segment being the section of a road between two intersections. Figure 1 shows an example of an assessment area with its segments. Each segment was identified with a unique number, resulting in a total of 3054 street segments for the 50 CCDs (average number of segments per CCD was 59, range 23-161).

Auditors carried out an objective environmental audit (including both sides of the street) on each segment by filling in a modified version of the System-

atic Pedestrian and Cycling Environmental Scan (SPACES) instrument, which measured characteristics from the Pikora framework. [24] For each item, segment scores were aggregated to the area level (CCD) by calculating the average score of the segments in the assessment area. Inter and intra-rater reliability was conducted among the auditors prior to data collection. Both inter- and intra-rater reliability of the items in the instrument have been found to be high in general[24], however, in the current investigation 7 of the 31 items (i.e. path maintenance, path continuity, traffic volume, traffic speed limits, path/lane obstruction, cleanliness, architecture) were excluded from the analyses because of their low inter-rater reliability (kappa < 0.30). We used Melways to calculate the total length of walking and cycling tracks (paths for walking and cycling that were not on a road) and the total area of parks for an area with a 2km radius from the centre point of each CCD. (See Table 2 for details of area characteristics).

Figure 8.1 Example of an assessment area and its segments



Individual characteristics

Occupation was coded to the Australian Standard Classification of Occupations, and further recoded into professionals (managers, administrators, professionals, and paraprofessionals), white-collar employees (clerks, salespersons, and service workers) and blue-collar employees (tradespersons, machine operator, drivers, labourers, and related workers). A fourth category 'not in labour force' was created for respondents who were retired, studying, unemployed, not looking for work, or unable to work. Respondents reported their highest school level completed and any post-school qualifications. Responses were recoded as (1) bachelor degree or higher, (2) diploma (associate or undergraduate) (3) vocational and (4) no post-school qualification. Information on age and sex were obtained from the survey responses or from the electoral roll data if these items were missing.

Analyses

Distributions of individual and area characteristics over high, medium, and low socioeconomic areas were investigated with ANOVA, and associations of individual and area characteristics with recreational cycling were conducted with logistic regression models, both in SPSS (version 14). We used MLwiN version 2.02 to examine area deprivation inequalities and between-area differences in recreational cycling. Since recreational cycling was a binary outcome, we performed multilevel logistic analyses using the logit-link function and 2nd order PQL estimation methods.[25] Between-area differences in recreational cycling were determined by calculating the median odds ratio (MOR) with 95% credible intervals (CrL), using the posterior distribution of the area variance as provided by the Markov Chain Monte Carlo (MCMC) procedure in MlwiN.[26] The intraclass correlation coefficient (ICC) is often calculated for continuous outcomes, and represents the proportion of total variance in the outcome that is attributable to the area level. However, the interpretation of the ICC for dichotomous outcomes is difficult to understand as the individual level variance and the area level variance are not directly comparable [27]. Therefore, we calculated the MOR instead of the ICC to determine clustering of recreational cycling within areas. The MOR was computed with the following formula: [27]

$$\begin{aligned} \text{MOR} &= \exp[\sqrt{(2 \times \text{area variance})} \times 0.6745 \\ &\approx \exp(0.95\sqrt{\text{area variance}}) \end{aligned}$$

An advantage of the MOR over the between-area variance is its consistent and intuitive interpretation. If the MOR would for instance be 1.50, this shows that in the median case the residual heterogeneity between areas increased by 1.5 times the individual odds of recreational cycling when randomly selecting two persons in different areas – that is, if a person moves to another area with a higher probability of recreational cycling, their odds of engaging in recreational cycling will have a median increase of 1.5 times. [27]

To examine the contributions of different groups of compositional and contextual factors, we used a sequential modelling strategy. Firstly, we fitted a two-level random intercept model without any explanatory variables ('null' model), and then included area SES (model 1). Further, we added sex and age (model 2), and education and occupation (model 3), to examine to what extent area differences and area socioeconomic variations in recreational cycling could be accounted for by compositional characteristics. Then, we added each of the four groups of area characteristics separately (i.e. functional, safety, aesthetics, and destination; models 4-7), to observe how much of the remaining area differences and area socioeconomic inequalities each group explained (contextual effects). The contribution of explanatory factors to area differences was assessed by reductions in the MOR. The contribution of factors to area socioeconomic inequalities in recreational cycling was assessed by attenuation of the odds ratios for area SES.

Results

Cycling

Of all participants, 81.8% (n=1802) reported no cycling at all in the previous month, whereas 1.8% (n=40) cycled at least once a month for transportation only, 12.8% (n=282) for recreation only, and 3.6% (n=79) cycled at least once a month for both transport and recreation purposes. Low statistical power did not permit us to investigate cycling for transport in relation to areas and area characteristics, therefore participants cycling for transport only (n=40) were excluded from the analyses. We focused on recreational cycling, with 361 participants who cycled for recreation at least once a month (i.e. those cycling for recreation only, plus those cycling for both recreation and transport), and 1802 participants never cycling.

The contribution of compositional characteristics

Compared to high socioeconomic areas, participants residing in low socioeconomic areas were older, less educated, and a higher proportion did not participate in the labour force (see Table 1). Women and older participants were significantly less likely to cycle for recreation compared to men and younger participants. Participants with no post school qualification (OR=0.66; 95% CI: 0.48-0.91) and those not in the labour force (OR=0.72; 95% CI: 0.51-1.03) were less likely to cycle compared to their higher status counterparts (although these differences were not significant).

Influence of contextual characteristics

As shown in Table 2, four of the eight design features were significantly related to recreational cycling, i.e. presence of an on-road cycle lane, total track length (km), prevalence of traffic control devices, and prevalence of alternative routes.

Table 8.1 Sample (compositional) characteristics by area socioeconomic level, and their associations with recreational cycling[a]

	TOTAL		Area socioeconomic level				Likelihood of recreational cycling[a]		
			High	Medium	Low	p[b]	OR[c]	95% CI	p[c]
	(N=2163)		(N=795)	(N=725)	(N=643)				
	n	%	%	%	%				
Recreational cycling						*			
At least once a month	361	16.7	18.7	17.5	13.2				
Never	1802	83.3	81.3	82.5	86.8				
Sex						n.s.			***
Male	933	43.1	43.3	42.5	43.7		1.00		
Female	1230	56.9	56.7	57.5	56.3		**0.48**	(0.37-0.62)	
Age group						***			***
18-24	172	8.0	7.8	8.0	8.1		1.00		
25-34	391	18.1	14.1	21.9	18.7		0.76	(0.48-1.20)	
35-44	470	21.7	20.5	21.4	23.6		0.74	(0.47-1.15)	
45-54	469	21.7	25.3	19.4	19.8		**0.54**	(0.34-0.85)	
55-64	357	16.5	20.0	16.4	12.3		**0.42**	(0.25-0.68)	
65>	304	14.1	12.3	12.8	17.6		**0.35**	(0.19-0.62)	
Education						***			n.s.
1 Bachelor or higher	724	33.5	40.4	34.9	23.3		1.00		
2 Diploma	243	11.2	12.6	9.5	11.5		0.90	(0.61-1.34)	
3 Vocational	411	19.0	16.6	19.4	21.5		0.91	(0.64-1.29)	
4 No post school qualification	785	36.3	30.4	36.1	43.7		**0.66**	(0.48-0.91)	
Occupation						***			n.s.
1 Professional	805	37.2	44.5	38.9	26.3		1.00		
2 White collar	362	16.7	16.6	16.3	17.4		0.82	(0.57-1.19)	
3 Blue collar	262	12.1	8.1	14.6	14.3		0.97	(0.66-1.43)	
4 Not in labour force	734	33.9	30.8	30.2	42.0		0.72	(0.51-1.03)	

a Likelihood of recreational cycling, 'at least once a month' vs. 'never'.

b P-values indicate whether high, medium, and low socioeconomic areas have different prevalences of the given characteristics. P-value is based on a X^2 distribution; with n.s. = not significant; *= p<0.05; **= p<0.01; ***= p<0.001.

c Odds ratios were adjusted for area socioeconomic level, sex, age, education, and occupation. P-values indicate whether characteristics are significantly associated with recreational cycling.

Table 8.2 Area (contextual) characteristics of assessment areas (N=50) by area socioeconomic level, and associations of area characteristics with recreational cycling (recreational cycling reported by residents of the 50 areas (N= 2163))

Variables	Measurement of area characteristics[a]	All areas (N=50)		Area socioeconomic level mean [SD]				Likelihood of recreational cycling	
		mean [SD]	range	High (n=17)	Medium (n=16)	Low (n=17)	p[b]	OR[c]	95% CI
Design									
Cycling surface									
Path	Proportions of segments with a walking/cycling path present	0.83 [0.16]	0.20-1.00	0.75 [0.20]	0.88 [0.13]	0.86 [0.12]	*	1.04	(0.54-2.00)
Cycle lane	Proportions of segments with an on-road cycle lane	0.05 [0.08]	0.00-0.28	0.06 [0.07]	0.09 [0.10]	0.01 [0.01]	*	**5.40**	(1.29-22.60)
Slope	The degree of incline on walking/cycling tracks measured by the average path-slope-score (1= flat/gentle, 2= moderate, 3=steep)	1.20 [0.30]	1.00-2.60	1.38 [0.42]	1.10 [0.14]	1.11 [0.15]	*	0.87	(0.61-1.25)
Track length	Total length of walking/cycling tracks (km)	15.70 [9.95]	3.55-49.87	15.58 [7.94]	18.74 [14.20]	12.94 [5.84]	n.s.	**1.02**[d]	(1.01-1.03)
Streets									
Width	Average number of lanes on road	2.65 [0.24]	2.00-3.27	2.61 [0.25]	2.64 [0.14]	2.69 [0.29]	n.s.	0.81	(0.49-1.35)
Vehicle parking	Proportions of segments with vehicle parking restriction signs present	0.26 [0.25]	0.00-0.95	0.23 [0.26]	0.31 [0.29]	0.25 [0.21]	n.s.	1.52	(0.92-2.53)
Traffic									
Traffic control devices	Proportions of segments with at least one traffic control device (i.e. speed bumps, traffic calming structures that effect the speed/flow of traffic)	0.26 [0.14]	0.01-0.62	0.24 [0.13]	0.30 [0.17]	0.25 [0.13]	n.s.	**2.90**[e]	(1.19-7.02)
Alternative routes									
Other access points	Proportions of segments with one or more other route available (that provide alternative ways of cycling around the neighbourhood)	0.23 [0.11]	0.00-0.45	0.23 [0.11]	0.22 [0.10]	0.23 [0.13]	n.s.	**4.49**	(1.55-13.00)
Safety									
Personal									
Lighting	Proportions of segments with street lights present	0.56 [0.08]	0.40-0.80	0.56 [0.07]	0.57 [0.11]	0.54 [0.07]	n.s.	0.72	(0.17-3.16)

Table 8.2 (Continued)

Variables	Measurement of area characteristics[a]	All areas (N=50)		Area socioeconomic level mean [SD]				Likelihood of recreational cycling	
		mean [SD]	range	High (n=17)	Medium (n=16)	Low (n=17)	p[b]	OR[c]	95% CI
Surveillance	Average surveillance-score (1= others can observe cyclists from <50% of buildings, 2= from 50-75% of buildings, 3= from >75% of buildings)	2.22 [0.46]	1.00-2.86	2.14 [0.48]	2.25 [0.55]	2.25 [0.38]	n.s.	1.11	(0.85-1.45)
Traffic									
Crossings	Proportions of segments with one or more crossings present (e.g. zebra, traffic signals, bridge/overpass, underpass)	0.07 [0.06]	0.00-0.27	0.05 [0.05]	0.08 [0.07]	0.08 [0.05]	n.s.	0.32	(0.02-3.22)
Crossing aids	Proportions of segments with one or more crossing aids (e.g. median refuge, traffic island, kerb extensions)	0.23 [0.14]	0.02-0.58	0.22 [0.13]	0.27 [0.17]	0.22 [0.13]	n.s.	0.73	(0.30-1.78)
Verge width	Average path-location-score (1=next to road, 2= <1m from kerb, 3= 1-2m from kerb, 4= 2-3m from kerb, 5= 3>m from kerb)	3.30 [0.92]	1.08-4.58	3.41 [0.86]	3.10 [1.10]	3.38 [0.81]	n.s.	**0.89**	(0.78-1.01)
Absence of driveway crossovers	Average score for driveway-crossovers (1= most buildings have driveway, 2= ½ of buildings have driveway, 3= ¼ of buildings have driveway, 4= no driveways)	1.61 [0.62]	1.00-3.29	1.54 [0.49]	1.76 [0.83]	1.53 [0.49]	n.s.	**1.43**	(1.18-1.73)
Destinations									
Destination present	Proportion of segments with at least one destination present	0.40 [0.19]	0.12-0.93	0.36 [0.15]	0.36 [0.21]	0.48 [0.19]	n.s.	**1.91**	(0.99-3.69)
Destination variety	Average number of different destinations along a segment	0.39 [0.27]	0.07-1.28	0.31 [0.20]	0.34 [0.25]	0.50 [0.33]	n.s.	1.44	(0.91-2.27)
Bike parking facilities	Proportions of segments with bike parking facilities	0.02 [0.03]	0.00-0.13	0.02 [0.02]	0.02 [0.03]	0.03 [0.04]	n.s.	8.93	(0.13-607.8)
Aesthetics									
Streetscape									
Absence of trees	Average score for trees along the road (1= one or more trees per house block, 2= one tree for every 2 house blocks, 3= one tree for every 3> house blocks, 4=no trees)	2.06 [0.55]	0.68-2.76	2.14 [0.48]	2.10 [0.64]	1.95 [0.55]]	n.s.	0.89	(0.72-1.11)

Table 8.2 (Continued)

Variables	Measurement of area characteristics[a]	All areas (N=50)		Area socioeconomic level mean [SD]				Likelihood of recreational cycling	
		mean [SD]	range	High (n=17)	Medium (n=16)	Low (n=17)	p[b]	OR[c]	95% CI
Lack of garden maintenance	Average score for garden maintenance (1= >75% well maintained, 2= 50-75% well maintained, 3= <50% well maintained)	1.24 [0.21]	1.00-1.86	1.14 [0.14]	1.22 [0.22]	1.36 [0.21]	n.s.	**0.55**	(0.29-1.04)
Lack of verge maintenance	Average score for verge maintenance (1= >75% well maintained, 2= 50-75% well maintained, 3= <50% well maintained, 4=verge undergoing work)	1.37 [0.28]	1.03-2.29	1.28 [0.31]	1.40 [0.30]	1.41 [0.24]	n.s.	1.08	(0.68-1.69)
Park area	Total park area (km^2)	0.94 [0.72]	0.12-3.51	1.10 [1.00]	0.98 [0.65]	0.73 [0.34]	n.s.	**1.26**	(1.09-1.46)
Views									
Urban view	Proportions of segments with an urban view (houses, household gardens)	0.90 [0.18]	0.00-1.00	0.93 [0.14]	0.89 [0.25]	0.89 [0.17]	n.s.	0.85	(0.35-2.06)
Commercial view	Proportions of segments with a commercial view (shops, offices)	0.27 [0.22]	0.00-0.80	0.22 [0.20]	0.24 [0.25]	0.36 [0.21]	n.s.	1.35	(0.78-2.33)
Natural view	Proportions of segments with a natural view (park, lake, river)	0.22 [0.17]	0.00-0.67	0.25 [0.18]	0.20 [0.18]	0.20 [0.15]	n.s.	1.16	(0.60-2.26)

a Area characteristics were collected during field observations with the SPACES instrument, except for the total length of tracks and the km^2 of parks, which were calculated by GIS.

b We used ANOVA to compare the area characteristics among the socioeconomic areas. P -values indicate whether high, medium, and low socioeconomic areas have different prevalences of the given characteristics, with n.s. = not significant; *= p<0.050; **= p<0.010; ***= p<0.001.

c Odds ratios express the likelihood of recreational cycling (at least once a month vs. never). All models included only the predictor variable of interest in the model and were age- and sex-adjusted. Odds ratios in bold indicate a significant or borderline significant association with recreational cycling.

d Example 1 for interpretation of results: the odds ratio for track length means that for each one unit increase in length (so for each additional kilometre), the odds of recreational cycling increases by 2%.

e Example 2 for interpretation of results: The odds ratio for traffic control devices reflects the effect of an increase in the proportion of segments with traffic control devices from zero (no segment) to 1 (100% of the segments).

Also, two out of six safety features (i.e. verge width, and absence of driveway crossovers), one out of three destination features (i.e. prevalence of destinations), and two out of seven aesthetic features (i.e. total park area, and lack of garden maintenance) showed a (borderline) significant association with recreational cycling. Larger verge width and lack of garden maintenance was negatively associated with recreational cycling, whereas the other features showed a positive association.

Between-area differences in recreational cycling

We found significant between-area differences in recreational cycling for the null model (i.e. MOR= 1.49 (1.26-1.77); see Table 3). The MOR did not change when area socioeconomic level (model 1), and compositional factors (models 2 and 3) were added to the null model, and neither changed when design, destination, or aesthetic characteristics were separately added to model 3. However, a drop in the MOR was seen when safety features were included (MOR reduced to 1.27(1.03-1.60)). Two safety features (surveillance and absence of driveway crossovers) were independently related to recreational cycling.

Area socioeconomic inequalities in recreational cycling

As presented in Table 3, area socioeconomic inequalities remained borderline significant when adjusting for age, sex, education, and occupation, with residents of low socioeconomic areas least likely to cycle for recreation (OR=0.65; 95% CI: 0.42-1.01). When design, safety, or destination features were added to the model, area socioeconomic inequalities increased marginally. However, area socioeconomic inequalities were attenuated when aesthetic features were added to the model.

Discussion

Principal findings

Our study in the city of Melbourne, Australia, showed that there were between-area differences in recreational cycling and that residents of socioeconomically deprived areas were less likely to cycle for recreation, independent of residents' age, sex, occupational and educational level. Safety characteristics partially explained between-area differences in recreational cycling, and poorer aesthetic characteristics in deprived areas made a contribution to explaining the lower rates of engagement in recreational cycling among residents of these areas. Improving the safety and aesthetic characteristics of areas are strategies that may increase recreational cycling.

Table 8.3 The effect of area design, safety, destination and aesthetic characteristics on area differences[a] and area socioeconomic (area SES) variations in the likelihood of recreational cycling[b] (odds ratios (OR) and 95% confidence intervals (CI))

	Model 0	Model 1: area SES	Model 2: area SES + age + sex	Model 3: area SES + age+ sex+ education + occupation	Model 4: model 3 + design features	Model 5: model 3 + safety features	Model 6: model 3 + destination features	Model 7: model 3 + aesthetic features
Random effects								
MOR (95% CrI)	1.49 (1.26-1.77)	1.47 (1.22-1.74)	1.52 (1.25-1.82)	1.48 (1.24-1.78)	1.49 (1.24-1.82)	1.27 (1.03-1.60)	1.48 (1.22-1.77)	1.51 (1.23-1.82)
Fixed effects								
Area ses								
High		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium		0.90 (0.60-1.36)	0.83 (0.56-1.25)	0.84 (0.55-1.29)	0.79 (0.49-1.27)	0.69 (0.47-1.01)	0.82 (0.55-1.22)	0.91 (0.60-1.39)
Low		**0.66** (0.43-1.00)	**0.60** (0.40-0.89)	**0.65** (0.42-1.01)	**0.64** (0.41-0.99)	**0.61** (0.41-0.91)	**0.56** (0.36-0.87)	0.76 (0.46-1.23)
DESIGN								
Path					1.92 (0.58-6.37)			
Slope					1.06 (0.59-1.90)			
Track length (km)					1.01 (0.99-1.04)			
Street width					1.17 (0.62-2.21)			
Vehicle parking signs					0.81 (0.30-2.20)			
Traffic control devices					1.96 (0.49-7.91)			
Other access points					3.24 (0.70-14.9)			
SAFETY								
Lighting						1.05 (0.08-13.8)		
Surveillance						**1.81** (1.04-3.17)		
Crossings						0.53 (0.01-41.6)		

Table 8.3 (Continued)

	Model 0	Model 1: area SES	Model 2: area SES + age + sex	Model 3: area SES + age+ sex+ education + occupation	Model 4: model 3 + design features	Model 5: model 3 + safety features	Model 6: model 3 + destination features	Model 7: model 3 + aesthetic features
Crossing aids						0.20 (0.04-1.09)		
Verge width						1.02 (0.81-1.29)		
Absence of driveway crossovers						**2.16** (1.52-3.06)		
DESTINATIONS								
Destination present							0.90 (0.04-21.8)	
Destination variety							1.95 (0.21-18.0)	
AESTHETICS								
Absence of trees								0.81 (0.50-1.31)
Lack of garden maintenance								0.47 (0.20-1.13)
Lack of verge maintenance								1.37 (0.71-2.65)
Park area								1.21 (0.94-1.57)
Urban view								3.04 (0.81-11.5)
Commercial view								1.60 (0.59-4.35)
Natural view								1.05 (0.37-2.94)

a Area differences are indicated by the median odds ratio (MOR) with 95% credible intervals (CrL), using the posterior distribution of the area variance as provided by the Markov Chain Monte Carlo (MCMC) procedure in MlwiN [25].

b Odds ratios express the likelihood of recreational cycling (at least once a month vs. never), and are adjusted for all variables that were included in the specific model. Odds ratios in **bold** indicate a significant association between the area characteristic and recreational cycling.

Study strengths and weaknesses

This is the first known multilevel study that has investigated a large range of objective area characteristics in relation to recreational cycling, and the contribution of those characteristics to area socioeconomic inequalities and between-area differences in recreational cycling. However, this study has a number of limitations. Firstly, it was restricted to a specific geographic area, the city of Melbourne. Therefore, results may only be generalisable to similar areas. Furthermore, audit areas had a 400m radius, although cyclists are likely to travel further than 400 meters. Someone's immediate surrounding was expected to make a difference for whether people even *consider* cycling, and more practically, for a data collection method as resource/labour intensive as an environmental audit, this area was the size that we could most cost-effectively collect information. The cross-sectional design did not allow us to determine whether area characteristics caused recreational cycling differences or whether residents self-selected into areas according to physical activity opportunities, including bikability. The low prevalence of cycling did not allow us to use a cut-off point of which a larger health impact might be expected, for instance, cycling for recreation at least three times per week (instead of at least once a month), nor could we examine transport-related cycling. Additionally, we did not collect information on destinations that participants cycled to. It may be that the design, safety, destination and aesthetic characteristics of areas where participants cycled to were more influential on their recreational cycling than characteristics of their immediate residential areas. Finally, area characteristics were systematically measured with Pikora's SPACES instrument, [24] however not all items could be included in the analyses. Some items were excluded because of their low inter-rater reliability (seven items), their low overall prevalence in the assessed areas (two items), or because information on them was not collected (four items). However, we were still able to examine twenty-two area characteristics, most of which have never been investigated in relation to recreational cycling.

Interpretation of findings

A previous multilevel paper based on the VicLANES study did not find an association between area socioeconomic level and overall cycling levels. [6] In contrast, focusing on recreational cycling rather than overall cycling, we did find area socioeconomic variation, showing that area effects may differ even for closely-related physical activity outcomes. We found that area socioeconomic inequalities in recreational cycling reduced to non-significance when aesthetic characteristics were taken into account, which is in line with a study from the Netherlands, that found that people residing in the most disadvantaged areas had an increased probability of almost never cycling, walking, and gardening for recreation, which was partly mediated by poorer general neighbourhood attractiveness.[7] Total park area was one of the aesthetic features that showed a significant positive association with recreational cycling (as also found for

transportational cycling [18]), and decreased with area socioeconomic level (although not significantly). These results are consistent with the literature on perceptions of area characteristics, which has shown that residents of low socioeconomic areas have less positive perceptions of physical-activity related neighbourhood characteristics than residents of high socioeconomic areas [2, 28].

Although several specific design, destination, and aesthetic characteristics were associated with recreational cycling in bivariate associations (adjusted for age and sex), these did not contribute to between-area differences in recreational cycling. This may be due to the areas being relatively uniform in terms of these characteristics. Our findings suggest that some other individual- or area-level factor(s) not considered in the current study contributed to the between-area differences in recreational cycling found. Only safety characteristics explained part of the area differences in recreational cycling, and two specific safety items, surveillance level and absence of driveway crossovers, remained significantly associated with recreational cycling when adjusting for all safety features and compositional factors. This shows that personal as well as traffic safety were independently important for recreational cycling, as had been suggested by the framework developed by Pikora and colleagues [18]. In contrast, a U.S. study did not find associations between objective measures of traffic or personal safety and combined recreational cycling and walking [29], which may be due to e.g. their different safety measure (i.e. a summary score instead of analysing specific items), their different outcome measure, or because associations between environmental correlates and health behaviours may be country-specific [30].

Area socioeconomic inequalities in recreational cycling actually widened when design, safety, or destination characteristics were included in the explanatory model. This is probably due to a suppression effect.[31] In general, the adjustment of models for explanatory factors (with the highest socioeconomic group being the reference group), leads to a reduction in the magnitude of the inequalities, as explanatory factors are often most favourable for the highest socioeconomic group. However, as we found that some design, safety, and destination characteristics were more favourable in low than high socioeconomic areas, adjustment for these factors resulted in a widening of the socioeconomic area inequalities in recreational cycling rather than a decline.

Future research

The results of this study add to previous findings, confirming the potential role of the built environment on physical activity behaviours.[17, 19, 32] In future research, causal pathways between area characteristics and transport-related and recreational physical activities should be tested, either in a longitudinal study or 'natural experiment' in which activity is measured before and after an

environmental modification. Both objective and perceived area characteristics should be investigated, as agreement between the two has found to be small, [29, 33] and their relevance for public health action is still under debate.

Conclusions

This study provided evidence of significant area differences and socioeconomic area inequalities in recreational cycling that could be explained by some contextual effects, and only marginally by compositional factors. This study also showed that cycling levels are relatively low, also among residents of advantaged areas. Creating supportive neighbourhood environments, especially with respect to aesthetic and safety characteristics may have the potential to increase cycling levels. Lessons could be learned from countries like the Netherlands and Denmark where cycling is extremely popular, and where measures to improve the bikability of cities are readily available. [12]

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Part 3

Socioeconomic status, environmental factors and diet

9

A systematic review of environmental factors and energy and fat intakes among adults: is there evidence for environments that encourage obesogenic dietary intakes?

Giskes K, Kamphuis CBM, Van Lenthe FJ, Kremers S, Droomers M & Brug J (2007) A systematic review of environmental factors and energy and fat intakes among adults: is there evidence for environments that encourage obesogenic dietary intakes? *Public Health Nutr*, 10(10): 1005-1017.

Abstract

Background The goal of this study is to review the literature examining associations between environmental factors, energy and fat intakes among adults, and to identify issues for future research.

