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Food environments in socioeconomically disadvantaged and immigrant populations through a non-communicable disease lens

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Abstract

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Background: Globally, non-communicable diseases are increasing. With an evidenced link to the social determinants of health, this highlights a social gradient, whereby socioeconomic status, ethnicity and other factors influence poorer health outcomes. They are also linked to food environments, the interface of interaction between the food system and consumers.

Aim: The aim of this thesis is to improve understanding of the food environment and its interactions with a focus on socioeconomic disadvantage and immigrant populations through a non-communicable disease lens.

Methods: In Study I-III, the external food environment was mapped using a modified version of the Environmental Profile of a Community's Health observation tool. Study I included under-resourced and socioeconomically disadvantaged sites, one urban and one rural, in a low- (Uganda), middle- (South Africa) and high-income (Sweden) country. Further, twenty-two lower and middle socioeconomic status neighborhoods of Stockholm were mapped in Study II and III. Descriptive and inferential statistical analyses were carried out. Study IV, a scoping review, used the Analysis Grid for Environments Linked to Obesity (ANGELO) framework to analyze and interpret the data on the interaction between personal and external food environments.

Results: Across countries, food environments differed in the number of informal outlets present, the most found in Uganda and the least in Sweden. Primarily supermarkets, as well as other stores, were a source of both unhealthy and healthy food items, while advertising unhealthy items in store. Overall, outdoor advertisements of unhealthy foods were the most common and more prevalent in areas of higher socioeconomic disadvantage. Fruits and vegetables had similar prices across countries, though in the Swedish context, these cost less with lower neighborhood socioeconomic status. Structural and social factors like income, time, mobility and children's preferences influenced the healthiness of foods acquired by immigrants from low-and middle-income countries living in high-income countries.

Conclusion: Unhealthy items were both widely prevalent, as well as advertised across settings, at a higher rate in areas of higher disadvantage. Combined with structural and social factors that push consumers towards unhealthy practices, this could exacerbate existing health and nutrition inequities. Further research to better understand the food environment and its interactions with consumers are needed to facilitate healthier choices and improve health.

Keywords: Food environments, energy-dense nutrient-poor foods (EDNP), supermarkets, food prices, advertising, socioeconomic status, immigrant populations, non-communicable diseases

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“At the end of every scientific paper there is a familiar coda: more research is needed, more research is needed. What, I wondered, if we added a new coda: more action is needed. It need not be discordant with the first.”
— Michael G. Marmot

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

- I. Spires, M., Berggreen-Clausen, A., Kasujja, F. X., Delobelle, P., Puoane, T., Sanders, D., Daivadanam, M. (2020). Snapshots of Urban and Rural Food Environments: EPOCH-Based Mapping in a High-, Middle-, and Low-Income Country from a Non-Communicable Disease Perspective. *Nutrients*, 12(2):484.
- II. Berggreen-Clausen, A., De Man, J., Mölsted Alvesson, H., Andersson, A., Daivadanam, M. Food environment characteristics and neighborhood socioeconomic status in Stockholm. *Submitted to Public Health Nutrition*
- III. Berggreen-Clausen, A., Mölsted Alvesson, H., Álvarez Ahlgren, J., Spires, M., Daivadanam, M., Outdoor and in-store food advertising: unhealthy and health promoting advertisements in low and middle SES neighborhoods in Stockholm, Sweden. *Manuscript*
- IV. Berggreen-Clausen A, Hseing Pha S, Mölsted Alvesson H, Andersson A, Daivadanam M. (2022) Food environment interactions after migration: a scoping review on low- and middle-income country immigrants in high-income countries. *Public Health Nutrition*. 25(1):136-158

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Contributions

The contributions of Aravinda Berggreen-Clausen to the studies included in the thesis are as follows:

Study I: Together with co-authors collaborated on modifying the existing data collection tool. Collected data for the Swedish site together with the other first author (MS). Completed data entry for the Swedish setting; retrieved and processed data. Conducted statistical analysis under supervision of co-authors. Drafted and revised manuscript in collaboration with co-authors.

Study II: Used the same data collection tool that was modified for study I. Planned the study together with co-authors from conception to design. Collected part of the data and supervised the collection of the remaining data. Prepared the data for analysis; planned the statistical analysis with co-authors and worked closely with co-author (JDM) who conducted the statistical analysis. Drafted and revised manuscript in collaboration with co-authors.

Study III: Used the same data collection tool that was modified for study I. Planned the study together with co-authors. Data collection for study II and III were the same and a part of the data was used in this study. Extracted and processed the relevant data for this study and conducted statistical analysis with support from the Statistics Department (Uppsala University). Main responsibility for drafting and revising manuscript, with critical revisions from co-authors.

Study IV: Planned the study together with co-authors from conception to design. Together with other first author carried out literature searches and the inclusion process of articles with support from co-authors. Main responsibility for data analysis, with input from co-authors. Main responsibility for writing and revising manuscript, with critical revisions from co-authors.

Contents

Introduction.....	11
The prevalence and risk factors for non-communicable disease.....	12
Health and nutrition inequities.....	13
Inequities in social determinants of health.....	13
Socioeconomic inequities in diet and health outcomes.....	14
Food consumption and health outcomes in immigrant populations....	15
Food Environment.....	16
Influences on food choices and food access.....	16
Unhealthy options in food environments.....	18
The role of food environments in dietary behavior.....	19
Food environments as they relate to health outcomes.....	20
Food environments and disadvantaged or immigrant neighborhoods.....	21
Assessing food environments.....	23
Theoretical/conceptual framework.....	24
Socio ecological theory.....	24
Conceptual framework of food environments.....	25
Rationale.....	29
Aim.....	30
Research questions.....	30
Methods.....	31
SMART2D project.....	33
Paper I-III.....	34
Sample.....	34
Data collection.....	36
Statistical analysis.....	40
Study IV.....	41
Inclusion process for articles.....	41
Data analysis.....	43
Ethical considerations.....	44
Results.....	45
External food environment.....	45
Sample characteristics.....	45
Availability: Stores & Food items.....	46

Vendor and product properties: Vendor typology, product and food quality	47
Prices of food items	48
Marketing and regulation: outdoor, in-store advertising and food labels.....	48
Personal food environment.....	50
Sample characteristics	50
Accessibility	50
Affordability	51
Convenience	51
Desirability	52
Discussion	54
Prices & affordability	56
Outdoor advertising.....	58
Immigrants living in high-income countries	60
Methodological considerations.....	63
Sample selection (Study I, II, III)	63
EPOCH tool (Study I, II, III)	64
Score of neighborhood SES (Study II)	66
Scoping review (Study IV).....	67
Conclusions.....	68
Future perspectives	69
Svensk sammanfattning	71
Acknowledgements.....	74
References.....	77

Abbreviations

NCDs	Non-Communicable Diseases
SES	Socio-Economic Status
EDNP	Energy-Dense Nutrient Poor Foods (includes references to junk foods)
SDGs	Sustainable Development Goals
UN	United Nations
WHO	World Health Organisation
BMI	Body Mass Index
SSBs	Sugar-Sweetened Beverages
EPOCH	Environmental Profile of a Community's Health
ANGELO	Analysis Grid for Environments Linked to Obesity
GIS	Geographic Information Systems
LMICs	Low- and Middle-Income Countries
HICs	High-Income Countries
REDCap	Research Electronic Data Capture
SMART2D	Self-Management and Reciprocal learning for Type 2 Diabetes
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children
SNAP	Supplemental Nutrition Assistance Program

Introduction

This thesis has taken a broad look at food environments. By utilizing a non-communicable disease (NCD) lens, it aims to better understand aspects of the food environment relevant for improving health, particularly in neighborhoods of higher socioeconomic disadvantage. The prevalence of overweight, obesity and NCDs such as type 2 diabetes and cardiovascular diseases have been increasing worldwide, responsible for a large share of the global burden of disease and mortality.⁽¹⁾ This is well-recognized, not only in research, but also in the policy sphere, particularly by the World Health Organization (WHO) and the United Nations (UN) through the Sustainable Development Goals (SDGs). Specifically, SDGs 2, 3, and 10 highlight the importance of understanding and improving the links between food, society, environment, and health of populations. It is, however, important to note that NCDs are not equally distributed in society. Those with low income and education, or living in disadvantaged neighborhoods, tend to have disproportionately higher levels of poor health outcomes as compared to those with better income and education, or those living in more affluent neighborhoods.⁽²⁾ Diets with an inadequate intake of fruits and vegetables or increasing consumption of energy-dense nutrient-poor (EDNP) processed foods are established risk factors for NCDs.^(3, 4)

In the context of this work, food environments are the interface between the wider food system and the consumer, including the space and factors relating to acquisition of food. Food environments are of increasing interest in relation to their role in health and health outcomes of populations.⁽⁵⁾ There is a growing recognition of the role that food environments play in food choices and health outcomes, as opposed to assigning full responsibility to individual agency and choice.⁽⁶⁾ Research shows that not all food environments are created equal. Socioeconomically disadvantaged neighborhoods often exhibit a lower availability of healthy foods and a higher presence of food outlets selling unhealthy foods.⁽⁷⁾ Through the work undertaken in this thesis, I contribute to an improved understanding of food environments with an NCD lens, in the context of socioeconomically disadvantaged and immigrant populations.

The prevalence and risk factors for non-communicable disease

NCDs are the main cause of death and global burden of disease worldwide.⁽¹⁾ In 2020, NCDs including cardiovascular disease, type 2 diabetes and cancer were the reason behind 70% deaths worldwide.⁽¹⁾ Globally the prevalence of type 2 diabetes has increased, from 108 million with diabetes in 1980 to 422 million in 2014.⁽⁸⁾ Previously considered an adult-onset disease, type 2 diabetes is now increasingly diagnosed children.⁽⁸⁾ Similarly, obesity rates are high and continue rising, currently three times higher than in 1975.⁽⁸⁾ In the WHO European region, almost 60% of adults and approximately one in three children are overweight or obese.⁽⁹⁾ Countries in Southern Europe had a higher prevalence of childhood obesity compared to Northern European countries.⁽¹⁰⁻¹²⁾ In Sweden, 52% of the population aged 16-84 years were overweight or obese according to self-reported data from 2021.⁽¹³⁾ Worldwide, overweight and obesity were risk factors for morbidity and mortality from Covid-19, and societal changes during the pandemic further increased their incidence.⁽⁹⁾

Overweight and obesity are the fourth most common risk factor for NCDs after blood pressure, dietary risks and tobacco use.⁽¹⁾ Many NCDs are linked to everyday practices, often referred to as 'lifestyle' in the literature and are therefore considered largely preventable.^(1, 8, 14) Lifestyle factors, such as tobacco use, unhealthy diet, lack of physical activity and excessive alcohol are responsible for the majority of NCDs and their risk factors.⁽¹⁾ Furthermore, obesity during childhood is linked to a variety of health issues and increased risk of early markers of cardiovascular disease. Overweight children also run a higher risk of obesity and disability as an adult as well as suffering from premature death.^(14, 15)

Dietary factors are a major contributor to the burden of disease,⁽¹⁶⁾ with an estimated one in every five deaths worldwide being preventable through an improvement in diet.⁽¹⁷⁾ Although overall diet quality has improved somewhat globally, large differences in dietary components and quality are apparent across age, sex, education, urbanicity, time and world regions.⁽¹⁸⁾ The main dietary factors linked to morbidity and mortality are diets high in sodium (particularly in the older ages), processed meats, sugar-sweetened beverages (SSBs) and diets low in nuts or seeds, seafood (omega-3), vegetables and fruits.⁽³⁾ EDNP foods, such as highly processed convenience and fast foods are a significant risk factor in the development of

NCDs. The consumption of EDNP foods and beverages have been associated with negative health outcomes including overweight, obesity, cardio-metabolic risks, cancer, type 2 diabetes and cardiovascular diseases.^(3, 19) The relative importance of dietary risk factors varies by ethnicity, age and education.⁽³⁾ Due to the established association between diet and risk of NCDs, in this thesis, the term ‘healthy’ food primarily refers to fruits and vegetables, while ‘unhealthy’ foods includes EDNP foods, such as confectionaries and SSBs.

Globally, there has been an increase in consumption of EDNP foods over the last decades. High-income countries (HICs) had the highest per capita sales and highest variety of EDNP foods and beverages, far more than upper- and lower middle-income countries.⁽²⁰⁾ As the economic status of countries improve, populations are consuming more of these unhealthy foods.⁽²⁰⁾ As the share of EDNP food increases, diet quality decreases, exceeding the WHO recommendations for free sugars, total fat, saturated fat and sodium.⁽⁴⁾

Health and nutrition inequities

Inequities in social determinants of health

Overall figures from national surveys as well as smaller studies are more likely to represent the health status and dietary intake of majority groups. This may mask underlying differences between sub-groups. Though individual dietary intake is shaped by numerous factors, characteristic trends are observed in population groups. This results in unequal distribution of health outcomes across the population, for example by gender, socioeconomic position or by race/ethnicity.⁽²⁾ Inequities in health outcomes across the population are largely due to the unfair distribution of structural factors and circumstances affecting daily life, over the life course.^(21, 22) Known as the social determinants of health, these include income, education, work-life conditions, food security, housing, early childhood, social inclusion and accessible, high-quality health services.⁽²²⁾ These factors are further shaped by forces and systems at a higher level, such as economic and social policies, social norms, political systems and commercial determinants of health.^(22, 23) Social determinants of health are considered the causes of the causes, i.e. the main explanation to differences in diet, tobacco, alcohol consumption or other risk factors between population groups.⁽²⁴⁾ Social determinants of health are estimated to cause between 30-55% of health outcomes worldwide.⁽²²⁾

Studying the social determinants has identified a social gradient in health, which shows how health improves incrementally with socioeconomic position.⁽²⁵⁾ A resulting gap in life expectancy, cardiovascular health profile, self-assessed health and risk of stroke, is apparent between those of higher and lower disadvantage.^(2, 26-28) Socioeconomic factors weigh in heavily in the social determinants of health and should not be overlooked in reducing the burden of disease and mortality.^(29, 30) The relationship between socioeconomic factors and health is dynamic, interactive and complex, where epigenetic processes can change gene expression.⁽²⁴⁾ This relationship is challenging to research in terms of determining causation, as health outcomes can manifest decades after exposure.⁽²⁴⁾ SES is used to illustrate the effects of social determinants on health, either at the individual or area-level.⁽³¹⁾ SES at the individual level can be measured by income, education and/or occupation among other measures, while SES at area-level may use an aggregate measure of individual data related to SES, for example education, employment, occupation, housing conditions, income and wealth measures.⁽³²⁾ However, though these are widely used, area-based measures are prone to ecological fallacy, where all residents are assigned the same level of SES, not accurately reflecting reality.^(33, 34) Aggregate SES scores may also hide differences in the relationship with health outcomes. Illustrating this, European studies showed indicators of SES, like income, education, perceived family wealth, employment status and residential property value had different strength of association to body mass index (BMI).^(10, 35)

Socioeconomic inequities in diet and health outcomes

In HICs, lower socioeconomic position is associated with higher risk of obesity in adults and children.^(2, 10, 12, 13, 26, 35-41) For example, a meta-analysis and systematic review of data from HICs found that low neighborhood SES was associated with a 31% higher chance of overweight and 45% higher likelihood of obesity than high neighborhood SES.⁽⁴²⁾ However, in low- and middle-income countries (LMICs), the opposite is the case, where weight increases with wealth.^(35, 43) A study from the UK combined analysis of data by socioeconomic strata, and by ethnicity, to better understand how BMI relates to SES within different ethnic groups.⁽⁴⁴⁾ The study revealed that higher obesity and worse health behaviors were associated with being poor White, compared to more affluent White. In other ethnicities (Black Caribbean/African, Indian, Pakistani/Bangladeshi) this link was either weak or an increase in SES was associated with worse health outcomes and

worse dietary behavior.⁽⁴⁴⁾ On the other hand, a study on the Ghanaian diaspora living in Europe, showed that with increasing level of education, the prevalence of type 2 diabetes decreased.⁽⁴⁵⁾ The relationship between overweight and disadvantage in HICs is an indication of a widening social gap in obesity and health in general across settings.

