Contextual correlates of dietary behaviours in adults across Europe

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Chapter 1

General Introduction

A growing evidence base demonstrates the importance of diet for population health and the prevention of non-communicable diseases. Unhealthy dietary behaviours are considered to be a main risk factor driving the global burden of disease and mortality [1, 2]. In the context of the Health 2020 policy framework and strategy, the World Health Organization (WHO) has recognised that a healthy diet may contribute to achieve the 2025 target reduction of 25% in mortality caused by non-communicable diseases such as diabetes, cardiovascular diseases, cancer and obesity [3].

Dietary behaviours can be defined as any behaviour that relate to individuals and food [4], and it represents an umbrella concept capturing different dietary aspects such as *food choices* (as determined by e.g., preferences, perceived barriers, intentions and price of foods); *eating behaviour* (which encompasses e.g., dietary habits, portion sizes, frequency of meals et cetera); and *dietary intake* (as defined by such factors as e.g., dietary patterns and nutrient intake) [4-6]. In order to enable evidence-informed policy and interventions to promote healthy eating it is essential to understand its determinants. Both individual ('downstream') and contextual ('upstream') factors can influence dietary behaviours [7, 8]. While individual determinants of dietary behaviours such as biological (e.g., age, sex) and psychological and social-cognitive factors (e.g., preferences, beliefs and intentions) have been frequently investigated in recent decades, more recently, attention has shifted towards potential contextual determinants (e.g., aspects of the social, and built environments), and the interactions between these two broad categories [8-10].

This General Introduction will first describe the link between dietary behaviours and health outcomes in Europe, dietary recommendations and adherence to dietary guidelines. Then, the most common individual and contextual determinants of dietary behaviours will be presented. A section on measurement of dietary behaviours and food environments will follow, and in that section, challenges in linking food environments to dietary behaviours and research gaps will be presented. This General Introduction will end by exhibiting the research aims and the outline of this thesis.

DIETARY BEHAVIOURS, DIETARY RECOMMENDATIONS AND HEALTH IN EUROPE

The link between dietary behaviours and health outcomes has been subject to much research. Healthier dietary choices such as reduced energy intake, lower consumption of saturated fat and sugar, higher consumption of whole grains, nuts, fruit and vegetables, and higher dietary fibre intake are associated with decreased risk for non-communicable diseases [11-15]. On the other hand, unhealthier dietary choices such as higher sodium intake, regular consumption of sugar-sweetened beverages and excessive consumption of red and processed meat are also associated with increased risks of non-communicable diseases such as cardiovascular diseases, type II diabetes and cancer [16-19]. The Global Burden of Disease Diet Collaborators explored the consumption of 15 dietary factors across 195 countries and concluded that in 2017, 11 million deaths were attributed to dietary risk factors such as low intake of whole grains and fruit and vegetables, and high intake of sodium [1]. According to the World Health Organization (WHO), the European region is the most affected by non-communicable diseases related to high BMI and unhealthy dietary behaviours among the six WHO regions [20].

Considering the important role of diet for health, several dietary recommendations have been developed. Traditionally, dietary recommendations and nutritional guidelines were focused on quantitative recommendations for the consumption of specific nutrients such as vitamins and minerals. To address the rising problem of non-communicable diseases, those traditional dietary recommendations evolved to a focus on a food groups-based advise with the aim to reduce, for instance, saturated fat and sugar intake [21]. The World Health Organization currently recommends that a healthy diet should maintain energy intake and expenditure in balance; include at least 400 grams of fruit and vegetable per day; and have less than 30% of energy obtained from fat and less than 10% from saturated fat, less than 10% of energy obtained from free sugars and maintain salt intake at a maximum of 5 grams per day [22]. Despite those recommendations, current dietary patterns in most developed countries are characterised by the consumption of foods that are energy-dense, high in saturated fat, sugar and salt and of relatively unfavourable nutrient profile. This includes a high consumption of edible oils and added sugar, animal food products, ultra-processed foods (UPF) and sweetened beverages, along with a relatively low consumption of whole grains and fruits and vegetables, fresh products and home-cooked meals [23-25]. Even