Methods Literature searches of studies published between 1980 and 2004 were conducted in major databases (i.e. PubMed, Human Nutrition, Web of Science, PsychInfo, and Sociofile). Additional articles were located by citation tracking.

Results Twenty-one articles met the inclusion criteria. No study provided a clear conceptualisation of how environmental factors may influence these dietary intakes. Availability, social, cultural and material aspects of the environment were relatively understudied compared with other factors such as seasonal/day of the week variation and work-related factors. Few studies examined the specific environmental factors implicated in the obesity epidemic, and there was little study replication. All studies were observational and cross-sectional.

Conclusion It is too premature to conclude whether or not environmental factors play a role in obesogenic and unhealthy dietary intakes. More studies need to examine associations with those environmental factors thought to contribute to obesogenic environments. There needs to be more development in theories that conceptualise the relationship between environmental factors and dietary intakes.

Introduction

Unhealthy dietary intakes are risk factors for cardiovascular diseases and some forms of cancer [1], which are the most common causes of mortality in western countries [2-3]. High levels of energy intakes play a role by contributing to overweight and obesity [4-5]. Total fat and saturated fat intakes supply energy which contributes to overweight and obesity, and saturated fat influences blood levels of harmful (LDL) cholesterol [1]. In an effort to achieve reductions in morbidity and mortality, dietary guidelines have been developed that endorse a suitable energy intake and promote low consumption levels of total and saturated fats [5-6].

Until recently, the mainstream thought was that most determinants of dietary intakes occurred within the individual. Taste preferences, habit, nutrition knowledge, intentions, attitudes, outcome expectancies, self-efficacy and a number of other individual-level factors were considered to primarily drive what people eat [7-8]. However, these determinants were found to only explain a small portion of the variance in dietary intakes [9]. Recently, there has been a growing interest in the role of the environment in influencing people's dietary behaviour. This social ecological view of health emphasises that individuals interact with their environments [10] and that characteristics of the environment influence their health behaviours.

The rising prevalence of overweight and obesity is one of the major public health concerns today. Changes in dietary and physical activity behaviours are thought to underlie this trend. The determinants of these changes are less well known. Since Swinburn and Egger introduced their ecological paradigm for understanding obesity [11], and argued that an increasingly 'obesogenic environment' contributed to the trends, there has been great popularity in examining whether environmental factors are associated with obesity-related behaviours.

A number of position papers and narrative reviews have identified environmental factors associated with the obesity epidemic [12-13]; however no systematic review has examined the role of environmental factors in dietary intakes. For example, the increasing densities of fast food restaurants and convenience stores are thought to promote unhealthy food choices [14]. Media marketing of high-fat foods, their low prices and the greater range of convenience foods available are considered to be contributing factors [11, 14]. The increased participation of women in the workforce has resulted in a greater reliance on convenience foods and less structured meal patterns, contributing to less healthy dietary intakes [15]. The greater variety of foods available in supermarkets may contribute to populations deviating from their traditional diets, adopting less

healthy intakes, and portion sizes have increased [15]. The presumed importance of these environmental determinants of unhealthy dietary behaviours have resulted in strong appeals for a better understanding of the role of environmental factors in dietary intakes and environmental interventions.

We conducted a systematic review of studies on environmental factors associated with energy, total and saturated fat intakes to summarise the current scientific evidence. We aimed to address which environmental factors have been examined in relation to these dietary outcomes to date, and identify issues for future research.

Methods

For the purposes of this study, the environment was defined as everything outside the individual [16]. A framework used in previous research [17], that identifies four categories of environmental factors related to health behaviours was used to classify different environmental factors during the review process. The framework shares common features with ecological models [18-19], stressing the importance of multiple types of environmental influences. The four categories that form this framework are:

(a) Accessibility and availability. Including physical and financial accessibility of products and shops that are needed for an (un)healthy diet (e.g. access to shops, and availability of high fat foods and less healthy snacks).
(b) Social conditions. These arise from inter-personal interactions and include social relationships (e.g. family/marital status), social support and psychosocial stressors such as relationship difficulties.
(c) Cultural conditions. These are the result of non-personal interactions or engagement with a larger group of people, such as culture-specific eating patterns, health value orientations, food experiences in childhood, and cultural participation.
(d) Material conditions. Including financial situation (e.g. household income), material and social deprivation, and unfavourable working, housing and neighbourhood conditions (e.g. neighbourhood deprivation). These may affect behaviour through one of the previous environmental factors. For instance, a person's budgetary situation may partly determine one's access to products and facilities. And living or working in an unfavourable environment might induce stress, which may relate to indifference concerning a healthy diet.

Search strategy

The current study was conducted within a larger study reviewing the literature of environmental factors associated with energy, fat, fruit and vegetable consumption among adults. Therefore, literature searches were conducted for a

broader range of outcomes than those presented here, and included keywords for fruits and vegetables. Results on environmental factors associated with fruit and vegetable intakes can be found elsewhere [20].

A review protocol based on guidelines from the Cochrane Reviewer's Handbook [21] was used. Studies conducted among human subjects between 1 January 1980 and 31 December 2004 were located by searches of several major databases (i.e. PubMed, Human Nutrition, Web of Science, PsychInfo, and Sociofile).

Broad search terms were used in the database searches to ensure that all potentially relevant articles entered the screening process. Each database was searched using database-specific indexing terms; suitable terms were selected from lists of the database indexing system. For databases that did not have their own indexing terms (i.e. Human Nutrition and Sociofile), we searched for keywords in titles. The sensitivity of searches was tested by seeing whether they located several key articles. Searches located 20653 potentially relevant titles (7440 in PubMed, 8325 in Human Nutrition, 4828 in Web of Science, 58 in PsychInfo and two in Sociofile). Detailed search strategies for each database can be found at: http: //mgzlx4.erasmusmc.nl/pwp/?ckamphuis.

Inclusion criteria

To be included, studies must have been published in English and conducted among a population-based sample of adults (i.e. studies examining disease or patient sub-groups, those conducted among participants below 18 years or above 60 years of age were excluded) and they must have quantified dietary intakes. In addition to this, studies must have been conducted in an established market economy as defined by the World Bank [22], and the dependent variable(s) must have been energy intake, total/saturated fat intakes or fruit and vegetable intakes. Intervention studies and studies with a research design that made it impossible to decipher associations between environmental factors and the outcome behaviours were excluded.

Title scanning

The title screening process was performed by two reviewers (KG and CK) and took place in three steps. Firstly, the titles located from the search results were scanned, to exclude those out of the scope of the current study. Then the abstracts of all titles were examined by the reviewers. At this step, each reviewer produced a list of suitable articles. These lists were then combined, and both reviewers examined the pooled list independently. They read all study abstracts in the pooled list, and each produced a 'short list' of suitable articles. Discrepancies between reviewers in the 'short lists' were discussed, and a consensus was reached on whether or not the article(s) in question would be incorporated.

A total of 55 articles were identified for inclusion at this stage. The reference lists of these articles were scanned and the selection of studies from the reference lists followed the same procedure outlined above. Another 12 publications extracted from reference lists were included in the review.

Data extraction and summarisation

The reviewers extracted data from half of the studies each. The study's details (i.e. the environmental factor(s) and dietary outcome(s) examined, whether environmental factors were objectively measured or self-reported, sample size, response rate, factors adjusted for in the analyses and the associations found) were summarised in data extraction tables.

In studies where sufficient data were available, effect sizes (ES) were calculated to interpret the magnitude of association of the environmental factors and make comparisons between studies. The formulae of Cohen [23] were applied, adjusting for sample size. The magnitude of the ES were also interpreted according to the guidelines of Cohen, with cut-off points of 0.2-0.5 for small ES, 0.5-0.8 for moderate ES and >0.8 for large ES.

Results

Twenty-seven of the 67 studies selected for detailed review were excluded because they were design/theoretical papers or only mentioned environmental factors in their Discussion sections. Nineteen articles were excluded because they did not examine energy, total fat or saturated fat intakes, therefore 21 articles remained in the current review. Table 1 summarises the country where the study was conducted, the environmental factor(s) examined and their measurement. Most studies examined more than one dietary outcome, and were conducted in the USA (n=11), UK/Europe (n=6) or Canada/Australia/Israel (n=4). Just less than half of the studies (n=9) measured the environmental factors objectively. All studies were cross-sectional. Only one study used multilevel analyses [24], census block districts were the area-level used in these analyses. All remaining studies were individual-level analyses.

Table 9.1 Details of included studies

First author (year)	Dietary outcomes examined	Country	Environmental factor(s)	Was environmental factor subjectively or objectively measured?
Cheadle (1991) (43)	Total fat	U.S.A.	Shelf space occupied by healthy foods in stores	objective
De Castro (1992) (44)	Energy, total fat	U.S.A.	Number of people present during meal	subjective
De Craene (1990) (35)	Total fat	Belgium	Location of residence, marital status,	subjective (both)
Diehr (1993) (45)	Total fat	U.S.A.	Percentage community not reaching recommended intakes	subjective
Diez-Roux (1999)	Saturated fat	U.S.A.	Median income of neighbourhood, household income	subjective (both)
Friel (2003) (25)	Energy, total fat, saturated fat	Ireland	Urban/rural residence, marital status, living situation (alone/with others)	subjective (all)
Gibney (1993) (46)	Energy, total fat	Ireland	Family circumstances (married, children)	subjective
Haines (2003) (29)	Energy, total fat	U.S.A.	Weekend/weekday, season	subjective
Hellerstedt (1997) (38)	Total fat	U.S.A.	Psychological demands, job latitude, job strain	subjective
Johansson (1999) (36)	Total fat	Norway	Location of residence Household income	objective (both)
McCann (1990) (33)	Energy, total fat, saturated fat	U.S.A.	Period of high/low workload	objective
Morland (2002) (47)	Total fat, saturated fat	U.S.A.	Whether or not there were the following food stores in the residential area: Supermarkets, Grocery stores, Full service restaurants Fast food restaurants	objective (all)
Pomerleau (1997) (37)	Total fat	Canada	Household income, Source of income	subjective (both)
Raynor (2004) (48)	Total fat	U.S.A.	Availability of high fat foods at home	subjective
Rolls (2002) (27)	Energy	U.S.A.	Portion size	objective
Rolls (2004) (28)	Energy	U.S.A.	Portion size	objective
Rutishauser (1994) (26)	Energy, total fat, saturated fat	Australia	Residing in a low or high socioeconomic area	objective
Shahar (2001) (30)	Energy, total fat, saturated fat	Israel	Season (summer/winter)	objective
Subar (1994) (31)	Energy, total fat	U.S.A.	Season: summer or winter	objective
Tarasuk (1999) (49)	Energy, total fat	Canada	Household food insecurity	subjective
Van Staveren (1996) (32)	Energy, total fat, saturated fat	The Net-herlands	Season: summer or winter	objective
Wardle (2000) (34)	Energy	U.K.	Period of high/low workload	objective
Wardle (2000) (34)	Total fat, saturated fat	U.K.	Period of high/low workload	objective

The studies examined 81 associations between intakes and environmental factors, of which 41 were significant. Table 2 briefly summarises the associations found between environmental factors and each of the dietary intakes. This table shows that associations between environmental factors and intakes have been examined mostly for total fat consumption (39 associations were tested) compared to energy and saturated fat consumptions (22 and 20 associations were tested, respectively). Relatively few associations tested the potential influence of cultural factors on dietary intakes. There was little replication of studies testing the same hypotheses; often two associations were tested in different samples (e.g. men and women) from the same study.

Table 9.2 Summary of associations found in the reviewed articles

Environmental factors	Dietary intakes		
	Energy	Total fat	Saturated fat
Availability			
high fat food stocked in stores		+1	
high fat foods available at home		+1	
grocery store in the residential area		1	*+1*
supermarket in the residential area		1	1
full service restaurant in the residential area		1	1
fast food restaurant in the residential area		1	1
Social factors			
being married	+2	+2 / 2	*-2*
having children	1	1	
living with others	+1 / -1	+2	*+2*
Cultural factors			
presence of others during mealtimes	+1	+1	
% community exhibiting high fat intakes		+1	
Material factors			
living in a rural area (compared to urban area)	+2	+2/2	+2
living a disadvantaged area	2	2	4/-2
household income		3	
household food insecurity	-1	1	
Other factors			
portion size	+2		
weekend (compared to weekdays)	+1	+1	
winter (compared to summer)	+1/2/3	+2/1	+1/1
workload	+2	+1/1	+1 / 1
work-related psychological demands		+1/1	
job strain		+1/1	
job latitude		2	
living in a northern region (in Belgium)		*+2*	

blue: number of significant effects found for the combination determinant - dietary outcome.
black: number of non-significant effects found for the combination determinant - dietary outcome, or for which information on significance was not available.
\+ positive association between environmental determinant and dietary outcome.
\- negative association between environmental determinant and dietary outcome.

Tables 3-5 detail the study characteristics and findings for each dietary outcome more extensively. For brevity, the following sections only describe findings for environmental factors for which two or more associations were tested.

Associations between environmental factors and energy intakes

Table 3 details the characteristics and findings of studies examining associations between environmental factors and energy intakes. Fourteen of the 22 associations examined in these studies demonstrated a significant relationship between the environmental factor and energy intakes.

No studies looked at associations between availability factors (such as types of stores available and what they stocked) and energy intakes. The influence of social factors (i.e. being married, having children or living with others) on energy intakes were examined in a number of studies. Living with others demonstrated large associations with energy intakes that differed in direction for men and women [25]. One study found that men living alone had lower energy intakes than those living with others; however lower energy intakes were found among women that lived with others. The same study found that marital status was strongly associated with energy intakes; intakes were higher among married participants compared to their single counterparts [25].

Only one study examined associations between cultural factors (the presence of others during mealtimes) and energy intakes, while a number of studies looked at material factors. Urban/rural residence demonstrated a large association with energy intakes; men and women living in rural areas had greater energy intakes than those in urban areas [25]. In a study that contrasted the energy intakes of men and women living in areas with different socioeconomic characteristics, no differences were found [26].

Other potential determinants of energy intakes that were examined in other studies were portion size, weekday/seasonal variations in intakes and associations between workload and energy intakes. Two studies demonstrated strong direct effects between portion sizes and energy intakes [27-28]. Seasonal variations in intakes were measured in countries differing considerably in their climate (US, Israel and Europe), and mixed associations were seen [29-32]. Two studies found small differences in mean energy intakes between winter and summer, one found that intakes were marginally lower in winter among men [31] while another study among men found that energy intakes were slightly higher in winter [30]. A study among women found no seasonal variation in energy intakes [32]. Greater energy intakes have been associated with higher workload in two studies, but the magnitude of these effects were small [33-34].

Table 9.3 Results of studies examining environmental factors associated with energy intakes

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
De Castro (1992) (44)	153 (not available)	Number of people present during meal	Intake increased 22.50 Cal per person present	Y	Unable to calculate	Nil
Friel (2003) (25)	6539 (63)	Marital status, urban/rural residence, living situation (alone/with others)	Single men consumed 0.26 MJ/day less than married men, those living in rural areas consumed 0.03 MJ/day more than those in urban areas and those living alone consumed 1.2 MJ/day less than men living with others. Single women consumed 0.15 MJ/day less than their married counterparts, women in rural areas consumed 0.19 MJ/day more than those in urban areas, and women living alone consumed 0.51 MJ/day more than women living with other people.	Men: Marital status: Y Urban/rural: Y Living situation: Y Women: Marital status: Y Urban/rural: Y Living situation: Y	Men: Marital status: large Urban/rural residence: large Living situation: large Women: Marital status: large Urban/rural residence: large Living situation: large	Age, gender, education, occupation, medical card eligibility, marital status, location of residence, number in household.
Gibney (1993) (46)	87 women only (94)	Family circumstances (married, children)	Single mothers consumed 0.3 MJ/day less than mothers with 1-2 children.	Not available	Unable to calculate	Nil
Haines (2003) (29)	990 (not available)	Weekend/weekday and season	Intakes 82 Cal/day higher on weekends and 23 Cal/day higher in winter.	Day of week: Y Season: Y	Unable to calculate	**Age, gender, ethnicity, income, region, urban/rural residence, household size, receipt of social security/food assistance.**
McCann (1990) (33)	10 (not available)	Workload	During periods of high workload participants consumed 240 cal/day more than periods of low workload.	Y	Small effect	Nil

Table 9.3 (Continued)

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Rutis-hauser (1994) (26)	225 (57-77)	Residing in a low or high socioeconomic area	Men and women living in disadvantaged areas consumed 0.5 and 0.4MJ/day less energy (respectively) than those in advantaged areas.	NS for men and women	Small	Nil
Shahar (2001) (30)	94 men only (not available)	Season (summer/winter)	In winter, men consumed 158 cal/day more than in summer.	NS	No effect	Nil
Subar (1994) (31)	20143	Season (summer/winter)	In winter, men consumed 39 Cal/day less than in the summer. In winter, women consumed 14 Cal/day more than in the summer.	Not available	Unable to calculate	Age, race, region, education, poverty index.
Tarasuk (1999) (49)	145 women only (68.3)	Household food insecurity	Women in households with high food insecurity consumed 1058 kj/day less then those with low food insecurity.	Y	Unable to calculate	Disposable income, presence of employment income, presence of a partner in the household, women's level of education, smoking status, ethnic identity
Van Staveren (1996) (32)	114 women only (not available)	Season: summer or winter	There was no difference in energy intakes between summer and winter	NS	No effect	Day of week
Wardle (2000) (34)	90 (not available)	Workload	During a high workload period, energy intakes were 109 Cal/day higher than during a low workload period	Y	Small effect	Nil

a Y= effects was statistically significant ($p \leq 0.05$). NS= effect was not significant.

Associations between environmental factors and total fat intakes

Studies examining associations between environmental factors and total fat intakes are described in Table 4. Sixteen of the 39 associations tested reached statistical significance.

There were no associations between availability factors and total fat intake that were replicated. A number of studies examined potential social determinants of fat intakes. Marital status and living situation demonstrated large effects with fat intakes in a US study [25] and showed being married or living with others was associated with higher fat intakes compared to being single or living alone. However, a Belgian study found no association between marital status and fat intakes [35].

There were no replicated associations tested for any cultural factors and total fat intake. However, a number of studies examined associations with material factors. A US study found that living in a rural area was associated with a higher fat intake, and the effect size of this relationship was large [25]. However, a Norwegian study found no significant urban/rural differences [36]. Fat intakes in relation to the socioeconomic characteristics of the residential area were examined in one study but no significant association was found [26]. Two studies examined the economic circumstances of households in relation to fat intakes, and took a number of confounding factors into account, but found that household income was not associated with fat intakes [36-37].

The majority of studies examined associations with other factors. There were mixed findings about seasonal variations in fat intake. Two small studies (one in Israel and one in Europe) demonstrated higher fat intakes in winter compared to summer [30, 32], however a US study found very marginal differences in fat intakes between seasons [31]. Three studies examined associations between work conditions such as psychological demands, job strain and workload and fat intakes [33, 34, 38]. One study found no association between psychological demands and job strain and women's fat intakes, whereas men with high psychological demands and high job strain consumed more fat than their counterparts with low psychological demands and low job strain [38]. A small study showed a positive relationship of moderate magnitude between workload and fat intakes [33], whereas another study found no association between work stress and fat intakes [34]. Location of residence also showed a relationship with fat intakes in a Belgian study, which illustrated significant regional differences in fat consumption [35].

Table 9.4 Results of studies examining environmental factors associated with total fat intakes

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Cheadle (1991) (43)	5654 (53.4)	Shelf space occupied by healthy foods in stores	Correlation co-efficient between store healthfulness scale and percentage energy from fat –0.52.	Y	Small-moderate effect	Nil
De Castro (1992) (44)	153 (not available)	Number of people present during meal	Regression slope for number of people present: 8.45 kcal from fat per person present	Y	Unable to calculate	Nil
De Craene (1990) (35)	1609 (75)	Marital status, location of residence	Single men had a fat consumption score 10 points lower (healthier) than married men, whereas single women had a fat consumption score 5 points higher (less healthy) than married women. Men and women living in the northern region had a higher fat consumption score (less healthy) than those in the southern region (13 and 16 points for men and women, respectively).	Marital status Men: NS Women: NS Region Men: Y Women: Y	Unable to calculate for marital status and region of residence.	Age, gender
Diehr (1993) (45)	335 (not available)	Percentage community not reaching recommended intakes	When added to a model to explain fat consumption, the percentage of community exhibiting high fat intakes explained 1.4% of the total variance.	Y	Small	Nil
Friel (2003) (25)	6539 (62)	Marital status, living situation (alone/with others), urban/rural residence	Single men consumed 0.3% less energy from fat than their married counterparts, men in rural areas consumed 0.7% more energy from fat, and men living alone averaged 0.2 % less energy from fat than men living with others. Single women consumed 1.8% less energy from fat than married women, those in rural areas consumed 0.5% more energy from fat and women living alone consumed 0.6% less energy from fat than women living with other people.	Men: Marital status: Y Urban/rural: Y Living situation: Y Women: Marital status: Y Urban/rural: Y Living situation: Y	Men: Marital status: large Urban/rural residence: large Living situation: large Women: Marital status: large Urban/rural residence: large Living situation: large	Age, gender, education, occupation, medical card eligibility, marital status, location of residence, number in household.

Table 9.4 (Continued)

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Gibney (1993) (46)	87 women only (94)	Family circumstances (married, children)	Single mothers consumed 5.4% less of their energy intake as fat than mothers with 1-2 children.	Not available	Unable to calculate	Nil
Haines (2003) (29)	9900 (not available)	Weekend/weekday	0.7% higher energy from fat on weekends.	Y	Unable to calculate	Age, gender, ethnicity, energy intake, income, region, urban/rural residence, household size, receipt of social security/food assistance
Hellerstedt (1997) (38)	3843 (range of 50-93% by worksite)	Psychological demands in job, job latitude and job strain	Men with high psychological demands in their job consumed 51 Cal/day more than men with low psychological demands. Women with high psychological demands consumed 4 Cal/day less. Men and women with low job latitude consumed 14 and 3 Cal/day less (respectively) than their counterparts with high job latitude. Men with high job strain consumed 22 Cal/day more and women with high job strain consumed 3 Cal/day less than those with low job strain.	Psychological demands Men: Y Women: NS Job latitude Men: NS Women: NS Job strain Men: Y Women: NS	Unable to calculate for psychological demands Unable to calculate for job latitude No effect for job strain for men and women	Gender, age, marital status, race, time employed, hours worked per week, job category, salary, environmental/physical hazards, education.

Table 9.4 (Continued)

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Johansson (1999) (36)	3144 (63)	Household income, location of residence	There was no difference in fat intakes between income groups for men and women. Rural men and women derived 1% more of their energy intakes from fat compared to their counterparts living in cities.	Income and place of residence were NS for men and women	Income and place of residence no effect for men and women	Age, gender, education
McCann (1990) (33)	10 (not available)	Workload	During periods of high workload participants consumed 5% more energy from fat than periods of low workload.	Y	Moderate	Nil
Morland (2002) (47)	10623 (not available)	Types of food stores in residential area	The likelihood of a low fat consumption with the following stores in the residential area: Supermarkets 1.09 (1.01, 1.18) Grocery stores 0.97 (0.90, 1.04) Full service restaurants 0.95 (0.87, 1.05) Fast food restaurants 0.99 (0.91, 1.08)	All outlets NS	No effect for all outlets	Education, income and other types of food stores
Pomerleau (1997) (37)	43099 (77-97)	Household income	The likelihood of a low fat intake among those with low household income was 0.95 (0.75, 1.19)	N	No effect	Gender, age and marital status, other socioeconomic variables
Raynor (2004) (48)	162 (not available)	Availability of high fat foods at home	The percentage of high fat foods available at home was positively related to total fat intake r=0.25	Y	Moderate	Nil
Rutishauser (1994) (26)	225 (57-77)	Residing in a low or high socioeconomic area	Men and women deprived areas consumed 0.5g/day and 1.6 g/day more fat (respectively) than those in advantaged areas.	NS for men and women	Men: no Women: no	Nil

Table 9.4 (Continued)

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Shahar (2001) (30)	94 men only (not available)	Season (summer/winter)	In winter, men consumed 9g/day more fat than in summer	Y	Moderate	Energy intake
Subar (1994) (31)	20143	Season (summer/winter)	In winter, men consumed 1.1g/day less than in the summer. In winter, women consumed 0.1g/day less than in the summer.	Not available	Unable to calculate	Age, race, region, education, poverty index.
Tarasuk (1999) (49)	145 women only (68.3)	Household food insecurity	Women in households with a high food insecurity consumed 8.45g/day less of fat than those in a household with low food insecurity	NS	Unable to calculate	disposable income, presence of employment income, presence of a partner in the household, women's level of education, smoking status, ethnic identity
Van Staveren (1996) (32)	114 women only (not available)	Season: summer or winter	Fat contributed 2.2% more to total energy intake in winter compared to summer	Y	Unable to calculate	Adjustment for time of the week: weekends, Friday, Monday-Thursday
Wardle (2000) (34)	90 (not available)	Workload	During a period of high workload, total fat contributed 1% less to total energy intake compared to low workload periods.		No effect	Nil

a Y= effects was statistically significant ($p \leq 0.05$). NS= effect was not significant.

Associations between environmental factors and saturated fat intakes

Studies examining associations between environmental factors and saturated fat intakes are shown in Table 5. Nine of the 20 associations tested were statistically significant.

Similar to that reported for energy and total fat intakes, no associations with availability factors were replicated. Studies that examined potential social determinants found that single adults had moderately higher saturated fat intakes than their married counterparts, and that these differences were large in magnitude [25]. The same study found a large positive association between saturated fat intake and living alone, participants that lived alone had higher intakes compared to those living with others [25].

No studies examined associations between saturated fat intakes and cultural factors; however a number looked at the potential influence of material factors. Living in an urban area was associated with higher intakes in one study [25], and the differences in intakes between urban and rural areas were large in magnitude. The influence of living in a deprived neighbourhood was examined in two studies [24-26]; both found no significant differences in saturated fat consumption between people residing in socioeconomically contrasting areas. A US study found that household income was positively related to saturated fat intakes among men and women [24].

A number of other studies looked at the potential influence of other factors on saturated fat intakes. A study among men in Israel showed that saturated fat intakes were moderately higher in winter compared to summer [30]. However, no significant seasonal differences in saturated fat intakes were seen among women in Belgium [32]. Two studies examining the influence of working conditions showed that workers consumed slightly (but significantly) more saturated fat during periods of high workload [33], but the other found that intakes were not different during periods of high work stress [34].