There are some differences in dietary patterns between countries, though countries of similar economic development had similar patterns.⁽⁴⁶⁾ In HICs, those in higher socioeconomic strata had a higher likelihood of reporting daily fruit and vegetable consumption,^(38, 46-48) and in some countries studied, wealth was related to an overall 'healthy' food pattern.⁽⁴⁹⁻⁵¹⁾ Lower SES and living in a place of high area-level disadvantage showed consistent associations with obesogenic dietary behavior; for example lower diet quality, higher fast-food intake, consumption of snacks, sweets and soda consumption.^(12, 37, 38, 46, 49, 50, 52-56) Those with lower SES in a European wide study consumed a lower quality diet, both through the consumption of more unhealthy foods, as well as a lower consumption of healthy foods like fruits and vegetables.⁽⁴⁹⁾ The socioeconomic disparities in dietary behavior may explain part of the link between disadvantage and overweight or obesity.⁽⁵⁷⁾

Food consumption and health outcomes in immigrant populations

Immigrants and ethnic minorities in HICs generally have a lower socioeconomic position and live in more disadvantaged neighborhoods compared to the majority population. In HICs countries, studies have found immigrants, particularly recent ones from LMICs, to be generally healthier than the host population.^(13, 58-63) However, over time immigrants suffer from higher rates of some types of negative health outcomes, including obesity, type 2 diabetes and other diet related chronic diseases.⁽⁶⁴⁻⁶⁷⁾ An indication of this is the earlier onset of NCDs in immigrants, while also having a higher risk at the same BMI compared to whites. This is partly due to differences in risk related to fat distribution phenotypes, though most studies do not take this into consideration.⁽⁶⁸⁾ Data for BMI is readily available and can be based on self-reported weight and height, hence its extensive use as an indicator in research in spite of its limitations.

At the individual level, important risk factors for developing non-communicable diseases following migration are the stress of moving and settling, and genetic pre-disposition.^(64, 65, 69) In addition, changes in dietary

practices, including an unhealthy diet, related to acculturation and a rapid nutrition transition, as well as physical inactivity are also important factors.^(66, 70) The dietary change that takes place following migration is known as dietary acculturation, a phenomenon where minorities are thought to take on the food habits of the majority population.⁽⁷¹⁾ The difference in overweight and obesity prevalence by level of SES and by ethnic groups may be partly due to differential exposures to risk factors working throughout the life course, influenced by the social situation and environment, including the food environment.⁽⁷²⁾ There is however some evidence indicating immigrants in HICs have a higher diet quality, including consuming more fruits and vegetables as compared to the host populations.^(73, 74) However, over time these differences are less clear. Several factors over time lead immigrants to consume more energy-dense diets: higher in fat and caloric sweeteners, fewer fruits and vegetables, bigger portion sizes and more convenience foods.^(69, 75) The diet of immigrants seems to vary between countries, with studies not necessarily reporting length of stay, which may play a role in diet. For example, in the Nordic context there are findings of non-ethnic Norwegians consuming less EDNP foods than ethnic Norwegians.⁽⁵⁴⁾ On the other hand, another study showed that children whose parents were born outside of a Nordic country consumed both more fruits and vegetables and more EDNP foods compared to those whose parents were born in a Nordic country.⁽⁵⁶⁾

Food Environment

Influences on food choices and food access

At the individual level, life course events shape a food choice trajectory, with a range of factors like cultural ideals, personal factors, resources, social factors and present context.⁽⁷⁶⁾ These food choice values are negotiated through analyzing situations and foods, interacting to form food decisions, which in turn express themselves as food behavior.⁽⁷⁶⁾ From the perspective of a food insecure population in a HIC, cost of foods, accessibility of shops, health issues and food rationing strategies were found to be important in food choices.⁽⁷⁷⁾ Food decisions were made primarily based on cost related to income, and though healthy food was valued, it was out of reach. In addition, a study on the added layer of ethnicity showed how ethnicity shaped food choices through ideals, identities and roles that interacted depending on the context.⁽⁷⁸⁾ For immigrants having moved to HICs, a number of factors have been identified that influence the process of food choice, that can be grouped into demographic or individual level, social

and economic, ethno-cultural norms, and exposure to the host culture.⁽⁷¹⁾ In the host country, availability of foods, urbanization and lack of time for food preparation are among the important factors that have an influence on the diet of immigrants.⁽⁷⁹⁾

The role of the food environment in food practices and health outcomes are gaining increasing interest; compared to the individual-based explanations of health outcomes, where the focus is on treating these and attempting to change behavior. The food environment can be considered the interface between the wider food system and consumers' food acquisition, in turn leading to dietary intake and thus further related to health outcomes.^(5, 80) Nations have unique social, cultural, economic and regulatory environments, determining how food provision, purchase and consumption take place; the neighborhood level may be an illustration of these playing out.⁽⁸¹⁾ As the food environment is the interface between people and the food system, by default there is an interaction between each person that acquires food and their food environment.

Food choice is a complex dynamic between dimensions of food access combined with social, cultural and material conditions. Food access is influenced by the availability, accessibility, affordability, appropriateness and accommodation of foods and stores.^(52, 82, 83) Importantly, the food environment, also signals to the consumer what to buy, through which products are available, their prices, placement and promotion, which can further shape food choices.^(84, 85) Furthermore, advertising of food products plays a role in increasing desirability and thus influences food choices, particularly in children.^(85, 86) A large share of food advertising promotes EDNP foods and more disadvantaged and areas with a higher share of ethnic minorities and/or immigrants are exposed to higher levels of advertising.^(87, 88) In addition, excess exposure to advertising of EDNP foods through different sources has been linked to obesity.⁽⁸⁹⁾ However, a scoping review of outdoor advertising did not find a clear link between advertising and diet and health outcomes, perhaps due to difficulties in establishing a direct link because of the nature of outdoor advertising.⁽⁸⁸⁾

It is important to also note that demographic, psychosocial or perceived environment at the individual level can moderate or mediate the effect of the physical environment on the individual's food choices.⁽⁹⁰⁾ Through an interplay of environmental, social and individual factors, these interactions can have different trajectories in relation to health outcomes, affecting risk of developing chronic disease.⁽⁹⁰⁾ This is complex and not fully understood.

In addition, the majority of studies on the food environment and diet link were based on cross-sectional studies, where no causal inference can be established. Hence, there is a lack of understanding of the underlying dynamics, for different population groups.

Unhealthy options in food environments

The built environment plays a role in enabling physical activity and a healthy diet and may also limit the possibilities to live a healthy life. Through green spaces, safer neighborhoods to be active in and healthier food environments; these favorable environments may promote health.^(91, 92) When the food environment facilitates unhealthy choices, by inadvertently making the unhealthy options the default choice, it can lead to health outcomes like overweight/obesity and NCDs.⁽⁹²⁾ In such cases, overweight and obesity are a normal result of residing in such environments.^(93, 94) The factors through which these ‘obesogenic’ environments have an influence on the food environment-diet relationship are multi-faceted.⁽⁸²⁾ Some examples include stores dedicating more space to EDNP foods as compared to fruits and vegetables; promoting less healthy options at fast food restaurants in spite of the availability of healthy items on the menu, and healthy foods being double the price of unhealthy options, contributing to default unhealthy food choices.⁽⁹⁵⁻⁹⁷⁾ Confirming this, in a systematic review, those actively trying to manage their weight reported it being a constant struggle due to the pervasive nature of unhealthy food items in neighborhoods.⁽⁹⁸⁾ As a society, the consumption of unhealthy foods can be normalized when there is an inundation of these, paired with messages encouraging their consumption, developing into social norms and preferences.^(99, 100) Thus, food environments have an important role to play in the foods that people acquire and consume and have the potential to enable a healthy diet or facilitate less healthy choices.

Food environments are also dynamic and changes over time vary between settings and countries. Some settings, like the US and New Zealand have shown increased density and shorter distance to food outlets such as supermarkets, fast-food, full-service restaurants, bakeries and convenience stores over time.^(101, 102) On the other hand in Sweden the opposite was found to be true, and saw an overall decrease in access to food outlets, with greater distance to stores over time, primarily affecting those in rural areas and those living in own houses in urban areas, populations that generally have access to cars.⁽¹⁰³⁾ In this same study, those living in blocks of flats, including disadvantaged populations, were less affected by these changes,

not having worse access over time⁽¹⁰³⁾. In addition, food retail outlets have been found to cluster together, highlighting the multi-dimensional nature of food environments.⁽¹⁰⁴⁾

The role of food environments in dietary behavior

There are mixed results on the link between food environments and diet, with some studies finding no associations between these.^(37, 48, 67, 105) For example, there was no association between fruit and vegetable consumption in an older population with access to stores selling these, to fast food outlets, or the overall diversity of the food environment across 20 towns in the UK.⁽⁴⁸⁾ Higher prices of healthy foods are associated with better dietary outcomes, as those with the means can spend more to achieve a healthy diet.⁽⁷⁾ Interestingly, lower cost of a staple food basket at the preferred store was associated with lower BMI, but not associated with dietary intake.⁽⁶⁷⁾

On the other hand, studies have found an association between characteristics of the food environment and diet. People with better access to fruits and vegetables have significantly higher intake of these,⁽⁸²⁾ though studies vary in how availability of such healthier foods link to diet and health outcomes. In a systematic review, measures of availability were more likely to be significantly related to diet as compared to accessibility.⁽¹⁰⁶⁾ A study from the US based on geographic information systems and participant ranking of food environment found that those living in lowest ranked food environments had a poorer diet than those in highest ranked environments.⁽¹⁰⁷⁾ In the same study, those with no supermarkets near their home were less likely to have a healthy diet compared to those surrounded by the most stores.⁽¹⁰⁷⁾ Both closer distance to any food store and a higher density of food stores was associated with higher BMI and a higher consumption of fast food, snacks, SSBs and lower consumption of fruits and vegetables.⁽⁶⁷⁾ A systematic review on community and consumer food environment on children's diet found moderate evidence of a relationship between these.⁽¹⁰⁸⁾ Distance to and high access to supermarkets, small stores and fruit and vegetables stores were most associated with fruit and vegetable intake,^(38, 109) lower fast food consumption, lower risk of overweight or obesity.⁽³⁸⁾ While fast food outlets and convenience stores had the strongest association with unhealthy food intake including fast food.^(109, 110) In one study, only the highest density of unhealthy food outlets was associated with a less healthy dietary pattern.⁽¹⁰⁶⁾ For example, low fast-food access was associated with a healthier diet.⁽³⁸⁾ Higher availability of healthy food items at the closest grocery store was linked to lower intake of SSBs.⁽⁶⁷⁾

Other factors may also explain some of the discrepancies in the relationship between the food environment and diet. One limitation is the dietary data that these studies are based on. Representative dietary data can be difficult to capture; there are different methods, each with their own limitations, including recall bias in 24 hour recalls to lack of precision and misreporting in food frequency questionnaires.⁽¹¹¹⁾ As for other possible explanations, Shaw (2006) suggested different types of food desert, determined by whether barriers to accessing foods are financial, physical or the attitude and knowledge of the consumer, as some people experience unsupportive food environments in spite of being surrounded by food sources selling fruits and vegetables.⁽¹¹²⁾ For example, transport is an important but often overlooked factor related to food access. In line with this, one study in the US found a positive association between diversity of food outlets and fruit and vegetable intake only in those that did not own a car and were therefore accessing stores in the vicinity of their homes.⁽⁴⁸⁾ Similarly, one study from the US did not find an association between supermarket presence and diet, which may be due to the majority owning cars and therefore accessing further supermarkets.⁽¹⁰⁵⁾ Additionally, peoples' perception of accessibility may be more associated with dietary behavior than objective measures of the food environment, such as measured distance to stores.^(83, 113) In a study from Japan, the perception of affordable healthy food in the environment was associated with a higher vegetable intake in all income groups.⁽¹¹⁴⁾ Also, perceived availability of healthy foods, had a significant indirect effect on fruit and vegetable intake.⁽¹⁰⁵⁾ Higher presence of supermarkets per census tract was associated with perceived availability of healthy food as well as ease of access.⁽¹⁰⁵⁾ Good perceived environment and self-efficacy have been associated with a higher fruit and vegetable intake.⁽¹¹⁵⁾

Food environments as they relate to health outcomes

The findings on a direct link between aspects of the food environment and health outcomes have also been inconsistent. One systematic review of 56 studies did not find that food items in stores was a determinant of diet or obesity, perhaps partly due to heterogeneity in measurements and contexts, but also the complex dimensions of determinants of food choice.⁽¹¹⁶⁾ Other studies have also indicated lack of a clear association between aspects of the food environment and BMI.^(36, 39, 67, 81, 104, 117-119) Counterintuitively, some even found a slight negative association with availability of fast food outlets and obesity.^(39, 119) This may be due to the complexity of interactions and influences, where store types categorized as either providing healthy food, such as supermarkets and grocery stores, or providing unhealthy

foods, such as fast food and convenience stores, may in reality sell a variety of both healthy and unhealthy options.

However, other studies have found a relationship between aspects of the food environment and health outcomes. Higher access to unhealthy food, through distance to and density of unhealthy outlets, seems to play a role, where more of these stores increased the likelihood to have obesity,^(52, 67, 117-120) likewise for type 2 diabetes⁽¹²¹⁾ and stroke⁽²⁷⁾. People with food outlets in the vicinity of their homes were more likely to have overweight or obesity as compared to those living further way from outlets.^(40, 118) As for food items, availability of EDNP snack foods has been positively associated with BMI.⁽⁹⁷⁾ Also, one study found that if healthy food items were stored at the preferred store (as opposed to closest), it was associated with lower BMI.⁽⁶⁷⁾

Food environments and disadvantaged or immigrant neighborhoods

Factors related to socioeconomic position and ethnicity shape the relationship between food environment and obesity.^(81, 122, 123) At an individual level, higher education and income have been linked to living in food environments with better access to healthy food.⁽¹²⁰⁾ The majority of food access research has centered around disadvantaged neighborhoods and populations, as a way to explain the disparities in health outcomes, in particular obesity, between more or less affluent populations. Two terms that are often used to describe areas regarding the availability or lack thereof of healthy versus unhealthy foods are food deserts and food swamps. Areas that have low access to healthy foods have been termed as ‘food deserts’,⁽¹¹²⁾ using the presence of a supermarket as a proxy for access to healthy food. Extensive research in the US, include an interactive nationwide food desert atlas,⁽¹²⁴⁾ and these have indicated that disadvantaged neighborhoods and people of color have less access to healthier foods like fruits and vegetables, though this is less clear in other HICs.^(7, 122, 125) In addition to considering access to healthy foods, there has been a recognition of the availability of less healthy foods like EDNP foods offered by fast food outlets and convenience stores.⁽¹²⁶⁾ ‘Food swamps’ on the other hand describe areas where there is an inundation of unhealthy foods or outlets, often outweighing the presence of healthy foods,^(127, 128) primarily based on presence of fast food outlets and convenience stores. Food swamps were found to predict obesity better than food deserts in the US.⁽¹²⁹⁾ At the neighborhood level in England, disadvantaged areas were

more likely to be inundated with fast food outlets than more affluent ones.^(37, 130) Studies from Sweden and the US have shown a higher presence of all types of food outlets, both healthy and unhealthy, in more disadvantaged neighborhoods.^(67, 131)

Access to food outlets that offer healthy or unhealthy options impact sub-populations differently.⁽³⁸⁾ It seems that the most disadvantaged may suffer the consequences of unhealthy local food environments the most. In the US, those who had limited mobility to access stores, and were tied to their local or closely accessible food environments had a higher risk of obesity, compared to those who were able to access stores further away.⁽¹¹⁷⁾ Among low-income participants, a healthier local food environment was not found to be protective against obesity, perhaps because supermarkets also sell cheaper unhealthy foods.⁽¹²⁰⁾ On the other hand, areas with a higher share of immigrants often have smaller ethnic stores with cultural foods and fresh produce that are generally not included in food access studies.⁽¹³²⁾ Immigrants have been found to value fresh, healthy and cultural foods and were willing to travel further and spent time and effort to find affordable foods, often from a variety of sources such as markets and stores.^(133, 134) A study from Paris found that immigrants from a neighbourhood under study, viewed the whole city, as the area to source food, whereas the native population were more likely to limit themselves to the local neighbourhood and report that there was practically nowhere to buy food.⁽¹³⁴⁾

Interventions to improve access to healthy affordable food with the aim of reducing health inequities need to ensure opportunities are available to all and in particular that the needs of the most disadvantaged are met.⁽⁶⁷⁾ Access barriers would also need to be identified and solutions need to be found to ensure equitable access to healthy foods. Ensuring sufficient healthy foods are accessible and affordable for all could improve diet quality, which in turn is linked to better health. This relates to the Sustainable Development Goals: Good Health and Wellbeing (3), Reduced Inequalities (10) and Sustainable Cities and Communities (11). The success of the goals should not rely on those that have the interest and the means to support the cause. The food systems, including the food environment, need to be transformed in such a way that all choices support sustainable development.⁽¹³⁵⁾ In this way, improving food environments could contribute to achieving the Sustainable Development Goals (Agenda 2030).⁽¹³⁶⁾