though such dietary patterns are a global trend, the intake of healthy and unhealthy foods varies across European countries and populations [26, 27]. For instance, individuals living in southern European countries consume on average the highest amount of fruit and vegetables (600 g/d) while individuals living in eastern European countries consume the lowest amount (310 g/d) [27]. Data from the European Nutrition and Health Report 2009 showed that only Austria, Germany, Italy and Poland met the recommended amount of 400 grams of fruit and vegetable per day [28]. Concerning the consumption of UPF, the amount of purchased energy from UPF varied from 10.2% in Portugal to 50.7% in the UK [29].

A more recent focus on overall diet quality has gained attention and some dietary recommendations are focusing on more qualitative aspects of the diet such as food processing methods, and dietary patterns [21]. For example, ultra-processed food products (e.g., frozen pizzas, chicken nuggets and instant sauces), are generally energy dense, high in added sugar, fat and salt, low in fibre and with little or no nutritional value, and therefore contribute to a lower diet quality [30-35]. As such, the consumption of ultra-processed food has been linked to important health outcomes including obesity, metabolic syndrome, cancer and all-cause mortality [36-39]. Several individual-level strategies have been promoted in order to improve adherence to dietary recommendations, and replacement of ultra-processed foods with minimally processed and fresh products is one possibility that may contribute to dietary improvement [40]. In this context, increasing the frequency of home-cooked meals – i.e., meals cooked from fresh and/or little-processed ingredients - is an alternative to increase the amount of fresh products in the diet and consequently improve diet quality and adherence to dietary guidelines [41, 42]. Indeed, higher frequency of consumption of home cooked meals has been associated with lower sugar and fat consumption and higher consumption of fruit and vegetables [43, 44] and also with cardio-metabolic health indicators such as lower adiposity [42].

DETERMINANTS OF DIETARY BEHAVIOURS

Dietary behaviours are not simply the result of individual personal choices, but are rather shaped by a range of interacting individual and contextual factors. Such interactions between behavioural determinants are for example proposed in socio-ecological frameworks such as the 'rainbow model' from Dahlgren & Whitehead (1993) [45], and the Ecological model for barriers and opportunities for healthy eating from Afshin et. al. (2014) [46]. These models present in the centre layer individual factors such as age, sex, socio-economic status (SES), behaviours, attitudes, perceived barriers, and personal norms. Those factors are influenced by further layers depicting the social (e.g., social norms and cultural values) and community influences (e.g., neighbourhood environment and availability and accessibility to food retailers). The more distal layers represent economic and wider and more general environmental contexts such as the industrial and agricultural markets (e.g., food system production), governmental policies (e.g., health care system and food policies) and global influences (e.g., international trade agreements) [45, 46].

Individual correlates and determinants of dietary behaviours

Dietary behaviours greatly vary according to individual characteristics, which are regarded as important correlates and determinants of dietary behaviours. Such individual characteristics include age, sex, SES, behaviours, attitudes, preferences, perceived barriers, perceived behavioural control and self-efficacy, and personal norms. Dietary behaviours, requirements and recommendations are dependent of biological factors such as age and sex. As dietary requirements change during the life course, age is an important determinant of dietary behaviours. For instance, energy intake tends to decrease up to 1200 calories in men and 800 calories in women from early to late adulthood [47]. Sex differences towards food choice and dietary intake have also been shown: women tend to have more knowledge regarding nutrition, are more likely to engage in dieting, and generally make healthier food choices than men [48, 49].