Table 9.5 Results of studies examining environmental factors associated with saturated fat intakes

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Diez-Roux (1999) (24)	13095 (not available)	Median income of neighbourhood, household income	Men in the poorest neighbourhoods consumed 0.3g/day of saturated fat less than those in advantaged areas, whereas women in disadvantaged areas consumed 0.4g/day more. Men and women in the poorest households consumed 0.5g and 0.9 g of saturated fat/day less (respectively) than the most wealthy group.	NS neighbourhood differences men and women Y household income men and women	Unable to calculate Unable to calculate	Age, gender, race, energy intake, field center, individual-level income.
Friel (2003) (25)	6539 (62)	Marital status, living situation (alone/with others), urban/rural residence	Single men consumed 0.1% more energy from saturated fat than married men, those living in rural areas consumed 0.4% more energy from saturated fat and those living alone consumed 0.2% less saturated fat compared to men living with others. Single women consumed 0.1% more energy from saturated fat than their married counterparts, those living in rural areas consumed 0.4% more energy from saturated fat compared to those in urban areas, and women living alone consumed 0.2% energy from saturated fat less than women living with others.	Men: Marital status: Y Urban/rural: Y Living situation: Y Women: Marital status: Y Urban/rural: Y Living situation: Y	Men: Marital status: moderate Urban/rural residence: large Living situation: large Women: Marital status: moderate Urban/rural residence: large Living situation: large	Age, gender, education, occupation, medical card eligibility, marital status, location of residence, number in household.
McCann (1990) (33)	10 (not available)	Workload	During periods of high workload participants consumed 3% more energy from saturated fat than periods of low workload.	Y	Small	Nil

Table 9.5 (Continued)

First author (year)	Sample size (response rate %)	Environmental factor(s)	Findings	Was association significant?[a]	Magnitude of effect size	Adjusted for
Morland (2002) (47)	10623 (not available)	Types of food stores in residential area	Likelihood of a low saturated fat consumption with the following outlets in the residential area: Supermarkets 1.09 (0.99, 1.20) Grocery stores 0.92 (0.84, 1.00) Full service restaurants 1.03 (0.91, 1.15) Fast food restaurants 0.95 (0.86, 1.05)	NS for all stores except for grocery stores	No effect for all stores except for grocery stores which had a small effect	Education, income and other types of food stores
Rutishauser (1994) (26)	225 (57-77)	Residing in a low or high socioeconomic area	Men and women living in deprived areas consumed 1.4 and 1.3g/day more saturated fat than those in advantaged areas.	NS for men and women	Unable to calculate	Nil
Shahar (2001) (30)	94 men only (not available)	Season (summer/winter)	In winter men consumed 3g/day more saturated fat than in summer.	Y	Moderate	Energy intake
Van Staveren (1996) (32)	114 women only (not available)	Season: summer or winter	Saturated fat contribution 0.7% more to energy intake in winter compared to summer.	NS	Unable to calculate	Adjustment for time of the week: weekends, Friday, Monday-Thursday
Wardle (2000) (34)	90 (not available)	Workload	During periods of high workload, saturated fat contributed 0.45% more to energy intake than low workload periods.	NS	No effect	Nil

a Y= effects was statistically significant ($p \leq 0.05$). NS= effect was not significant.

Discussion

We performed a systematic review of the literature examining associations between environmental factors and energy, total and saturated fat intakes. Potentially relevant environmental factors from social-ecological models for health behaviours (like availability, social, cultural and material conditions) were relatively understudied in relation to these specific dietary outcomes-research has predominantly focused on other environmental influences (I.e. season/day of the week variation, work-related factors). Few studies have examined the specific environmental factors that have been implicated in the obesity epidemic, such as fast food/convenience stores, marketing of unhealthy foods and larger portion sizes. Therefore, it is too premature to conclude that the environment does or does not play an important role in unhealthy dietary behaviour among the adult population at the current time.

Both the public and health professionals have a great deal of interest in the presumed impact of the food environment on weight gain and health. However, our systematic review indicates these notions are currently not well-supported by scientific evidence. The evidence base in this area still needs to grow before extensive investment in developing environmental interventions to bring about dietary change can be justified. But how can we tackle this?

Firstly, there is a need for more theoretical growth in this area before our knowledge can be advanced by further research. Research on environmental factors associated with dietary intakes needs to develop beyond the phase of merely reporting associations between environmental factors and dietary intakes. The relationship between the environment and how it influences food choice needs to be conceptualized. There needs to be some more empirical thought given to which environmental factors are most likely related to dietary intakes i.e. are they accessibility and availability issues, social factors, cultural conditions and/or material factors? There needs to be some consideration given to the pathways/mechanisms by which environmental factors are likely to influence intakes. Most studies included in the review examined associations between environmental factors and dietary intakes without stating clear hypotheses regarding the underlying mechanisms. Being aware of the mechanisms by which environmental factors influence dietary intakes is necessary so the research can be translated to effective interventions among the population. For example, does the actual environment influence people's behaviour, or are people's perceptions of the environment a stronger influence? Another question is whether the environment operates directly on dietary behaviour, or whether its' influence is mediated through other environmental-level factors (e.g. urbanization or area deprivation) or individual-level factors (e.g. self-efficacy or nutrition knowledge). Existing conceptual models are of some assistance, but these are

still in their formative stages. Some ecological theories of health behaviour may also offer some direction, however they are also limited as they list and categorise potential environmental factors but do not specify how they influence behaviour [39]. Further development of this theory is necessary to facilitate the formation of recommendations for health practitioners and for deriving hypotheses to be tested in subsequent research. We should also take advantage of knowledge from other fields of research such as sociology, urban geography, economy, as these fields know much about the consequences of physical and/or social deterioration in neighbourhoods. Fields like economics have a stronger knowledge about the effects of advertising and the way people spent their money. Cross-fertilisation of knowledge from different fields may be the key to growth in this area.

Furthermore, the influence of the environment needs to be examined in relation to other 'traditional' (i.e. individual-level) determinants of dietary behaviour [40]. No known study has simultaneously looked at the relative influence of (and interaction between) environmental and individual-level factors on dietary behaviour. Examining the relative influence of factors at different levels is an important step to help determine where research to understand how dietary behaviour, and interventions and resources to bring about behaviour change could be best targeted.

Stronger study designs will also help to un-pack the relationship between the environment and dietary behaviour. All the studies in the current review were observational and examined cross-sectional associations between environmental factors and dietary intakes. These study designs provide an indication of significant associations, but are limited for examining causal relationships between the factors of interest and dietary intakes [41]. Longitudinal and experimental study designs would enable environmental determinants (rather than correlates) of dietary behaviour to be identified. The use of 'natural experiments' (e.g. examining intakes of residents before and after the opening of a takeaway food store, or making cross-country comparisons to examine the influence of cultural factors) may offer opportunities to examine the influence of environmental factors that are difficult to manipulate [42].

Our search strategy only located studies that were published in peer-reviewed journals and referenced in electronic databases; therefore they may be influenced by publication bias. We tried to minimize this by also performing searches in smaller and more specialized databases. The studies included in the review tested 81 associations of which 41 were found to be significant, suggesting that publication bias may have played a role in the current study with an over representation of studies showing significant effects. Other limitations that may have influenced the study findings were differences in the conceptu-

alization, measurement and summary of the environmental determinants and/or dietary intakes in the different studies. Even though strict inclusion criteria were used, environmental or dietary intake measurements sometimes differed markedly between studies, and may have contributed to variation in the associations found.

The findings of this review suggest that there is currently insufficient evidence to conclude that environmental factors do or do not influence obesogenic or unhealthy dietary behaviours. Further research needs to examine the environmental factors that the current literature implicates as part of an obesogenic environment, as we found few studies that examined these factors. The evidence base in this area still needs to grow in the ways mentioned above, before practice recommendations can be made or extensive investment in developing environmental interventions to bring about dietary change can be justified. Examination of environmental factors associated with dietary habits preceding energy and fat intakes (such as food choice and habits) may help to further unpack whether the environment influences health outcomes through dietary behaviour. Additionally, study replication is necessary to confirm or disprove the findings of previous studies.

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10

Environmental correlates of fruit and vegetable consumption – a systematic review

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Abstract

Background The current ecological approach in health behaviour research recognises that health behaviour needs to be understood in a broad environmental context. This has led to an exponential increase in the number of studies on this topic. It is the aim of this systematic review to summarise the existing empirical evidence pertaining to environmental influences on fruit and vegetable (FV) consumption.

Methods The environment was defined as 'all factors external to the individual'. Scientific databases and reference lists of selected papers were systematically searched for observational studies among adults (18–60 years old), published in English between 1 January 1980 and 31 December 2004, with environmental factor(s) as independent factor(s), and fruit intake, vegetable intake or FV intake combined as one outcome measure as dependent factor(s).

Results A great diversity in the environmental factors studied was found, but the number of replicated studies for each determinant was limited. Most evidence was found for household income, as people with lower household incomes consistently had a lower FV consumption. Married people had higher intakes than those who were single, whereas having children showed mixed results. Good local availability (e.g. access to one's own vegetable garden, having low food insecurity) seemed to exert a positive influence on intake.

Conclusions Improved opportunities for sufficient FV consumption among low-income households may lead to improved intakes. For all other environmental factors, more replicated studies are required to examine their influence on FV intake.

Introduction

Non-communicable diseases, such as cardiovascular diseases and cancer are the current major causes of death in developed countries [1]. Fruit and vegetable (FV) consumption play a protective role in the onset of these chronic diseases [2-4] and a low FV intake is one of the leading risk factors for death from cancer worldwide [5]. Considerable reductions in morbidity and mortality from diet-related diseases can be achieved if the population adopts recommended dietary behaviours, including adequate FV intakes [6]. To understand and promote behaviour change towards recommended FV intakes, health behaviour research has predominantly focussed on individual-level factors, including individuals' knowledge, intentions, attitudes, self-efficacy, motivation, taste, personal traits, and other personal factors related to FV consumption [7-10].

Over the last decade there has been a movement towards a more ecological approach to people's health behaviour, which has resulted in an exponential increase in the number of studies on living environments [11, 12]. Environmental and policy interventions are now promoted as promising strategies for creating population-wide improvements in health behaviours [13-15]. However, no clear overview exists of environmental factors that have consistently shown to be related to FV consumption. It is the aim of this systematic review to summarize the existing empirical evidence pertaining to the association between environmental influences and FV consumption, to identify knowledge gaps, and to provide recommendations for policy and intervention development. More specifically, we address the following research questions:

1) What environmental determinants of FV consumption have been examined in existing empirical research?
2) For what environmental factors does the existing evidence show a relationship with FV consumption?

Methods

Since we were interested in any influence but individual level factors, we kept our definition of the environment as broad as possible, i.e. 'all factors external to the individual' [16]. A framework used in previous research [17], that identifies four categories of environmental factors related to health behaviours, was a helpful tool in classifying different environmental factors during the review process. The framework shares common features with ecological models [18, 19], stressing the importance of multiple types of environmental influences that affect health behaviour. The four categories of this framework are:

(a) Accessibility and availability. Including physical and financial accessibility of products and shops that are needed for an (un)healthy diet (e.g. access to FV shops, and availability of FV and less healthy snacks).
(b) Social conditions. Including social relationships (e.g. family/marital status), social support, and psychosocial stress.
(c) Cultural conditions. Culture-specific eating patterns, health value orientations, food experiences in childhood, and cultural participation.
(d) Material conditions. Including financial situation (e.g. household income), material and social deprivation, and unfavourable working, housing and neighbourhood conditions (e.g. neighbourhood deprivation). These may affect behaviour through one of the previous environmental factors. For instance, a person's budgetary situation may partly determine one's access to products and facilities. And living or working in an unfavourable environment might induce stress, which may relate to indifference concerning a healthy diet.

Any environmental influence that could not be placed under the heading of one of these categories would be referred to as 'other factors'.

The current study was conducted as part of a larger study examining environmental determinants of several dietary outcomes, namely total energy, total fat, saturated fat, and FV intakes. Search strategies therefore also included keywords for energy and fat intakes. Results on environmental determinants of these dietary outcomes can be found elsewhere (Giskes et al, submitted).

Data sources and search strategy

The study protocol was based on guidelines from the Cochrane Reviewer's Handbook [20]. The following databases were searched: PubMed, PsychInfo, Web of Science and Human Nutrition. Broad search terms were used so as not to miss any potentially relevant articles during the search procedure. The sensitivity of search strategies was tested by seeing whether they located key articles [21, 22], that were known by the researchers to fit the inclusion criteria. For each database, relevant indexing terms relating to energy, fat and FV intakes, and environmental determinants were selected and included in the search phrases. For example, in Pubmed, the medical subject headings (MeSH) 'social environment', 'environment', or 'residence characteristics' were combined with the MeSH terms 'fruit', 'vegetables', 'energy intake', 'dietary fats', 'nutrition', or 'diet' to search for papers. Identical search terms were used for other databases. Detailed search strategies for every database can be found on http://mgzlx4.erasmusmc.nl/pwp/?ckamphuis.

Study selection

The selection criteria for inclusion were:

- Observational studies published in English between 1 January 1980 to 31 December 2004;
- Studies conducted among a population-based sample of adults (i.e. no patient groups), aged 18-60 years;
- Dependent variable(s) were intakes of energy, fat, fruits, vegetables, or fruits and vegetables combined as one outcome measure;
- Independent variable(s) were variables that could be classified as an 'environmental' factor according to the definition of Sallis & Owen (2002), i.e. 'all factors external to the individual';
- Studies must have been conducted in an 'established market economy' as defined by the World Bank (http://www.worldbank.org/).

Intervention studies were excluded from the scope of the current study. Those with a research design that made it impossible to decipher the effects of several environmental determinants on the outcome behaviour were also excluded. Studies among children were excluded, since environmental factors typically investigated in relation to children's fruit and vegetable intake (e.g. parent's behaviour, parenting style, availability of fruits and/or unhealthy snacks at school [23]) differed significantly from those potentially relevant for adults.

The selection of articles located from the database searches took place in several steps. Firstly, titles (and if necessary abstracts) were scanned by the first and second author independently (CK and KG), to exclude those out of scope. When a sound judgement about an article's suitability could not be made based on title and/or abstract, the article remained in the review process. In the second step, the lists of included articles generated by both authors were compared. Discrepancies between the co-authors were discussed until consensus was reached. Then, the full text of each remaining paper was viewed by both CK and KG, and again papers were excluded with consensus of both authors. Finally, the reference lists of all remaining papers were scanned. The selection of studies from the reference lists followed the same steps as outlined above.

Data extraction and study assessment

The first two authors each extracted data from half of the studies. Each study's details were summarised in tables. Environmental factors as reported by the participant were referred to as 'self-reported' (e.g. marital status, household income), whereas factors extracted from objective databases or systematically measured by the research team were called 'objective' (e.g. the actual number of supermarkets in a neighbourhood, as counted by the researcher).

Though we have made no formal attempt to gauge study quality, a crude indicator was developed to make a rough distinction between studies of acceptable quality and studies of limited quality. Assessing sample size, response rate and whether adjustment was made for a limited set of confounders (age and sex), seemed to be sufficient to distinguish acceptable study quality. A study was judged as being of acceptable quality, if it fulfilled at least two of the following criteria: sample size>500, response rate>55% and adjustments made for potentially relevant confounders [24]. Note that study quality was no inclusion criteria, so no study was excluded from the review on the base of this crude quality measure.

Results

The literature searches yielded 7440 titles of potentially relevant articles in Pubmed, 58 titles in Psychinfo, 4828 titles in Web of Science, and 8325 titles in Human Nutrition. After scanning titles and abstracts, a total of 55 potentially relevant articles were identified. This vigorous reduction in the number of potentially relevant articles based on title/abstract only, was due to the broad search terms used, in combination with the strict inclusion criteria regarding dependent variables, and the overlap in titles identified by the databases. The reference lists of the 55 selected articles were scanned, which resulted in another 12 publications for inclusion. When examining the full texts of the total of 67 articles, another 26 articles were excluded, because they were either methodological or theoretical papers, described a naturally occurring intervention, or just mentioned environmental determinants of dietary behaviour in their Discussion. Of the remaining 41 articles, a total of 24 articles had fruit and/or vegetable consumption as outcome variable(s). These papers and their findings are described below. The other papers had fat and/or energy intakes as outcome variables, and are described in another review [25].

Table 10.1 Details of studies included in the review

First author (year)	Country	Dietary outcome[a]	Environmental determinants and measurement (self-reported (S) or objectively measured (O))		Aspects of study quality[b]			Association(s) tested for subgroups
					N	%	C	
Agudo (1999)	Spain	F, V	North-south location of residence within Spain	O	+	+	+	-
Billson (1999)	U.K.	FV	Region of residence within the UK, receiving benefits, marital status, having home grown produce.	S (all)	+	+		Men, women
Devine (1999)	U.S.A.	F, V	Having a vegetable garden, parental and marital status, presence of others during mealtime	S (all)	+	+	+	-
Dibsdall (2003)	U.K.	FV	Perceived accessibility of FV, perceived affordability of FV, and perceived car access	S	+			-
Diez-Roux (1999)	U.S.A.	F, V	Median income of neighbourhood	S	+		+	Men, women

Table 10.1 (Continued)

First author (year)	Country	Dietary out-come[a]	Environmental determinants and measurement (self-reported (S) or objectively measured (O))		Aspects of study quality[b]			Association(s) tested for subgroups
					N	%	C	
Forsyth (1994)	U.K.	F, V	Residing in a deprived vs. advantaged area	O	+		+	-
Giskes (2002a)	Australia	F, V	Household income	S	+	+	+	Men, women
Giskes (2002b)	Australia	F, V	Household income	S	+	+	+	Men, women
Johansson (1998)	Norway	FV	Household income	S	+	+		Men, women
Johansson (1999)	Norway	FV	Residing in a rural vs. urban area in Norway, household income	O	+	+	+	Men, women
Kinter (1981)	U.S.A.	FV	Aspects of family functioning (cohesion, expressiveness, conflict, independence, achievement orientation, intellectual-cultural orientation, active-recreational orientation, moral-religious emphasis, organization, control)	S				Men, women
Laaksonen (2004)	Finland	V	Household income	O	+	+	+	Men, women
Morland (2002)	U.S.A.	FV	Whether or not there were the following food stores in the census tract (as approximation of neighbourhoods): Supermarkets, Grocery stores, Full service restaurants, Fast food restaurants	O	+		+	Blacks, whites
Naska (2000)	Europe	F, V, FV	How much fruit and vegetables are available in the food supply in different countries	O	+			-
Pan (1999)	U.S.A.	F, V	Residing in the US for a minimum of 6 months (compared to an Asia country)	S				-
Papadaki (2002)	U.K.	F, V	Residing in Scotland (compared to Greece)	S		+		-
Pollard (2001)	U.K.	F, V FV	Region of residence in the UK, having children, marital status	S (all)	+	+		-
Shohaimi (2004)	U.K.	FV	Deprivation of residential area	S	+		+	Men, women
Staveren, van (1996)	Nether-lands	F, V	Season (summer or winter)	O			+	-
Steptoe (2004)	U.K.	FV	Social support: from family, from others	S			+	-
Subar (1994)	U.S.A.	FV	Season (summer or winter)	O	+		+	-
Tingay (2003)	U.K.	F, V	Food insecurity[c]	S		+	+	-
Wandel (1995)	Norway	F, V	Having children, household size, household income, region of residence in Norway.	S (all)	+	+		-
Ziegler (1987)	U.S.A.	F, V	Season (summer-spring or winter-fall)	S	+	+		-

a F = fruit intake; V = vegetable intake; FV = fruit and vegetable intake combined in one outcome measure.

b Study quality aspects. N marked with a '+' means: sample > 500; % marked with a '+' means: response rate is reported; C marked with a '+' means: adjustments made for at least age and sex.

c Food insecurity has been defined as the limited or uncertain availability of nutritionally adequate safe foods, including experiences like running out of food, running out of money to buy food, or buying cheaper foods because of financial constraints (Tingay *et al.*, 2003)

Table 1 summarizes the details of each study. Thirteen studies examined fruit and vegetable intake separately, nine studies combined fruit and vegetable intake as one outcome variable, and two presented results for all three outcomes [22, 26]. Nine studies examined associations between environmental determinant(s) and dietary outcome(s) for men and women separately; one study compared subgroups of blacks/whites [21]. Studies were conducted in the U.K. (N=8), U.S. (N=7), Europe (N=7) (e.g. Norway, Spain), and Australia (N=2). Dietary outcomes were predominantly measured with a food frequency questionnaire, and less often with a 7-day food consumption diary or 24-h dietary recall. All studies had a cross-sectional design. A wide range of different environmental determinants were studied. Seven of the 24 studies fulfilled one or none of the quality criteria, eleven studies met two quality criteria, and six studies fulfilled all three criteria. Table 2 shows that the 24 studies examined a total of 97 associations between environmental determinants and intakes, and 57 of these were statistically significant. Detailed results for each dietary outcome are shown in Tables 3 to 5.

Fruit consumption

Material factors have been studied most often with regard to fruit intake (Table 3). People living in households with a higher income had a greater fruit consumption [27-29]. The same association was found among people living a neighbourhood with a higher median income, even after adjustment for individual level SES [30]. Neighbourhood deprivation was associated with lower fruit consumption [31]. Accessibility and availability factors have received little attention in the literature to date. However, one study investigated the consequences of food insecurity on fruit intake, where food insecurity was defined as the limited or uncertain availability of nutritionally adequate and safe foods, including experiences like running out of food, running out of money to buy food, or buying cheaper foods because of financial constraints [32]. Being food insecure was associated with significantly lower consumption [32]. Another study found that having a vegetable garden was positively and significantly associated with fruit consumption [33]. Considerable disparities between European countries in availability of fruit at the national level were found, which could be a probable explanation for the divers percentages of low fruit consumers (< 150 g/person per day) in countries, ranging from 81% of the population in Poland to 32% in Greece [26]. The few studies examining social factors showed that being married and the number of people living in the household were positively related to fruit intake, whereas having children showed mixed associations [22, 29, 33, 34]. Country and regional differences in fruit intake were significant for three out of five associations [22, 29, 35-37]. No significant associations were found for seasonal influences [38, 39].

Table 10.2 Summary of the number of associations between environmental determinants and fruit and vegetable intake[a]

Environmental determinants	Fruit intake	Vegetable intake	Fruit and vegetable intake
Accessibility factors			
availability of FV at national market	1[b]	1	1
grocery store in the census tract			2
supermarket in the census tract			+1/1
full service restaurant in the census tract			2
fast food restaurant in the census tract			2
perceived accessibility (of shops, of FV in shops)			+1
perceived affordability (of FV in shops)			+1
household food insecurity	-1	-1	
car access			1
having a vegetable garden or home grown produce	+1	+1	+2
Social factors			
being married	+1/1	+2	+2/+1
household size	+1	+1	
having child(ren) (compared to no children)	+1/-2	-1/+1/-1	+1
family functioning			1
social support from family members			+1/+1
social support from others			+1
Cultural factors			
presence of others during mealtimes	+1	1	
intellectual-cultural orientation of a family			+1
Material factors			
median income of neighbourhood	+1/+1	+2	
neighbourhood deprivation	-1	-1	-1/1
household income	+4/+1	+7	+1/+1/-2
receiving benefits			-2
Other factors			
living in a rural area (compared to urban)			-2
living in a northern region of Norway	1	-1	
region of residence in Spain	1	1	
living in the north of the UK	-1	-1	-1/ 2
living in London/South-East of the UK			+1
residing in the U.S. (instead of Asia)	+1	-1	
residing in Scotland (instead of Greece)	-1	-1/ 1	-1/1
winter (compared to summer)	+2/-1/-1	-1/-1	+2/-1

a When a study tested associations for subgroups separately, all associations are reported in this table. Results from acceptable as well as minor quality studies are presented.

b The numbers in the table should be interpreted as follows:

blue number of significant effects found for the combination determinant - dietary outcome.

black number of non-significant effects found for the combination determinant - dietary outcome, or for which

\+ positive association between environmental determinant and dietary outcome.

\- negative association between environmental determinant and dietary outcome.

(some non-significant associations do not have a plus or minus sign, as this information was not available in all cases)

Table 10.3 Results of studies examining environmental determinants of fruit consumption[a]

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Accessibility and availability					
Naska (2000)	142715 households (response rate % not available)	How much fruit is available in the food supply in different countries	In Poland, a country with low availability of fruit (i.e. 100 g/person per day) 81% of the population did not reach the recommended intake. In Greece, a country with high availability of fruit (i.e. 350 g/person per day) 32% of the population did not reach WHO recommendations.	Not available	Nil
Devine (1999)	592 (82%)	Having a vegetable garden	Having a vegetable garden was positively and significantly associated with fruit consumption.	Y	Age, gender, education, race.
Tingay (2003)	431 (87%)	Food insecurity	Participants with food insecurity had a likelihood of 0.57 (0.36, 0.90) for consuming fruit daily compared to their counterparts that were food secure.	Y	Age, sex.
Social factors					
Devine (1999)	592 (82%)	Parental and marital status	Being married + having a young child, or being single + having a young child (vs. being married + having no child) was positively and significantly associated with fruit consumption among whites.	Y	Age, gender, education, race.
Pollard (2001)	35367 women only (58%)	Having children, marital status	Those without children consumed 0.26 portions of fruit more than participants with children. Single participants consumed 0.21 fewer portions of fruit than their married counterparts.	Children: Y Marital status: Y	Nil
Wandel (1995)	14960 (77%)	Having children, household size	Those with children were 0.90 more likely to consume fruits seldomly than participants without. Participants in household with more than 2 people were 1.54 times less likely to consume fruits seldomly.	Y for children and household size.	Nil
Cultural factors					
Devine (1999)	592 (82%)	Presence of others during meal time	Eating with others was positively associated with fruit consumption.	Y	Age, gender, education, race.
Material factors					
Diez-Roux (1999)	13095 (response rate % not available)	Median income of neighbourhood	Men and women in the poorest neighbourhoods were 1.67 and 1.41 times more likely to have low fruit consumption (respectively) than those in the most advantaged neighbourhoods.	Men: Y Women: NS	Age, gender, race, energy intake, field centre, individual-level income.
Forsyth (1994)	691 (response rate % not available)	Living in a deprived vs. advantaged area	Residents of disadvantaged areas consumed 3.4 less servings of fruit per week compared to those living in the most advantaged areas.	Y	Age, gender, occupational class.