Assessing food environments

Researching the ‘foodscape’ can help us understand the complex social systems in which food, places and people interact.⁽¹³⁷⁾ Food environments can be measured in a wide range of ways, and this is illustrated by the heterogeneity of methods in previous food environment research.^(7, 119, 138) This makes it difficult to make comparisons across studies and may limit the ability to draw conclusions. In addition, a systematic review on food environment measures in studies published between 2007 to 2015 revealed that most studies on the food environment were cross-sectional, while a small fraction were longitudinal.⁽¹³⁸⁾

To facilitate food environment research, Glanz et al conceptualized the food environment relating to food access into two levels, (1) the community and (2) consumer food environments, relating to the neighborhood and in-store levels respectively.⁽⁹⁰⁾ Measures of the community food environment can be quantity, density, distance to food outlets, access to ‘healthy’ (supermarkets) or ‘unhealthy’ (fast food outlets, convenience stores) food, variety of different outlets present^(90, 119, 139) as well as advertising.⁽⁵⁾ However, categorizing food outlets dichotomously to represent either ‘healthy’ or ‘unhealthy’ food access is not a true representation of the foods that people actually acquire from these stores.⁽¹⁴⁰⁾ In reality, those labeled as providers of ‘healthy’ food, like supermarkets and grocery stores, are also a documented source of EDNP foods.⁽¹⁴¹⁾ Similarly, fast food restaurants, representing ‘unhealthy’ food provision, may also offer healthy options.⁽¹⁴²⁾ One systematic review highlighted that food access studies are primarily carried out using geographic analysis based on business registers, available health and demographic information and home addresses.⁽¹³⁸⁾ These methods can give an indication of the characteristics of food environments, in order to understand access and exposure.⁽¹³⁹⁾ However, considering health outcomes in relation to these indicators may sometimes be misleading, which may explain discrepancies in the association between the food environment and diet or health outcomes. Other methods include checklists, interviews and questionnaires on the perception of food environments and availability of a market basket.^(138, 143)

Consumer food environments refer to the more detail-oriented in-store level, or other food environments such as schools or work places. In these environments, the types of foods (and their nutritional qualities), price, promotions, advertising, quality and other characteristics are evaluated.⁽⁹⁰⁾ Research on consumer food environments is more limited^(7, 119, 138) perhaps

due to the labor intensity of this type of study, where data needs to be collected through in-store observations. Observations include measuring shelf space allocated to healthy and unhealthy foods, prices, food item availability, product placements, promotions or advertising. This type of data on food environments would be more representative, but is more challenging to carry out on a larger scale. Tools used to observe the in-store food environment, can aid in evaluating the availability of specific food items, healthy or less healthy options, price and quality of the food.^(140, 144, 145) Availability (shelf space, varieties of type, quality), affordability (price), indicators of prominence (ratios between healthy and unhealthy), promotion and advertising, and food labels are some examples of characteristics observed.^(140, 143) Lived experience research relating to the food environment can reveal underlying factors that influence food acquisition that may be missed in other types of food access studies.⁽¹⁴⁶⁾ There are a multitude of methods and measures to evaluate elements of the food environment, however, in order to make studies more comparable, efforts should be made to harmonize these.

Theoretical/conceptual framework

Socio ecological theory

Food environment research has its origins in Bronfenbrenner's socio ecological systems theory.⁽¹⁴⁷⁾ Understanding that food choices and health outcomes of individuals do not exist in a vacuum, and are the product of interactions between the individual, economic, social and political influences at closer and more distant levels. Here, environments can be seen as belonging to the macro- or micro-spheres on whether they are more immediate or act more indirectly.⁽¹⁴⁸⁾ The microenvironment consists of family and home environments, social and peer environment and physical environments (workplaces, daycare, schools, food retail outlets, restaurants and fast food).⁽¹⁴⁹⁾ Macroenvironments can include income and SES, cultural norms and values, food marketing, agriculture and food policies.⁽¹⁴⁹⁾ This approach takes into account the diversity of factors and settings that shape diet for the individual.⁽⁸⁵⁾ Swinburn et al (1999) applied this approach to obesity, to understand the factors in the food environment at play, outside of the individual, that may be part of driving the obesity epidemic.⁽¹⁴⁸⁾ I used the Analysis Grid for Environments Linked to Obesity (ANGELO framework) to aid in the analysis of paper IV (Table 1).

Table 1. The Analysis Grid for Environments Linked to Obesity (AN-GELO framework) (as adapted from Swinburn et al.⁽¹⁴⁸⁾⁽¹⁵⁰⁾)

Domain	Scale
	micro-environment diet-related / activity-related <i>(e.g. household; community)</i> macro-environment <i>(e.g. regional; national)</i> diet-related / activity-related
Physical	What is available, for example, buildings, amenities, facilities and use patterns? Includes built environment, landscapes and internal / enclosed spaces
Economic	What are the monetary cost factors/influences/consequences? Includes price incentives / disincentives / taxes and cost savings driven measures
Legislative	What are the rules/legal guidance/statutory provisions/political messages? Also includes codes of conduct and acceptable standard practices / behaviours
Socio-cultural	What are the attitudes, beliefs, perceptions and values? Also covers prevailing cultural norms at national and community levels

Conceptual framework of food environments

The food environment has been referred to as the physical, economic, political and socio-cultural context where consumers interact with the food system, shaping choices relating to acquiring, preparing and consuming food.⁽⁸⁰⁾ In this thesis, the food environment was defined according to Turner et al (2018), who developed a conceptual framework in alignment with the socio-ecological theory.⁽⁵⁾ In this framework, the food environment is influenced by the food system, and is the interface between the food system and consumers making decisions and acquiring food.⁽⁸⁰⁾ Here, two broad domains are presented: the external and personal food environment (Figure 1).⁽⁵⁾ First, the external food environment of availability, prices, vendor and product properties and marketing and regulation; secondly, the personal domain entailing accessibility, affordability, convenience and desire, influencing how the individual interacts with the external food environment.⁽⁵⁾ This conceptual framework is novel in that it acknowledges the centrality of personal factors, encompassing the way people interact with the food environment, through access to foods and food outlets, which foods they can afford in relation to their income, the convenience of food stores and foods and the desirability, including, for example, the skills and preferences relating to food preparation. In this

model, the interaction between these two domains determine food acquisition, leading to what is consumed and therefore contributing towards diet and health outcomes.⁽⁵⁾

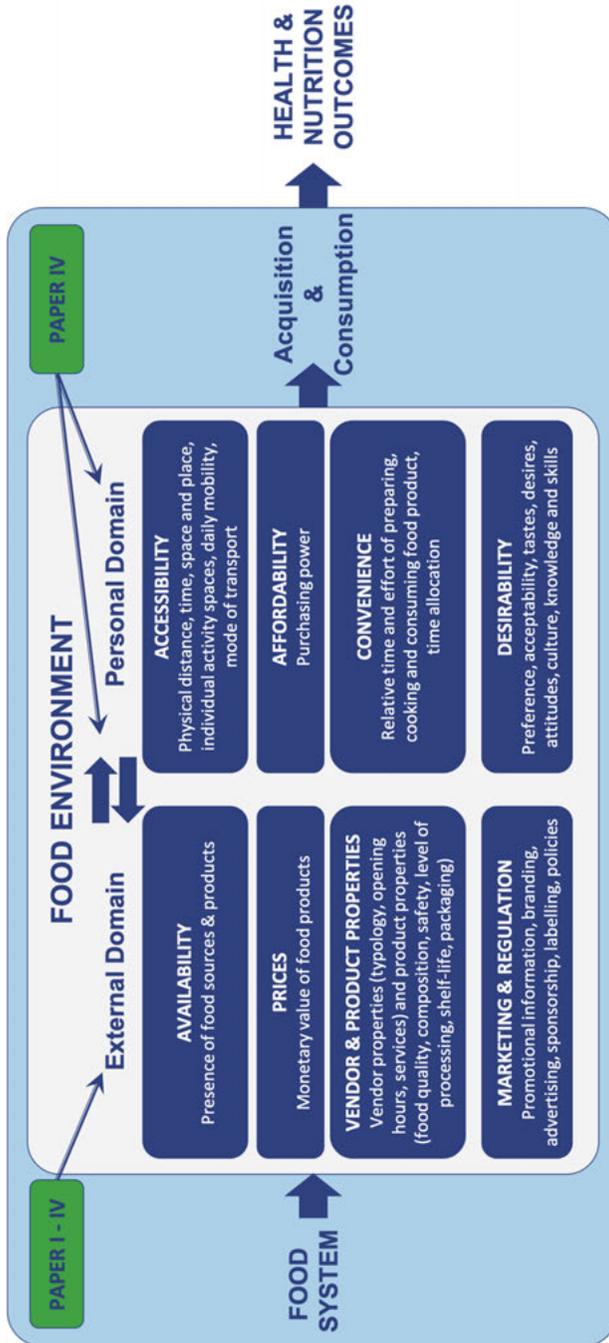


Figure 1. The conceptual framework for food environments showing studies I-IV⁽⁵⁾

Though this framework is highly applicable in relation to detailed aspects of the external and personal food environments, it has some limitations. This framework does not specify in which way the food system influences the food environment, for example global drivers influencing the food system and thus the types of food and prices available to individuals. Though the framework is developed on the socio-ecological approach, the conceptual model lacks an explicit connection between the individual level and other broader factors of influence, how each of these in turn are also the product of the wider system. The conceptual framework developed by the High Level Panel of Experts for the Nutrition and Food Systems report (FAO) can be referred to as it shows these wider factors and how they have an impact on food supply chains, the food environment and consumer behavior, leading to diet, nutrition and health outcomes.⁽⁸⁰⁾ Outside of diet, other factors, in particular lifestyle factors like smoking, excessive alcohol consumption and physical activity, also have a strong influence on health outcomes. Thus the food environment and diet do not determine health outcomes alone, though they do play an important role. Regarding the interaction between the external and personal food environment, the arrows between these show an interaction, but does not illustrate the specific ways that these would interact and how this interaction could shape acquisition, dietary intake and health outcomes. Some food access and retail research has tried to better understand the dynamics between the food environment and structural and individual factors and the way these play out, to establish causal pathways.^(151, 152) However, neither of these were sufficiently explanatory in relation to food environment and interactions and were therefore not applied to this research.^(151, 152)

The studies in this thesis fit into different sections of the conceptual framework of food environments; in particular, the external and personal food environments and the way they interact. Though this framework was developed to be applied to food environment research and work in LMICs, it is suitable for studies included in this thesis as they map food environments and try to better understand interactions between personal and external food environments. Categories are broad and relevant, as well as encompassing a range of aspects within each category. The conceptual framework includes the relevant aspects of the external food environment, such that I could use it to help interpret results pertaining to both community and consumer environments. The overall results from the thesis have been interpreted through these two domains in order to better understand how these findings contribute to the knowledge and improve food environment research in each of these specific areas.

Rationale

There is an increased presence of EDNP foods worldwide, along with high and increasing levels of NCDs, following a social gradient. The food environment is the interface between the food system and the individual, where factors relating to the food system strongly negatively influence the types of foods available. For all individuals, the personal food environment determines in which way they access foods. Those in lower socioeconomic groups, including immigrant groups are strongly limited by a low income. These interactions are complex and are not well understood, but shedding light on these is crucial to advance understanding of the food environment, dietary intake and health outcome link. Food environment research in general and particularly in Sweden has based studies on general categorizations of food outlets as indicators of food access. Mapping of the food environment is the basis to understand the environmental factors relating to food acquisition, thus enabling further studies on the human interactions and resulting diet and health outcomes. There has been an increasing interest in the role of the food environment on health, with fewer studies specifically including immigrants as well as a dearth of evidence from Europe; Sweden in particular. Food environment research has been primarily focused on objective measures like those based on geographic information systems. A more representative picture of the food environment is lacking. There is a need to bridge this gap through new knowledge and evidence to shape future interventions at individual and structural levels. This is particularly relevant for the prevention and management of NCDs, with particular focus on disadvantaged and immigrant populations. These studies focus on understanding different food environments through physical observations, as well as how the intersection with socioeconomic status and migration is shaped by a variety of interacting factors that influence diet and health outcomes. In order to improve public health and prevent NCDs, it is essential to understand food environments as well as how people experience and interact with them.

Aim

The aim of this thesis is to enable understanding of the food environment and its interactions with a focus on socioeconomic disadvantage and immigrant populations through a non-communicable disease lens.

Research questions

Study I: What are the external food environment characteristics between urban and rural sites across three country income settings?

Study II: How are store type, food pricing and availability of healthy and unhealthy food items associated with neighborhood SES?

Study III: What are the differences in outdoor and in-store advertising in low and middle SES neighborhoods of Stockholm from an NCD perspective?

Study IV: What are the factors that characterize and moderate the interaction between the food environment and immigrant populations from low- and middle-income countries living in high-income countries?

Methods

The methods section will be presented in two parts. This thesis uses both qualitative and quantitative methods and table 1 provides an overview of the four sub-studies in terms of the main objectives, data sources and methods. In the text that follow, sub-studies I-III will be presented together as they share the same methodology, and study IV will be presented separately.

Table 2. Overview of the included papers in the thesis

Study	Main objective	Data sources	Design/method
I Snapshots of Urban and Rural Food Environments: EPOCH-Based Mapping in a High-, Middle-, and Low-Income Country from a Non-Communicable Disease Perspective	To describe and compare selected aspects of the external food environments in an urban and rural setting in a low-, middle- and high-income country	Observational data of the food environment from one urban and one rural site each from Uganda (low-income), South Africa (middle-income) and Sweden (high-income)	Observations using the modified Environmental Profile of a Community's Health (EPOCH) tool, cross-sectional, quantitative
II Food environment characteristics and neighborhood socioeconomic status in Stockholm	To assess how the characteristics of the external food environment (type of store, price, availability) are associated with low and middle SES neighborhoods in Stockholm, Sweden	10 low SES, 12 middle SES neighborhoods of Stockholm municipality, Sweden; 92 food retail outlets	Observations using the modified Environmental Profile of a Community's Health (EPOCH) tool, cross-sectional, quantitative

III Outdoor and in-store food advertising: unhealthy and health promoting advertisements in low and middle SES neighborhoods in Stockholm, Sweden	To investigate socioeconomic disparities between low and middle SES neighborhoods relating to outdoor and in-store advertisements in Stockholm, Sweden	10 low SES, 12 middle SES neighborhoods of Stockholm municipality, Sweden; 92 food retail outlets	Observations using the modified Environmental Profile of a Community's Health (EPOCH) tool, cross-sectional, quantitative
IV Food environment interactions after migration: a scoping review on low- and middle-income country immigrants in high-income countries	To map and characterize the interactions between the food environment and immigrant populations from low- and middle-income countries living in high-income countries.	68 research articles carried out in high income countries, including an immigrant population from low- or middle-income countries	Scoping review using thematic qualitative analysis

The focus of this thesis is on disadvantaged neighborhoods. The thesis investigates factors outside the individual that may play a role in the higher burden of negative health outcomes in such areas. This work acknowledges the social determinants of health as a way to understand the uneven distribution of negative health outcomes in society.⁽¹⁵³⁾ We use the word ‘healthy’ throughout this thesis to mean primarily fruits and vegetables. As an essential source of nutrients, they have been used in food environment studies to represent access to healthy food and are known to be protective against health complications. With the term ‘unhealthy’ foods we mean discretionary, non-core, processed or convenience foods that are EDNP foods, as these have been linked to negative health outcomes. This thesis focused on these two ends of the spectrum; though we acknowledge all the types of foods in between that are also essential and beneficial alongside others that do not contribute to a higher quality diet. Basing our assessments principally on these two sides of the spectrum does not reflect the way people eat, but it may be useful in making an assessment about whether the given food environment is facilitating or a barrier to a healthy life. Therefore, with the risk of oversimplifying a very complex area we have chosen to primarily look at ‘healthy’ and ‘unhealthy’ foods and advertisements. Similarly, we use the term ‘immigrant’ for those who have

moved from LMICs to HICs, without differentiating what type of migration that has taken place. Migrants will have a different migration backgrounds and processes, which can affect their opportunities and health differently.^(154, 155) This thesis takes the premise of immigrants in high-income countries being socioeconomically disadvantaged, though there are some that admittedly are in higher income categories. However, studying these different cases in depth is beyond the scope of this thesis.