In addition to biological factors, socioeconomic factors such as income and education are important individual determinants of dietary behaviours. Education is an important determinant of health behaviours not only because higher education may lead to higher earnings, but also because higher educated

individuals may have more nutritional knowledge and skills that enable healthier dietary choices than lower educated individuals [50]. Research consistently shows that high SES individuals generally have healthier lifestyle choices including healthier dietary behaviours such as higher consumption of whole grains, fish, and fruit and vegetables. Low SES individuals, in turn, are less likely to consume fruit and vegetables and are more likely to consume refined grains and fat [51, 52].

Social-cognitive factors such as individual attitudes and intentions, individual norms, self-efficacy and perceived barriers have also been reported as important individual determinants of dietary behaviours [8]. For instance, a systematic review on social-cognitive factors predicting intention towards fruit and vegetable intake found that motivation, knowledge, taste preferences and habit strength were consistent factors for predicting fruit and vegetable intake behaviours [53]. In addition, as suggested by health behaviour theories (e.g., Social Cognitive Theory and the Theory of Planned Behaviour), individuals' experiences, expectations and self-efficacy determine whether or not an individual will engage in a certain behaviour [54, 55].

Environmental determinants of dietary behaviours

In addition to the individual level factors, socio-ecological frameworks suggest that more 'upstream' or contextual factors also influence dietary behaviours. Contextual factors are known as the community or environmental influences [45, 46]. The food environment is the environment accommodating behaviours and opportunities related to food and has previously been conceptualised in the *Model of Community Nutrition Environments* [56]. According to this model, the food environment can be classified into the community food environment (type, location and accessibility of food retailers), organisational food environment (home, work or school settings), consumer food environment (availability of healthy foods, price and promotions) and information food environment (media and marketing) [56].

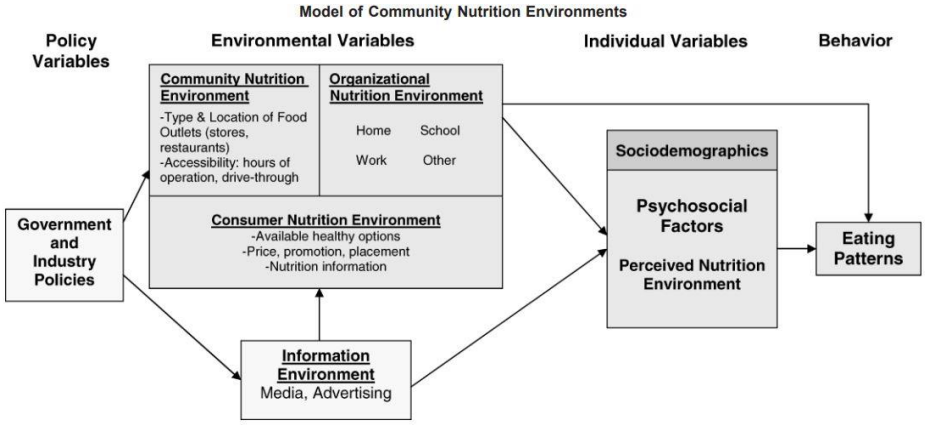

Figure 1. The Model of Community Nutrition Environments as proposed by Glanz et al., (2005) [56].

In research on the community food environment, exposure is usually determined according to individual *access* to food or food retailers. The concept of *access* is, however, broad, and may be classified in five dimensions as firstly proposed by Penchansky and Thomas (1981). This concept has been adapted and used as a theoretical framework for the characterisation of the food environment which includes the dimensions of *availability, accessibility, affordability, acceptability*, and *accommodation*. As suggested by the work of Charreire et al. (2010) and Caspi et al. (2012), in the context of the food environment, *availability* refers to the presence of foods or food retailers in the individuals' surroundings. It can be measured, for instance, as the count of food retailers in a neighbourhood. *Accessibility* refers to the geographic location of food retailers and it can be measured as the distance or travel time from the individual home to the closest food retailers. *Affordability* reflects the price of foods in relation to individuals' resources. *Acceptability* is the perception of an individual about its environment and how this environment is supportive of meeting their preferences and/or needs? Finally, *accommodation* reflects how the food environment is able to adapt to individuals' demands, for instance by adjusting opening times or offering new services. From those five dimensions, objectively measured availability and accessibility are often determined by their geographic location and its association with individual behaviours and health outcomes have been a major focus of current food environment research [10, 57-59].