Table 10.3 (Continued)

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Giskes (2002a)	8883 (61%)	Household income	Men and women in the lowest income quintile consumed 77g and 73g less fruit (respectively) in the previous 24 hours than their counterparts in the highest income quintile.	Y for both men and women	Age, gender, energy intake
Giskes (2002b)	7695 (61%)	Household income	Men and women in the lowest income quintile were 2.3 and 2.5 times more likely (respectively) to *not* consume vegetables on a daily basis.	Y for both men and women	Age, gender, energy intake
Wandel (1995)	14960 (77%)	Household income	High-income groups were -1.78 less likely to consume fruits seldomly compared to low income groups.	NS for household income	Nil
Other factors					
Agudo (1999)	41448 (55-60% depending on region)	North-south location of residence within Spain	Overall, no consistent differences were observed between southern and northern regions regarding fruit intake (one region from the south consumed higher amounts of fruits than the remaining regions).	NS	Age, gender
Pan (1999)	63 (53%)	Residing in the US for a minimum of 6 months, instead of residing in an Asian country	When moving to the US, the frequency of fruit consumption increased from 12 to 15 times a week compared to when living in the Asian country of origin.	Y	Nil
Papadaki (2002)	80 (95,2%)	Residing in Scotland instead of Greece	Moving to Scotland (from Greece) resulted in 40% of the students changing their fresh fruits consumption from > 1 time/day to less than 1 time/day.	Y	Nil
Pollard (2001)	35367 women only (58%)	Region of residence in the U.K.	Participants in the north west of the UK consumed 0.39 portions less than those in the south west.	Y	Nil
Wandel (1995)	14960 (77%)	Region of residence in Norway	Living in the north, middle, south/west, east or the capital of Norway had no significant influence on being a frequent fruits consumer.	NS	Nil
Subar (1994)	20143 (response rate % not available)	Season (summer or winter)	In winter, men consumed 0.7 servings of fruits per week more than in the summer. In winter, women consumed 0.9 serving per week more than in the summer.	Not available	Age, race, region, education, poverty index.
Van Staveren (1996)	114 women only (response rate % not available)	Season (summer or winter)	Fruit consumption was 7g lower in winter compared to summer.	NS	Adjustment for time of the week: weekends, Friday, Monday-Thursday
Ziegler (1987)	900 (64%)	Season (summer-spring or winter-fall)	In winter-fall, participants ate 40 servings of fruit less per month than in summer-spring.	Not available	Nil

a Studies are grouped by the environmental determinant(s) they examine (following the classification of the framework). Within each subgroup, studies are grouped by specific determinants.

b Y= effects was statistically significant ($p \leq 0.05$). NS= effect was not significant.

Vegetable consumption

As for fruit, material factors were studied most often in relation to vegetable intake (Table 4). Household income demonstrated a consistent and significantly positive association with vegetable intake in seven associations [27-29, 40], even after adjustment for education and occupational social class [40]. People living in higher income neighbourhoods generally had higher energy-adjusted intakes of vegetables, than those living in lower income neighbourhoods [30], and this pattern was still present after adjustment for individual level income. Living in the most socially disadvantaged neighbourhood of Glasgow was associated with the poorest intakes [31], also when individual characteristics such as occupational class and income were taken into account. The same availability and social factors were studied for vegetables as for fruits, and associations were comparable to those with fruit intake as described above. Country and regional differences in vegetable intake were often significant [22, 29, 35-37]. Winter was negatively associated with vegetable intake in two studies [38, 39].

Fruit and vegetable consumption

The group of environmental factors that have been studied most often are those related to accessibility and availability of FV, though only five of the fourteen associations tested were statistically significant (Table 5). Men and women who reported eating home grown produce had a significantly higher FV consumption than those who did not [41]. The presence of a supermarket in the census tract where a participant lived had a significant relationship with the FV intake for black residents [21]. The presence of other food facilities in the census tract showed no significant relationships with the FV intake of blacks or whites [21]. Another study showed that positive perceptions of the accessibility of shops, the variety of FV in shops, and the affordability of FV were all positively related to FV intake, whereas car access showed no significant results [42]. Considerable differences between European countries in FV availability at the national level were found, with parallel differences in FV consumption between the populations [26].

Other categories of factors were less frequently studied for FV than for fruits and vegetable consumption as separate outcomes, but results were comparable. One exception was household income, where no significant differences in FV intake between high and low income households where found for men [43] and women [44], but the latter study showed a significant positive association between income and FV intake for men. People receiving benefits consumed significantly less FV than people not in receipt of benefits [41]. Residential area based deprivation significantly predicted FV intake, independently from occupational class and educational level [45]. Significant negative associations between living in a rural area and FV intakes were found for men and women [44].

Table 10.4 Results of studies examining environmental determinants of vegetable consumption[a]

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Accessibility and availability					
Agudo (1999)	41448 (55-60% depending on centre)	North-south location of residence within Spain	Overall, no consistent differences were observed between southern and northern regions regarding fruit intake (one region from the south consumed higher amounts of vegetables, while another from the north had lower amounts of vegetables than the remaining regions).	NS	Age, gender.
Cultural factors					
Devine (1999)	592 (82%)	Having a vegetable garden	Having a vegetable garden was positively and significantly associated with vegetable consumption.	Y	Age, gender, education, race.
Devine (1999)	592 (82%)	Parental and marital status	Being married + having a young child, or being single + having no child (vs. being single + having a young child) was positively and significantly associated with vegetable consumption.	Y	Age, gender, education, race.
Devine (1999)	592 (82%)	Presence of others during meal time	Eating with others was not associated with vegetable consumption.	Not available	Age, gender, education, race.
Diez-Roux (1999)	13095 (response rate % not available)	Median income of neighbourhood	Men and women in the poorest neighbourhoods were 1.20 and 1.11 times more likely to have low vegetable consumptions (respectively) than those in the most advantaged neighbourhoods.	NS men and women	Age, gender, race, energy intake, field centre, individual-level income.
Forsyth (1994)	691 (response rate % not available)	Living in a deprived vs. advantaged area	Residents of deprived areas reported consuming 2.2 servings less of vegetables per week than those in advantaged areas.	Y	Age, gender, occupational class.
Giskes (2002a)	8883 (61%)	Household income	Men and women in the lowest income quintile consumed 18g and 16g less vegetables (respectively) in the previous 24 hours than their counterparts in the highest income quintile.	Y for men and women	Age, gender, energy intake.
Giskes (2002b)	7695 (61%)	Household income	Men and women in the lowest income quintile were 1.6 times more likely to *not* consume vegetables on a daily basis.	Y for men and women	Age, gender, energy intake.

Table 10.4 (Continued)

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Laaksonen (2004)	1992 (70%)	Household income	Men and women in low-income households were 1.54 and 1.42 times more likely to be low vegetable consumers (respectively) compared to those in high income households.	Y for men and women	Age, study year, education and occupation, marital status, having dependent children in the family.
Material factors					
Naska (2000)	142715 households (response rate % not available)	How much vegetables are available in the food supply in different countries	In Norway, a country of low availability (i.e. 102 g/person per day) 93% of the population did not reach the recommended intake for vegetables, whereas in Greece, a country of high availability (267 g/person per day) 56% of the population did not reach WHO recommendations.	Not available	Nil
Other factors					
Pan (1999)	63 (53%)	Residing in the US for a minimum of 6 months instead of residing in an Asian country.	When moving from an Asian country to the US, the frequency of vegetable consumption decreased from 26 to 21 times per week.	Y	Nil
Papadaki (2002)	80 (95.2%)	Residing in Scotland instead of Greece.	Moving to Scotland (from Greece) resulted in 52% of the students changing their raw vegetables consumption from > 1 time/day to less than 1 time/day. Moving to Scotland (from Greece) had no significant effect on the consumption of cooked vegetables.	Raw vegetables: Y Cooked vegetables: NS	Nil
Pollard (2001)	35367 women only (58%)	Having children, marital status	Those without children consumed 0.17 portions less than participants with children. Single participants consumed 0.60 fewer portions of vegetables than their married counterparts.	Children: Y Marital status: Y	Nil
Pollard (2001)	35367 women only (58%)	Region of residence	Participants in the north west consumed 0.32 portions less than those in the south west.	Region of residence: Y	Nil
Social factors					
Tingay (2003)	431 (87%)	Food insecurity	Participants with food insecurity had a likelihood of 0.43 (0.25, 0.74) for consuming vegetables daily compared to their counterparts that were food secure.	Y	Age, sex

Table 10.4 (Continued)

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Van Staveren (1996)	114 women only (response rate % not available)	Season: summer or winter	Vegetable consumption was 45g lower in the winter compared to summer.	Y	Day of the week
Wandel (1995)	14960 (77%)	Number of children in household, household size	Those with children were -0.15 less likely to be frequent consumers of vegetables than participants without. Participants in households with more than 2 people were 1.11 times more likely to be frequent vegetable consumers than those living alone.	NS for having children Y for household size.	Nil
Wandel (1995)	14960 (77%)	Household income	High-income groups were -0.89 times less likely to consume vegetables seldomly than low income groups.	Y	Nil
Wandel (1995)	14960 (77%)	Region of residence	Those living in the north of Norway were –0.73 less likely to be frequent vegetable consumers than those living in Oslo.	Y	Nil
Ziegler (1987)	900 (64%)	Season: summer-spring or winter-fall	In winter-fall, participants ate 11 servings of vegetables less per month than in summer-spring.	Not available	Nil

a Studies are grouped by the environmental determinant(s) they examine (following the classification of the framework). Within each subgroup, studies are grouped by specific determinants.
b Y= effects was statistically significant ($p \leq 0.05$). NS= effect was not significant.

Table 10.5 Results of studies examining environmental determinants of fruit and vegetable consumption[a]

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Accessibility and availability					
Billson (1999)	1444 (70%)	Having home grown produce	Eating home grown produce was very significantly associated with higher FV consumption. More than 40% of the men and women in the highest FV consumption quartile consumed home grown produce.	Y for men and women	Nil
Naska (2000)	142715 households (response rate % not available)	How much fruits and vegetables are available in the food supply in different countries	In Ireland, a country of low availability (i.e. 233 g/person per day) 88% of the population did not reach the recommended intake for FV, whereas in Greece, a country of high availability (617 g/person per day) 37% of the population did not reach WHO recommendations.	Not available	Nil
Dibsdall (2003)	680 (23%)	Accessibility (of shops, choice of FV in shops), affordability, car access	People that indicated to eat five or more portions of FV per day had a significantly more positive attitude towards their accessibility of FV than people eating two or less FV portions per day. People that indicated to eat five or more portions of FV per day had a significantly less negative attitude towards the affordability of FV than people eating four or less FV portions per day. 68% of the people that indicated to eat five or more portions had access to a car, while resp. 55% and 48% of the people that ate 0-2 and 3-4 portions had car access.	Accessibility: Y Affordability: Y Car access: not reported	Nil
Morland (2002)	10623 (response rate % not available)	Whether or not there were the following food stores in the census tract: - Supermarkets - Grocery stores - Full service restaurants - Fast food restaurants	Likelihood of reaching fruit and vegetable recommendations for white Americans (N=8231) with the following stores in the census tract: - Supermarkets 1.08 (0.89, 1.30) - Grocery stores 0.93 (0.78, 1.10) - Full service restaurants 0.94 (0.75, 1.19) - Fast food restaurants 1.12 (0.91, 1.37) Likelihood of reaching fruit and vegetable recommendations for black Americans (N=2392) with the following stores in the census tract: - Supermarkets 1.54 (1.11, 2.12) - Grocery stores 1.07 (0.83, 1.38) - Full service restaurants 1.06 (0.79, 1.41) - Fast food restaurants 0.94 (0.74, 1.21)	White Americans: NS for all types of food outlets Black Americans: Supermarkets: Y Other outlets: NS	Education, income and other types of food stores

Table 10.5 (Continued)

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Social factors					
Billson (1999)	1444 (70%)	Marital status	Among men, being married was associated with increased FV intake and being single or divorced/separated was associated with low FV intake.	Men: Y Women: NS	Nil
Kintner (1981)	84 (response rate % not available)	Overall family functioning Cohesion-aspect of family functioning (whether family members help and support each other)	Overall, the associations of family functioning with FV intakes were small and non-significant. Family help and support was significant and positively correlated with FV consumption among women (not among men).	Overall family functioning: NS Y for help and support among women.	Nil
Pollard (2001)	35367 women only (58%)	Having children, marital status	The likelihood of being a high FV consumer was 1.09 (0.98, 1.21) for women with children compared to women with no children, and 1.62 (1.38, 1.91) for married women compared to single women.	Having children: NS Married: Y	Age, physical activity status, vegetarian status, intake of vitamin supplements, illnesses, alcohol consumption, education level, employment status, occupation, region of residence.
Steptoe (2004)	218 (response rate % not available)	Social support: from family, from others	Regression co-efficient for social support (family) is 0.10 (0.012, 0.18); change in variance: 1.9% Regression co-efficient for social support (other) is 0.10 (0.011, 0.19); change in variance 1.8%	Social support (family): Y Social support (other): Y	Experimental group, gender, ethnicity, income, smoking, baseline F/V consumption
Cultural factors					
Kintner (1981)	84 (response rate % not available)	Intellectual-cultural aspect of family functioning	The intellectual-cultural aspect of family functioning (whether the family is concerned about political, social, intellectual, and cultural activities) was significantly correlated with FV intake for women.	Y for intellectual-cultural aspect among women.	Nil
Material factors					
Billson (1999)	1444 (70%)	Receiving benefits	Being in receipt of benefits was negatively associated with FV intake	Men: Y Women: Y	Nil

Table 10.5 (Continued)

First author (year)	Sample size (response rate %)	Environmental determinant(s)	Findings	Was association significant? [b]	Adjusted for
Shohaimi (2004)	22562 (38%)	Deprivation of residential area	Men and women in the most deprived areas consumed 26.5g/d and 16g/d less fruit and vegetables (respectively) compared to their most advantaged counterparts.	Men: Y Women: NS	Occupational class, education, age
Johansson (1998)	1564 (87%) + 3144 (63%)	Household income	Low income men consumed 1g less fruit and vegetables per day than high income men. Low income women consumed 35g more fruit and vegetables per day than their high income counterparts.	Men: NS Women: Y	Nil
Johansson (1999)	3144 (63%)	Household income	Low income men consumed 32g less fruit and vegetables than high income men. Low-income women consumed 7g more fruit and vegetables than high income women.	Men: Y Women: NS	Age, gender, education
Other factors					
Billson (1999)	1444 (70%)	Region of residence in the U.K.	Among women, living in Scotland was negatively associated with FV intake, whereas living in London or the South-East of the U.K. was positively associated with FV consumption.	Women: Y Men: NS	Nil
Johansson (1999)	3144 (63%)	Residing in an urban vs. rural area in Norway	Men living in rural areas consumed 47g less fruit and vegetables than those in cities, whereas women in rural areas consumed 58g less fruit and vegetables than their counterparts living in cities.	Men: Y Women: Y	Age, gender, education
Papadaki (2002)	80 (95,2%)	Residing in Scotland instead of Greece	The median estimated daily intake of fruit and vegetables decreased from 363g in Greece to 124g in Glasgow.	Not available	Nil
Pollard (2001)	35367 women only (58%)	Region of residence in the UK	The likelihood of being a high FV consumer was 0.71 (0.55, 0.93) for women living in the northwest of the UK and 2.09 (0.62, 6.99) for women in Northern Ireland, compared to women in the north east.	NS	(See above)
Subar (1994)	20143 (response rate % not available)	Season (summer/winter)	In winter, men consumed 0.5 servings per week more than in the summer. In winter, women consumed 1 serving per week more than in the summer.	Not available	Age, race, region, education, poverty index.
Ziegler (1987)	900 (64%)	Season (summer-spring or winter-fall)	In winter-fall, participants ate 49 servings of FV less per month than in summer-spring.	Not available	Nil

a Studies are grouped by the environmental determinant(s) they examine (following the classification of the framework). Within each subgroup, studies are grouped by specific determinants.

b Y= effects was statistically significant ($p \leq 0.05$). NS= effect was not significant.

Discussion

We performed a systematic review of environmental determinants of FV intakes. Household income was investigated in six studies that showed in general consistent positive associations with FV intakes [27-29, 40, 43, 44]. Being married [22, 33, 41], and residing in an advantaged area (even after adjustment for individual characteristics like occupation or income level) [30, 31, 45] showed positive –though not always significant- associations with FV consumption, in at least three studies of acceptable quality. Good local availability of FV (e.g. by growing FV in one's own garden, or having low food insecurity) also seemed positively related to intakes, although the evidence was limited. Overall conclusions should be drawn with caution, due to the confined number of studies for each specific environment–intake association.

Income and being married, two of the factors studied most frequently, may not sound as typical environmental influences. However, income has been described as a feature of an individual's micro-environment elsewhere [46]. In our view, household income is a true environmental influence, as all household members are exposed to one and the same household income -whether they are breadwinner, housewife or child. Being married (i.e. living together with a partner) compared to being single, can be viewed as a socio-environmental factor, since the presence of a partner may affect a person's FV intake via his/her eating patterns, social support, sociocultural norms, home availability of FV (when the partner does most of the groceries, often the case for men), etc.

The finding that people living on a smaller household budget or in disadvantaged areas consume less FV may be due to the perceptions that FV are expensive [47, 48] [17], have a short shelf life, or are difficult to store [28]. Although food has been found to be equally or lower priced in deprived areas [47, 49], people pay a relatively higher premium on the price of healthy compared to less healthy foods in deprived areas [47, 48]. Interventions to improve opportunities for sufficient FV consumption among low-income households seem necessary to improve intakes. Offering discount coupons for FV-rich menu items has been shown to be an effective strategy to encourage consumption of these foods in certain venues [50]. Nevertheless, more research into the associations between household income and FV consumption is necessary to better understand the precise mechanisms that lead from low incomes to low intakes.

Three dependent variables, i.e. fruit consumption, vegetable consumption, and FV consumption combined, were studied. As can be derived from Table 2, no major differences in their relationships with environmental factors were observed. However, associations have been studied most for FV consumption when combined (45 tests) and less for fruit and vegetable consumptions sepa-

rately (27 and 28 tests respectively). Researchers might assume that environmental determinants relate to fruit and vegetable consumption in the same way, and therefore take both dietary measures together as one outcome. It seems reasonable to presume that, for instance, the presence of a supermarket in one's neighbourhood relates to the accessibility of fruits and vegetables in the same way. Other factors, however, can be important for fruit rather than for vegetable intake (e.g. the presence of fruit in the fruit bowl on the home table may elicit fruit consumption) and vice versa (e.g. cultural specific eating patterns may determine the amount of vegetables eaten during meals). Other research has found that similar behaviours (such as walking and cycling) do in fact show different associations with some environmental factors [51, 52]. Hence, it seems important for future research to investigate environmental influences on fruit and vegetable consumption separately.

Four categories of environmental variables were distinguished in this study. We have found about an equal, though fairly low number of studies examining accessibility, social and material factors (resulting in 24, 20 and 26 tests respectively). Only two studies examined cultural factors (3 tests in total), of which one study was of doubtful quality [53]. This very low number of studies for cultural factors might be surprising, since culture has been known as the foundation that underlies food choices, as it determines what people consider to be acceptable and preferable foods, and the amount and combinations of food they choose [54]. On the other hand, cultural influences may be difficult to conceptualise and measure, and they have rarely been specified in health behaviour models. One exception is the Theory of Triadic Influences, that incorporates the cultural environment as one of the ultimate influences on health behaviour [55]. A more specific conceptualisation of cultural factors in health behaviour models may be needed to explore the pathways between, for instance, cultural-specific eating patterns and FV consumption.

Two groups of factors, regional and seasonal influences, were grouped under a separate heading of 'other factors', since it was unclear how they relate to FV intake. This could, for instance, be via availability of FV in a certain area or season, or via culturally determined FV consumption patterns in an area or season. Although studies were often of low quality, it can be concluded that living in the north of the U.K is not beneficial for one's FV consumption compared to other parts of the U.K. [22, 41] or to living in Greece [37]. This can be related to the fact that average income levels are generally known to be lower in the North East of England and Scotland compared to the South East of England. Seasonal influences showed mixed associations with intakes.

Study limitations

There were several limitations of this review study that have to been taken into account in the interpretation of the findings. The search strategies did not locate 'grey literature' (e.g. unpublished studies, local reports, PhD and Masters abstracts). However, it was reasoned that problems with including grey literature (poor study quality due to lack of peer review [56] and time and costs involved in identifying and retrieving grey literature [57]), outweighed the possible advantage of preventing our results from the influence of publication bias. However, we could have missed important 'grey literature' that could have contributed to this review (e.g. [58])

Another limitation is that measurements of dietary intakes differed between studies. In sixteen papers, intakes were measured by a food frequency questionnaire, with the number of food items ranging from 2 (one for fruit and one for vegetables) [59] till 217 different food items [22]. Less frequently used measurement tools were a 7-day food consumption diary [41], and a 24-h dietary recall [27, 28, 38]. The validity of the measures was hardly discussed in these papers. It is likely that the variation in measures for fruit and vegetable intakes, as well as for the environmental determinants, may have contributed to 'noise' or variation in the associations found.

Three other limitations directly relate to the relatively few studies found in this area of research. Firstly, there is very little known about appropriate confounders in the relationship between the environment and FV intake. Some studies included in this review may 'overcorrect' for individual factors that are on the pathway between the environment and FV intake (e.g. being a vegetarian), which wrongly diminishes the actual association. In studies that do not correct for confounders or only adjusted for a limited set (age, sex, and education/occupation), associations might be overestimated. This makes it possible that this review gives an 'overestimated' overview of relevant environmental factors. It is likely that future research, when taking correct confounders into account, will show that some associations are non-existent.

Moreover, this review lacks an estimation of the relative importance of environmental compared to individual level factors, as most studies did not report on the strength of the associations found. Just one study reported that social support from family and social support from others accounted for 1.9% and 1.8% of the variance in fruit and vegetable intake, respectively [59]. Compared to the proportion explained variance by typical individual level factors, this is rather small [7, 8]. For instance, four psychosocial correlates – importance of eating vegetables, health benefits, convenience and taste of raw vegetables, and taste of cooked vegetables – explained 14% of the variance in vegetable intake [7]. In general, the proportion of variance explained by environmental factors will be

substantially smaller than for individual level factors, since the latter factors are much closer related to the actual behaviour. Subsequent research in this area should focus on the relative importance of these factors.

Finally, the fact that studies in this review originate from different countries makes the interpretation of the results difficult. Relevant availability-related influences may be country specific, as, for instance, neighbourhood differences in the accessibility of supermarkets and grocery stores appear to only exist in the U.S. [60]. As can be derived from Table 1, factors related to local availability of FV (i.e. having one's own vegetable garden, low food insecurity, presence of a supermarket in the residence area, and positive perceptions of the accessibility of FV shops) were positively associated with intakes in the U.S. as well as the U.K. Nevertheless, the availability of FV on the national level differed considerably for European countries (in 1990), ranging from 233 g of FV per person per day in Ireland to a total of 617 g/person per day in Greece, with parallel differences in intakes. [26].

Comparison with other reviews

We located four other reviews on environmental determinants of either FV consumption or healthy diets, by searching several databases and the reference lists of studies. These reviews differed from ours in that they were not performed in a systematic way, had a more narrative tenor or focused on other dietary outcomes. Our findings are in line with these studies regarding the associations of accessibility and household income with FV consumption [8, 61] or healthy eating [62, 63]. Individual consumers need sufficient access to quantities of fruits and vegetables at affordable prices and in forms that meet standards for quality, taste, palatability and convenience to be able to meet recommended intake levels. This is often not the case, especially among low income households in poor central cities and sparsely populated rural areas [64]. The increasing numbers of meals being consumed away from home was also stressed as an important factor for unhealthy eating [62, 63]. Away-from-home foods typically have higher energy and fat densities and larger portion sizes, which are associated with a decreased diet quality and increased total energy intake [63]. Reviews also stressed the necessity to improve our understanding of food environments, referring to the small number of studies in this research area, and that existing studies suffer many limitations (e.g. small population sizes, non-longitudinal designs, and geographic isolation) [62, 63].

Conclusions and recommendations

There is a clear need for more research on supportive food environments, ideally for different dietary intakes separately, as relevant environmental factors may differ for various outcomes. This research should preferably be longitudinal, to understand the causal pathways between the environment and intakes.

Studies should investigate the strength of the associations observed, or specifically, study the relative importance of environmental compared to individual-level factors, as has been done for environment-physical activity associations [11, 65]. A good theoretical framework should underlie this research, so that hypotheses can be formed and tested, to further develop scientific knowledge and theory in this emerging field. Specifically, extensive research into accessibility- and availability-related influences and cultural influences can result in new explanations for variations in FV consumption, and offer new avenues to promote behaviour change towards recommended FV intakes.

In summary, with the available data, it can be concluded that consumption of FV is likely to be higher among people with higher incomes, being married, living in an advantaged neighbourhood and/or with good local availability and accessibility of FV. However, the evidence base for the latter determinants is still too thin to justify large-scale interventions targeting those environmental determinants. The only exception to this is household income. Interventions to improve opportunities for sufficient FV consumption among low-income households are likely to lead to improved intakes.

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11

Household and food shopping environments: do they play a role in socioeconomic inequalities in fruit and vegetable consumption? A multilevel study among Dutch adults

Giskes K, Kamphuis CBM, Van Lenthe FJ, Huisman M, Brug J Mackenbach JP Household and food shopping environments: do they play a role in socioeconomic inequalities in fruit and vegetable consumption? A multilevel study among Dutch adults. (in press with *Journal of Epidemiology and Community Health*)

Abstract

Background Fruit and vegetables are protective of a number of chronic diseases, however their intakes have been shown to vary by socioeconomic position (SEP) and between areas. Household and food shopping environmental factors are thought to contribute to these differences. The objective of this study is to determine whether household and food shopping environmental factors are associated with fruit and vegetable (FV) intakes, and contribute to socioeconomic and between-area variations in FV consumption.

Methods Cross-sectional data were obtained by a postal questionnaire among 4333 adults (23-85 years) living in 168 neighbourhoods in the south-eastern Netherlands. Participants agreed/disagreed with a number of statements about the characteristics of their household and food shopping environments. Education was used to characterize socioeconomic position (SEP). Main outcome measures were whether or not participants consumed fruit or vegetables on a daily basis.

Results Household and food shopping environmental factors only made a small contribution to explaining fruit and vegetable consumption. Participants who perceived FV to be expensive were more likely to consume them. There were significant socioeconomic and between-area variations in fruit and vegetable consumption; however these were not explained by any household or food shopping environmental factors.

Conclusions Improving access to FV in the household and food shopping environments will only make a small contribution to improving population consumption levels, however they will not decrease socioeconomic and between-area variation in their consumption.

Introduction

Dietary behaviours have been established as risk factors for a number of chronic diseases. In Western countries, the most prevalent of these diseases are cardiovascular diseases and cancer [1-2]. Population-based nutrition messages, such as dietary guidelines, have focused on improving intakes of total fat, saturated fat and antioxidant vitamins to decrease the incidence of these diseases. These guidelines almost universally encourage increased consumption of fruits and vegetables (FV) [2-4]. However, research has shown that a large proportion of the population does not meet dietary recommendations for FV consumption [2-5]. Consumption of FV has been shown to be particularly low among socioeconomically-disadvantaged groups [6-8].