SMART2D project

The PhD project, excluding paper IV, was nested in the formative phase of a larger implementation research project (SMART2D) in three settings, Uganda, South Africa and Sweden.⁽¹⁵⁶⁾ SMART2D stands for ‘A people centered approach to self-management and reciprocal learning for the prevention and management of type 2 diabetes’. The SMART2D project strongly focuses on contextualization as a key factor in the development and implementation of self-management support interventions for type 2 diabetes, recognizing the importance of the participant’s daily environment as a key to intervention impact and sustainability.⁽¹⁵⁶⁻¹⁵⁸⁾ In part, through these studies, SMART2D seeks to understand the relationship between the characteristics of the local food environment and food acquisition behaviors; to understand its role in the prevention and management of type 2 diabetes in socioeconomically disadvantaged and under-resourced areas. These studies were carried out as part of the context evaluations and applied a NCD perspective, unhealthy diet being a common risk factor.

The sites that were included in the SMART2D trial were in Uganda, South Africa and Sweden, each representing a low, middle and high-income country respectively. Within these countries, specific sites were chosen to represent under-resourced or socio-economically disadvantaged areas. In Uganda, nine study sites (defined as selected primary healthcare facilities with their catchment areas) located in two rural districts of Iganga and Mityana in the eastern part of Uganda were included in the SMART2D trial. In South Africa, the large urban township of Khayelitsha in Cape Town, Western Cape, was included.⁽¹⁵⁹⁾ In Sweden, two urban socioeconomically disadvantaged districts (*stadsdelar*) in Stockholm municipality were included.⁽¹⁵⁹⁾ Both these districts were typified by low incomes, low education, high unemployment rates and high proportion of immigrants compared to overall Stockholm.^(160, 161)

Paper I-III

Sample

The sample for papers 1-III comprised study sites (physical, geographical spaces) selected using specific inclusion criteria. Sample for paper I included study sites in three countries (Uganda, South Africa and Sweden), while that for papers II and III included selected neighborhoods within the municipality of Stockholm.

For the purpose of study I, we used a two-step inclusion process for the sites. Firstly, we did a purposive sampling from within the SMART2D trial, one site per country, in communities identified by local researchers and stakeholders, where a discreet geographical unit with a central retail area was present. In the second step, a socio-demographically comparable urban or rural site was identified so that there were one urban and rural pair in each country. Included sites in Uganda and South Africa were considered under-resourced and in Sweden socioeconomically disadvantaged.

In Uganda, a 1.3km² area of a rural town council in Mayuge, eastern Uganda was the chosen primary site, with a population density of 437 individuals per km².⁽¹⁶²⁾ There were low literacy rates and the area was considered under-resourced. The matched site was a 0.4km² area of Kampala's central business district, with a population density of 8,562 people per km².⁽¹⁶³⁾ Though this was not primarily a residential area, residents of the city were known to use this food environment; overall in Kampala many have low socioeconomic means and live in slum dwellings.⁽¹⁶⁴⁾

In South Africa, the primary site was a 2km² area of the peri-urban township Khayelitsha, in Western Cape. As of the last census in South Africa in 2011, the population density here was 10,265 people per km².⁽¹⁶⁵⁾ This township had high unemployment rates at just under 20%, a third of the population having a high school diploma and under 5% of the population with higher education.⁽¹⁶⁵⁾ The paired rural site was Mount Frere in Eastern Cape, a 7.5 km² area with a population density of 700 people per km². Here unemployment was just under 11%, 38% had a high school diploma and 26% had a higher education.⁽¹⁶⁵⁾

In Sweden, the primary site was a 2 km² suburb of Stockholm municipality with a population density of 9,403 people per km².⁽¹⁶⁶⁾ The majority of residents (60.5%) were immigrants, from a range of ethnicities.⁽¹⁶⁶⁾ Overall there were low incomes, unemployment was at 8.2% and 28% had a higher

education.⁽¹⁶⁶⁾ The rural matched site was the largest town center of the rural municipality of Ljusnarsberg, of which 2 km² was included, covering all stores. The population density here was 457 people per km²⁽¹⁶⁷⁾; 10% were unemployed and 11% had a higher education.⁽¹⁶⁸⁾ Here, this municipality received the highest number of migrants in relation to population, of those seeking refuge from the war in Syria (2015) in Sweden, leading to 21% of the population in the municipality being born outside of Sweden.⁽¹⁶⁹⁾

In studies II & III, we wanted to build on the SMART2D focus of socioeconomically disadvantaged neighborhoods in Stockholm. Our focus in these two studies was disadvantaged neighborhoods as we know from other studies and statistics that these communities are more likely to suffer from negative health outcomes. Middle SES neighborhoods were included for comparison. The studies did not look at the food environments in the more affluent parts of Stockholm as the middle SES neighborhoods, that form the majority of neighborhoods of Stockholm, were deemed a more appropriate comparison group.

In Stockholm, the majority, just under 60% of the population, live in neighborhoods deemed as having good socioeconomic conditions.⁽¹⁷⁰⁾ On the other hand, around 10% live in areas that have socioeconomic challenges, out of which just under 5% live in areas with large socioeconomic challenges.⁽¹⁷⁰⁾ Only just below 14% of people in Stockholm live in those areas having very good socioeconomic conditions.⁽¹⁷⁰⁾ According to this, in our sample, all of the 12 middle SES neighborhoods are neighborhoods rated as having good socioeconomic conditions. In the low SES group, five neighborhoods had large socioeconomic challenges, four belonged to the category having socioeconomic challenges and one was considered a mixed type of area.

In Sweden, those with low income live primarily in rental housing, resulting in a spatial segregation of income groups.⁽¹⁷¹⁾ Sweden's housing system is an important factor in creating and maintaining socioeconomic inequality.⁽¹⁷²⁾ In Stockholm, low-income suburbs, primarily have rental apartments.⁽¹⁷²⁾ On the other hand, other areas, partly in the gentrification process, have a decreasing number of rental opportunities and in this way cultivate a primarily white and wealthy population.⁽¹⁷³⁾ In fact, Stockholm is among the most ethnically spatially segregated cities in Europe.⁽¹⁷⁴⁾ When taking a closer look at these smaller geographical entities making up the city, they are heterogenous, including rates of employment, educational

level and percentage with a foreign background. These have been referred to as ‘superdiverse’ due to the large degree of heterogeneity observed within geographically small areas in terms of ethnicity.⁽¹⁷⁵⁾ The gap in earnings between low and high-income earners increased in the 2000s. In Stockholm, the median yearly income for those born in Sweden is 411,400 SEK as compared to those born outside Sweden, at 279,400 SEK.⁽¹⁷⁶⁾ The rate of sickness or activity compensation is higher amongst the foreign-born population, at 6,5%, compared to the overall population at 3,7%.⁽¹⁷⁶⁾ People in the two lowest income quintiles and those with low education had a higher than expected mortality rate.⁽¹⁷⁶⁾

In order to select the low and middle SES neighborhoods, we created deciles out of the 130 districts (*stadsdelar*), hereafter referred to as neighborhoods in the municipality of Stockholm. This meant that 10% of the districts were represented in each of these categories, from 1-10, with one being the lowest rank and 10 the highest. This was based on demographic data on average income and unemployment for each neighborhood in the municipality, using available data at the time.⁽¹⁷⁷⁾ The lowest decile comprised 10% of the neighborhoods that had the lowest average income and the highest unemployment. We selected the neighborhoods in decile 1 (lowest) for both these variables as the low SES group. Middle SES group included the neighborhoods in decile 5 or 6 for the same variables. Neighborhoods that fell under one or other variable, but not both, for the correct decile were not included in our sample. We included 10 out of 13 neighborhoods in the lowest decile and 12 neighborhoods from deciles 5 and 6. This approach was pragmatic rather than based on sample size calculations. Other geography-related factors such as their location within the city (city center vs suburb) or density of housing were not considered during this selection process. The geographical boundaries of the district were used to define each selected neighborhood and were each required to include some form of food retail space ranging from individual outlets or a community center. Two neighborhoods in the middle SES group were excluded after a walkabout revealed no stores in the area, only residential properties. Paper II and III were based on the same sample of 22 neighborhoods.

Data collection

Data collection took place between 2017-2019. Though the data collection used the same method, the data was collected firstly for paper I, followed by papers II and III together.

Data collection tool: A modified version of the Environmental Profile of a Community's Health (EPOCH) tool was used to carry out the food environment observations. It was an effective way to collect food environment data on food environment characteristics associated with NCD risk factors, in order to provide reliable measures of direct community observation.⁽¹⁴³⁾ With permission, EPOCH was modified for the purpose of this study. EPOCH originally included the following domains, a community observation walk, tobacco store assessment, grocery store assessment, medication availability assessment, restaurant assessment and perceptions of the food environment. We carried out the community observation walk and grocery store assessment, which were further modified. Presence of food retail outlets, availability of pre-selected food items, price of items, advertising, health promotion and food labels were included in the data collection. Pre-selected items were part of the EPOCH tool representing items that were protective of NCDs (fruits and vegetables), those related to risk of NCDs (SSBs and confectionaries) and other items (breakfast cereal, bread, pasta, milk, yoghurt).

Data collection process: There were a total of four people involved in the data collection, though two carried out most of the work, with one person administering the data management system, overseeing the data collection and planning the routes after the first few neighborhoods had been mapped (Figure 2). Training and familiarization of the EPOCH tool and method was carried out in one to two sessions focusing on the content of the tool. Collecting data in one neighborhood together with a more experienced data collector also helped to clarify questions related to the procedure or content of the tool and was a practical way to learn the method.

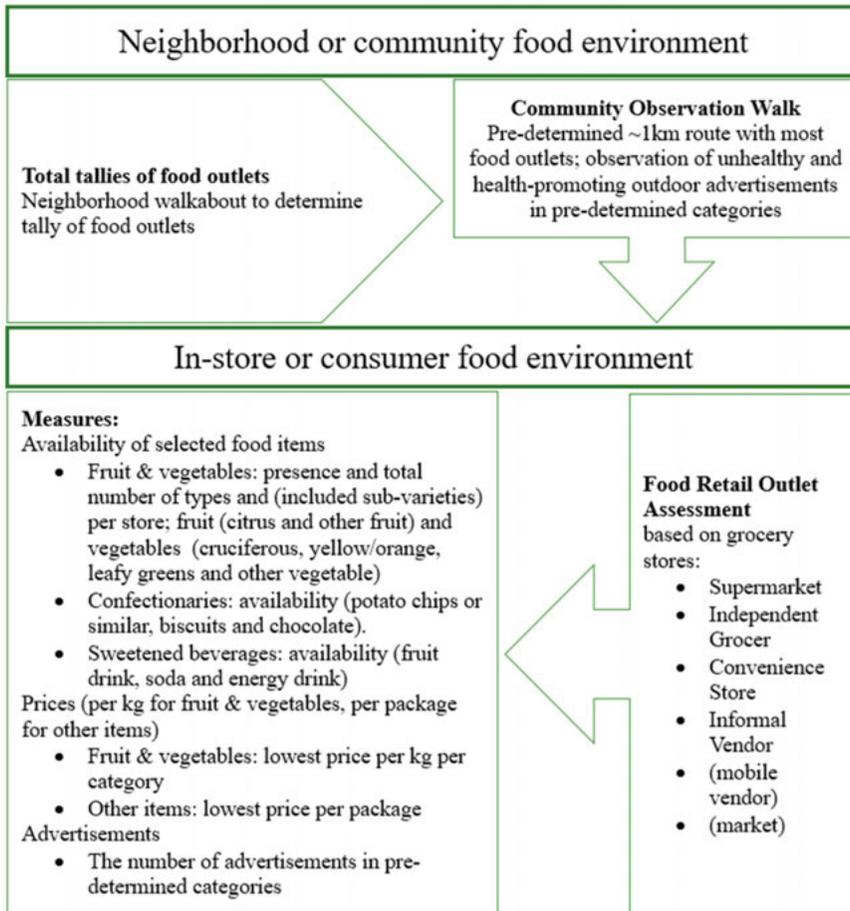


Figure 2. Flow chart of data collection for studies I-III

To prepare for each data collection moment, google maps were used to become familiar with the neighborhood, noting its geographical boundaries and identifying major food retail spaces. Following this, an app (<https://www.plotaroute.com/>) was used to mark the approximately 1 km long route encompassing the highest number of food retail outlets within this geographical boundary. This formed the basis of the data collection done on foot and on the ground, the method known as ‘ground truthing’.⁽¹⁷⁸⁾ Paper copies of the tool were used, or online using the iPad to directly register observations. The choice of paper-based versus online was based on the convenience of the data collector, as well as the specific parts of the data being collected or the need for discretion. All the data was entered into REDCap (Research Electronic Data Capture), either directly online or by

entering the data after data collection. Study data were collected and managed using REDCap electronic data capture tools hosted at Karolinska Institutet.^(179, 180)

Walkabout for total tally of food outlets: The next step was walking the entire geographical boundary, street by street. We used this time-consuming method due to two reasons; google maps are not fully accurate or up-to date; and seeing things in person allowed for easier and more accurate categorization of food retail outlets. The purpose of the walk was to create a total tally of all the food retail outlets that were present in the neighborhood based on the categories present in the EPOCH tool. We used a checklist approach, checking off items as we walked, noting how many of each type were present.

Community observation walk: The community observation walk was based on our prior preparations, where one route, including the busiest stretch of the neighborhood with the most food retail outlets was planned. We followed standard operating procedures from the start to the end of data collection. The first food stores that were encountered during this walk, in the categories of supermarket, independent grocer, convenience store and informal vendor (market stall in the Swedish context; mobile vendor and market), were included in the in-store assessment, with a target of two of each store type. If not available, the nearest outlet to the walking route was identified and included. Images or advertisements representing any of the pre-determined categories of advertisements in the EPOCH tool were noted.

In-store food retail outlet assessment: In larger stores, as per the standard operating procedure, we discreetly carried out data collection, while in all the smaller stores, we asked for permission from the shop manager and in some cases this was also done in the larger stores, where this was deemed appropriate. Approximately six independent grocers did not grant permission for data collection and one closed the shop half way through data collection and was subsequently excluded from the study. The food retail outlet assessment form of the EPOCH tool was used to collect data in-store. Images or advertisements representing any of the pre-determined categories of advertisements in the EPOCH tool were noted. When choosing the food items in the food retail outlet assessment, the cheapest item in the category was chosen. Where there were two items of the same price, firstly weight was considered and following that the healthiest option was chosen (in terms of sugar, fiber and fat content) for grains (breakfast cereal and

bread) and dairy (yoghurt and milk), but the added sugar version was chosen for beverages.

Statistical analysis

Including a total tally of all the food outlets as well as mapping a large share of the food retail outlets would allow for detections of meaningful differences by SES. Descriptive statistics were conducted on the food environment-related characteristics with relevant point estimates (total, mean, proportion) for each setting in paper I. Additionally, based on the study objectives, non-parametric comparative statistical analyses were limited to between countries. Independent samples Kruskal-Wallis test with Dunn's post hoc pairwise comparison including Bonferroni correction was used to compare price of food items, likewise number of fruit and vegetable varieties between countries.⁽¹⁸¹⁾ In order to compare availability of food items across countries, Fisher's exact test was used with adjusted residual post-hoc testing. When data from all three countries was grouped, Spearman's correlation coefficient was used to assess the correlation between outdoor health promoting advertising and unhealthy product advertising.⁽¹⁸¹⁾

For the analysis in paper II, we first developed the SES score. Average income, unemployment and education were the three variables used to create the score.⁽¹⁸²⁾ All three variables were then transformed and added up to give each neighborhood its own score. We did this by using the variables ' % with higher education', 'average income 20-64 years' and ' % unemployed'. The latter needed to be reversed first by subtracting it from 100, to generate a ' % employed'. These were then added up. The lower the score, the higher the socioeconomic disadvantage. For multivariate analyses, different regression techniques were used to study the association between variables of interest and socioeconomic status based on the distribution of the dependent variables. For count data (for example, number of each type of store) negative binomial regression was used in order to capture overdispersion. Generalised linear models with a logit link function modelled probabilities, e.g. food availability. Continuous data with assumed normal distribution used robust regression based on MM estimation to account for outliers. Adjusted p-values were recalculated based on Benjamini & Hochberg correction for multiple testing, a procedure that helps to avoid Type 1 errors.⁽¹⁸³⁾ The natural logarithm of surface area was included as an offset variable in these models to account for the variation in surface area across communities. Population density was controlled for in

the analysis of food outlets. Additionally, we ran a sensitivity analysis considering the covariate ‘central commercial area’, which did not result in meaningful differences. In order to present the incidence rate, estimates of the presence of food retail outlets were exponentiated. Dependent variables included type of store, food item price, food item availability and varieties of fruits and vegetables.