As food environments worldwide are characterised by an abundant availability of foods in general and a great amount of unhealthy foods, research on food environment is timely and relevant. Food environment research has indicated that several elements of the food environment may influence dietary behaviours differently [60-62]. For instance, while the neighbourhood availability of grocery stores and farmers' markets has been associated with healthier diets [43, 63, 62], the availability of convenience stores, takeaway and fast food outlets has been associated with less healthy diets [43, 60, 64]. However, current evidence for a link between the food environment and dietary behaviours is inconsistent, and many studies have shown null or contra-intuitive results. In addition, most part of the studies linking food environment and diet were conducted in the US, which is also the country where studies have reported more consistent findings, and where food environments differ greatly from those in Europe [10].

MEASUREMENT OF DIETARY BEHAVIOURS AND FOOD ENVIRONMENTS

Measurement of dietary behaviours

In order to understand the relations between dietary behaviour and its determinants as well as between dietary behaviours and health outcomes, it is crucial to obtain good quality dietary data. The evaluation of each aspect of dietary behaviours demands specific assessment tools. For instance, measurement of eating behaviours, which is related to aspects such as portion size, meal frequency and dieting, are often assessed via questionnaire items that ask about the frequency of a specific eating behaviour, for instance: "How many times a week do you cook a meal from scratch?" [65]. Dietary intake, in turn, refers to actual food consumption, and its evaluation encompasses factors such as dietary patterns (e.g., healthfulness of food consumed) and food intake (e.g., quantity of grams consumed from specific food groups, energy or nutrient intake) [4]. Commonly used methods for the assessment of self-reported dietary intake include the recall of the very recent dietary intake as captured by diet-recording methods such as food diaries and 24-hour dietary recalls, and more distant recall methods of the long-term habitual intake as captured by food frequency questionnaires (FFQ).

FFQ is the most frequently used method for dietary intake evaluation in large-scale epidemiological studies [66].

Different methods are used for the processing and analysis of dietary intake data. When non-communicable diseases became a bigger source of concern than nutritional deficiency in most developed countries, the focus shifted from the evaluation of specific nutrient intake to a focus on the evaluation of dietary patterns. As individuals do not consume nutrients in isolation, but foods that are part of a pattern, the evaluation of dietary intake by means of dietary patterns identification has been proposed as a more promising approach for the evaluation of the relation between diet and non-communicable disease risk [67, 21]. Several dietary indices have been developed for the evaluation of dietary intake and diet quality assessment. Examples include the WHO's Healthy Diet Indicator (HDI), based on the WHO international dietary guidelines for prevention of chronic diseases, and the Mediterranean Diet Score [68]. Such indices are known as *a priori* dietary patterns and they evaluate individual compliance to a dietary index by scoring individuals according to their intake on specific food items. Dietary patterns can also be empirically derived from the data, such patterns are known as *a posteriori* dietary patterns. A posteriori dietary pattern are based on statistical methods that, based on the correlation between food items in a dataset, aggregates highly correlated food items forming a component, or pattern. Commonly used methods to generate posteriori dietary patterns are principal component and cluster analysis [67, 69, 70].