A number of factors have been thought to contribute to low FV consumption among the population. These can be broadly classified as operating at the individual or environmental levels. Individual-level factors are those that operate *internal* to the individual and include knowledge, beliefs, attitudes and cognitions about FV consumption. Nutrition knowledge and beliefs about their health benefits have been associated with higher consumptions of FV [9, 10]. Greater self-efficacy, motivation and perceived norms for FV consumption have also been associated with higher consumptions of FV [9, 11]. Taken together, individual-level factors only account for 20-35% of the variance in FV consumption [12]. Therefore, efforts to bring about change in these factors have only shown limited effects.

Over the past decade there has been an increased movement toward a more ecological approach to understanding health-related behaviours [13]. This has partly resulted from studies showing significant between-area differences in a range of health-related behaviours, thereby implicating that environmental factors play an important role in shaping people's health-related behaviour [14]. Social ecological theory posits that people interact with their environment and that characteristics of these environments (such as access and availability) influence their health behaviours and may constrain their ability to bring about change [15]. The recent increased popularity of the social ecological approach has resulted in an upsurge in the number of studies examining the role of factors *outside* individuals, such as characteristics of household and residential environments, and their influence on health-related behaviours [16, 17].

Discussion in the literature suggests that household and food shopping environments play an important role in FV consumption. Specifically, availability of fruit and vegetables in the household, the FV consumption of other household members as well as access to shops selling FV and the selection, quality and price of FV in these shops have been suggested to play an important role

[18-20]. However, two recent systematic reviews examining the empirical evidence for environmental factors associated with energy, fat and FV intakes concluded that there is little evidence to support these assertions [21, 22]. A major limitation of previous research is that there have been few replicated studies examining FV consumption as outcomes, and the contributions of the household and food shopping environments specific to FV intakes. Furthermore, the contributions of these factors to socioeconomic inequalities in FV intakes have remained largely unquantified. Environmental interventions, and policies targeted at changing the characteristics of environments are now being promoted as promising strategies to improve health behaviour among the population [17, 23]. Due to the limited evidence base, it is currently not known which elements of the household and food shopping environments need to be targeted in order to improve population intakes of FV, and to decrease socioeconomic inequalities in their intakes.

The current study addresses this knowledge gap. Specifically, it aims to determine whether household and food shopping environmental factors are associated with fruit and vegetable (FV) intakes, and whether these factors contribute to socioeconomic inequalities in FV consumption.

Methods

Participants

Data for this cross-sectional study were obtained by postal survey from the latest wave of the longitudinal GLOBE study (October 2004). The GLOBE study is a Dutch study examining the determinants of socioeconomic inequalities in health, and is comprised of a stratified population-based sample from the south-eastern region of the Netherlands. Detailed information about the objectives, design and findings of the GLOBE study are available elsewhere [24].

Participants in this wave of the GLOBE study (n=6377, response 64.4%) consisted of two sub-samples. One of these (n=4323, response 74.4%) comprised of participants that responded to the baseline questionnaire of the GLOBE study (undertaken in 1991). Attrition from the baseline postal survey was due to death (12.3%), emigration (2.0%), refusal to be followed up longitudinally (2.2%) and addresses that could not be traced (2.8%). Due to these factors, the sub-sample was no longer representative of the population. Therefore, a second sub-sample comprised of new participants (n=2054, 55.0% RR) was added to restore the population representativeness of the GLOBE study sample.

Fruit and vegetable intakes

Fruit and vegetable intakes were measured by a food frequency questionnaire (FFQ) that has been shown to have good validity and reliability among the

Dutch population [25]. The FFQ had a reference period of one month and included the types or categories of fruits and vegetables (including juices) consumed most frequently by the Dutch population. Potatoes were not included in the FFQ as they are not considered a vegetable in the Dutch dietary recommendations [25]. Participants were asked how many times they consumed each item on a weekly or monthly basis. Subsequent questions asked participants to indicate how many portions they ate on a typical occasion (e.g. how many pieces, serving spoons, glasses). Intakes of each item were calculated by multiplying consumption frequency and portion size. Intakes were summed across the various items to obtain total fruit and vegetable intakes, these were then dichotomised to identify participants most in need of intervention for fruit and vegetable intakes; i.e. those consuming no fruit or vegetables (i.e. 0 grams) daily.

Food environment

Prior to developing the postal questionnaire, we conducted focus groups and a systematic review of the literature to identify the most salient environmental factors in relation to fruit and vegetable consumption. The focus groups comprised of GLOBE study participants from different socioeconomic backgrounds. During the focus groups, participants were asked about their main barriers and facilitators to consuming fruit and vegetables [21]. Those factors mentioned with the most frequency, the greatest intensity and that were talked about differentially among socioeconomic groups were selected for inclusion in the postal questionnaire. We also conducted a systematic literature review summarising the evidence pertaining to environmental factors associated with fruit and vegetable intakes among adults and selected the most important factors identified in the literature [8, 21]. Using these methods, seven salient environmental factors were identified in relation to fruit consumption and eight factors regarding vegetable consumption. On the postal questionnaire participants were presented with a series of statements relating to each factor (e.g. 'fruit is expensive') and were provided the response categories 'agree' and 'disagree'. Also, participants indicated the frequency with which these factors were actual barriers for their FV consumption (often, sometimes, seldom/never). Responses to these statements were missing for approximately 5% of the sample. Missing values were imputed by drawing randomly from the binomial distribution using observed prevalences per education class as probabilities.

Socioeconomic position

Participants were asked about their highest attained level of education. From the eight response categories, four categories were constructed: elementary (8 or less years), lower secondary (9-11 years), higher secondary (12-13 years) and tertiary (14 or more years). We also measured household income, asking participants to report their net monthly household income (0-1200 euro,

1200-1800 euro, 1800-2600 euro, 2600 euro or more, and 'don't want to say/ don't know').

Statistical analyses

Participants that had moved out of the study region (n=1528) were excluded from the analyses. Those with missing values for education or fruit/vegetable consumption (n=277) were excluded, as well as participants with missing values for one or more of the confounding variables, i.e. age, sex (n=93). Furthermore, we excluded participants residing in neighbourhoods with less than three participants (n=146). Therefore, the analytic sample comprised of 4333 participants, who resided in 168 neighbourhoods (mean number of participants per neighbourhood= 26, range 4-112).

To take into account clustering in the environmental factors between neighbourhoods, multilevel models consisting of participants (level 1) nested in neighbourhoods (level 2) were used in all analyses. The analyses for this study comprised of two phases: a descriptive phase and a multivariable modelling phase. In the descriptive phase, associations between SEP, the food environments and fruit/vegetable consumption were examined by cross-tabulations.

In the multivariable modelling phase, logistic regression models (using the link-logit function and 2nd order PQL estimation methods [26]) examined the associations of (groups of) household/food shopping environmental factors with FV consumption. Subsequent analyses examined education differences in fruit/vegetable consumption. Household and food shopping environment factors were then entered (first separately, then simultaneously) in order to investigate their contribution to the education inequalities. The factors of interest in these analyses were the direction and significance of the fixed effects for the household/food shopping environment factors, and the attenuation of the magnitude of inequalities when groups of factors were added. Clustering of fruit/vegetable consumption within neighbourhoods was determined by calculating the median odds ratio (MOR) with 95% credible intervals (CRI), using the posterior distribution of the area variance as provided by the Markov Chain Monte Carlo procedure. The MOR was calculated using the following formula [27]:

$$\begin{aligned} MOR &= \exp[\sqrt{(2 \times \text{area variance})}] \times 0.6745 \\ &\approx \exp(0.95\sqrt{\text{area variance}}) \end{aligned}$$

All analyses were weighted to take into account the over-representation of older participants, and participants with chronic diseases in the sample (relative to the population of the region). Additionally, all analyses were adjusted for gender and age (continuous) and were conducted in MLwiN version 2 [28].

Results

The mean age of the sample was 48.0 years (sd = 13.3 years) and 54.1% were female. 86.5% and 85.1% of respondents consumed fruit and vegetables on a daily basis (respectively). Table 1 summarises the associations between environmental factors and fruit consumption, and education differences in the perceptions of environmental factors. Participants who reported there was not much fruit in their household, that there were no shops where they could buy fruit in their neighbourhood or had difficulty getting to shops that sold fruit were less likely to consume fruit. However, those who perceived fruit as expensive were more likely to consume it.

Table 11.1 Bivariate associations between household/food shopping environments, fruit consumption and education

	OR of no fruit consumption		Proportion of respondents by education level				
	OR [a]	95% CI	1 (low)	2	3	4 (high)	p [b]
Household environment							
There is not much fruit in my household							
Agree	1.86	1.33 to 2.59	11.3	5.8	8.3	8.6	
Disagree	1.00		88.7	94.2	91.7	91.4	<0.01
My family do not eat much fruit							
Agree	1.17	0.87 to 1.57	15.7	15.7	17.0	12.9	
Disagree	1.00		84.3	84.3	83.0	87.1	0.03
Food shopping environment							
In my neighbourhood there are no shops where I can buy fruit							
Agree	1.60	1.06 to 2.41	3.0	4.1	3.1	3.8	
Disagree	1.00		97.0	95.9	96.9	96.2	0.52
Fruit is expensive							
Agree	0.79	0.62 to 1.00	53.9	53.6	44.5	41.0	
Disagree	1.00		46.1	46.4	55.5	59.0	<0.01
The selection of fruit is limited							
Agree	1.45	0.87 to 2.41	7.5	3.0	2.6	3.5	
Disagree	1.00		92.5	97.0	97.4	96.5	<0.01
It is difficult to get to shops that sell fruit							
Agree	2.12	1.07 to 4.20	2.2	1.1	0.7	1.0	
Disagree	1.00		97.8	98.9	99.3	99.0	0.09
The fruit is of bad quality							
Agree	1.12	0.61 to 2.05	3.0	2.0	2.8	3.5	
Disagree	1.00		97.0	98.0	97.2	96.5	0.11

a Analyses adjusted for gender, age.
b Denotes p-value for education differences in prevalence of responses.

Overall, a large proportion of participants (52.5%) perceived that fruit was expensive and this perception was more frequent among lower socioeconomic groups. Only a small proportion (10-15%) reported household factors as being important. There were small education gradients in household factors being reported as important, with lower-educated groups agreeing with the statements more frequently. Few participants (<10%) agreed with other statements relating to the food shopping environment, however there were small education gradients for some factors that reached statistical significance.

Table 11.2 Bivariate associations between household/food shopping environments, vegetable consumption and education

	OR of no vegetable consumption		Proportion of respondents by education level				
	OR [a]	95% CI	1 (low)	2	3	4 (high)	p [b]
Household environment							
There are not many vegetables in my household							
Agree	1.21	0.85 to 1.72	9.4	6.4	8.3	9.5	
Disagree	1.00		90.6	93.6	91.7	90.5	0.02
My family do not eat many vegetables							
Agree	1.07	0.77 to 1.50	7.7	9.3	10.4	8.0	
Disagree	1.00		92.3	90.7	89.6	92.0	0.14
The person who cooks in my household does not cook many vegetables							
Agree	3.03	1.90 to 4.86	2.8	2.1	2.8	2.7	
Disagree	1.00		97.2	97.9	97.2	97.3	0.65
Food shopping environment							
In my neighbourhood there are no shops where I can buy vegetables							
Agree	1.67	1.13 to 2.46	8.3	5.6	3.8	4.5	
Disagree	1.00		91.7	94.4	96.2	95.5	<0.01
Vegetables are expensive							
Agree	0.79	0.63 to 0.98	53.3	49.1	41.2	37.3	
Disagree	1.00		46.7	50.9	58.8	62.7	<0.01
The selection of vegetables is limited							
Agree	1.45	0.98 to 2.14	7.5	4.7	4.3	5.6	
Disagree	1.00		92.5	95.3	95.7	94.4	0.07
It is difficult to get to shops that sell vegetables							
Agree	1.37	1.12 to 3.92	3.3	1.5	1.1	1.0	
Disagree	1.00		96.7	98.5	98.9	99.0	<0.01
The vegetables are of bad quality							
Agree	1.27	0.69 to 2.33	3.9	2.5	3.5	3.7	
Disagree	1.00		96.1	97.5	96.5	96.3	0.30

a Analyses adjusted for gender, age.
b Denotes p-value for education differences in prevalence of responses.

Associations between environmental factors and vegetable consumption, and education differences in the perceptions of environmental factors in relation to vegetable consumption are shown in Table 2. Living in a household where the cook did not prepare many vegetables was strongly associated with not consuming vegetables. Likewise, having no shops in the neighbourhood where vegetables could be purchased or having difficulty getting to shops that sold them was associated with not consuming them.

The majority of participants (55.9%) agreed that vegetables were expensive. However, only a small proportion agreed with other statements relating to household or shopping environmental factors. There were inverse education gradients in participants reporting there were no shops where they could buy vegetables, that vegetables were expensive, that the selection of them was limited where they shopped, and that it is difficult for them to get to shops that sold vegetables. The magnitude of these gradients were small, however the large sample size resulted in them reaching statistical significance.

The contribution of the household and food shopping environmental factors to fruit consumption is shown in Table 3. The base model showed direct and graded associations between education and fruit consumption; participants with lower education were more likely to not consume fruit daily. Subsequent models in this table show that the addition of household and food shopping environmental factors (in separate and combined models) did not make a contribution to explaining socioeconomic differences in fruit consumption. Three environmental factors were significantly associated with fruit consumption in the fully-adjusted model; having no fruit at home and living in a neighbourhood where there were no shops to purchase fruit were associated with no consumption. However, participants that perceived fruit as expensive were more likely to consume it.

Table 11.3 Contribution of the household and food shopping environments to education and between-area inequalities in consumption of no fruit[a]

	Base model	Base model + household environment	Base model + shopping environment	Base model + all predictors
	OR of no fruit consumption (95% CI)			
Education level				
1 (low)	4.26 (3.00 to 6.07)	4.14 (2.91 to 5.89)	4.44 (3.18 to 6.19)	4.35 (3.06 to 6.19)
2	2.36 (1.80 to 3.11)	2.41 (1.83 to 3.17)	2.48 (1.85 to 3.33)	2.51 (1.87 to 3.37)
3	1.60 (1.15 to 2.23)	1.60 (1.15 to 2.23)	1.63 (1.17 to 2.28)	1.63 (1.17 to 2.28)
4 (high)	1.00	1.00	1.00	1.00
Household environment				
There is not much fruit in my household				
Agree		1.86 (1.31 to 2.65)		1.88 (1.29 to 2.72)
Disagree		1.00		1.00
My family do not eat much fruit				
Agree		0.94 (0.69 to 1.29)		0.95 (0.70 to 1.30)
Disagree		1.00		1.00
Food shopping environment				
In my neighbourhood there are no shops where I can buy fruit				
Agree			1.68 (1.09 to 2.59)	1.67 (1.08 to 2.56)
Disagree			1.00	1.00
Fruit is expensive				
Agree			0.71 (0.56 to 0.90)	0.70 (0.55 to 0.88)
Disagree			1.00	1.00
The selection of fruit is limited				
Agree			1.25 (0.69 to 2.24)	1.14 (0.62 to 2.09)
Disagree			1.00	1.00
It is difficult to get to shops that sell fruit				
Agree			1.54 (0.69 to 3.43)	1.49 (0.65 to 3.40)
Disagree			1.00	1.00
The fruit is of bad quality				
Agree			1.01 (0.49 to 2.09)	0.97 (0.46 to 2.04)
Disagree			1.00	1.00
Random effects				
Between area variance (SE)	0.17 (0.05)	0.16 (0.05)	0.17 (0.05)	0.16 (0.05)
Median Odds Ratio (MOR, 95% CrI)[b]	1.47 (1.18 to 1.67)	1.46 (1.16 to 1.69)	1.47 (1.17 to 1.67)	1.46 (1.16 to 1.69)

a Analyses adjusted for gender, age.
b MOR = exp (0.95√area variance) [27], CrI= credible interval.

Table 11.4 Contribution of the household and food shopping environments to education and between-area inequalities in consumption of no vegetables[a]

	Base model	Base model + household environment	Base model + shopping environment	Base model + all predictors
	OR of no vegetable consumption (95% CI)			
Education				
1 (low)	5.47 (3.92 to 7.64)	5.47 (3.92 to 7.64)	5.64 (4.04 to 7.87)	5.64 (4.04 to 7.87)
2	2.39 (1.81 to 3.14)	2.39 (1.78 to 3.20)	2.48 (1.85 to 3.33)	2.48 (1.85 to 3.33)
3	1.68 (1.23 to 2.30)	1.68 (1.23 to 2.30)	1.72 (1.25 to 2.35)	1.72 (1.23 to 2.39)
4 (high)	1.00	1.00	1.00	1.00
Household environment				
There are not many vegetables in my household				
Agree		1.02 (0.70 to 1.48)		1.03 (0.71 to 1.50)
Disagree		1.00		1.00
My family do not eat many vegetables				
Agree		0.85 (0.59 to 1.24)		0.85 (0.58 to 1.26)
Disagree		1.00		1.00
The person who cooks in my household does not cook vegetables				
Agree		3.16 (1.86 to 5.36)		2.97 (1.75 to 5.05)
Disagree		1.00		1.00
Food shopping environment				
In my neighbourhood there are no shops where I can buy vegetables				
Agree			1.54 (1.06 to 2.23)	1.46 (0.99 to 2.16)
Disagree			1.00	1.00
Vegetables are expensive				
Agree			0.69 (0.56 to 0.86)	0.69 (0.56 to 0.86)
Disagree			1.00	1.00
The selection of vegetables is limited				
Agree			1.34 (0.85 to 2.10)	1.34 (0.85 to 2.10)
Disagree			1.00	1.00
It is difficult to get to shops that sell vegetables				
Agree			1.43 (0.77 to 2.68)	1.30 (0.68 to 2.48)
Disagree			1.00	1.00
The vegetables are of bad quality				
Agree			1.11 (0.56 to 2.19)	1.01 (0.51 to 2.01)
Disagree			1.00	1.00
Random effects				
Between area variance (SE)	0.14 (0.06)	0.13 (0.06)	0.15 (0.06)	0.14 (0.06)
Median Odds Ratio (MOR, 95% CrI)[b]	1.40 (1.10 to 1.62)	1.41 (1.09 to 1.63)	1.44 (1.13 to 1.66)	1.40 (1.11 to 1.64)

a Analyses adjusted for gender, age.
b MOR = exp (0.95√area variance) [27], CrI= credible interval.

Table 4 summarises the contributions of household and food shopping environmental factors to vegetable consumption. The baseline model confirmed a marked socioeconomic gradient in vegetable consumption. However, the environmental factors examined did not contribute to explaining these inequalities in vegetable consumption. Living in a household where vegetables are not prepared and residing in a neighbourhood where there are no shops where vegetables can be purchased was associated with a reduced likelihood of vegetable consumption. Having the perception that vegetables are expensive was independently associated with their consumption.

All analyses were also performed using household income as SEP measure. The direction and magnitude of the income inequalities were similar to those reported for education. The role of household and food shopping environmental factors remained the same with household income. The addition of household income into the multivariate models did not decrease socioeconomic differences in FV consumption.

Discussion

Our study showed that perceptions of some household and food shopping environmental factors were related to FV consumption. However, due to their general low prevalence and small inequalities, they did not play a role in socioeconomic inequalities in their consumption. These findings suggest that interventions aimed at improving access to FV in the household and/or food shopping environments may only make a small contribution to improving population consumption levels. Moreover, the selected household and environmental characteristics may not decrease socioeconomic inequalities in their consumption.

Similar to other studies [2, 6, 7] we found strong socioeconomic gradients in FV consumption. The finding that the food shopping environment only made a small contribution to FV consumption, and did not contribute to socioeconomic inequalities in FV consumption was in line with both the emerging literature. Research from the UK [29] and Australia [10, 30] suggests that the food shopping environment may not play an important role in food purchasing decisions, or for explaining socioeconomic variation in food choice and FV purchasing. In contrast, findings from the US suggest that the food shopping environment in socioeconomically deprived areas is less conducive to making healthy food choices compared to more advantaged areas [31]. However, the Dutch situation may differ from the US in many ways that affect the food shopping environment. The Dutch population is less stratified along socioeconomic lines, is less geographically segregated by SEP, and the population density in the Netherlands is greater than the US [29, 32] and (consequently) shops are

always nearby. A recent Australian study found that a significant proportion of socioeconomic inequalities in FV consumption were explained by perceived availability, accessibility and affordability factors. However, this study was only conducted among women and measured general perceptions of the food environment, rather than perceptions of the food environment specific to FV [33]. Previous research that has examined socioeconomic differences in perceptions of barriers to consuming a health diet has shown that these are greater when perceptions about diet in general are measured, rather than when perceptions are assessed relative to a specific food group.

The finding that perceptions of the food shopping environment explained little of the socioeconomic variation in FV consumption is also in accordance with objective measures of the food shopping environment. Environmental audits of food shopping environments with respect to FV purchasing were conducted on a sub-set of 14 areas covered by the study (7 socioeconomically disadvantaged areas, 7 advantaged areas). An area of 1km from the centroid of each area was audited. Audits assessed the price and availability of fruits and vegetables in 61 shops. Deprived areas had greater access to supermarkets compared to advantaged areas, and were equally serviced in terms of fruit and vegetable shops (Table 5). The variety, price and quality of fruits were similar in socioeconomically deprived and advantaged areas, however vegetables were marginally (~10%) cheaper (on average) in deprived areas (Table 5). These findings suggest that deprived areas were at least equally (perhaps even slightly better) serviced in terms of their food shopping infrastructure with respect to FV purchase compared to socioeconomically advantaged areas. Similarly, an Australian study also found no differences in FV food shopping infrastructure, and the availability and price of FV in deprived and advantaged areas [30].

Our study is the first (known) study to quantify associations between accessibility of FV in the household and their consumption among adults. Studies among children/adolescents have found that household availability of FV, and the FV consumptions of parents are associated with their intakes [34]. However, we found little evidence to support that the household food environment plays a role among adults. This may be because adults exert a greater influence than children/adolescents on the food available in the household, and make most food purchasing decisions.

The findings of the current study suggest that the low FV consumption among adults, and socioeconomic inequalities in their consumption may have little to do with household and food shopping environments. In addition to perceptions, we also measured objective characteristics of the food environment, however we could not quantify the contribution of these factors to socioeconomic inequalities in FV consumption as only a limited number of neighbourhoods

were audited. Other environmental factors, such as cultural factors, may be more important. Culture has been known as the foundation that underlies food choices, as it determines what people consider to be acceptable and preferable foods, and the amount and combinations of food they choose [35, 36]. However, cultural influences were not measured in this study, as they are difficult to conceptualise and no validated questionnaires concerning cultural aspects of diet are known to be available. Variations in FV consumption could also be more a consequence of individual-level factors. A number of individual-level factors have been relatively under-researched in relation to FV consumption and inequalities in these, such as taste preferences, cooking skills and habit [37, 38]. Additionally, other household-level factors that were not measured in the current study such as facilities for FV preparation and storage, and the negotiation of food purchasing decisions among household members have been implicated to play a role in other studies [6, 38].

Table 11.5 Shop availability and price of fruits and vegetables in socioeconomically disadvantaged and advantaged areas [a]

	Disadvantaged areas (n=7)	Advantaged areas (n=7)
Shop (total n)		
Supermarket	34	15
Fruit & vegetable shop	4	3
Specialty shop (e.g. delicatessen, ethnic food store)	1	4
Average fruit prices (per kg, euro)		
Apples	1.15	1.21
Oranges	1.44	1.56
Banana	1.60	1.59
Kiwi	2.15	2.16
Pear	1.44	1.57
All fruit combined	7.77	8.08
Average vegetable prices (euro)		
Broccoli (1 head)	2.26	2.66
Beans (1 kg)	3.70	4.01
Cauliflower (1 head)	1.92	2.02
Carrots (1 kg)	1.20	1.68
Tomatoes (1 kg)	2.02	2.04
All vegetable combined	10.92	12.41

a All areas in the study region (n= 86) were ranked by their NIVEL deprivation index (derived from the proportion of the population that is economically active, average income, proximity index and proportion of the population who are non-western foreigners). The seven lowest and highest ranking areas were selected for audits.

There is little evidence to justify that interventions aimed at improving FV consumption in the Netherlands, and at reducing socioeconomic inequalities in them should target our selected determinants of the household/food shopping environments. The current study suggests that research into other environmental factors, such as cultural aspects of dietary habits, and individual-level factors could bring forth more salient determinants of FV consumption. Changes in these potentially important factors are more likely to bring about population dietary change and reducing inequalities in FV consumption than making changes to the household and/or food shopping environments.

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Part 4
Discussion

12

General Discussion

General Discussion

In this thesis, a series of studies are presented that focus on socioeconomic differences in health-related behaviours and the role of environmental factors. The objectives of this thesis are threefold: (1) to investigate socioeconomic differences in physical inactivity and diet, (2) to identify neighbourhood factors associated with physical inactivity or diet, (3) to study to what extent (and via which pathways) neighbourhood factors contribute to the explanation of socioeconomic differences in physical inactivity and diet. In this chapter, the main findings of the various studies are summarised (paragraph 12.1), methodological issues concerning the studies are addressed (12.2), results are interpreted and compared to findings from other studies (12.3), and implications of the results are considered, for theory (12.4), future research (12.5) and policy development (12.6).

12.1 Main findings

Moderate to large socioeconomic differences in health-related behaviours were observed, with those from most disadvantaged backgrounds being most likely to behave unhealthy, i.e. not participating in sports, not walking/cycling for recreation, and not consuming fruits and vegetables. Unfavourable perceptions of the neighbourhood, particularly with respect to attractiveness, safety and social cohesion, were related to several physical inactivity outcomes, and were more prevalent among lower SES groups. Our findings suggested that the neighbourhood environment has a moderate but significant contribution to the explanation of socioeconomic differences in specific types of physical inactivity. Neighbourhood factors may partly mediate the association between SES and physical inactivity *via* individual cognitions. On the other hand, our tests did not support that neighbourhood- or household-level factors contributed to socioeconomic inequalities in fruit and vegetable consumption. Perceptions of some household and neighbourhood factors were related to fruit and vegetable consumption, e.g. the availability of fruits in the household, whether or not the household cook prepared vegetables for dinner, and the presence of fruit and vegetable outlets in the neighbourhood. However, due to their general low prevalence and small inequalities, they did not play a role in socioeconomic inequalities in fruit and vegetable consumption.