Paper III was based on the same sample as paper II, analyzing the association between outdoor and in-store advertising between low and middle SES neighborhoods. For this we used a dichotomous categorical independent variable for SES, low and middle SES. In the analysis of outdoor advertising, the non-parametric Mann-Whitney U test was used to compare the overall health promoting and unhealthy advertisements as well as differences between the food related advertisements: healthy and unhealthy.⁽¹⁸¹⁾ This test was also used to compare the two types of advertisement categories between low and middle SES areas. We also conducted a type of sensitivity analysis by considering population of the area and this did not result in meaningful differences. A linear regression model was fitted to examine the associations of in-store advertisements with SES category as well as store type. To decrease the false discovery rate, the Benjamini & Hochberg procedure was used to adjust for multiple testing.⁽¹⁸³⁾ Data analysis was carried out using IBM SPSS Statistics for papers I and III, while paper II used the R software. Statistical significance was set at 0.05.

Study IV

Inclusion process for articles

Study IV was a scoping review, aiming to understand how immigrants from LMICs living in HICs interacted with their food environment. A five-step methodology was used, proposed by Arksey and O’Malley and modified by Levac et al.^(184, 185): identifying the research question(s), study selection, charting the data and summarizing and reporting the results; including a qualitative synthesis.⁽¹⁸⁵⁾ The reporting for the scoping review followed the relevant PRISMA-ScR guidelines.⁽¹⁸⁶⁾

The review was carried out between February 2020 and August 2021. Three electronic databases (Embase, PubMed and Web of Science) were used as primary search sources. The search strategy was developed in consultation with the Uppsala University Library, where a search string of key

words related to food environment and immigrant populations was developed. Peer reviewed research articles published between 1st January 2007 to 14th May 2021 (the last search) were eligible to be included. In addition to the database searches, backward and forward snowballing or referencing of all included articles was done systematically as well as simplified searches in google scholar.

Two reviewers carried out the initial search, entered the references into the Rayyan software, which enabled a convenient way to blind the title and abstract review.⁽¹⁸⁷⁾ This was followed by the full text review. Discussions took place for those articles where there was no agreement on inclusion and when necessary, a third reviewer was consulted in the process. We developed a format to rank the relevance of the content of articles, to increase consistency between reviewers and facilitate the inclusion process. The articles needed to include a population group coming from LMICs, settled in a HIC, where the study would have been carried out. We carried out two updated searches with the same keywords on separate dates, with the last one in May 2021. For the full inclusion process, refer to Figure 3. The content of the articles was extracted into a charting form, following the PICO model (population, intervention, comparison, outcome of interest). Each of the two reviewers charted half the articles, and reviewed the other's charting. A total of 2,835 articles were identified in the database searches, as well as back and forward referencing and google scholar search, 228 articles were included in the full text screening for the scoping review.

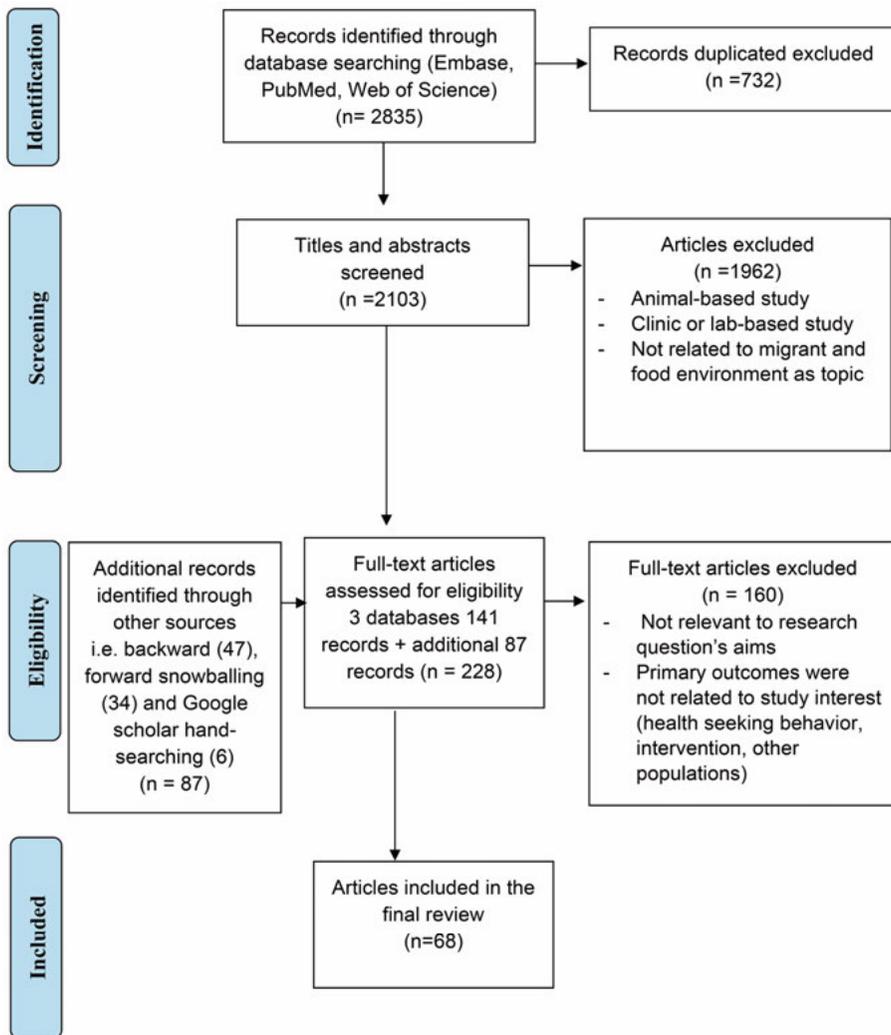


Figure 3. Flow diagram of literature search and selection (Study IV)

Data analysis

As suggested by Levac, et al., we carried out an additional qualitative synthesis of the results and discussion sections of the included articles.⁽¹⁸⁵⁾ In order to analyze the content of the included articles, a 'Best fit' framework synthesis was applied, based on the ANGELO framework to guide the coding and analysis and help interpret the data (Table 1).^(188, 189) Swinburn and colleagues developed this framework to assess obesogenic aspects of environments (physical, economic, political and socio-cultural) and levels of influence, the micro (settings) and macro level (sectors) with the aim of improving environments

to promote health.^(148, 189) After considering the material in the included articles, it was decided that due to the lack of macro level data, we would not separate these two levels in the results. We coded data from the results and discussion sections against this *a priori* framework. The relevant material that was left after this coding was analyzed using qualitative thematic analysis, resulting in additional themes.

Ethical considerations

Ethical approval for Papers I was sought and granted through the Makerere University (Uganda), University of the Western Cape (Cape Town, South Africa) and the Regional Ethics Review Board in Stockholm (Sweden). In Sweden, studies II and III were approved as part of the overall SMART2D project and trial (2015/712-31/1 and 2016/2521-31/1), and no further application was sought as the data collection activities were observational in nature, with no data collection involving participants and hence not required by law.

Letters of ethical approval from the respective ethical review boards in each country were carried by the data collectors. Additionally, we carried a letter from the university to hand out to shop managers, explaining our study and with our contact details. During the ‘food retail outlet assessments’ the store owner and (or) manager were approached before collecting data for permission to conduct the observations. In the respective manuscripts, we have not named study areas or shop names in order to respect the integrity of the stores or owners. Some of those working in independent grocers, from socioeconomically disadvantaged neighborhoods in particular, gave the impression that they were unsure what authority we may have represented, in spite of the information given, partly due to language barriers. In these cases we tried to emphasize that we came from the University, that there was no need to feel worried and that there was a contact number in case they wanted to verify the visit to their stores. Paper IV, being a scoping review of peer-reviewed scientific articles, did not require ethical clearance.

Results

The results section integrates findings from papers I – IV, with descriptions of sample characteristics included at the beginning of the sections on the external and personal food environment. Results for studies I-III are reported together in terms of the four domains of the external food environment in the conceptual framework for food environments. The four domains are: (1) availability; (2) vendor and product properties; (3) prices; and (4) marketing and regulation⁽⁵⁾. Following this, the results for study IV are presented according to the four personal food environment domains of: (1) accessibility; (2) affordability; (3) convenience; and (4) desirability.

External food environment

Sample characteristics

For study I, the total tally of food outlets identified 990 outlets over 6 sites, in one urban and one rural area of Uganda, South Africa and Sweden. Out of these, a total of 50 outlets were included in the in-depth food retail outlet assessment. For studies II and III, 22 neighborhoods of Stockholm were included, with a total of 829 food outlets. In total, 92 out of the 829 outlets were included in the food outlet assessments: 34 supermarkets (13 low SES, 21 middle SES); 24 independent grocers (14 low SES, 10 middle SES); 29 convenience stores (14 low SES, 15 middle SES); 5 informal vendors (5 low SES, 0 middle SES). Of these, two supermarkets and 10 independent grocers were ethnic stores (selling ‘ethnic’ food and other cultural items⁽¹⁹⁰⁾) situated in low SES neighborhoods, whereas there was only one ethnic independent grocer in middle SES neighborhoods.

These were sampled from low and middle SES neighborhoods in Stockholm and varied therefore in their demographics. The ten low SES neighborhoods included in the study had average incomes that ranged between 195100 and 265500 SEK per year, compared to between 360400-406200 SEK in middle SES neighborhoods. The level of higher education also varied, between 21-39.5% of the population in low SES neighborhoods had a higher education compared to 54-71.7% in middle SES neighborhoods. The rates of unemploy-

ment were higher in low SES (4.9-9.5%) compared to middle SES neighborhoods (1.4-2.5%). To note as well, that the percentage foreign born was highly correlated with SES (0.94).

Availability: Stores & Food items

From the mapping of the six food environments (study I), in urban and rural areas in Uganda, South Africa and Sweden, we observed differences in the number of different outlet types. Overall, Uganda had the most food outlets followed by South Africa and Sweden in that order (586, 354 & 50 respectively). This wide variation in the numbers can be attributed mainly to the number of informal type of outlets (including vendors), where Uganda had the most followed again by South Africa and Sweden (404, 220 and 2 respectively). Uganda also had the greatest number of food service outlets such as sit-down restaurants. The formal food outlets, the majority of which provided food to prepare and consume at home, in terms of supermarkets, independent grocers and convenience stores were however the least in Uganda and the most in South Africa (14 in Uganda, 59 in South Africa and 22 in Sweden). There were relatively few stores with specialty food products in all three countries and some urban and rural differences were also observed in all three countries.

In the Swedish context (study II), no significant differences were found in the number of supermarkets, convenience stores and fast-food outlets across neighborhood SES. However, other food service outlets (sit down restaurants, cafes, delis) were positively associated with SES, with a 12% increase for each unit increase of SES score. The presence of independent grocers was negatively associated with SES, with a 20% decrease in incidence rate for each unit increase in SES score.

Across all settings (study I, II), in terms of food items, formal food retail outlets, offered both healthy and unhealthy items. Of all the types of food outlets, supermarkets sold all the food items followed by independent grocers, which provided the majority of the selected food items. By country (study I), Sweden had the highest availability of the selected food items (80%), compared to 66% in South Africa and 47% in Uganda. In Uganda and South Africa, there was higher availability in the urban setting. The opposite was true for Sweden, where convenience stores in the rural area had a larger selection of food items (including 'other groceries' not usually present in other convenience stores) compared to those in the urban area. The rural Ugandan site had a lower availability of food items overall, with a more granular insight being that the availability of confectionaries was lower and the presence of SSBs was higher in overall comparison to other foods. Comparatively, Sweden had a significantly higher availability of confectionaries in relation to Uganda but not in relation to South Africa. Supermarkets in all three countries, markets in Uganda, and

informal vendors in Sweden collectively provided a high variety of fruits and vegetables, while mobile vendors and informal vendors (in Uganda and South Africa) sold a limited range of fruits or vegetables.

In the Swedish context (study II), there were no significant differences in availability of food items across neighborhood SES. Regarding food items, overall there was higher availability of confectionaries and SSBs compared to fruits and vegetables. There was a high presence of confectionaries and sweetened drinks in supermarkets, independent grocers and convenience stores. In the Swedish context (study II) all supermarkets included in the food retail outlet assessments sold all the selected items with a high variety of fruits (mean 35 types) and vegetables (mean 62 types). The majority (70%) of independent grocers sold fruits and vegetables, with a mean of 15 fruit and 20 vegetable types per store. Convenience stores sold no vegetables, a few sold fruits with an average of three types of fruits per store. Informal vendors only sold fruits and vegetables, with a high variety (mean for fruits 37, vegetables 43).

Vendor and product properties: Vendor typology, product and food quality

We found similarities in *vendor typology* across settings (Study I and II). Supermarkets sold all the listed food items, whereas independent grocers sold a selection of the items. Convenience stores sold confectionaries and SSBs primarily. Informal vendors, mobile vendors and markets sold primarily fruits and vegetables.

Relating to the *quality of fruits and vegetables*, supermarkets in Sweden had less damaged fruits and vegetables compared to supermarkets in Uganda and South Africa (Study I). Apart from supermarkets in Sweden, food retail outlets with a higher variety of fruits and vegetables had more damaged ones.

When looking at the three countries, we found that the *properties of the food items* selected by being the cheapest item in the category varied between products and countries (Study I). For example, the majority of the breakfast cereals at the lowest price noted across the countries were healthier options, being medium or low in sugar and high in fiber. Conversely, the type of bread at the lowest price varied, with the majority in South Africa being wholemeal, while in Sweden approximately half were wholemeal and in Uganda the majority were white. The lowest priced milk included low or reduced fat in Sweden, whereas full cream milk in Uganda and South Africa. In South Africa and Uganda, the lowest priced yoghurt was sweetened, came in small packages, while in Sweden it was plain and sold in 1L packages.

Prices of food items

When considering *prices of food items* across three countries (Study I), chips and biscuits were significantly cheaper in Uganda and South Africa compared to Sweden. There was no significant difference in the price of fruits and vegetables between countries. Bread and energy drinks were more expensive in Uganda compared to Sweden. Yoghurt had a lower price in South Africa than Sweden. Supermarkets and independent grocers offered most of the items at the lowest prices, though supermarkets were cheaper for fruits and vegetables and other grocery items, while independent grocers for confectionaries and SSBs. Urban sites had the lowest prices at supermarkets and rural sites at independent grocers. In the rural Ugandan site, markets and informal vendors offered the cheapest vegetables and fruits respectively. In the Swedish setting (study II), lower neighborhood SES was associated with lower prices of fruits and vegetables (apart from green leafy and yellow vegetables). With six types of fruit and vegetables together, there was an average increase of 4.0 SEK per unit increase in SES score. After adjusting for multiple testing, there was no significant difference in price of sweetened drinks across SES. Of the confectionaries, only chips were significantly associated with SES, with a 1 SEK increase for each increase in neighborhood SES score.

Marketing and regulation: outdoor, in-store advertising and food labels

The promotion of unhealthy products was high in all three country settings, and across neighborhoods in Stockholm, Sweden (Study I and III). For Uganda, South Africa and Sweden (Study I), of the categories noted, there were the most advertisements for EDNP food and SSBs and a negligible number of advertisements for tobacco (study I). Uganda had the most advertisements (247), compared to South Africa (111) and Sweden (81). The most striking finding was a high number of advertisements for SSBs in rural Uganda (170). Health promoting advertisements were few overall, present primarily in Sweden (26) (Uganda 0, South Africa 3). The majority of these were commercial in nature. In the Swedish context (Study III), EDNP food and sweetened beverage advertisements represented the majority (60%) of the advertisements noted. Tobacco and alcohol represented just 4% and 7% of noted advertisements respectively, while around 30% of advertisements were health promoting, though none promoting cessation of alcohol in any neighborhood. Overall, there were twice as many unhealthy advertisements (69%), compared to health promoting ones (31%) (study III). The same was true for diet related advertisements with 2.8 EDNP food and SSB advertisements for each diet-related health promoting advertisement. Low SES neighborhoods had a higher number of unhealthy advertisements (twice as many) as well as health promoting advertisements (six times as many) than middle SES neighborhoods

though these differences were not found to be significant after adjusting for multiple testing. The ratio between unhealthy and health promoting advertisements was higher and significant in middle SES neighborhoods (Study III). There were 1.8 and 3.5 unhealthy advertisements for each health promoting advertisement in low and middle SES neighborhoods respectively. The same trend was seen for food related advertisements, with 2.2 and 6.6 EDNP food and sweetened beverage advertisements for each diet related health promoting advertisement in low and middle SES neighborhoods respectively.