Measurement of food environments

The community or neighbourhood food environment, encompassing type, location and accessibility of food retailers, can be measured using both subjective and objective methods. Subjective methods evaluate the perception of individuals about the accessibility or availability of food retailers and are usually collected using surveys. Methods for the objective measurement of the food environment include secondary and primary data sources [71, 72]. Secondary data are not collected for the exclusive purpose of a study. Instead, they are systematically collected by third parties for surveillance or commercial purpose. Examples of secondary data sources include government inventories or business listings (e.g., yellow pages) and commercial retail data. Primary data sources are collected via field audit by direct observation of the presence of food retailers, normally using

methods of spatial analysis based on Geographic Information System (GIS). Field audits are considered to be the "gold standard" for the acquisition of food environment data. The main advantage of performing a field audit is that the data are collected to answer a study specific research question, but they involve high monetary and human resource costs [73, 74]. GIS-based methods are very often used to measure the availability and accessibility of food retailers, and the processing and analysis of such data involve many challenges [10, 57-59].

Challenges in linking food environments to dietary behaviours

The definition of geographically measured exposure to the food environment is not simple and many challenges are involved with this task. Those challenges include: 1) decisions on the type of geographic measure to use such as geographic availability or accessibility to food retailers, and 2) the type and/or variety of food retailers to consider. Decisions related to the definition of areas under study include the use of 3) administrative neighbourhoods or individual buffers; 4) size of individual buffers; 5) differences across neighbourhood characteristics

1) Type of geographic measure

While defining geographically measured exposure to food retailers, researchers may choose between measures of availability or accessibility. Measures of geographic availability include the count or density of a determined or several food retailers within a certain determined area. Measures of geographic accessibility (i.e., indicating proximity) include travel time or travelled distance from an individual origin point (e.g. home, work or school) to a destination (e.g. the closest food retailer or the mean of distances to several food retailers within a determined search radius). An additional decision is related to the measurement of availability or accessibility, for instance, distance to the closest food retailer, can be derived using Euclidian or street network analysis [57]. Most studies published to date have relied on the use of simpler measures, i.e., measures expressing only geographic accessibility or geographic availability. However, as exposure to food retailers is complex and context-dependent, the use of simpler measures may not capture true individual exposure [10, 57, 75]. When choosing for one type of measure, researchers have to decide on what exposure would be the most relevant. For

instance, they decide on what would translate to a higher exposure; to live just five metres away from a fast food restaurant or to live 500 metres away from three fast food restaurants. Since such decisions are not always an obvious choice, there is a need of exploring more complex measures of exposure to the food environment that considers both constructs of availability and accessibility.

2) Type and/or variety of food retailers

Another issue in the field of food environment research, and more specifically, research on exposure to the food environment, is the focus on absolute measures. Most studies consider only one type of food retailer to determine exposure, while ignoring the influence that different types of food retailers may have on individual food choices [76, 77]. It has been suggested that the neighbourhood presence of healthier food retailers may balance the presence of less healthy ones [78]. Therefore, the use of measures that consider the variety of food retailers in a neighbourhood should be explored as it may be a more accurate measure for the definition of exposure [78-81].

3) Study area: administrative neighbourhoods or individual buffers

In addition to the type of geographic measures to use, another challenge on the definition of individual exposure and its link with dietary behaviours is related to the definition of the area under study, often referred to as neighbourhoods. According to Chaix et. al. (2009), neighbourhoods can be classified in two main domains: territorial neighbourhoods and ego-centred neighbourhoods. The first domain includes neighbourhoods often defined according to administrative boundaries at the area level, i.e., well-defined legal and administrative borders, such as those defined by a local government; the second category includes varied sizes of Euclidian, and to a lesser extent, street network buffers around an individual's home, and self-defined neighbourhood boundaries [82, 83]. Ego-centred neighbourhoods are more likely to represent an area that individuals move around in, and as a result has the potential to better represent individual exposure to the food environment [82].

4) Study area: size of individual buffers.

However, an additional challenge related to definition of the study area is to define the size of the individuals' buffers, as too small areas may not capture enough variation in the food environment and too big areas may not represent the area where individuals visit for their grocery shopping or meals [84]. Therefore, there is

a need for innovative ways of defining the study area that better represent the activity space (i.e., the space where individuals move around in). The activity space can be measured by tracking individual's daily mobility, for example, moving from home to the children's school, to work and back home, representing an individual's spatial behaviour [85]. However, an individual 'self-defined neighbourhoods' may be a proxy for activity space, as by drawing the boundaries of what individuals consider as their neighbourhood on a map are likely to represent the space they circulate on a regular basis [82, 83, 58, 86].