Income and educational differences in health-related behaviours

In the chapters regarding socioeconomic differences in sports participation (Chapter 5), recreational walking (Chapter 6) and fruit and vegetable consumption (Chapter 11), we performed the same explanatory analyses separately for education and income as SES-indicators. The results suggest that the magnitude of the socioeconomic gradient in physical inactivity differs for different

SES-indicators, but that specific factors linking these indicators with physical inactivity do not differ markedly. Both with regard to sports participation and recreational walking, we found larger socioeconomic differences with education compared to income. Educational attainment attempts to capture the knowledge-related components of the concept of SES, whereas income most directly measures the material resources component of SES. This may suggest that socioeconomic differences in physical inactivity are more a result of differences in knowledge and preferences between SES-groups, than of differences in material resources available in the household. However, factors that contributed to the explanation of educational and income inequalities in health behaviours were similar for both SES-indicators. Explanatory factors contributed to a larger proportion of the income differences than educational differences in physical inactivity (partly a result of the fact that income differences were smaller to begin with). For fruit as well as vegetable consumption, the direction and magnitude of the socioeconomic gradient was similar for education and income, and the (lack of) explanatory value of household and food shopping environmental factors was the same for both outcomes and both SES-indicators.

Specificity in outcomes

The strength and, sometimes, the direction of associations with neighbourhood factors differed for specific physical inactivity outcomes. Perceived physical and social neighbourhood factors showed independent associations with doing any (vs. no) sports, but no neighbourhood factors were significantly associated with meeting (vs. not meeting) recommended levels of sports activity. However, poor neighbourhood attractiveness and neighbourhood safety (objective as well as perceived measures) appeared to be important for explaining socioeconomic differences in three physical activity behaviours: sports inactivity, lack of recreational walking, and lack of recreational cycling.

Objective versus perceived neighbourhood factors

Although most of the neighbourhood factors we studied were perceptions (i.e. self-reported by residents), the results suggested that these are at least partly a reflection of actual (objective) characteristics of neighbourhoods. We found that unfavourable neighbourhood perceptions of low SES-groups were partly explained by their actual less appealing and less safe neighbourhood environment, and additionally by individual psychosocial factors. That perceptions reflect actual neighbourhood circumstances was moreover shown by the finding that resident's perceptions of neighbourhood unattractiveness and unsafety clustered within neighbourhoods. This clustering reduced to a great extent when objective neighbourhood characteristics were taken into account, which underlined the importance of objective characteristics for neighbourhood perceptions. Lastly, our study in the city of Melbourne showed that objective area

characteristics play an important role for physical activity: objective measures of neighbourhood aesthetics and safety were found to contribute to the explanation of (socioeconomic) area variations in recreational cycling.

12.2 Methodological issues

The studies described in this thesis were conducted by an experienced research team, and great care was taken to attain valid results. However, several potential sources of bias may have threatened the internal validity (i.e. whether applied measures measured what we aimed to measure) and external validity of our results (i.e. whether results may be generalised to other populations than our research sample). In the next paragraphs, measurement issues regarding self-reported data and objective neighbourhood data will be discussed in a more detailed way, and, lastly, we will discuss the generalisability of our results.

Measurement issues regarding self-reported data

The majority of the data analysed in this thesis was self-reported by participants, i.e. self-reported SES-indicators (education and household income), self-reported neighbourhood-, household-, and individual-level factors and self-reported health-behaviours. Self-reported measures have the advantage that they are relatively easy to obtain compared to objective measures (if even available). On the other hand, self-reports have the disadvantage that several types of reporting bias may take place.

First, there is bias due to social desirability. In general, people are susceptible to social norms and tend to fill in survey questions towards perceived socially-desirable standards. As we were mainly interested in differences *between* SES-groups, bias due to social desirability would have only seriously affected our results if this had occurred differentially according to SES. Neighbourhood factors measured in our mailed survey do not seem very sensitive to social norms and perceptions of social desirability and hence, to (differential) reporting bias. For instance, it is not so likely that a social norm regarding neighbourhood attractiveness exists, and even less likely that a participant reports his/her neighbourhood as more attractive or unattractive than he or she actually perceives it. Physical activity and fruit and vegetable consumption, on the other hand, are well documented as health-enhancing behaviours, and therefore, participants may have over-reported engaging in these behaviours [1, 2]. If all socioeconomic groups overstated their health behaviour to the same extent, this would not have affected the socioeconomic gradient in the behaviours. There is some indication that people with a higher socioeconomic status value health and a healthy lifestyle more than people from lower SES-groups [3, 4]. This may make them more inclined to overestimate their health behaviours. On the other hand, as unhealthy behaviours are more prevalent among lower SES

groups, over-reporting of healthy behaviours may have particularly occurred among these participants. As both high and low SES groups may be likely to over-report their health behaviours, no or little differential reporting of health behaviours may have affected our results in the end.

Another bias that may have affected participants' responses is the so called 'same-source bias', meaning that responses may have systematically been influenced, either positively or negatively, by a participant's overall view of life. A negative worldview may originate from pessimism ('generalized negative outcome expectancies'), negative affectivity ('the extent to which individuals generally feel upset or unpleasantly aroused'), particular personality traits, and feelings of depression [5] [6]. These factors have been found to be more prevalent among lower socioeconomic groups [7-10]. Our finding that the lowest SES-group was more likely to agree with the statement that 'it is often poor weather' (27%) compared to higher SES-groups (about 17%), also points in the direction of a more negative world view (Chapter 5). Therefore, same-source bias could have resulted in an overestimation of the contribution of perceived neighbourhood factors to socioeconomic differences in health behaviours. On the other hand, we have shown that socioeconomic differences in neighbourhood perceptions could largely be explained by objective neighbourhood characteristics, and only partly by feelings of depression/nervousness (Chapter 7). This suggests that self-reports (at least partly) reflect the actual neighbourhood situation, and do not only reflect a negative worldview.

Another type of reporting bias that may have affected our results is what one could call 'self-justification' bias, related to Festingers's *cognitive dissonance theory* [11]. This theory holds that people want their thoughts, attitudes, and actions to be consistent with one another. When they realise their actions (e.g. smoking) are dissonant from their attitudes (smoking is bad for my health), they feel uncomfortable and will try to make them consistent again. As it is difficult to change behaviour (quit smoking), people rather justify their actions by changing inconsistent attitudes (smoking is not so bad), even if these attitudes are irrational. Similarly, people who reported in our survey not to be physically active may have agreed with the statement 'my neighbourhood is not attractive for physical activity', just because they wanted to justify their unhealthy behaviour for themselves, i.e. to make their attitudes in line with their actions. As lower socioeconomic groups were more often inactive, they may have also been more likely to justify this behaviour with reporting an unattractive neighbourhood, which then would have over-stated the contribution of neighbourhood factors to socioeconomic differences in physical inactivity. On the other hand, the finding that people who agreed with the statement 'fruits are expensive' actually were *more* likely to consume fruits than those who disagreed (Chapter 11), shows that 'self-justification' has not necessarily been going on among the survey participants.

There is little indication that the measurement of SES-indicators, education and household income, has been biased. Education is often used as SES-indicator, as it is considered a good indicator of SES in the Netherlands [12], is seen as more important to health status than occupation or income [13], is comparatively easy to measure in self-administered questionnaires, is associated with high response rates, and is relevant to people regardless of age or working circumstances [14]. The GLOBE survey 2004 was one of the first Dutch surveys to include a question on household income. Income is not often measured in studies, as it is perceived a sensitive and private topic, and may be more susceptible to non-response than education. As it is known that questions asking the respondent to provide an exact amount elicit the highest non-response rates [15], the GLOBE survey asked participants to tick one of four rather broad income categories, i.e. 0-1200 euro, 1200-1800 euro, 1800-2600 euro, 2600 euro or more (or 'I don't want to say /I don't know'). As the income question was put at the very end of the survey, non-response because of the inclusion of this particular item in the questionnaire was minimised.

Overall, the use of self-reported data may have led to biases operating in different directions. However, we do not believe these have substantially influenced our conclusions.

Measurement issues of objective neighbourhood characteristics

In two studies as described in this thesis, one carried out in the city of Eindhoven, the Netherlands, and the other one in Melbourne, Australia, we examined 'objective' neighbourhood characteristics. These characteristics were not self-reported by participants, but assessed in a systematic way by trained observers that visited the neighbourhoods during field observations. There are some methodological problems concerning these types of neighbourhood measurements.

First, there is a lack of validated audit instruments that measure relevant aspects of the neighbourhood context. We developed our own environmental audit tool, as existing tools had been developed for other purposes and in other countries than the Netherlands, and could not simply be applied in our study [16-20]. Inter-rater reliability of the audit instrument was good [5]. Content validity has not been confirmed: to what extent did the instrument measure what we wanted to measure? Also unknown is whether the specific area characteristics, i.e. the specific items in the instrument, when taken together in a sum score truly reflected broader constructs of social unsafety, traffic unsafety, design, etc. (construct validity). Did we measure all specific aspects of 'traffic unsafety' or did we forget about some, or, otherwise, did we include items in the sum score that had nothing to do with traffic unsafety? Although this is difficult to test, the fact that the selection of specific items for each construct was based on

an existing theoretical framework reflects a well-deliberated choice. The overlap between the objective and subjective measures of area aesthetics (Chapter 7), suggests that, at least for the concept of area aesthetics, objective characteristics have been measured that people take into account in perceptions of area aesthetics. The finding that objective measures of aesthetics rather than objective measures of safety explained perceptions of safety, shows that the objective sum scores for traffic safety and social safety did not include all aspects of safety that people take into account when forming perceptions of safety.

Furthermore, one can wonder what the appropriate scale is to measure area effects, and how this scale should vary by health behaviour. The attractiveness of the area within a 5-minute walk from home may affect recreational walking, however, for recreational cycling, one could argue that a much larger area will matter. Also, characteristics of destinations that people walk or cycle to may be at least as important as characteristics of one's area of residence. These issues show that the objective measurement of neighbourhood characteristics is a very young field of research with many opportunities for improvement.

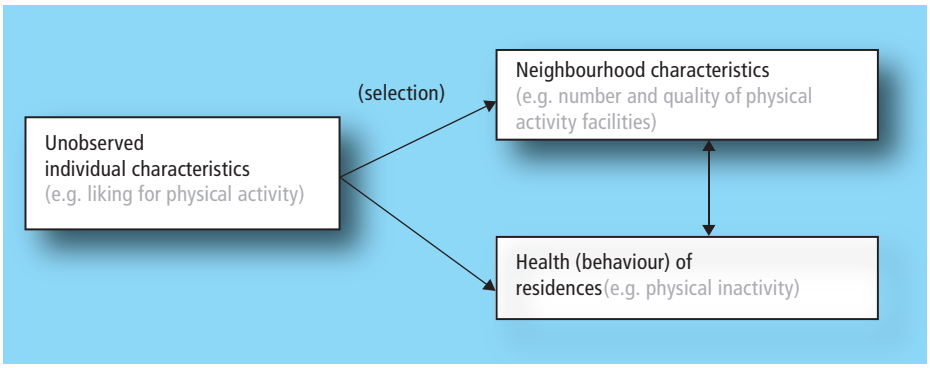
Cross-sectional analyses

All studies in this thesis (apart from the focus group study and the review studies) had a cross-sectional design, i.e. the measurement of SES, neighbourhood factors, individual factors, and health-behaviours took place at the same moment in time. This precludes causal inferences being drawn. Overall, more support has been found for causation rather than selection processes related to SES and health behaviours [21-24], and, also, it is highly unlikely that the unequal distribution of explanatory factors across SES is due to an effect of these factors on someone's SES. However, there are other possible, more general factors, such as personality, culture and intelligence [25], that may have affected both SES (e.g. eligibility and interest for secondary and higher education) and health behaviours. These factors have not been studied in the current thesis, and require further investigation. Regarding individual cognitions, health behaviour models particularly stress causal associations between those factors (i.e. attitude, social norm, perceived behaviour control, intention) and behaviour. However, it has been recognised that also selection mechanisms may play a role, for example: people that try different kinds of fruit may also be more likely to have a positive attitude towards at least one kind of fruit.

Also neighbourhood factors may be subject to selection processes related to health-behaviours. This phenomenon is referred to as *endogeneity* (related to, though not similar to the concept of confounding), and occurs because of the presence of common prior causes of neighbourhood-level exposures and health outcomes. For example, it is supposed that easy access to good quality facilities for physical activity in a neighbourhood may decrease the risk of physical inac-

tivity for local residents. However, it is equally plausible that sports facilities decide to open their businesses in particular locations were demand by local residents is largest, or that residents with an active lifestyle move to neighbourhoods with good facilities available. In this example, liking physical activity is an unobserved variable that is related to both the location of facilities as well as the risk of inactivity.

Figure 12.1 Example of endogeneity



To circumvent endogeneity, relevant characteristics of individuals should be measured to correct for in neighbourhood-behaviour associations. Several studies in this thesis took into account individual characteristics, such as attitude towards physical activity, and, with that, minimised the possible influence of this bias. Overall, we presume, though, that the results in this thesis are more likely a result of causal rather than selective processes between SES, neighbourhood factors, individual factors, and health-behaviours.

Another methodological issue that cannot be tackled with a cross-sectional design, is the so-called 'lag effect' between exposure to neighbourhood characteristics and health behaviours. We don't know since when and for how long certain characteristics have been present in neighbourhoods. A single 'snapshot' observation of a neighbourhood does not capture the dynamics of the neighbourhood. We neither know for how long residents have lived in their neighbourhoods. A middle-aged person, who has lived under deprived neighbourhood circumstances for the whole his life, may have accumulated more negative experiences over his life course than someone who recently moved into the neighbourhood. Furthermore, day-to-day exposure to neighbourhood characteristics may vary for residents. Older people may spend more time in their neighbourhood than young adults, who may work full-time and spend most of their leisure time outside the neighbourhood. The fact that time exposed to specific neighbourhood characteristics has not been taken into account in our

analyses, may have underestimated the contribution of neighbourhood factors to socioeconomic differences in health behaviours.

Generalisability of the results to the Dutch population

Our conclusions cannot just be generalised to the whole of the Dutch population, given the omission of certain population groups in the study sample. This applies in particular to ethnic minorities, illiterate persons, and institutionalised persons. The exclusion of the latter is not very likely to affect our conclusions, as the proportion of people residing in institutions is rather small (about 1,3% of the total Dutch population; http://statline.cbs.nl/, accessed 3 January 2008). In contrast, about 1,5 million persons in the Netherlands, almost 13% of the Dutch adult population, have poor or low literacy skills, which means that filling in a 16-page postal questionnaire may be difficult (http://www.lezenenschrijven.nl/, accessed 3 January 2008). Also, ethnic minorities may have difficulties with the Dutch language, and therefore are less likely to participate in our study. They comprise a considerable part of the total Dutch population (19% of Dutch inhabitants have at least one parent born outside the Netherlands and is thus classified as non-native; http://statline.cbs.nl/, accessed 3 January 2008). These two subgroups that were less likely to participate in our postal survey are also more likely to have a low SES. Furthermore, as they may experience difficulties to fully participate in Dutch society, they may be more dependent on their direct neighbourhood facilities and nearby social network compared to the literate and/or native Dutch. This could imply that the role of neighbourhood factors in explaining socioeconomic differences in health behaviours is actually larger for the whole of the Dutch population, than we observed in our study sample.

Generalisability of the results to other countries

The final question with regard to the generalisability of the results is: are conclusions also applicable to other Western countries than the Netherlands? There are a number of issues that should be taken into consideration, especially with regard to differences in patterns of socioeconomic differences in healthbehaviours, and differences in the geographical, cultural and policy environments across countries.

Although associations between SES and health behaviours are (in general) rather consistent [26], socioeconomic differences in health behaviours in other countries do not necessarily resemble the patterns observed in the Netherlands. For instance, Caverlaars and colleagues found a north-south pattern through Europe for socioeconomic differences in smoking, with strong gradients in northern European countries and weaker or reversed gradients in southern European countries, most noticeable among women [36]. A literature review study found that in the majority of the studies, with the exception of a few in

Southern and Eastern Europe, consumption of vegetables and fruits was more common among those with higher education [27]. The results also suggested that in regions where consumption of vegetables and fruits was more common (e.g. Spain, Greece), the lower social classes tended to consume more of these than the higher social classes. Lastly, large variations in leisure time physical inactivity have been observed when comparing European countries. Next to a North-South gradient, with lower levels of sedentariness in the Northern countries, a West-East gradient was apparent, with higher level of sedentariness in Eastern European countries [28]. These findings were linked to European differences in the presence and content of national initiatives to promote physical activity [28], perceptions of environmental opportunities for physical activity [29, 30], and perceptions of health benefits of physical activity, with less positive beliefs observed among southern Europeans [31, 32].

Second, there are geographic and spatial differences between the Netherlands and other countries, which may decrease the generalisability of our findings. The Netherlands is a small, flat and densely-populated country, and has a moderate climate with mild temperatures. This, in contrast to large, hilly and sparsely populated countries such as the U.S. and Australia, were temperatures can go to extremes. These basic differences in physical lay-out can make a large difference to environmental effects on health behaviours. For instance, walking and cycling for both transport and recreation are very popular in the Netherlands, as distances are small, there are no hills, and there is a good infrastructure for pedestrians and cyclists. Walking and cycling is far less common in the U.S. and Australia, which may be partly attributed to the physical design of cities, generally unsupportive for walking or cycling. However, even if good quality walking and cycling paths, safe crossings, and other infrastructural necessities would be made available throughout U.S. and Australian cities, even then, geographic, spatial and climate-related barriers make it unlikely that walking and cycling participation will ever reach Dutch levels.

There are also cultural differences in health behaviours, which can hinder generalisability of results to other countries. Food habits are to a large extent embedded in cultural practices, as culture determines what people consider to be acceptable and preferable foods, and the amount and combinations of food they choose [33]. A typical Japanese diet, with fish and rice and little meat, is completely different from an American diet or a Mediterranean diet. What most people eat is what the market tends to sell, and what is most easily available, although these products are not necessarily the healthiest. Even if healthy products are readily available, changes in eating habits of a population may only take place over a long time, just because it is not in a country's cultural to eat certain products, and because other, unhealthier products (e.g. fast food) are even more easily available. The same applies to physical activity behaviours:

if walking, cycling or certain sports activities are more culturally-embedded, or if doing sports is valued high within certain countries, than the likelihood that people practice physical activity is likely to be higher.

Governmental action and policies in the Netherlands differ from those in other countries, and this may affect the extent to which neighbourhood factors can contribute to the explanation of inequalities in health behaviours. The sociologist Esping-Andersen distinguishes between three types of welfare regimes, i.e. liberal regimes (e.g. U.K., U.S.), conservative-corporatistic regimes (e.g. Germany, France), and social-democratic regimes (e.g. Sweden, Denmark). The type of regime is related to, for instance, the degree of income redistribution, the access to (de)commodified services (education, health, etc.) and arrangements of the housing system [34]. These are also central factors that shape the extent of socio-spatial segregation in a country, which means: do the poor live among the poor and the rich among the rich (segregated), or have residential areas a more mixed composition and do socioeconomic groups interact (desegregated)? Therefore, the level of socio-spatial segregation may affect whether neighbourhood factors can contribute to socioeconomic inequalities in health behaviours: only if people with lower incomes and lower levels of education live in other, more deprived neighbourhoods and do not interact with their higher status counterparts, then exposure to neighbourhood factors may vary by socioeconomic status. In the U.S., with a liberal welfare regime, residential segregation is more pronounced than in Europe: poor people live highly concentrated and suffer from high levels of social exclusion [34]. In the Netherlands (classified as a 'hybrid' welfare system, with characteristics of both social-democratic and conservative-corporatistic regimes), special social housing programs allow low-income groups to live in mixed neighbourhoods, and with that, prevent poverty concentrations. Therefore, in the Netherlands, apart from some areas in large cities like The Hague, Rotterdam and Amsterdam, residential segregation levels are relatively low and neighbourhood compositions rather mixed, which implies that neighbourhood effects on socioeconomic differences in health-behaviours may only be moderate. In the U.S., on the other hand, these effects may be larger.

Also determined by governmental rules and regulations is the extent to which businesses may themselves decide in which location to open an outlet. In the Netherlands, large sport facilities, such as swimming pools, cannot operate where they wish, but the municipality board decides in which location new sport facilities are needed. In the U.S., on the other hand, sports facilities may decide to open their businesses in locations were demand by local residents is expected to be largest, i.e. high-income neighbourhoods. This could make their accessibility difficult for low-income groups. In the Netherlands, where facilities are more equally distributed across neighbourhoods, no differential

access to facilities may be experienced by residents of either deprived or advantaged neighbourhoods.

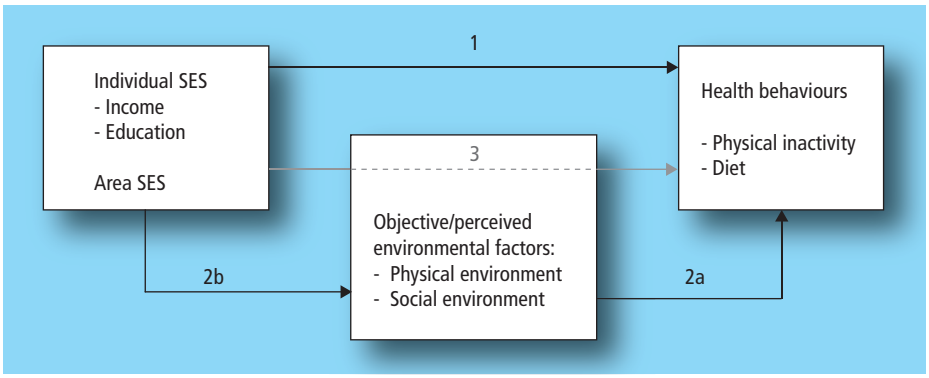
These issues lead to the remark that results may be generalised to other countries, though with caution. Results are probably most applicable to countries that are alike to the Netherlands with regard to patterns of socioeconomic differences in health behaviours, and regarding the geographical, cultural and policy environment.

12.3 Interpretation of findings

This thesis provides important indications of the contribution of neighbourhood factors to the explanation of socioeconomic difference in health behaviours. The picture as shown in Figure 12.2 is drawn to facilitate the interpretation of the findings.

In our study, we hypothesized three associations as depicted in the picture below: (1) associations between SES and health behaviours (research question 1), (2a) associations between neighbourhood factors and health behaviours and (2b) associations between SES and neighbourhood factors (research question 2). Only when all three associations exist, then contributions of neighbourhood factors to socioeconomic differences in health behaviours would be likely to find (research question 3). We will compare our results to evidence from other studies following the three associations in Figure 12.2.

Figure 12.2 Hypothesised associations between SES, environmental factors and health behaviours



Research question 1 – SES and health behaviours

Socioeconomic differences in health-behaviours have been found over time and for a large range of health behaviours, with those from lower socioeconomic

backgrounds in general behaving less healthy [35]. Studies that have compared disparities in health-behaviours over several European countries sometimes found exceptions to this rule [27, 28, 36, 37]. However, our studies contribute to the rather consistent evidence for an association between SES and health behaviours, with large gradients found for sports participation (Chapter 5), and fruit and vegetable consumption (Chapter 11), and moderate gradients in recreational walking (Chapter 6).

Another body of literature has examined associations between area deprivation or area SES and health behaviours, showing that for physical activity as well as dietary behaviours, large to moderate differences between advantaged and deprived areas were observed, even when individual characteristics were taken into account [38-43]). Results of Chapter 8 contribute to this evidence, as our study in the city of Melbourne, Australia, showed that residents of socioeconomically deprived areas were less likely to cycle for recreation, independent of residents' age, sex, occupational and educational level.

Research question 2a – Neighbourhood factors and health behaviours

For physical activity, literature reviews have shown some repeated associations between physical neighbourhood factors and physical activity behaviours [44-48], although the evidence is still limited. The objective and perceived availability and accessibility of facilities, as well as the objective and perceived general design of neighbourhoods (e.g. the presences of sidewalks) and perceived aesthetics have found to be positively associated with various types and levels of physical activity [47]. In general, our results are in line with these findings. However, we did not find the perceived availability of facilities to be (significantly) associated with sports activity (Chapter 5). As argued before, the Netherlands is a densely populated country, where distances are small and public transport is well organised, which may make the availability of facilities in the direct surroundings less of a barrier for physical activity.

For neighbourhoods in the city of Melbourne, we found significant associations between objective area characteristics and cycling for recreation: four design features (i.e. presence of on-road cycle lanes, total track length, prevalence of traffic control devices, and prevalence of alternative routes), two safety features (i.e. verge width, and absence of driveway crossovers), one destination feature (i.e. prevalence of destinations), and two aesthetic features (i.e. total park area, and lack of garden maintenance) showed associations with recreational cycling (Chapter 8). Although perceived neighbourhood aesthetics was associated with both sports participation (Chapter 5) and recreational walking (Chapter 6), and perceptions of neighbourhood aesthetics could be partly explained with objective measures of aesthetics (Chapter 7), we did not find direct associations between objective characteristics of neighbourhoods in Eindhoven (i.e. neigh-

bourhood design, social unsafety, traffic unsafety or aesthetics) and cycling or walking for recreation [49]. The sample of this sub-study may have been too small for statistical models to detect a direct association between objective neighbourhood factors could and health behaviours. As said before, the research field of objective neighbourhood characteristics in association with health behaviour is very young, and future research should reveal to what extent, for which countries and for which specific behaviours direct associations between neighbourhood characteristics and residents' health-related behaviours exist.

Perceived social support and having a companion for physical activity have been found consistently associated with different types of physical activity [48], which is again comparable to our findings for sports and recreational walking. Not many studies have investigated associations between more general social neighbourhood factors, like social networks and social capital, and physical activity. Our results are supported though by a Swedish study: where we found social cohesion and social network to be associated with sports activity and recreational walking, Lindstrom and colleagues found social participation to be associated with leisure time physical activity [50].

For dietary behaviours and their associations with environmental factors, the picture is quite different. First and foremost, the body of research that investigated environmental influences on diet is very small: our systematic literature reviews with regard to potential environmental determinants of fruit and vegetable consumption (Chapter 9) and fat and energy intakes (Chapter 10) came to the same conclusion, namely that more research into specific environment-intake associations is needed before conclusions can be reached. In Chapter 11, limited availability of fruits in the household, no vegetables prepared by the household cook, and absence of fruit and vegetable outlets in the neighbourhood were associated with no fruit and vegetable consumption, however, only very small percentages of participants actually perceived these environmental barriers. However, in the U.S., several studies reported positive associations between proximity to supermarkets/health food stores and dietary patterns [51, 52]. One publication reported that African-American adult's fruit and vegetable intake increased with each additional supermarket in their area of residence [53]. Also, the number of fast food establishments in the U.S. has grown rapidly over recent decades, which is linked to the current obesity epidemic, as fast food consumption is associated with weight gain and dietary intakes less consistent with recommendations [54, 55]. This suggests that availability of resources for healthy and unhealthy products may play a more important role in the U.S. than in other Western countries. This may be partly the result of the generally larger distances between places in a country like the U.S. - an extra supermarket in the direct neighbourhood may indeed make a difference, more

than in a country like the Netherlands were supermarkets are close-by almost everywhere. Easy availability of fast food may also be more influential on U.S. people's diets, as the 'away-from-home-eating' culture may be more common in the U.S. than other Western countries – a fast food outlet in the neighbourhood may then indeed attract families to rather eat out than at home.