For the in-store advertisements, across countries (Study I), Sweden had the most EDNP food advertisements, significantly more so than Uganda. SSB advertisements were similar across countries. All countries had a negligible number of advertisements for fruits and vegetables. Sweden had the most advertisements for tobacco. By store type, supermarkets had the most advertisements, followed by convenience stores and independent grocers. Informal types of outlets/vendors had very few advertisements. Overall, 88% of noted in-store advertisements in the Swedish context (Study III) were for unhealthy products, most of which were for EDNP foods (39%) and SSBs (28%), which made up 65% together. Tobacco products and fruit and vegetables had similar number of advertisements representing 15% and 12% respectively and the lowest number of advertisements was noted for alcohol (5%). By store type, supermarkets had the most advertisements and informal vendors had no advertisements.

The majority of packaged products observed in Uganda, South Africa and Sweden had back of pack food labels which included nutrition information in the appropriate language (90.8-100%), the presence of an ingredients list (77.2-92.0%) and nutrition facts table or list (68-96.7%). There were fewer packages with front of pack labels. Consumer guidance information like guideline daily amounts or the Nordic Keyhole symbol were found on approximately 10% of products in Uganda, 20% in South Africa and 50% in Sweden. Nutrition claims were highest in South Africa at approximately 40%, while Sweden and Uganda had between 15-20% of packages containing these claims. Health claims were the lowest in Sweden (4.8-9.1%), while in South Africa it was 20.6-23.7%; Uganda had the highest number of health claims on products (24-29.8%). We did not carry out a similar analysis on the Swedish neighborhoods.

Personal food environment

Sample characteristics

The focus in paper IV was on immigrants from LMICs living in HICs. Of the sixty-eight articles included in the review, the majority (45) were based in the USA, followed by Canada (10), Australia (7), UK (3), Switzerland (1), Norway (1) and the Netherlands (1). Immigrant groups were represented from LMICs in Asia, Africa, the Middle East, South and Central America and the Caribbean, with a large portion being Latinos in the US based studies. The majority of the studies were qualitative (42), followed by mixed methods (17) and quantitative studies (9). Approximately, 35% of articles focused solely on women and the rest were of mixed populations.

Accessibility

Outlets, food items: Fast food outlets and unhealthy food items were present in close range to where immigrants resided. Fresh foods were perceived as more difficult to access in areas with a higher density of immigrant population as they were not always present or of good quality in smaller local stores. The availability of cultural and halal foods generally increased over time, although access to cultural foods varied for different ethnic/cultural groups. Lack of access to healthy foods led to an adaptation to the food environment, for example serving children unhealthy foods due to limited access to healthier ones.

Location and transport: Physical access determined where immigrants purchased their food. Transportation meant not being restricted to the food choices available in the near environment. Having access to a car or a ride in a car from family or within the social network, allowed for the acquisition of healthier affordable foods, by being able to travel further and to visit multiple stores that offered a wider variety of affordable food. Public transport, while allowing for travel away from the local neighborhood, came with both time and monetary costs as well as physical inconvenience, particularly for those living further away from the city center and with less efficient options. Also, they were limited to what they could carry themselves; this meant that the number of stores visited would be fewer as more time would be spent on travel. Being accompanied by children also made public transport options more challenging to manage. Immigrants were, however, generally willing to travel further to buy food in order to access items suitable in relation to cost, quality, personal value and cultural food preferences.

Affordability

Low incomes & food prices: Overall, immigrants across studies had low and inconsistent incomes, although this improved over time. Considerations of food and other competing needs came after arguably more fixed costs like rent and utilities. Additionally, some immigrants sent remittances to their families in the home country, which further reduced the funds available for food budgets and disposable incomes. Food decisions were highly influenced by income, which often led to a lack of control over food choices. Food provisions, including fresh fruits and vegetables, were bought at the beginning of the month, using up most of the budget. For immigrants, food prices were experienced as high in relation to overall income. This was particularly perceived for items such as fruits, vegetables, meat and fish. Food prices determined where immigrants shopped, what and how much they purchased and the variety they consumed. Immigrants generally tried to find the sources with the lowest prices for the items they wanted, particularly good quality, fresh food.

Food assistance programs: A majority of the identified papers were from the US, with findings that government food benefits were widely used and, though they were supplementary in nature, many families reported them being the main family food budget, although insufficient. These programs improved access to healthier food and culturally acceptable foods. Not all immigrants accessed these benefits, though they may have been entitled to them, due to barriers in the application process as well as fearing that claiming the benefits may compromise their immigration process. Emergency food assistance, for example from food pantries or banks were used by some immigrants, particularly in harder times or in the first couple of years. However, these foods were often donated items with a long shelf life, often culturally inappropriate, such as canned food or non-halal meat products.

Coping strategies: Due to financial constraints, participants reported compromising on the variety and quality of food in order to have a sufficient amount to eat. Immigrants had a wide range of methods to attempt to optimize the limited budget: utilizing store deals, accessing a range of stores to find the lowest prices for foods (especially fruits, vegetables and meat), as well as reducing the consumption of foods. They also turned to frozen, canned and cheap convenience foods, as well as kids taking advantage of food at school, or cooking cheaper cultural foods.

Convenience

Time: Available time, primarily linked to gender-based double work burden, limited food provisioning activities, such as spending more time shopping for money saving deals or buying fresh foods that would take longer to prepare.

Not having enough time meant that food provisioning needed to be fast and convenient as well as cheap. This sometimes led to time-saving shortcuts, including turning to and becoming reliant on convenience foods, leftovers, snacks, skipping meals or eating on the go, something they were aware was not conducive to their health. However, foreign-born women were more likely to view food provisioning as an essential task, as opposed to weighing in the effort required when deciding on what foods to buy and prepare.

Desirability

Preferences: Immigrants desired high quality, fresh, chemical-free and unprocessed foods, in particular fruits, vegetables and foods in their natural state, perceived as good for health. Overall, immigrants expressed a strong desire to eat their traditional foods, cooked at home, based on fresh ingredients. Maintaining these eating habits was important to them. For Muslims, religion was very important in determining their food choices. Immigrants regarded many common host country foods with suspicion, particularly processed, preserved, canned or frozen food, considering these as old and filled with chemicals. Fruits, vegetables and meat were experienced as having less taste and fragrance as compared with their home countries and therefore perceived as being of lower quality and nutritional value. Preparing traditional foods reinforced the link to the home country and was a way to pass on traditions, whereas adopting host country foods made them feel more integrated.

Children's preferences: The school food environment played a role in introducing children of immigrants to host country foods, including highly processed foods, leading to children developing a preference for these. There was a conflict between the food parents valued and what children desired. Children wanted parents to provide host country foods at home, often processed ones, while parents wanted to provide what they knew as good and healthy food. This was often rejected by their children, leading some to start cooking host country foods. Also, children's demands for fast food led families to eat out more often. In this way, children played a role in influencing the food habits in the family.

Skills: When moving to a new country, immigrants faced a new food environment and often a new language. Learning to navigate the food environment was facilitated by initially being guided by a fellow member of ethnic groups' social network, in terms of selecting stores, finding appropriate products and new ways of eating. Social media groups shared information on culturally appropriate and affordable foods including halal foods that were on current deals. Food procurement skills before migrating included acquiring quality fresh foods from markets, stores or home gardens, whereas foods in the new

food environment were not always recognizable in unfamiliar packaging, processing and storage, such as frozen foods. In the host country, language and literacy skills were required in order to identify foods, take advantage of price deals as well as reading and understanding food labels in order to enable a more conscious decision.

Discussion

This thesis focused on understanding the food environment and its interactions with consumers through an NCD lens and with a special focus on disadvantaged or under-resourced settings and populations. Supermarkets were a major source of both unhealthy and healthy items in the selected countries, as well as the neighborhoods in Sweden, as found through my studies. Considering the NCD lens, we found that together with other formal stores (independent grocer, convenience store), supermarkets ensured that unhealthy items were highly prevalent across all the areas and country settings we studied. In the Swedish context, no significant differences in availability of either healthy or unhealthy food items were observed between different levels of neighborhood SES. Here, lower neighborhood SES was associated with lower prices of fruits and vegetables. There was higher exposure to outdoor advertising in areas of higher disadvantage when looking at all country income groups. Rural Uganda (low-income country) had the highest level of unhealthy food advertising. Likewise in Sweden, low SES neighborhoods had more advertising overall, both unhealthy and health promoting compared to middle SES neighborhoods. Overall, EDNP foods and SSBs formed a large part of the unhealthy product advertisements. Additionally, the scoping review found that immigrants from LMICs living in HICs generally preferred traditional cultural food prepared with fresh healthy ingredients. Furthermore, mobility (through car access) helped them access more affordable foods, more in line with their preferences. However, the personal and external food environment that they experienced after migration potentially pushed them towards unhealthy choices through lack of time for shopping and preparing foods, children preferring host country (processed) food, easy and cheap access to convenience and fast foods, lack of money and comparatively high prices for healthier foods (primarily studies based in the US).

In general, food environment research often uses an NCD lens, although not stated explicitly, but seen in the ‘healthy’ versus ‘unhealthy’ approach used. Considering that the food environment consists of many different aspects, including types of stores, distance and density of these, personal factors related to food access and stores’ availability of an array of products, the choice of an NCD lens limits the scope of the overall food environment in a systematic and meaningful way. However, this may not always be an advantage, as it pre-

frames the findings within a certain remit and limits data collection. This means that many characteristics of the food environment would remain under researched. Having an open approach would have allowed for a more inductive study, for example, highlighting issues beyond the unhealthy and health promoting advertisements in communities observed in Study III. An inductive approach could have highlighted which are the most common advertisements overall and what methods are being used. This would put the NCD aspect into the larger context. However, as there is established evidence linking specific types of foods to health, findings from studies using the NCD lens may be more actionable than those with a more open approach.

Many studies on food access use supermarkets (or other grocery stores) as a proxy for the availability of healthy food. However, our study and others have shown that supermarkets and grocery stores are a double-edged sword, while stocking healthy food, also offering a range of unhealthy items such as SSBs and other EDNP foods.^(191, 192) In terms of consumer demand, consumption of SSBs and other EDNP processed foods are among those that have increased most in the last few decades, with a simultaneous rise in obesity⁽¹⁹³⁻¹⁹⁵⁾ and NCDs like type 2 diabetes.^(196, 197) Most household expenditure was carried out at supermarkets (65%), for both healthy and unhealthy food items, compared to other smaller stores.⁽¹⁹⁸⁾ A study from New York State found that 96% of participants acquired food at supermarkets.⁽¹⁹⁹⁾ Shopping at a supermarket was associated with higher BMI in the Black sub-group of a study from the US, perhaps linked to supermarkets selling a range of unhealthy items as well as healthy ones.⁽¹⁹⁹⁾ This illustrates the central role of supermarkets as the main provider of both unhealthy and healthy foods even though they are usually deemed as providers of healthy food items in food environment research. Supermarkets play an important role in providing unhealthy foods as well, where, for example, food desert residents sourced most of their EDNP food at supermarkets.⁽¹⁴¹⁾ This implies that there are even more sources of unhealthy foods than usually considered in those studies that use store type to represent presence of healthy and unhealthy foods. A more accurate way would be to use all stores (except fruit and vegetable stands) to represent unhealthy food availability while supermarkets and independent grocers, markets and informal vendors also represent healthy foods, i.e. the stores selling healthy foods would be incorporated into both groups, thus not being mutually exclusive.

Our findings show that all outlets, apart for the informal vendors selling fruits and vegetables, contributed to the obesogenic aspects of the food environment, by stocking a range of confectionaries and SSBs across sites (three countries and neighborhoods in Stockholm). A study from Australia comparing types of stores, found that a higher share of shelf space for these types of foods was present in areas with the highest socioeconomic disadvantage.⁽²⁰⁰⁾ In that same study, just over 66% of all measured shelf space was dedicated to such foods,

with ‘independent’ food stores notably having more shelf space for these foods as compared to other stores.⁽²⁰⁰⁾ In addition, another study from Australia confirms the high level of yearly sales for EDNP foods and beverages, and showed that this differed between store types, where grocery stores (like supermarkets) played a bigger part than convenience stores in their sales.⁽¹⁹²⁾ There is some evidence, though further research is warranted, that being of higher SES is protective against the exposure to an unhealthy food environment, impacting dietary behaviors differentially across socioeconomic position.⁽²⁰¹⁾ ‘Deprivation amplification’ is the double burden of disadvantage, where low individual level socioeconomic position is amplified by neighborhood deprivation, thought to lead to the negative health outcomes that we see in lower SES neighborhoods.⁽²⁰¹⁾ This may also explain why it is difficult to ascertain a direct relationship between food environment and dietary behaviors, as illustrated by many studies that find no significant relationship.⁽²⁰²⁾

Prices & affordability

In our study assessing prices of specific food items, we found that the price of fruits and vegetables was positively associated with SES across 22 neighborhoods in Stockholm, whereas there was no significant difference in the price of unhealthy (confectionaries and SSBs) items across SES. The evidence from other studies has been inconsistent. A systematic review of the literature on food deserts provides evidence of higher prices in primarily Black neighborhoods in the US, though mixed results between studies.⁽²⁰³⁾ In this same review, for countries outside the US, like the UK, Canada, Australia and New Zealand there was no evidence supporting higher prices in low SES areas.⁽²⁰³⁾ However, there are other studies that have highlighted that healthy food costs less in areas of lower SES, as seen in our study. For example, a study from Sidney, Australia comparing the cost of a food basket across 20 low and 20 high SES suburbs showed that the food basket cost significantly less (30%) in lower SES suburbs.⁽²⁰⁴⁾ In the US, a study found that for selected healthy items (fruit juice, frozen vegetables), as neighborhood SES decreased, so did the price of these foods, particularly so for neighborhoods with more Black/Hispanic residents.⁽⁹⁶⁾ Several studies have drawn out the relationship between those on low incomes spending less total money on food,⁽²⁰⁵⁾ which may indicate that those on low incomes take advantage of deals and are good at stretching their budgets. Other studies have illustrated that prices can vary significantly across store types⁽²⁰⁶⁻²⁰⁹⁾, which is also a potential explanation for our findings, as the neighborhoods in our Swedish study had different compositions of store type, with some socioeconomic patterning. However, it has also been shown that people of low SES spend less money than those of higher SES in all types of food outlets, except for dollar stores which may offer low cost foods overall.⁽²¹⁰⁾

The low SES neighborhoods in our study had more ethnic supermarkets, informal fruit and vegetable vendors (not present in middle SES neighborhoods) and more independent grocers, most also being ethnic. Though we did not compare prices across store type, other studies have found that foods are differentially priced across store type. For example, in a central, multi-cultural, socioeconomically disadvantaged area of London, UK, prices of contents of culturally acceptable healthy market baskets were compared at different store types.⁽²⁰⁷⁾ Fruits and vegetables were found to be cheaper at markets and smaller stores, whereas other food items that were cheaper at supermarkets.⁽²⁰⁷⁾ Fruits and vegetables represented 20%-27% and protein foods 30%-38% of food spending in the same study.⁽²⁰⁷⁾ Similarly, in the US, immigrant-run, low-cost curbside stands in low-income neighborhoods selling fresh fruits and vegetables sold these at lower prices than other types of food retail outlets.⁽²¹¹⁾ Fruits and vegetables were also lower in price in *Tiendas* (smaller Latino stores) compared to supermarkets.⁽²⁰⁶⁾ Though we did not differentiate between supermarket types in our study, discount supermarkets are more likely to be present in lower SES areas as seen in other studies, with fruits and vegetables available at lower prices there than in other stores and supermarkets.⁽²¹²⁾

Though lower neighborhood SES was associated with lower prices of fruits and vegetables, in Stockholm, it does not necessarily translate to better affordability. The cost relative to income in low SES neighborhoods may mean that lower prices will not necessarily result in those items being affordable.⁽²⁰⁴⁾ Fruits and vegetables in particular, represent a high share of food spending, indicating that those with low income may favor cheaper, EDNP foods.^(204, 213) In spite of lower prices of fruits and vegetables in lower SES neighborhoods, the share of this in the total food budget may still be comparatively high. There is evidence that prices greatly influenced how the food budget was spent and barriers to food access were overcome to some extent, with the goal of lower prices.⁽²¹⁴⁾ Available money was spent in relation to satiety and sufficient quantity for the whole family, desired food items, buffering capacity in hard financial times and food to feel good, the latter being prioritized in spite of insufficient money for other items.⁽²¹⁵⁾ Economic limitations were stated as the main reason for not adopting healthier diets, including the high price of fruits and vegetables.⁽²¹³⁾ Additionally, as income rises, the total amount spent on food increases, and those with low incomes spend a higher share of their income on food as compared to those with higher incomes.⁽²¹³⁾ Likewise, studies have shown that as diet quality increases, so does the cost of the diet.^(213, 216) One study found that a 20% increase in expenditure on food led to a 7.2% increase in percent energy from fruits and vegetables and negligible reduction in percent energy from less healthy foods and beverages (0.7%).⁽²⁰⁸⁾

Prioritizing food decisions based on their price or health qualities may lead to socioeconomic patterning, where prices may limit how healthy the choices are, or choosing healthier alternatives that drive up food expenditures, compromising other needs.⁽²⁰⁸⁾ In a study from Finland, those in the lowest quartiles of household income valued inexpensiveness of foods more than those in the highest quartile.⁽²¹⁷⁾ Residents of low SES neighborhoods may have the opportunity to seek out the lowest prices in order to maximize their gains, especially seeing as the stores included in our study were all based within these relatively small geographical boundaries. Even though lower prices do not necessarily mean that fruits and vegetables would be easily affordable for those on low incomes, it does mean that it is more achievable as compared to higher prices that would result in an even higher share of the food budget. Therefore, lower prices, as we found in our study, may decrease the barrier to accessing healthier foods, though the extent of this can be discussed and would require further research. Also, neighborhoods with lower prices may additionally serve those living outside these neighborhoods. People who are looking for more affordable fruits and vegetables may access these areas, as seen in our scoping review where people were willing to travel further to access foods at lower costs.