5) Study area: differences across neighbourhood characteristics

The distribution of food retailers across a determined geographical area (i.e., foodscape) is continuously changing. However, only few countries have been able to quantify changes in their foodscape. Evidence from the US and the UK has shown that the foodscape can change fast and that changes in the foodscape may be different for neighbourhoods of different SES and urbanisation levels [87-90]. Given the potential that changes in the foodscape have in influencing dietary behaviours and the limited evidence from countries other than the US and the UK, it is important to understand how those changes occur and whether changes are different according to different neighbourhood SES and urbanisation levels. In addition to that, it remains unclear whether different neighbourhood types experience similar changes in the foodscape over time. To understand that, we need to assess these trends over time.

These listed challenges are mostly related to methodological issues found in food environment research, and although these challenges are not the only ones faced in this field of research, they do highlight considerable research gaps in food environment research.

OBJECTIVES AND THESIS OUTLINE

Therefore, the general objective of this thesis was to explore how individual-level and environmental-level characteristics are associated with dietary behaviours in Europe, and how methodological decisions on the definition of exposure to the food environment may influence these associations.

Throughout this thesis, the approach used to determine dietary behaviours diverts from a view focused on nutrient intake. Rather, food consumption is analysed with the background view that individuals eat foods – not nutrients – in a determined context and as part of a habit. On the environmental level, a major focus is given to the definition of exposure to the food environment and potential consequences of methodological decisions on the relation between food environment and dietary behaviours across Europe. Considering this, the following general research questions will be discussed in the thesis section Original research.

1. How are different individual social-cognitive factors associated with dietary behaviours in adults from five European countries?

2. How does the definition of measures of exposure influence the relation between the food environment and dietary behaviours in a European adult population?

3. How does the study area, and the distribution of food retailers across it, influence the relation between the food environment and dietary behaviours?

Following the 'General Introduction', six chapters of original research are included in this thesis. On the individual level, the currently understudied relation between social-cognitive factors related to food consumption is explored. Chapter 2. aims to test the association between perceived barriers to healthy eating and

different types of dietary behaviours among adults within urban regions in five different European countries; and to test whether associations are different according to several individual socio-demographic characteristics. Chapters 3 and 4 aim to address the second general research question by addressing a common limitation in current food environment research, that is the fact that most studies ignore the complexity of the food environment while deriving an exposure measure. Most studies to date consider only one construct of *access* when defining exposure, i.e., either accessibility or availability and focus on a single type food retailers, while ignoring the influence that different types of food retailers may have on individual dietary behaviours. In Chapter 3, the use of a combined measure of availability and accessibility is explored, as well as ways to account for the influence of different food retailers on dietary behaviours. In Chapter 4, the associations of absolute and relative measures using simpler and more complex measures of exposure to food retailers with dietary patterns is explored. The third general research question is addressed in Chapters 5, 6 and 7. In Chapter 5 we explored whether the association of density of restaurants with home-cooking differs for two types of ego-centred neighbourhoods (Euclidean buffers around the residential address; and respondents' self-defined neighbourhood boundaries) and territorial neighbourhood definitions (administrative boundaries). In Chapter 6, changes in the Dutch foodscape between 2004 and 2018 and across neighbourhood SES and urbanization levels are analysed. In Chapter 7, much of common limitations on the definition of exposure to the food environment are taken into account as both measures of availability of and proximity to different types of food retailers are considered within buffers of different sizes, and using more complex methods for deveining exposure variables such as street network distances and kernel density estimates. In addition to that, an innovative way of classifying food intake, based on the level of food processing, is applied.

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