Research question 2b – SES and neighbourhood factors

The body of literature and our own studies with regard to associations between SES and neighbourhood factors can be split up in two parts: one part examining how neighbourhood socioeconomic status or neighbourhood deprivation level relate to objectively measured neighbourhood characteristics (investigated in Chapters 7 and 8 of this thesis), and a second part considering individual-level SES in association with perceived neighbourhood factors (examined in Chapters 5, 6, 7 and 11).

Neighbourhood-SES and objective neighbourhood characteristics

Of the two studies in which we examined associations between area-SES and area characteristics, one was carried out in the city of Eindhoven, the Netherlands, and the other in the city of Melbourne, Australia. Although miles apart, findings were quite similar: only aesthetic characteristics differed significantly between high- and low-SES areas, other characteristics did not. Those other characteristics, related to design, traffic safety and destinations, *did* differ between areas in general, however not by area deprivation level. These findings are in line with another Dutch study (based on previous data from the GLOBE study): this study found no relation between area-based economic environment and proximity to sports facilities, but disadvantaged areas showed poorer general physical design and poorer quality of green facilities [40].

Further, studies conducted in Europe and Australia have mainly focused on associations between the availability of services for physical activity and area socioeconomic context, which yielded inconsistent results. A British investigation showed lower accessibility of and proximity to local facilities in disadvantaged areas [56], while an Australian study showed the opposite: access to sports and recreational facilities was significantly higher for those living in socioeconomically disadvantaged compared to advantaged areas [57]. A study conducted in Spain showed that the number of sports facilities per 1000 population was associated with the level of absolute wealth —measured at a given moment or over time during a previous period —but not with income distribution [58].

Also in the U.S., studies investigating associations between neighbourhood-SES and objective neighbourhood characteristics mainly focused on the availability of facilities. Recreational facilities were found significantly less common

in lower-income and minority neighbourhoods [59-61] while parks were more equitably distributed [61]. On the other hand, in a study of 32 census tracts in the Midwest, Estabrooks and colleagues found that neighbourhoods did not differ in the number of pay-for-use parks, sport facilities, fitness clubs, community centres, and walking/biking trails; however, low-SES neighbourhoods had significantly fewer free-for-use resources [62]. Wilson and colleagues found that while respondents in lower-SES areas reported less availability of public recreational facilities, the perception of less availability was not substantiated by GIS data [63].

The body of research regarding 'nutrition environments' is small and results are mixed. Some studies in the U.S. and Canada have found neighbourhood differences in the price and availability of food, with 'healthier' foods generally more expensive and less available in poorer than in wealthier areas [53, 64]. Also, fast food restaurants have been found more available in disadvantaged and low-income areas in the U.S. [65, 66]. The picture outside North America is different. Initially, UK research undertaken in the late 1980s and early 1990s, based on mainly small-scale local surveys, did suggest similar inequalities, with high prices and poor availability being associated with area deprivation [67, 68]. However, more recently, larger and more robust observations found no differences in food price, food availability, and access to supermarkets between deprived and affluent areas [69-72], although the density of the 'big four' fast food restaurants was greater in more deprived areas in England and Scotland [73]. In two Australian studies [74, 75], in a study conducted in New Zealand [76], and in a prior study based on the GLOBE data [77], no socioeconomic differences in shopping infrastructure for fruit and vegetables between advantaged and disadvantaged areas were found. The existence of socioeconomic neighbourhood differences in the availability and price of healthy/unhealthy foods in the U.S., rather than in other Western countries, may be the result of social, cultural, economic, and regulatory differences between nations which govern the provision, purchase, and consumption of food. For instance, fruit and vegetable shops may open their outlets where they expect the most demand for healthy foods (i.e. high income neighbourhoods), and fast food outlets were they expect the most demand for unhealthy foods (i.e. low income neighbourhoods). Since many U.S. states lack governmental regulations to guide these processes, low income neighbourhoods may indeed end up with more resources for an unhealthy than healthy diet.

Individual-SES and perceived neighbourhood factors

Lower educated and lower income groups have been found more likely to perceive their neighbourhood as unattractive, unsafe, and providing few facilities, compared to their higher status counterparts [57, 63, 78]. Also, some support has been found for associations between individual-SES and perceived social

neighbourhood factors: lower SES-groups reported less social participation than high SES groups [50]. Results of this thesis contribute to the present evidence, as we found significant associations between SES and perceived physical neighbourhood factors (neighbourhood safety, attractiveness, availability of facilities), perceived social neighbourhood factors (social network, social cohesion), and household factors (material and social deprivation). These associations were found among adults in general (Chapter 5), among a sub-sample of older adults (Chapter 6), and among a sub-sample of adults living in seven deprived and seven advantaged neighbourhoods in the city of Eindhoven (Chapter 7).

Perceptions of food shopping and household environments and their associations with SES have been investigated in Chapter 11. Although statistically significant, no large differences between perceptions of low and high SES groups were observed, as the percentages of people that perceived poor availability and accessibility of fruits and vegetables in their neighbourhood or household, were very small. These findings are in line with findings from a British study reporting that few low income participants said that they experienced any difficulty visiting supermarkets, or perceived any problems in the choice of shops, or of fruit and vegetables, in their local area [79]. Also, an Australian qualitative study found that women from neighbourhoods across a range of SES were generally satisfied with their local food environment and availability of healthy foods [80]. However, a second Australian study showed perceptions of food availability, accessibility and affordability did differ across SES groups [81].

Research question 3 – Contribution of neighbourhood factors to socioeconomic differences in health behaviours

Although the literature provides studies that investigated either one or more of the associations between SES, environmental factors, and health behaviours, the body of literature that examined associations between all three groups of factors within one study, and quantified the contribution of environmental factors to the explanation of socioeconomic differences in health behaviours, is very small. A study conducted in Australia showed that a selection of personal, social, and physical environmental factors could explain educational inequalities in leisure-time walking to a large extent, however, this same selection did not substantial mediate effects on associations of education with transport-related walking [82]. A Swedish study found significant socioeconomic differences in leisure-time physical activity, which reduced to non-significance when social participation was taken into account [50]. The authors concluded that these results support the idea that insufficient psychosocial resources in some socioeconomic groups are a part of the important link behind the socioeconomic differences in leisure-time physical activity. These two studies are in line with our results, as we found that the perceived physical and social neighbourhood

environment had a moderate (but significant) contribution to the explanation of socioeconomic differences in several types of physical activity.

Our results for sports participation and recreational walking indicated that neighbourhood factors partly mediated the association between SES and physical inactivity *via* individual cognitions. Moreover, objective measures of area aesthetics contributed to the explanation of area socioeconomic difference in recreational cycling in Australia (Chapter 8), but other area characteristics regarding safety, design and destinations did not. As hardly any comparable studies could be found, these findings give a unique and promising contribution to the field of understanding socioeconomic differences in physical activity.

Evidence for the food environment to contribute to socioeconomic differences in diet has recently been reviewed by Cummins and Macintyre [83]. Their main conclusion was that even though neighbourhood socioeconomic differences in obesity and diet exist in many Western countries, evidence for neighbourhood influences on diet and obesity only exists for those who live in North American neighbourhoods [84]. In Chapter 11, no objective but only perceived environmental factors were considered, however, in line with the conclusion of Cummins and Macintyre for countries other than the U.S., no contribution of food shopping and household environmental factors to the explanation of individual socioeconomic differences in fruit and in vegetable consumption was found. In section 12.3, some policy and regulatory environmental differences have been indicated between the U.S. and other Western countries, which may account for the observed differences. Residential segregation according to SES and race may be larger in the U.S., and there is less governmental action to compensate for socioeconomic area differences than in other Western countries.

Conclusions

Research has shown repeated associations between SES and physical inactivity (research question 1) and between neighbourhood factors and physical inactivity (research question 2a), which are in line with our results. For the association between SES and neighbourhood factors (research question 2b), two of our studies, one conducted in Australian and one in a Dutch city, show the same result: deprived and advantaged areas differ with regard to aesthetic characteristics (e.g. green maintenance, garden maintenance, graffiti), while other area characteristics (i.e. with regard to design, traffic safety, social safety, and destinations) were less different. Other SES-neighbourhood research mainly focussed on the availability of physical activity facilities across deprived and advantaged neighbourhood, showing inconsistent findings. Lastly, only very few studies have tried to quantify the contribution of neighbourhood factors to socioeconomic differences in physical activity (research question 3). However, our results are in line with the few studies available, which concluded

that physical and social neighbourhood factors, together with more proximal determinants, have a moderate, but significant contribution to the explanation of socioeconomic differences in several types of physical inactivity.

Conclusions regarding fruit and vegetable consumption are quite different. Although large socioeconomic inequalities in fruit and vegetable consumption exist (research question 1), no evidence that the household or neighbourhood environment contributes to socioeconomic differences in fruit and vegetable consumption was found in this thesis (research question 2 and 3). This is similar to several studies from the U.K. and Australia, which neither found socioeconomic differences in shopping infrastructure, nor differences in food price, food availability, and access to supermarkets between deprived and affluent areas. U.S. studies, on the other hand, in general have found more support for socioeconomic disparities in food environments.

12.4 Implications for future research

In this thesis, we mainly focussed on neighbourhood factors, but other groups of environmental factors (e.g. cultural conditions) and from other environmental settings (e.g. work-related factors, or national-level factors, e.g. governmental regulations) are likely to play a role as well, and deserve further investigation.

Pathways between SES, explanatory factors and health-behaviours should be investigated for specific behaviours, as associations may differ for specific outcomes. Moreover, the predictive capacity of neighbourhood as well as individual factors is likely to increase when both would be measured behaviour- and context-specific, so for instance, 'feeling (un)safe in the neighbourhood when walking at night time', or 'self-efficacy to cycle to shops within 1,5 kilometres from home'. Also, early findings indicate that not only availability and accessibility of facilities may differ for lower and higher socioeconomic groups, but that also –and maybe more importantly- quality differences between resources should be investigated [84]. Deprived areas may have equal numbers of parks or facilities compared to advantaged areas, but these are less likely to be used when they are old, not well-maintained, and (perceived as) unsafe.

Future research should try to further disentangle relationships between SES, environmental contexts and health behaviours. An important limitation of many studies into place effects on health and health behaviours is that causation and selection mechanisms cannot be disentangled. One approach to circumvent problems of endogeneity, is for researchers to take advantage of "natural experiments" that provide exogenous sources of contextual variation. One example of such a natural experiment is the so-called Gautreaux program, a large public housing relocation program to remedy segregation the city of Chicago. Between 1976 and 1998, nearly 4,000 families volunteered to partici-

pate in the subsidized program that moved them to communities throughout the six-county Chicago metropolitan area. While all participants came from the same low-income and black city neighbourhoods, some moved to middle income white suburbs, while others moved to white and black urban neighbourhoods, regardless of clients' locational preference [85]. In such a setting, baseline and follow up measures of individual-SES, neighbourhood-SES, perceived as well as objective environmental factors, individual level factors, and health-behaviours, may give more inside in causal pathways between SES and health behaviours.

12.5 Implications for theory development

Frequently-employed theories for explaining variations in health-related behaviours, such as the Theory of Planned Behaviour and Social Cognitive Theory, focus on proximal cognitive determinants of behaviour, such as attitudes, perceived social norms and self-efficacy beliefs, and pay little attention to distal environmental factors. Social-ecological models have become more popular since the renewed interest in environmental determinants of health and health behaviours, as these models point to the importance of environmental factors, together with individual factors. However, ecological models are often stated in rather broad terms and lack specificity in hypothesized pathways between factors from different settings [86]. In this thesis, environmental factors and individual cognitions were combined in one model (Chapter 2), and associations between SES, environmental factors, individual cognitions and health behaviours were tested in subsequent chapters.

Individual cognitions towards regular physical activity (e.g. positive and negative outcome expectancies, social norm, and self-efficacy regarding regular physical activity) explained socioeconomic differences in sports participation and recreational walking to a large extent. Also, results suggested that individual cognitions partly *mediated* the associations between SES, neighbourhood factors, and health-behaviours. This shows that individual cognitions may be important for understanding socioeconomic differences in health behaviours, together with environmental factors. Therefore, to be able to formulate and test specific hypotheses concerning environment-individual associations, both groups of factors should be specified in one model. Models that have been suggested in the literature often do not specify the role of SES [87], and do not visualise the pathways SES relates to health behaviours [88, 89]. The model suggested in Chapter 2 may come quite close to what may be an appropriate model for testing the role of environmental and individual factors in socioeconomic variations in health behaviours. This model shows similarities to the Theory of Triadic Influences [90], with distal factors influencing health behaviours *via* more proximal cognitions; however, the Theory of Triadic Influences does not

specify the role of the physical environment nor SES. The studies described in this thesis only tested some of the pathways specified in the model of Chapter 2. Especially, cultural factors deserve more attention in future research, and should be better conceptualised in theories. Lastly, our studies showed that environmental factors that are important for explaining socioeconomic variations in health behaviours differ for specific outcomes, which suggests that it is important to develop specific models for specific behaviours [91].

12.6 Implications for policy and interventions to reduce socioeconomic inequalities in health-behaviours

Large socioeconomic inequalities in fruit and vegetable consumption exist, however, no evidence was found in this thesis that household or neighbourhood environments contribute to socioeconomic differences in fruit and vegetable consumption. Therefore, in this section, our recommendations will be restricted to physical inactivity.

Although the contribution of neighbourhood factors to socioeconomic inequalities in physical inactivity may be moderate compared to the contribution of more proximal, individual level factors, this does not mean that neighbourhood factors require less attention in policy and intervention development. From a population perspective, even small odds ratios for neighbourhood characteristics may imply that changes to (perceptions of) the neighbourhood context may have a significant effect on physical activity levels. Especially since we found that perceptions of neighbourhood unsafety and unattractiveness were more prevalent among lower socioeconomic groups, these may offer important opportunities to reduce socioeconomic inequalities in physical inactivity.

With this, we actually follow the reasoning expressed by Rose (1985) and, later, emphasized by Schwartz and Diez-Roux (2001), arguing that *the closer in the causal chain a factor is in the onset of the disease, the less opportunity there is for prevention* [92, 93]. Neighbourhood factors are distal to physical activity and offer much opportunity for prevention, but, since causal associations between neighbourhood factors and physical activity behaviours have not been confirmed (as nearly all research to date has a cross-sectional design), there is large causal uncertainty. However, despite greater uncertainty that might adhere to causes that are more distal, Rose argues that these causes should be given priority from a public health point of view. In the long run, once neighbourhoods have been redesigned to be more safe and attractive to their residents, they may positively influence resident's physical activity behaviours, and the maintenance of that behaviour requires less effort from individuals.

Interventions and policies aimed at increasing *population* rather than *individual* levels of physical activity have the disadvantage that they offer less for each participating individual (the 'prevention paradox') [94]. Therefore, to decrease physical inactivity among the lowest educated residing in the poorest neighbourhoods, special individual-level programs may be needed which do focus on reducing physical inactivity, but not without dealing with/changing environmental circumstances as well. Our results for sports participation suggested that intervention and policy strategies targeted towards lower socioeconomic groups would need to intervene on both neighbourhood, household and individual factors, to yield a maximal increase in physical activity among lower socioeconomic groups.

Lastly, important to notice in this context, is that not only behavioural interventions may have a positive effect on health and health behaviours, but that general policies may have health effects as well. Unfavourable neighbourhood perceptions were associated with physical inactivity (Chapter 5 and 6) and results of Chapter 8 showed that unfavourable neighbourhood perceptions of low SES-groups partly reflected their actual less appealing and less safe neighbourhoods, and partly their perceptions of low social cohesion and feelings of depression. Therefore, to yield a maximal improvement of neighbourhood perceptions among lower socioeconomic groups, environmental change strategies, for instance, improving neighbourhood aesthetics and traffic safety, would need to be combined with social community interventions to increase resident's involvement in social processes, and individual-level interventions. Even without focussing in these interventions on a health outcome or behavioural outcome specifically, ultimately, improved neighbourhood perceptions and truly 'better' neighbourhoods may increase resident's physical activity.

This is good news in light of a new initiative that the Dutch government started last year, called 'Krachtwijken', aimed at improving the physical lay-out, safety and social situation of forty poor neighbourhoods in the Netherlands (http://www.vrom.nl/pagina.html?id=31001, accessed May 8th, 2008). Although this project does not specifically aim to improve the health or health-behaviours of the (mainly low-SES) residents of these neighbourhoods, small effects on health behaviours or health outcomes may still be expected in the long run. In the future, more evidence-based, multilevel and multidisciplinary projects should be developed, implemented and evaluated, to improve health behaviours among lower socioeconomic groups, and ultimately, to reduce socioeconomic inequalities in health.

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Summary

Summary

Part 1: Introduction

Socioeconomic inequalities in health have existed for centuries. The general opinion is that these inequalities are unfair and should be reduced, and over the last few decades, there has been considerable attention from research and politics for socioeconomic inequalities in health. However, still today, in the Netherlands, those with a lower socioeconomic position on average live three to five years less than their higher status counterparts, and they also spend ten to fifteen more years in poorer health (Chapter 1). Not only do higher rates of morbidity and mortality exist among lower socioeconomic groups, this is also the case for several unhealthy behaviours (e.g. smoking, physical inactivity, and low fruit and vegetable intake). Therefore, unhealthy behaviours are an important possible explanation for health inequalities. To be able to change unhealthy behaviours, one should understand which determinants to focus on, or in other words, understand *why poor people behave poorly*. For a long time, research on the determinants of health behaviours has focused on cognitive and other 'proximal' determinants. However, in view of the collective nature of multiple health behaviours being less favourable for the disadvantaged, it is more likely that these behaviours are ultimately the result of common environmental exposures.

When we started the studies as presented in this thesis, no clear picture existed of which environmental characteristics would be most important for explaining socioeconomic inequalities in health behaviours. Research on nutrition and physical activity increasingly suggested that neighbourhoods in which poorer people live may be of poorer quality, for example, being less safe or having less access to health promoting amenities, than neighbourhoods in which the better-off live. Therefore, we focused on the neighbourhood as main environmental setting in this thesis, and the following three research questions were formulated:

1) To what extent do socioeconomic inequalities in specific types of physical inactivity and dietary behaviours exist?
2) To what extent are neighbourhood factors associated with specific physical inactivity and dietary behaviours (2a) and do they differ by SES (2b)?
3) To what extent and via which pathways are neighbourhood factors involved in the explanation of socioeconomic inequalities in physical inactivity and dietary behaviours?

To answer these research questions empirically, a stepwise protocol was designed in which complementary research methods were combined. This study pro-

tocol is described in Chapter 2. Via an eclectic approach, first, a conceptual model was developed, based on existing knowledge about mechanisms leading to socioeconomic health inequalities and knowledge on determinants of health behaviours. Subsequently, we held focus group interviews among low and high socioeconomic groups, to test the relevance of factors captured in the model, and to investigate whether participants perceived additional environmental influences. We selected the most salient environmental factors based on focus groups results and literature reviews, and included them in a large-scale postal survey, which would allow us to quantify the contribution of environmental factors to socioeconomic inequalities in health-behaviours. Subsequently, we held interviews with a sub-sample of the postal survey participants, to talk more in-depth about environmental influences and health behaviours. The neighbourhoods in which those interview participants lived were visited and area characteristics were scored in an objective, systematic way. These sub-studies are described in more detail in subsequent chapters of this thesis.

In Chapter 3, results of the qualitative focus group study are presented. In four focus groups, with adults from high and low socioeconomic backgrounds in separate groups, participants were asked: which environmental factors in your daily life influence your physical activity and fruit and vegetable consumption? Participants in all groups talked about their spouses' and friends' health behaviours and support as being highly important. People from lower socioeconomic backgrounds reported poor neighbourhood aesthetics, safety concerns and poor access to facilities as barriers for physical activity, while easy access of sports facilities was reported by high socioeconomic groups. The availability of fruits and vegetables at home was perceived as good by all participants. Overall, lower socioeconomic groups expressed more price concerns regarding sports facilities and fruit and vegetables. With few exceptions, factors that were discussed during the focus groups had been incorporated in the conceptual model beforehand.

Part 2: SES, environmental factors and physical activity

As specific neighbourhood determinants may only be important for some but not all physical activity behaviours, the second part of this thesis starts with an investigation of the relative importance of neighbourhood factors for two specific outcomes of sports activity (Chapter 4). The two outcomes studied were (a) doing any vs. no sports at all, and (b) meeting vs. not meeting recommendations for sports activity (i.e. >3 days per week for >20 minutes per occasion). We found that physical and social neighbourhood factors as well as all individual cognitions showed independent associations with doing any vs. no sports. On the other hand, no neighbourhood factors were significantly associated with meeting recommended sports activity levels, whereas self-efficacy and attitudes towards regular physical activity were strongly associated. So

favourable vs. unfavourable neighbourhood factors appeared to make a difference between inactivity and doing at least some sports, while for meeting recommended levels of sports activity, no neighbourhood factors were important.

In the next study, described in Chapter 5, we investigated whether socioeconomic groups differed in their sports participation, and to what extent perceived neighbourhood, household, and individual factors contributed to socioeconomic differences in sports participation. The lowest socioeconomic group was about three to four times more likely not to participate in sports compared to the highest socioeconomic group. Unfavourable perceived neighbourhood factors (e.g. feeling unsafe, having a small social network), household factors (e.g. material and social deprivation), and individual physical activity cognitions (e.g. negative outcome expectancies, low self-efficacy) were significantly associated with doing no sports, and reported more frequently among lower socioeconomic groups. Taking these neighbourhood, household, and individual factors into account reduced socioeconomic inequalities in sports participation to a large extent.

In Chapter 6, socioeconomic differences in another physical activity outcome where studied, namely recreational walking, and we examined to what extent neighbourhood perceptions and individual cognitions mediated the SES-walking relationship. These analyses focused on older adults (55 years of age or older), as they represent a rapidly increasing share of the general population, and physical activity is important to preserve their health and functioning. A moderate socioeconomic gradient in recreational walking was observed, with the lowest educated and least affluent about 1,5 times more likely not to engage in any recreational walking than their higher status counterparts. Individual cognitions towards physical activity (e.g. attitude, perceived behavioural control) contributed most to the explanation of these socioeconomic differences. However, perceived neighbourhood aesthetics had a significant contribution to the explanation as well, and mediated the association between SES and recreational walking largely *via* individual cognitions.

In the studies described so far, we noticed that lower socioeconomic groups were more likely to perceive their neighbourhood as unattractive and unsafe than higher socioeconomic groups. In Chapter 7, we examined whether objectively-measured neighbourhood characteristics and/or other factors could explain these differences in neighbourhood perceptions. We found that unfavourable neighbourhood perceptions of low socioeconomic groups were partly explained by their actual less appealing and less safe neighbourhoods, and additionally by self-reported psychosocial factors, such as feelings of depression, and low social neighbourhood cohesion. Additionally, we found that residents' perceptions of neighbourhood unattractiveness and unsafety clustered within neighbour-

hoods. This clustering reduced to a great extent when objective neighbourhood characteristics were taken into account, which underlined that the objective neighbourhood characteristics measured with the environmental audit reflected resident's general perceptions of their neighbourhoods quite well.

In Chapter 8, we studied cycling levels of residents in socioeconomically contrasting areas of the city of Melbourne, Australia. Results showed that, after adjustment for residents' characteristics (i.e. individual-level SES, age and sex), those residing in deprived areas were 1,5 times less likely to cycle for recreation than those in advantaged areas. Objectively measured area aesthetics tended to be worse in deprived areas and explained some of the area socioeconomic inequalities. Safety characteristics were not particularly worse in deprived areas but *did* differ significantly between areas in general, and also contributed to the explanation of overall area variations in recreational cycling. This last study with regard to physical activity confirmed that objective area characteristics may matter for physical activity.

Part 3: SES, environmental factors and diet

Similar to physical activity behaviours, also dietary intakes have been thought susceptible to contextual effects, e.g. via the availability of healthy and unhealthy products. The rise of obesity over the last decades has often been suggested the result of gradual environmental changes which resulted in an 'obesogenic' environment, i.e. an environment that encourages unhealthy food intake and discourages physical activity. To verify whether the food-intake part of this claim is supported by empirical studies, we performed two systematic reviews of the literature concerning environmental determinants of health-related dietary intakes. In a first systematic literature review, environmental determinants of obesity-related dietary intakes were investigated (i.e. saturated fat, total fat, and energy intake). Again, very few replicated studies for specific environment-intake associations were found (Chapter 9). Availability, social, cultural and material aspects of the environment were relatively understudied compared to other factors such as seasonal/day of the week variation and work-related factors. More studies are required to examine whether and which environmental determinants matter for (obesogenic) dietary intakes. The second systematic review investigated studies concerning two dietary outcomes that are believed to have a beneficial effect on health: fruit and vegetable consumption (Chapter 10). This review showed that a large variety of environmental factors have been studied in association with fruit and vegetable intakes, but that the number of replicated studies for each determinant was limited. All studies were observational and cross-sectional. Most evidence was found for household income, as people with lower household incomes consistently had lower FV consumption. Good local availability (e.g. access to one's own veg-

etable garden, having low food insecurity) seemed to exert a positive influence on intakes.

Although evidence was limited, we included neighbourhood and food shopping environmental factors in our postal survey, which have been suggested to matter for fruit and vegetable consumption in either the literature or the focus group study. In Chapter 11, large socioeconomic gradients in fruit and vegetable consumption were observed, with lower socioeconomic groups four to five times more likely not to consume fruits and vegetables, respectively. However, we did not find evidence for neighbourhood and food shopping environmental factors to explain these inequalities. We did find that respondents were more likely not to consume fruit or vegetables when they reported poor availability of fruits in their household, when the household cook did not cook vegetables, or when reporting there were no fruit and vegetable outlets in the neighbourhood. However, only very small percentages of participants actually perceived these environmental barriers, and none of these factors contributed to the explanation of socioeconomic inequalities in fruit and vegetable consumption.

Part 4: Discussion, conclusions, and implications

Chapter 12, the General Discussion, started with a summary of the main results of this thesis, followed by study limitations that should be acknowledged when interpreting the results. Measurement issues regarding self-reported data are discussed, e.g. bias due to social desirability, 'same-source bias', and bias due to processes of social cognitive dissonance. Also, some methodological problems concerning objective measurement of neighbourhood characteristics are reflected on, e.g. the lack of validated audit instruments, and lack of knowledge on the appropriate scale is to measure area effects. Next, limitations of a cross-sectional study design are described, with as main draw back that no causal inferences can be drawn. Also, the generalisability of our results to other Western countries is discussed. Results are probably most applicable to countries that are similar to the Netherlands with regard to patterns of socioeconomic differences in health behaviours, and with a similar geographical, cultural and policy environment.