Outdoor advertising

Studies from across the globe have reported a larger share of outdoor advertisements for unhealthy foods, namely EDNP foods and SSBs.^(87, 218-225) In addition to our study, another study from Sweden also found a higher presence of these advertisements in a low SES neighborhood as compared to a high SES neighborhood.⁽⁸⁷⁾ They included all food advertisements present in the neighborhoods as opposed to our approach of making observations within predefined categories and found that 65.4% of total food advertisements observed were for EDNP foods ('ultra-processed').⁽⁸⁷⁾ Other studies on the outdoor food advertisement landscape in HICs have also found socioeconomic disparities in the presence of outdoor advertising, where more disadvantaged neighborhoods had higher levels of advertising.^(87, 219, 220, 222, 224-227)

As individuals, we live in many advertising landscapes simultaneously, through our mobile phones, on computers, when we go shopping, in buses and trains, along routes and in neighborhoods, to name a few. Outdoor advertising, on the other hand, is something that we are exposed to irrespective of age and it is present round the clock. That it is more prevalent in low SES neighborhoods, in our study population also neighborhoods with the highest percentage of immigrants, is of concern. Low SES and other social determinants of health have been inextricably linked to NCDs: a review and meta-analysis found that

those of low SES had a higher risk of developing type 2 diabetes.⁽²²⁸⁾ Furthermore, in Sweden those of low SES and born outside Sweden had a much higher risk of developing type 2 diabetes compared to those born in Sweden.^(229, 230) Advertisements are used as a way to inform and persuade people. Therefore, a larger share of advertisements promoting unhealthy products may result in further normalizing the consumption of these products in an already vulnerable population.⁽²³¹⁾ Children in particular are more susceptible to the influence of advertising and may be disproportionately affected by these outdoor advertisements, in spite of not specifically targeting children.⁽²³²⁾ In addition, low SES households may be more susceptible due to a lack of material and psychological resources available to them at an individual and neighborhood level.⁽²⁰¹⁾

On a positive note, there were far more health promoting advertisements in the low SES neighborhoods that we studied as compared to the middle SES neighborhoods. However, these were primarily commercial in nature and the majority were images of fruits and vegetables on storefronts, as opposed to information promoting healthy eating, as one may expect. Further studies are required to better understand the dynamic between the presence and influence of unhealthy and health promoting advertisements, for example whether one type can counter the presence of the other type. A systematic review and meta-analysis showed that unhealthy food advertising can negatively influence choices,⁽²³³⁾ and there is also some evidence that health promoting advertising promotes healthy choices.⁽²³⁴⁾ In the low SES neighborhoods studied, there were simultaneously: a higher number of advertisements, particularly for unhealthy foods and SSBs; a high presence of unhealthy items in stores; a higher proportion of health promoting advertisements; and fruits and vegetables that cost less with lower neighborhood SES. However, how these competing influences play out in terms of their effects on food behaviors and health outcomes would require further research.

Generally, outdoor advertising is regulated under Swedish law. Among other requirements, content must follow appropriate marketing codes of abiding by tobacco and alcohol marketing regulations as well as responsible advertising that is not misleading to consumers.⁽²³⁵⁻²³⁷⁾ In addition to regulations, the International Chamber of Commerce has developed ethical codes to promote responsibility and a global level playing field by aiding self-regulation of the industry, though without specific recommendations regarding unhealthy foods.⁽²³⁸⁾ Also, requirements of outdoor advertising consists primarily of seeking permission from the correct authority, judgements about the aesthetics of the advertisements (whether they fit into the respective landscape) and keeping neighborhoods orderly.⁽²³⁹⁾ As such, EDNP food and SSB advertisements are permitted at appropriate or designated outdoor marketing spaces. While carrying out observations of the food environment, we did not note

where specifically advertisements were placed. However, it may be the case that many of the advertisements or images found in the outdoor food environment are placed on fronts of food retail outlets. Independent outlets, of which there are more in low SES neighborhoods, may be more likely to advertise on their store fronts in order to gain customers and communicate their deals to potential customers. Additionally, aesthetics may be implemented differently across neighborhood SES, particularly when it relates to the most prevalent type of housing (rented vs owned properties). A more cluttered neighborhood aesthetic may negatively influence real estate prices and perhaps making it more likely for marketing regulation at a local level to be more strictly implemented. Though these regulations are not linked to the types of food advertised, they are somewhat protective as opposed to countries that have less regulation on the use of the built environment for commercial purposes. When we compared countries of different income levels, rural Uganda (low-income) had the highest level of SSB advertisements, which may be due to a lack of regulations or guidelines about advertisements and, in particular, their placement.

Immigrants living in high-income countries

The scoping review focused on immigrants from LMICs living in HICs and given the skewed nature of scientific publications, the majority of the studies were based in the US. Given the focus of this thesis, one question to consider is how much the results would apply to immigrants from LMICs living in the Swedish context. To understand this, there are a number of aspects to take into account. Sweden is a social democratic welfare state, where there is a social safety net, though these do not fully apply to asylum seekers and undocumented migrants. Benefits are paid out without earmarking and it is up to individuals and families to prioritize as they see fit. This is different to other countries like the US, where there are specific food-related benefits, like the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP) that immigrants have reported accessing.

Immigrants from LMICs described in the scoping review, had a precarious financial situation, with low and unstable incomes. In Sweden, it takes a fairly long time to get established in the job market and the majority of immigrants fail to reach the income level of the Swedish-born population.⁽²⁴⁰⁾ In 2020, on average, immigrants had an income about 70% of what those born in Sweden had, with median incomes of 264,400 SEK and 364,900 SEK respectively.⁽²⁴¹⁾ In addition, there are variations within immigrant populations, with people from Africa and Asia earning 54% and 59% respectively of the earnings as compared to their Swedish-born or other Nordic-born counterparts.⁽²⁴¹⁾ Over

time this improves to 92% after 20 years in Sweden.⁽²⁴¹⁾ Immigrants are also more likely to be unemployed or receive benefits as compared to the Swedish-born population, this was 19.5% and 5.4% respectively in 2021.⁽²⁴²⁾ This figure partly reflects fewer years spent in Sweden for some within this group. On average, it took about eight years for half of those that came to Sweden as asylum seekers during the 2000s to become employed.⁽²⁴²⁾ Educational level plays a part in employment success even for those born in Sweden, but the level of education is lower in those born outside Sweden.⁽²⁴²⁾ In 2022 about 50% of those registered as unemployed or receiving paid training through the government were born outside Sweden.⁽²⁴²⁾ These differences are also clear when comparing the average incomes of the neighborhoods included in our Swedish study. The scoping review reported that immigrants were time poor, due to employment, perhaps holding several jobs or working long hours. Relating this to Sweden, officially employed immigrants worked similar or slightly more hours than those born in Sweden.⁽²⁴³⁾ However, due to the diverse nature of immigrant populations, it is likely that there is a more complex picture of the type of work, working hours and income experienced by this group.

Food environments described in the scoping review varied but did emphasize lack of access to fresh healthy foods and easier access to less healthy foods. Immigrants travelled further to access supermarkets with affordable products. A national study on the food environment in Sweden found that low SES neighborhoods were not less serviced and actually had shorter distances to different types of food outlets.⁽²⁴⁴⁾ Though we did not measure distance to stores, we noted all food outlets within relatively small administrative boundaries and there was no statistically significant difference in the number of supermarkets across SES. Despite this, the overall numbers increased as SES increased, and there were significantly more independent grocers as neighborhood SES decreased. The presence of informal vendors in lower SES neighborhoods provided fresh fruits and vegetables to these areas. This would suggest that there was relatively good access to food shopping opportunities on foot, from a range of outlets. However, our inclusion criteria for neighborhoods was a central shopping area or presence of food stores in the neighborhood. Immigrants living in other areas may face a different situation, where they need to use transport to access food stores. Contrary to the findings of the scoping review, we did not find fast food outlets to be more prevalent in lower SES neighborhoods, though other food service outlets were more prevalent as neighborhood SES increased. In the Swedish context, it seems that disadvantaged urban neighborhoods do not have a higher exposure to unhealthy food items or food stores known to sell less healthy foods. In addition, a study including Nordic countries reported that convenience foods were primarily valued for their role in saving cooking time, though in Sweden low prices were

also reported as important.⁽²⁴⁵⁾ This same study also found that those surveyed reported a low usage and negative attitude towards these foods.⁽²⁴⁵⁾

Immigrants in studies included in the scoping review reported that they valued fresh, healthy foods and preferred their cultural foods. For Muslims, eating according to religious principles was essential. A systematic mapping review including immigrant groups in Sweden and elsewhere identified factors influencing food choice, finding that socio-cultural environment, cultural beliefs and perceptions around food as the most often cited factors.⁽²⁴⁶⁾ In nationally representative surveys, the diets of children of immigrants in Sweden had a higher intake of fruits and vegetables,^(50, 56) while also having a higher intake of EDNP foods, compared to those with a Swedish background.⁽⁵⁶⁾ In the HELIUS study in the Netherlands, those with a foreign background were more likely to have a higher quality diet score at a lower cost than for Dutch participants, independent of educational status.⁽²¹⁶⁾ This shows an ability to acquire foods that are healthy, within the budget, in spite of cost barriers. It is possible that immigrants living in the low SES areas we studied could perhaps achieve this higher diet quality at a lower cost than living in a middle SES neighborhood, due to the lower costs of fruits and vegetables. Language barriers, found to be a barrier to navigating the food environment and transport in the scoping review, would also pose a challenge in Sweden as all signage and labelling is in Swedish. This may pose a double barrier for immigrants from LMICs, some of which have low level of education, with potentially lower food literacy when it comes to reading, understanding and interpreting food labels and signage to make active choices during food shopping.

Children came through in the scoping review as being a driving force in dietary acculturation of the family, partly by being exposed to host country foods, preferring and demanding these foods at home. The school food environment was reported as exposing and developing preferences in children to EDNP foods, which has to be interpreted with caution for the Swedish context as all school children are served a free hot lunch that should follow nutritional guidelines.⁽²⁴⁷⁾ However, Persson Osowski et al. found that children with a foreign background were more likely to skip school lunches.⁽²⁴⁸⁾ In Sweden, school food provides an exposure to host country foods from a young age as there is subsidized childcare from age one, but this is not an exposure to EDNP food. However, preferences for host country foods may form, thus potentially influencing eating patterns of the family. Further research is needed to identify whether this is the case and whether it would negatively influence dietary quality. However, children may be influenced by other parts of society. In Sweden, there are some customs that have become embedded in the culture, coming from both public health messaging and industry marketing. From the 50s, *lördagsgodis* (Saturday sweets) have been promoted as a way of reducing

the risk of dental caries, avoiding high frequency sugar consumption by avoiding sweets during the week and only consuming these on Saturdays. In Sweden, the majority of younger children are now caries free.⁽²⁴⁹⁾ It is not known to what extent immigrant communities have taken to these particular customs, as children of immigrants in Sweden suffer from higher rates of dental caries as compared to native children.⁽²⁵⁰⁾ However, this is likely also related to other factors like dental hygiene practices. Also, *fredagsmys* (cosy Friday) is a weekly family event marking the start of the weekend, which often included a movie or television programs, chips and soda, with variations, for the whole family. In Sweden, sales of soda and other beverages has increased by 150% since year 2000, sweet products have also increased steadily; but at the same time the sale of fruits and vegetables have also increased.⁽²⁵¹⁾

Results from the scoping review are limited to the included articles, in this case heavily based on Latino populations living in the US. New waves of immigration from other corners of the world, with different cultures and religious beliefs, may mean that research on food environment and immigrants from LMICs living in HIC may have different findings in the future.

Methodological considerations

Sample selection (Study I, II, III)

In study I, we aimed for snapshots of three different food environments in order to illustrate broad difference between them. The six sites were purposefully sampled with initial sites chosen in a larger project, based on socioeconomic or resourcing disadvantage. The initial sites were then 'paired' with an/urban or rural counterpart. The urban-rural built environments in different countries, in and of themselves would be expected to greatly differ in their characteristics. Further limiting the comparisons was the differences in sizes and characteristics between the areas. For example the urban suburb in Sweden as compared to the central business district in Kampala (Uganda), which is not primarily a residential area. The purposeful sampling and low number of sites limit the external validity of our findings as well as the power to detect significant differences, which limited our statistical analysis to a primarily descriptive one. However, the aim of the study was to understand main differences between the food environments from an implementation perspective for the larger project, which was achieved by the methods used.

In the Swedish context (study II and III), 22 areas of Stockholm were sampled, 10 from low SES neighborhoods and 12 from middle SES neighborhoods. We used two variables (income and unemployment) for inclusion; as the third var-

iable we considered (education) did not follow the average income or unemployment. We had sampled deciles one, and five-six, with clear differences between the groups. Hence, areas were sampled solely on the demographics, irrespective of where in the city they were geographically placed. Depending on the type of neighborhood, food environment characteristics would naturally vary, due to being a central location or a more residential area. This may have affected our results as those in inner city areas were bound to have more outlets, catering to an additional population visiting the area and creating the demand that would lead to a higher number of outlets in the food environment. We controlled for this during the analysis (study II) but we did not find any meaningful differences from our results. Though twenty-two could be considered as a small sample size, that is not the case in food environment research, which varies between one census block to nationwide studies based on available data.^(252, 253) In our case, the sampled neighborhoods represented a substantial proportion of the target neighborhoods. Out of a total of 130 neighborhoods in Stockholm municipality (in 2017), there were 13 neighborhoods in each decile. We sampled 10 from the lowest and 12 from the middle two deciles, which represents a majority within the target deciles. Our findings may therefore be generalizable to other low and middle SES urban neighborhoods in Stockholm. In Study II & III, we mapped the food environment within administrative boundaries, called *stadsdelar*. The boundaries do not necessarily reflect how the built environment is set up, in terms of where people might shop or interact with the food environment. My studies focus only on the neighborhoods themselves and not on the shopping habits of the residents. What we cannot draw conclusions about is who uses the food environments we have observed, as we know that people often move out of their local area to acquire food. We have observed these particular environments on the assumption that they serve as the food environment for those that live in the area and visit the area. This is a limitation that relates to much of food environment research, an uncertain geographic problem, particularly with lack of data and research on people's mobility, perceived food environment and the range of factors that shape the interactions.⁽²⁵⁴⁾

EPOCH tool (Study I, II, III)

The EPOCH tool was originally developed as an effective way of assessing the environmental risk factors for NCDs. In its initial form, it was tested for reliability, finding that direct observation of the food environment had a high inter-observer reliability in communities in the 5 countries studied.⁽¹⁴³⁾ After modifications to the tool, we did not carry out additional reliability testing. This decision can be debated as it is always a strength to carry out reliability testing. However, as part of the training, data collection was carried out together by two researchers in four of the 22 areas; mitigating any differences in the interpretation and documentation of observations. In addition, though

parts of the tool were modified to address some of the gaps identified by the original team (personal communication, Chow), the structure and method of data collection remained the same. The main modifications made to the tool were based on the direct observations from the in-store assessment of the environment and number and types of stores. We also categorized fruits and vegetables in order to identify those relevant to each setting, making the data more context-specific. Other approaches to categorization were considered, for example biological classification of fruits, but it was too complex and not meaningful from a nutritional standpoint. Modifications also included collecting additional data from food labels, as well as on the availability and price of food items. In the original EPOCH tool, data collection only took place in supermarkets and this was done discreetly, without necessarily gaining permission from the store. However, we included other types of stores like informal vendors, convenience stores and informal vendors to build a more complete picture of the local food environment. Following modifications to the tool, face validity was established through discussions and piloting of the tool. Content validity was evaluated by experts on food environment and consumption behavior within the SMART2D consortium. In addition, in study I the conceptual framework of the food environment was used to interpret results while simultaneously content validating the EPOCH tool used for data collection.