To answer the research questions which were formulated at the start of this project, we took into account our own studies, as well as evidence from other studies in this research field. The body of evidence for associations between SES and physical inactivity (research question 1) and for associations between neighbourhood factors and physical inactivity (research question 2a) is rather consistent, and in line with our results. Associations between SES and objective neighbourhood factors (research question 2b) are discordant in the available literature, however, two of our studies showed the same result: deprived and advantaged areas differed with regard to aesthetic characteristics (e.g.

green maintenance, graffiti), while other area characteristics were less different. Lower-educated and lower-income groups were found more likely to perceive their neighbourhoods as unattractive, unsafe, and lacking sufficient facilities (research question 2b). Our results are in line with the few studies available that have tried to quantify the contribution of neighbourhood factors to socioeconomic differences in physical activity (research question 3). This led to the conclusion that physical and social neighbourhood factors, together with more proximal determinants, have a moderate, but significant contribution to the explanation of socioeconomic differences in several types of physical inactivity.

Conclusions regarding fruit and vegetable consumption were quite different. Although large socioeconomic inequalities in fruit and vegetable consumption exist (research question 1), no evidence for the household or neighbourhood environment to contribute to socioeconomic differences in fruit and vegetable consumption was found in this thesis (research question 2 and 3). This is similar to several studies from the U.K. and Australia, that neither found socioeconomic differences in shopping infrastructure, nor differences in food price, food availability, and access to supermarkets between deprived and affluent areas. U.S. studies, on the other hand, in general found more support for socioeconomic disparities in food environments.

These results have implications for future research, theory development and intervention development. Future research should try to further disentangle relationships between SES, environmental contexts and health behaviours. Longitudinal designs or 'natural experiments' are needed to disentangle causation and selection mechanisms. Specific health-behaviours should be measured, in relation to behaviour- and context-specific environmental factors. Besides neighbourhood factors, also other environmental settings require further investigation. Important with regard to theory development is that both environmental factors (as described in ecological models) as well as individual cognitions (specified in social cognitive models) are important in the explanation of socioeconomic differences in physical inactivity. Therefore, to be able to formulate and test specific hypotheses concerning pathways between environmental and individual factors, both groups should be specified in one model. Our results suggest that intervention and policy strategies targeted towards lower socioeconomic groups would need to intervene on both neighbourhood, household and individual factors, to yield a maximal increase in physical activity among lower socioeconomic groups. Not only individual-level interventions targeted on behaviour change may be important, but general policies, aimed to improve physical and social aspects of neighbourhood environments may also have the potential to exert a positive effect on physical activity levels.

Samenvatting

Samenvatting

Deel 1: Introductie

Sociaaleconomische verschillen in gezondheid bestaan sinds mensenheugenis. De algemene opinie is dat deze verschillen onrechtvaardig zijn en zouden moeten worden verkleind. Sinds begin jaren negentig is in de politiek en in wetenschappelijk onderzoek relatief veel aandacht geweest voor sociaaleconomische gezondheidsverschillen. Toch bestaan ook vandaag de dag, in een modern en ontwikkeld land als Nederland, nog grote verschillen in gezondheid tussen sociale groepen. Vergeleken met Nederlanders in een hoge sociale positie leven zij met een lage sociale positie gemiddeld drie tot vijf jaar korter en bovendien brengen zij tien tot vijftien jaar méér, van hun toch al kortere leven, in ziekte of met gezondheidsklachten door (Hoofdstuk 1). Naast een hogere prevalentie van morbiditeit en mortaliteit komt ook ongezond gedrag vaker voor onder lage sociaaleconomische groepen (bijvoorbeeld roken, lichamelijke inactiviteit en lage groente- en fruitconsumptie). Ongezond gedrag wordt daarom beschouwd als één van de mogelijke verklaringen voor sociaaleconomische gezondheidsverschillen. Om dit ongezonde gedrag te kunnen veranderen, is het cruciaal om te weten welke determinanten ten grondslag liggen aan dit gedrag, of, in andere woorden, om te begrijpen *waarom* lage sociale klassen zich ongezonder gedragen. Heel lang ging men er vanuit dat ongezond gedrag een persoonlijke keuze is en richtte het onderzoek naar determinanten van gezondheidsgerelateerd gedrag zich vooral op deze cognitieve, persoonlijke factoren. Echter, aangezien niet slechts één maar een hele serie ongezonde gedragingen vaker voorkomt onder lagere dan hogere sociale groepen, is het waarschijnlijker dat dit het resultaat is van blootstelling aan ongunstige omgevingsfactoren.

Toen de studies zoals beschreven in dit proefschrift van start gingen, bestond er nog geen duidelijk beeld van welke omgevingsfactoren het belangrijkst zouden zijn voor het verklaren van sociaaleconomische verschillen in gedrag. Enige studies op het gebied van voeding en bewegen hadden al wel aangetoond dat verschillen in de fysieke en sociale structuur van de woonomgeving een rol kunnen spelen bij verschillen in gedrag. Daarom richt dit proefschrift zich op de buurt als belangrijkste setting. De volgende onderzoeksvragen staan centraal in dit proefschrift:

1) Hoe groot zijn sociaaleconomische verschillen in lichamelijke inactiviteit en voedingsgedrag?
2) Welke buurtfactoren zijn gerelateerd aan specifieke vormen van lichamelijke inactiviteit en voedingsgedrag (2a) en aan SES (2b)?
3) In hoeverre kunnen buurtfactoren sociaaleconomische verschillen in lichamelijke inactiviteit en voedingsgedrag verklaren?

Om deze onderzoeksvragen te kunnen beantwoorden, is een onderzoeksprotocol opgesteld met verschillende deelstudies die elkaar stapsgewijs opvolgen. Dit onderzoeksprotocol wordt beschreven in Hoofdstuk 2. Als eerste is een conceptueel model ontworpen, waarin de bestaande kennis over mechanismen die een rol spelen bij sociaaleconomische gezondheidsverschillen wordt gecombineerd met de literatuur over determinanten van gezondheidsgerelateerd gedrag. Vervolgens zijn kwalitatieve groepsinterviews gehouden onder mensen uit lage en hoge sociaaleconomische groepen. Hiermee is onderzocht of de factoren uit het conceptueel model ook daadwerkelijk als belangrijk worden beschouwd en of nog nieuwe factoren in de gesprekken werden genoemd. Uitgaande van de resultaten van deze kwalitatieve studie en de bestaande literatuur is een selectie van omgevingsfactoren opgenomen in de grootschalige, schriftelijke postenquête, om zo de bijdrage van omgevingsfactoren aan sociaaleconomische verschillen in gezondheidsgerelateerd gedrag te kunnen kwantificeren. Vervolgens zijn diepte-interviews gehouden met een selectie van de postenquête-deelnemers om met hun verder door te praten over omgevingsfactoren en gezondheidsgerelateerd gedrag. Bovendien zijn de buurten waarin de interviewdeelnemers woonden bezocht en kenmerken van deze buurten zijn op een objectieve en systematische wijze gescoord. Deze deelstudies (met uitzondering van de diepte-interviews) komen in de volgende hoofdstukken van het proefschrift uitgebreider aan bod.

In Hoofdstuk 3 worden de resultaten van de kwalitatieve focusgroepinterviews gepresenteerd. In vier aparte groepen – twee samengesteld uit mensen van hoge en twee uit mensen van lage sociaaleconomische achtergrond – werd aan deelnemers gevraagd: welke factoren die buiten uzelf liggen, hebben invloed op de mate waarin in u beweegt/groente eet/fruit eet? In alle vier de groepen spraken deelnemers over het gedrag van hun partner, familie en vrienden als zeer bepalend voor hun eigen gedrag. Daarnaast spraken mensen met een lage sociaaleconomische achtergrond over hun onaantrekkelijke en onveilige buurt en de beperkte toegang tot sportfaciliteiten als barrières om lichamelijk actief te zijn. Mensen met een hoge sociaaleconomische achtergrond benadrukten juist de goede toegang tot faciliteiten. Alle deelnemers vonden de beschikbaarheid van groente en fruit thuis voldoende. Over het algemeen spraken lagere sociaaleconomische groepen vaker over de hoge prijs van groente en fruit en hoge toegangsprijzen van sportfaciliteiten. Vrijwel alle factoren die tijdens de groepsinterviews door deelnemers werden genoemd, waren reeds opgenomen in het conceptueel model.

Deel 2: Sociaaleconomische status, omgevingsfactoren en bewegen

Niet alle specifieke buurtfactoren zijn van belang voor alle vormen van beweeggedrag (bijvoorbeeld, de aanwezigheid van sportfaciliteiten in een buurt is wellicht geassocieerd met sporten, maar minder vanzelfsprekend met wandelen).

Het tweede deel van dit proefschrift start met een studie die kijkt of het relatieve belang van zelfgerapporteerde buurtfactoren verschilt voor twee specifieke uitkomstmaten van sporten (Hoofdstuk 4). De twee uitkomstmaten die onder de loep zijn genomen, zijn (a) ten minste iets aan sport doen, versus helemaal niet sporten, en (b) sporten volgens de aanbevolen norm (dat wil zeggen, op ten minste 3 dagen per week gedurende minimaal 20 minuten), versus minder sporten dan de norm. Fysieke en sociale buurtfactoren bleken, samen met persoonlijke cognities, onafhankelijk geassocieerd te zijn met uitkomstmaat (a), sporten versus niet sporten. Daarentegen was geen enkel buurtkenmerk significant geassocieerd met uitkomstmaat (b), het wel of niet halen van de norm, terwijl persoonlijke cognities zoals eigeneffectiviteit en attitude ten opzichte van regelmatig bewegen in sterke mate samenhingen met deze uitkomstmaat. Het belang van specifieke buurtfactoren kan dus zelfs verschillen voor verschillende afkappunten van één beweeguitkomstmaat. Tevens liet de studie zien dat buurtfactoren dus vooral een verschil kunnen maken tussen iets of helemaal niets aan sport doen, terwijl ze een minimale rol spelen bij wel of niet sporten naar de norm.

In Hoofdstuk 5 is vervolgens onderzocht of er sociaaleconomische verschillen zijn in sporten en in hoeverre dit kan worden toegeschreven aan verschillen in zelfgerapporteerde buurtfactoren, omstandigheden in het huishouden en individuele cognities met betrekking tot regelmatig bewegen. Zowel een laag opleidings- als inkomensniveau bleek sterk samen te hangen met een grotere kans om niet aan sport te doen. Ongunstige buurtfactoren (bijvoorbeeld de eigen buurt als onveilig waarnemen, een beperkt sociaal netwerk hebben in de eigen buurt), ongunstige omstandigheden in het huishouden (bijvoorbeeld materiële en sociale deprivatie) en ongunstige individuele cognities (bijvoorbeeld negatieve uitkomstverwachtingen van regelmatig bewegen, een lage eigeneffectiviteit met betrekking tot regelmatig bewegen) waren significant geassocieerd met niet sporten en werden vaker gerapporteerd door de lagere sociaaleconomische groepen. Deze buurt-, huishoudens- en individuele factoren tezamen konden sociaal-economische verschillen in sporten voor een groot deel verklaren.

In Hoofdstuk 6 zijn sociaaleconomische verschillen in wandelen in de vrije tijd onderzocht en wel specifiek onder 55-plussers. Oudere volwassenen vormen door de vergrijzing een steeds grotere groep van de samenleving. Voor hen is lichaamsbeweging belangrijk om zo hun gezondheid en lichamelijk functioneren op peil te houden. Opnieuw bleek een lage sociaaleconomische status geassocieerd te zijn met lichamelijke inactiviteit. Lager opgeleiden waren vaker inactief met betrekking tot wandelen in de vrije tijd dan hoger opgeleiden en eenzelfde verband werd gevonden naar inkomensniveau. Individuele cognities met betrekking tot regelmatig bewegen (bijvoorbeeld houding en eigeneffectiviteit) droegen het meest bij aan de verklaring van deze sociaaleconomische

verschillen. Eén buurtfactor, namelijk of mensen hun buurt wel of niet als aantrekkelijk ervaren, bleek ook significant aan de verklaring van de verschillen bij te dragen. De invloed van deze buurtfactor verliep deels *via* de individuele cognities, dat wil zeggen: lager opgeleiden zagen hun buurt vaker als onaantrekkelijk, wat samenhing met een negatievere houding ten opzichte van regelmatig bewegen en vervolgens ook met een grotere kans om niet aan wandelen in de vrije tijd te doen.

In de hoofdstukken tot nu toe, vonden we dat lage sociaaleconomische groepen hun buurt vaker onaantrekkelijk en onveilig vinden dan hoge sociaaleconomische groepen. De literatuur laat zien dat dergelijke percepties van buurtbewoners niet automatisch één op één staan met objectieve kenmerken van een buurt. Daarom is in Hoofdstuk 7 onderzocht in welke mate objectieve buurtkenmerken sociaaleconomische verschillen in buurtpercepties kunnen verklaren en in hoeverre andere factoren hierbij een rol spelen. Het vaker voorkomen van negatieve buurtpercepties onder de lagere sociaaleconomische groepen bleek deels te kunnen worden verklaard door objectieve scores van buurtaantrekkelijkheid en buurtveiligheid. Daarnaast speelden ook psychosociale factoren (bijvoorbeeld een depressieve stemming) en sociale factoren (bijvoorbeeld de ervaren sociale cohesie in de buurt) een rol bij de verklaring van sociaaleconomische verschillen in buurtpercepties. Om het beeld dat lagere sociaaleconomische groepen van hun buurt hebben te verbeteren (en daarmee de kans op lichamelijke activiteit te vergroten), moet hun woonomgeving dus aantrekkelijker en veiliger worden, maar moeten sociale buurtomstandigheden en persoonlijke, psychosociale factoren ook verbeteren.

In het laatste hoofdstuk over lichaamsbeweging wordt een uitstapje gemaakt naar het buitenland, namelijk Australië. Hoofdstuk 8 betreft een studie naar recreatief fietsen onder inwoners van welgestelde buurten en gedepriveerde buurten van Melbourne. De resultaten laten zien dat inwoners van gedepriveerde buurten minder vaak recreatief fietsen dan inwoners van welgestelde buurten, óók wanneer rekening wordt gehouden met de verschillende samenstelling van gedepriveerde en welgestelde buurten (in gedepriveerde buurten wonen bijvoorbeeld meer lager opgeleiden en meer ouderen dan in de welgestelde buurten, die minder bewegen). Dit impliceert dat het niet kenmerken van de bewoners, maar 'iets' in de buurten zelf moet zijn wat deze verschillen in fietsgedrag kan verklaren. Objectieve scores voor de aantrekkelijkheid van de buurt (onder andere het onderhoud van groenvoorzieningen, het onderhoud van tuinen en de aanwezigheid van een park) waren slechter voor gedepriveerde buurten en konden de sociaaleconomische buurtverschillen in fietsen deels verklaren. Objectieve scores voor de veiligheid van de buurt waren niet zozeer slechter in gedepriveerde buurten, maar er waren wel significante verschillen in objectieve veiligheid tussen de onderzochte buurten in het algemeen. Daarmee

konden de verschillen tussen buurten in de mate waarin er gefietst werd grotendeels worden verklaard. In deze studie kon dus een direct associatie worden aangetoond tussen objectieve buurtkenmerken en lichaamsbeweging (namelijk recreatief fietsen).

Deel 3: Sociaaleconomische status, omgevingsfactoren en voedingsgedrag

Net als bij lichaamsbeweging is in het onderzoek naar gezond en ongezond voedingsgedrag de laatste jaren steeds meer aandacht gekomen voor de context waarin dit gedrag plaatsvindt. De oorzaak van de sterke toename van overgewicht en ernstig overgewicht (obesitas) over de afgelopen decennia wordt vaak gezocht in veranderingen in onze leefomgeving. De 'obesogene' omgeving die geleidelijk aan is ontstaan, maakt de consumptie van ongezonde voeding gemakkelijk (bijvoorbeeld door de alom aanwezige snackgelegenheden in winkelstraten), terwijl de noodzaak tot lichaamsbeweging wordt geminimaliseerd (bijvoorbeeld door de aanwezigheid van liften en roltrappen). Om na te gaan in hoeverre deze redenering wat betreft (on)gezond voedingsgedrag kan worden onderschreven met bewijs uit empirische studies, zijn twee systematische reviews van de literatuur uitgevoerd. In de eerste literatuurstudie, beschreven in Hoofdstuk 9, zijn op een systematische manier studies verzameld en beoordeeld naar associaties tussen omgevingskenmerken en aan obesitas gerelateerde voedingsconsumptie (namelijk inname van verzadigd vet, totaal vet en totale energie). Het belangrijkste resultaat van deze literatuurstudie is dat er nog zeer weinig studies naar omgevingsdeterminanten van vet- en energie-inname gedaan zijn. Naar veel van de onderzochte omgevingsdeterminanten is slechts één of enkele studies uitgevoerd, meestal in cross-sectioneel onderzoek. Voor een reviewstudie is dit onvoldoende bewijs om conclusies te trekken, laat staan om aanbevelingen voor beleid of interventies te doen. In de tweede reviewstudie is de bestaande literatuur over associaties tussen omgevingskenmerken en groente- en fruitconsumptie onderzocht (Hoofdstuk 10). Ook deze studie heeft als belangrijkste conclusie: gebrek aan bewijs. Veel verschillende determinanten zijn bestudeerd, variërend van wonen in een landelijke of stedelijke omgeving tot werkdruk. Voor vrijwel geen enkel omgevingskenmerk is naar de relatie met groenteconsumptie of fruitconsumptie vaak en goed genoeg onderzoek gedaan. Een uitzondering hierop is het inkomensniveau van het huishouden: mensen uit huishoudens met een laag inkomen consumeerden stelselmatig minder groente en minder fruit dan mensen met een hoog huishoudinkomen. Ook is er enig bewijs voor een associatie tussen de beschikbaarheid van groente en fruit in het huishouden (bijvoorbeeld door de aanwezigheid van een eigen groentetuin) en consumptie.

Hoofdstuk 11 is gebaseerd op data van de grootschalige postenquête en draagt hiermee bij aan het empirisch bewijs voor de rol van omgevingsfactoren bij groente- en fruitconsumptie. Tevens zijn in dit hoofdstuk sociaaleconomische verschillen in groente- en fruitconsumptie onderzocht. Mensen die rapporte-

ren dat er geen of onvoldoende groente en fruit in hun huishouden beschikbaar zijn, dat degene die kookt geen groenten bereidt, of dat in de buurt geen winkels zitten die groente en fruit verkopen, hebben een grotere kans om geen groente en fruit te consumeren. Echter, het percentage mensen dat deze barrières rapporteert is zeer laag. Sociaaleconomische verschillen in groenteconsumptie en in fruitconsumptie zijn groot, maar deze kunnen niet worden verklaard door de onderzochte huishoud- en buurtfactoren.

Deel 4: Discussie, implicaties en conclusies

Het Discussiehoofdstuk (Hoofdstuk 12) start met een samenvatting van de belangrijkste resultaten van dit proefschrift, gevolgd door een beschrijving van de belangrijkste beperkingen van de onderzoeksmethoden die zijn toegepast. Deze moeten in het achterhoofd worden gehouden bij het interpreteren van de resultaten. Zo zijn veel hoofdstukken gebaseerd op zelfgerapporteerde gegevens, wat de resultaten mogelijk vertekend zou kunnen hebben. Methodologische problemen die zich voor deden bij het meten van objectieve buurtkenmerken zijn onder andere het ontbreken van gevalideerde meetinstrumenten en gebrek aan kennis over wat de juiste schaal is om buurtkenmerken te meten. De meeste studies in dit proefschrift zijn cross-sectioneel van aard, wat wil zeggen dat zowel de verklarende factoren als de uitkomstmaat op hetzelfde moment in de tijd zijn gemeten. Hierdoor kunnen geen conclusies over causaliteit worden getrokken. Ten slotte komt de generaliseerbaarheid van de resultaten aan bod. De resultaten zijn niet direct toepasbaar op de gehele Nederlandse bevolking, omdat twee belangrijke bevolkingsgroepen onvoldoende in de studies zijn vertegenwoordigd, namelijk allochtonen en laaggeletterden. De resultaten uit dit proefschrift zijn ook van toepassing op andere westerse landen, die op Nederland lijken wat betreft patronen van sociaaleconomische verschillen in gezondheidsgerelateerde gedrag en met min of meer gelijke geografische, culturele en politieke omstandigheden.

In de beantwoording van de onderzoeksvragen die aan het begin van deze studie zijn geformuleerd, worden zowel de resultaten van de studies zoals beschreven in dit proefschrift meegenomen, als die van soortgelijke studies in het onderzoeksveld. Er is aanzienlijk en consistent bewijs voor associaties tussen sociaaleconomische status en lichamelijke inactiviteit (onderzoeksvraag 1) en voor associaties tussen buurtfactoren en lichamelijke inactiviteit (onderzoeksvraag 2a). De literatuur geeft geen consistent bewijs voor associaties tussen sociaaleconomische status en objectieve buurtkenmerken (onderzoeksvraag 2b), maar twee van de studies uit dit proefschrift laten wel eenzelfde resultaat zien: gedepriveerde en welgestelde buurten verschillen vooral van elkaar wat betreft aantrekkelijkheid van de woonomgeving (bijvoorbeeld onderhoud van groen, aanwezigheid van graffiti), terwijl verschillen in andere objectieve kenmerken minder groot waren. Lager opgeleiden en lagere inkomensgroepen zien hun buurt vaker als minder aantrekkelijk, minder veilig en met onvoldoende faci-

liteiten om te bewegen (onderzoeksvraag 2b). Ondanks het beperkte aantal studies dat geprobeerd heeft de bijdrage van omgevingsfactoren aan sociaaleconomische verschillen in lichaamsbeweging te kwantificeren, kan worden geconcludeerd dat fysieke en sociale buurtkenmerken, samen met meer proximale, individuele factoren, een gematigde maar significante bijdrage leveren aan de verklaring van sociaaleconomische verschillen in lichamelijke inactiviteit (onderzoeksvraag 3).

De conclusies met betrekking tot groente- en fruitconsumptie zijn geheel anders van aard. Ondanks dat grote sociaaleconomische verschillen in groente- en fruitconsumptie bestaan (onderzoeksvraag 1), geeft dit proefschrift geen bewijs voor een bijdrage van huishoud- en buurtfactoren aan de verklaring van deze verschillen (onderzoeksvraag 2 and 3). Deze conclusie is vergelijkbaar met die van een aantal studies uit het Verenigd Koninkrijk en Australië, die geen verschillen vonden tussen gedepriveerde en welgestelde buurten in het aanbod van winkels, prijzen van voedingsproducten en de toegankelijkheid van supermarkten. Daarentegen is in de Verenigde Staten wel bewijs gevonden voor sociaaleconomische verschillen in de voedingsomgeving.

Deze resultaten hebben implicaties voor onderzoek, theorieontwikkeling en mogelijke interventies. Meer onderzoek is nodig om associaties tussen sociaaleconomische status, omgeving en gezondheidsgerelateerd gedrag verder te ontrafelen. Longitudinale onderzoeksontwerpen (met meerdere meetpunten over de tijd heen) en 'natuurlijke experimenten' kunnen worden toegepast om causale en selectie-effecten van elkaar te onderscheiden. Gedrag en omgevingsfactoren moeten zo specifiek mogelijk worden gemeten, omdat alleen dan mogelijke associaties kunnen worden aangetoond. Naast buurtinvloeden verdienen ook andere omgevingsfactoren nader onderzoek, bijvoorbeeld de werkomgeving, nationaal beleid, het eigen huishouden en invloed van de media. Belangrijk voor de ontwikkeling van theorieën is dat zowel omgevingsfactoren (waarvan het belang wordt benadrukt in ecologische modellen) als individuele cognities (zoals gespecificeerd in sociaalcognitieve theorieën) een rol spelen in de verklaring van sociaaleconomische verschillen in bewegen. Daarom zouden beide groepen factoren moeten worden geïntegreerd in één model, om zo specifieke hypothesen tussen sociaaleconomische status, omgeving- en individuele factoren en gedrag te kunnen formuleren en testen. Om interventie- en beleidstrategieën, met als doel lagere sociaaleconomische groepen aan het bewegen te krijgen, te laten slagen, zouden deze zich gelijktijdig moeten richten op zowel buurt-, huishoudens- als individuele factoren. Naast persoonlijke interventies specifiek gericht op gedragsverandering, kunnen ook meer algemene beleid- en interventiestrategieën gericht op het verbeteren van de fysieke en sociale buurtomgeving (dus zonder een specifiek gezondheidsdoel), een belangrijke bijdrage leveren aan het bevorderen van beweeggedrag.

Tot slot

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Curriculum Vitae

Carlijn Barbara Maria Kamphuis werd geboren op 20 oktober 1979 te Zoetermeer. In 1998 behaalde zij haar VWO-diploma aan het Alfrink College in Zoetermeer. Na haar propedeuse HBO-Verpleegkunde te hebben behaald aan de Haagse Hogeschool, startte zij in 1999 met de studie Gezondheidswetenschappen aan de Universiteit Maastricht. In 2003 behaalde ze haar doctoraal Gezondheidswetenschappen (Master of Science), met als afstudeerrichting Gezondheidsvoorlichting. Van oktober 2003 tot april 2008 was zij als promovendus verbonden aan de afdeling Maatschappelijke Gezondheidszorg van het Erasmus MC in Rotterdam en voerde haar promotieonderzoek uit wat resulteerde in dit proefschrift. Gelijktijdig volgde ze de post-doctorale opleiding Public Health aan het NIHES (Netherlands Institute for Health Sciences) en behaalde in juni 2006 haar Master of Public Health. Van oktober tot en met december 2006 deed ze onderzoek aan de Queensland University of Technology (Brisbane) en aan de University of Melbourne, Australië. Sinds oktober 2007 is zij werkzaam als wetenschappelijk onderzoeker bij het Sociaal en Cultureel Planbureau in Den Haag.

Carlijn Barbara Maria Kamphuis was born on October 20, 1979, in Zoetermeer, the Netherlands. She obtained her secondary school education at the Alfrink College in Zoetermeer in 1998. She studied Nursing for one year, and then enrolled at university to study Health Sciences. In 2003 she graduated with her Master of Health Sciences (majoring in Health Education and Promotion) from the University of Maastricht. She was then employed as a PhD-student at the Department of Public Health at the Erasmus Medical Centre in Rotterdam, where she carried out the research presented in this thesis. During this time, she also enrolled in the Master of Science programme at the Netherlands Institute for Health Sciences, and obtained her Master of Public Health in June 2006. From October to December 2006, she worked as a visiting researcher at the Queensland University of Technology in Brisbane and the University of Melbourne, Australia. Carlijn is currently employed as researcher at the Netherlands Institute for Social Research/SCP, The Hague.

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