In retrospect, there were some food environment related characteristics that would have been useful to include in the tool to better understand our findings. For example, regarding outdoor and in-store advertisements, we only noted extreme categories of healthy and unhealthy, which excluded the overall picture in relation to exposure to advertisements. Noting all the advertisements, taking a picture of each as well as data on the placement of the outdoor advertisements could have made our findings more directly applicable to policy or interventions. Also, shop size in terms of aisles, shelf space or square meters would allow comparisons between number of in-store advertisements or healthy vs unhealthy items while considering store size as a confounder. Other ways of promoting products were not part of the observations. Advertising is just one way of promoting products at the point of choice and there are a range of other strategies in action at store-level. Furthermore, when collecting food data between countries, or in multi-cultural, or super diverse neighborhoods in Sweden, the relevance and comparability of data comes into question. In study I, we included other food items such as breakfast cereal, pasta, milk and yoghurt, however, it is difficult to interpret results on availability and prices as we do not know to what extent these are part of the local food cultures in these three different countries and urban and rural settings. Collecting food basket data would be valuable provided the foods are relevant to the local population. Qualitative interviews or surveys on common food items and habits could be used to construct representative food baskets, equating to more

relevant data. However, this would limit the comparability across settings and the generalizability of the findings.

It is also important to note that all the parts of the original EPOCH tool were not administered in this study. The observation walk and food retail outlet assessment were selected as part of the contextualization for the SMART2D project. However, had we carried out the restaurant assessment and the perceptions of the food environment questionnaire, this would have resulted in a more nuanced evaluation of the food environment. Seeing as the food outlet tally showed that most food outlets across neighborhoods were for food service outlets, assessing these would have resulted in a more complete view of the food environment in the studied settings.

Score of neighborhood SES (Study II)

The neighborhood SES score was created in order to test associations between neighborhood SES and various characteristics of the food environment. Area level deprivation was measured by choosing three indicators: average income of the neighborhood; percentage with a higher education and percentage that are unemployed. Income is an indicator that shows material resources, that can fluctuate over a lifetime.⁽²⁵⁵⁾ This was important as both immigrants and native Swedes in low SES neighborhoods have low incomes, lower levels of education as well as higher rates of unemployment compared to the those living in more affluent neighborhoods.⁽²⁵⁶⁾ One could argue that the indicator used to represent education could have been based on those with less than a secondary school education rather than the percentage with a higher education. Those with less than a completed secondary school education in Sweden have a hard time finding employment and there is a higher percentage of immigrants in this group.^(257, 258) This may have captured the extremes better than higher education, though higher education may be more representative of middle SES. In addition, when related to health outcomes, those with higher education have a lower likelihood of several negative health outcomes as compared to those with a secondary education.⁽²⁵⁹⁾ Others have used different indicators. A more recently developed index assessing the whole of Sweden (*Segregationsbarometern*) used the following variables to classify different types of area: number of people with a low economic standard, share of people with less than a high school education, share of people that have received benefits for at least ten months and/or been unemployed more than six months.⁽¹⁷⁰⁾ Though this web application is more recent, this was cross-checked with the chosen low- and middle SES neighborhoods and found that they were categorized in a similar way, which further validates our methodology.

Scoping review (Study IV)

A 'Best-fit' framework synthesis using the ANGELO framework was carried out. This combined the goal of interpreting the data through a food environment framework to bring out different aspects, while not forcing all the material into the framework. This meant that data which did not fall naturally into the framework underwent further qualitative thematic analysis, which made the analysis more nuanced and the results more meaningful. Also, to allow the results of the scoping review to be more relevant for application, this method did not go to a high level of abstraction. The ANGELO framework itself was an appropriate choice for the research question with broad domains, allowing other categories and sub themes to emerge.

The majority of the articles included in the scoping review were from the US. Therefore, the results largely reflect the situation of immigrants in the US, where there is a large Latino community, including undocumented migrants. Some of the findings, such as the issue of time scarcity, may therefore not be transferable to the European setting where there is more of a social safety net. However, as immigrants are also a marginalized group in Europe, undocumented work conditions and hours may go undetected, in spite of the existence of regulations protecting workers rights. Recent changes in rules relating to work permits in Sweden are an acknowledgement of this issue and may be beneficial in preventing exploitation to some degree.⁽²⁶⁰⁾

Conclusions

Gaining a better understanding of the food environment and its interactions relating to socioeconomic disadvantage and immigrant populations is important, especially as food environments are linked to food practices and health outcomes. There was a high presence of unhealthy food items (confectionaries and SSBs) in the observed food environments. Primarily supermarkets, but also other formal food outlets, were found to supply a range of these foods as well as advertise them in-store. Lower neighborhood SES was associated with lower prices of fruits and vegetables. Low SES was also highly correlated with percentage of foreign-born residents in neighborhoods. These neighborhoods had more informal vendors selling fruits and vegetables, ethnic supermarkets and independent grocers, which may have contributed to the lower prices. Immigrants valued fresh healthy and cultural foods, but factors like limited income, lack of time and transport, and children's demands for processed foods influenced the trajectory of food habits after migration. Outdoor advertising was observed across neighborhoods and, of the categories noted, EDNP foods and SSBs beverages were the most prominent, with disadvantaged or under-resourced areas having higher levels of advertising.

These findings highlighted factors in the observed environments contributing towards an obesogenic food environment, potentially normalizing and enabling the consumption of less healthy foods. Lower prices of fruits and vegetables may enable a healthier diet, though to what extent this translates to affordability for those with low income is unclear. Higher exposure to advertising in low-income neighborhoods may indirectly accentuate health inequities already present. In spite of a lack of regulations on content of outdoor and in-store advertising in Sweden, strict general regulations relating to outdoor advertising, including responsible marketing codes and limited to designated displays, may reduce, but not prevent, exposure. In order to improve health and reduce health and nutrition inequities, it is important to address the high presence of unhealthy foods and beverages, as well as the advertising of these types of products. In addition, having a better understanding of other physical, economic and sociocultural barriers to access could contribute towards more equitable access to food environments.

Future perspectives

Research on the food environment is needed, in particular in countries and settings that currently have low representation in the literature. More detailed studies on the food environment, selected in a strategic way so as to represent the main types of environments within a country, should be carried out. Lived experience research to identify the values, motivations and main barriers and facilitators to a healthy diet in these settings could aid in creating targeted actions. Future research should make all efforts to observe a wide range of elements in the food environment, including informal vendors that were found to provide healthy foods. More foods than just fruits and vegetables should be used to represent healthy food access, including those that have documented positive effects on health outcomes, such as nuts, seeds, wholegrains and fish.

The complex mechanisms of action and interaction between low socioeconomic status, food acquisition and food choices should be investigated through mixed methods research. The low consumption of fruits and vegetables may be partly due to lack of access, both physical and economic, as well as food culture and habits where the desired diet consists of a low share of fruits and vegetables. In the latter case, other interventions on behavior change may be needed, as improving the food environment would likely not have a strong effect.

Predictive modelling could help to present potential scenarios in modifying food environments. Finding the ‘tipping point’, where income is no longer a barrier to consuming a healthy diet, could inform policy to ensure that the most vulnerable have equal opportunity to acquire foods to live a healthy life.

The field of food environment research is highly intersectional and experts within these fields should collaborate. For example, studying the stakeholder power that influences the placement and promotion of unhealthy foods and beverages in stores; the business models and functioning of smaller and larger stores; or the redesign of community-food environments to enable default healthy behaviors. These actions require interdisciplinary and intersectional expertise, involving law, urban planners, public health, economists, as well as relevant stakeholders in the respective settings.

Studies have illustrated that food environments provide a range of unhealthy items as well as promote them in the outdoor and in-store environments and through other media channels. Most food outlets, except informal vendors, play a major role in contributing to an *unhealthy* food environment. This is primarily being tackled through downstream determinants and a focus on lifestyle by trying to change the way people interact with the food environment but without improving the quality of the food environment and its ability to promote default healthy behaviors. Restricting types of food permitted to be advertised by using nutrient profiling may be a way to reduce exposure to the least healthy advertisements both in community and consumer environments. Zoning policies on limiting unhealthy food outlets could include convenience stores (in the Swedish setting) as they practically only sold unhealthy food items. Enabling market stalls for selling fruits and vegetables in all neighborhoods, through prioritizing permits and simplifying the set-up process, would be a relatively low cost way to increase access in the near future. As supermarkets and independent grocers were a source of both essential items, fruits and vegetables, and unhealthy items, it would be important for public health policy to make progress on guidelines that limit the space and range of unhealthy items in stores. Following on from the UK, implementing and regulating volume price and placement of foods high in fat, salt and sugar in stores, to apply to all stores ⁽²⁶¹⁾. Implementing strong visual food labelling using nutrient profiling could spur industry innovation while protecting consumers.

The food environment also increasingly encompasses digital food environments, with more people than previously buying groceries online as well as food deliveries from restaurants ⁽²⁶²⁾, while being exposed to online advertising ⁽²⁶³⁾. This is an emerging area and not much is known yet regarding the influence of these digital food environments on health ⁽²⁶²⁾ and requires further research.

Also, without governments addressing the underlying issue of people having insufficient incomes to afford a quality diet, there is a high likelihood that the status quo will continue. Meanwhile, to overcome the current issue, we also need to work downstream, by modifying interactions with the existing food environment: improving food literacy, exposing people to culturally acceptable healthy options and teaching food skills to support this process. Food environment transformations that are inclusive of all sections of the society is urgent if we are to reduce the burden from NCDs.

Svensk sammanfattning

Globalt sett ökar livsstilsrelaterade sjukdomar som till exempel hjärt- och kärlsjukdom, typ 2 diabetes och obesitas. Vissa samhällsgrupper påverkas i högre grad av dessa, som de som har det socioekonomiskt sämre samt vissa etniciteter. Kosten är en viktig orsak till dessa livsstilsrelaterade sjukdomar. Konsumtion av energität och näringsfattig mat samt snabbmat ökar, samtidigt som de är lättillgängliga och marknadsförs. Konsumenter införskaffar mat från sin matmiljö: från till exempel mataffärer av olika typer, restauranger och marknadsstånd. Därför kan matmiljön ses som ett steg mellan det stora livsmedelssystemet och konsumenten, där en interaktion sker för att införskaffa mat. Matmiljöer spelar en roll för kost- och hälsa genom bland annat närhet till, och typ av, affärer. Vidare så avgörs här vilka livsmedel som finns och prissättningen av dessa, samt vilka typer av livsmedel som marknadsförs. Forskning har oftast använt typ av mataffär för att studera hälsosam eller ohälsosam mattillgång.

Syftet med denna avhandling är att möjliggöra en mer nyanserad förståelse av matmiljön och interaktioner med denna, med fokus på socioekonomiska skillnader och invandrarpopulationer. Vad vi har valt att studera inom ämnet matmiljö har styrts av ett perspektiv med fokus på risk för livsstilsrelaterade sjukdomar. Studierna I-III syftade till att förbättra förståelsen för den externa matmiljön, genom att studera parametrar såsom typ av mataffär, tillgänglighet och priser på matvaror samt reklam, i stadsdelar med låg och medelhög socioekonomisk status i Stockholm, Sverige. I studie IV undersöktes de faktorer som kännetecknar och påverkar interaktionen mellan personliga och externa aspekter av matmiljön; i detta fall matmiljön och invandrabefolkningar från låg- och medelinkomstländer som bor i höginkomstländer.

I studie I-III kartlades den externa matmiljön med hjälp av en modifierad version av ett formulär för att notera observationer av matmiljön, *Environmental Profile of a Community's Health* (EPOCH). Studie I inkluderade resurssvaga och socioekonomiskt utsatta områden i ett låg- (Uganda), medel- (Sydafrika) och höginkomstland (Sverige), med ett område från tät- och glesbygd per land. Tjugotvå stadsdelar i Stockholm kartlades för Studie II och III, av dessa var 10 av lägre och 12 av medelsocioekonomisk status. Beskrivande och analy-

tiska statistiska analyser utfördes i dessa studier. En *scoping review* genomfördes för studie IV, med hjälp av ANGELO ramverket för att analysera och tolka data om invandrare från låg- och medelinkomstländer som bor i höginkomstländer.

Matmiljöerna i Uganda, Sydafrika och Sverige skiljde sig främst åt i antalet informella matbutiker/stånd, där låginkomstlandet (Uganda) hade flest och höginkomstlandet (Sverige) hade minst (Studie I). I det svenska sammanhanget minskade antalet små oberoende livsmedelsbutiker med 20 % och serveringar (exklusive snabbmatsrestauranger) ökade med 12 % för varje ökning av stadsdelars socioekonomiska index (Studie II). Tillgänglighet till specifika matvaror varierade inte med stadsdelarnas socioekonomiska status i Sverige, men för observationerna från de olika länderna hade Sverige den högsta tillgängligheten och Uganda den lägsta, totalt sett (Studie I och II). Stormarknader och andra livsmedelsbutiker var en viktig källa till både ohälsosamma och hälsosamma livsmedel; samt marknadsföring för ohälsosamma produkter (Studie I, II och III). Frukt och grönt var prissatta på liknande vis i de olika länderna (Studie I); men var lägre i det svenska sammanhanget i områden med lägre socioekonomisk status (Studie II). Marknadsföring av ohälsosam mat och dryck var den vanligaste typen av reklam, både utomhus och i butiker (Studie I och III). Utomhusreklam var vanligare i de mer socioekonomiskt utsatta områdena: landsbygdsområdet i Uganda hade mest reklam jämfört med området i Sydafrika och Sverige (Studie I); socioekonomiskt utsatta stadsdelar i Stockholm hade mer reklam jämfört med stadsdelar med en medelsocioekonomisk status (Studie III). För invandrare i höginkomstländer fann vi att några strukturella och sociala faktorer påverkade val: brist på tid för att handla och laga mat, barn som efterfrågade ohälsosam mat från den nya matkulturen, enkel och billig tillgång till halvfabrikat och snabbmat, brist på pengar och jämförelsevis höga priser på hälsosammare livsmedel, vilka kunde leda till mer eller mindre hälsosamma val.

Fyndet från denna avhandling visar att stormarknader och andra mataffärer är en källa till ohälsosamma livsmedel samtidigt som dessa marknadsförs. Att det fanns mer marknadsföring överlag samt för ohälsosamma livsmedel i socioekonomiskt utsatta områden än de områden med medelsocioekonomisk status kan spela en roll i socioekonomiskt drivna skillnader i hälsa och kost mellan stadsdelar. Lägre priser på frukt och grönt i socioekonomiskt utsatta stadsdelar i den svenska kontexten skulle kunna underlätta tillgängligheten till dessa hälsosamma livsmedel, dock krävs det ytterligare forskning för att undersöka till vilken utsträckning det påverkar inköp. Med tanke på att strukturella och sociala faktorer som kan påverka typ av mat som konsumeras, är det viktigt med en matmiljö som möjliggör hälsosamma val. Detta kräver en bättre förståelse för matmiljöer och de hinder som kan finnas till att välja hälsosam mat. Samtidig behövs lagar och insatser för att begränsa exponeringen för

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