Obesity and dental caries in children:
Are there more common determinants than diet?

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ABSTRACT

Objective: To examine common risk factors and determinants for overweight/obesity and dental caries in the family setting of children between the ages of 0 and 11 years of age.

Methods: A conceptual framework on the social determinants of childhood dental caries and overweight/obesity was developed in this study based on previous literature. It was tested through a qualitative study (Study 1), consisting of semi-structured interviews with parents of obese children in Sheffield and a quantitative study (Study 2) using structural equation modelling (SEM) with data from the Born in Bradford Cohort Study (BIB), dental general anaesthetics (GA) and data from the oral health survey of 5-year-old children 2014/2015 of the same population.

Results: Study 1: 13 parents participated in the interviews with a total of 15 children. 8/15 children had previous experience of dental caries. All children were classified as obese. Parents highlighted a diet high in sugar affecting dental caries and overweight/obesity in children. In addition, weather and neighbourhood safety were mentioned as important factors related to physical activity and therefore overweight/obesity prevention.

Study 2: 171 children were included in the analysis, 136/171 (GA treatment), 35/171 (oral health survey of five-year-old children 2014-15) with an average dmft of 9.1 and 0.9 respectively. 23.4% of all children were overweight/obese. 46.2% of the sample were male. Six determinants were found to be significant for both childhood dental caries and overweight/obesity: frequency of drinking sugar-sweetened beverages, sex, emotional and behavioural well-being of the child, level of deprivation, caregivers feeding style, and maternal alcohol consumption.

Conclusion: Six common risk factors and determinants for childhood dental caries and overweight/obesity were identified. Parents of obese children confirmed the influence of a high sugary diet on childhood dental caries and overweight/obesity.

FREQUENTLY USED ABBREVATIONS

ANK	Alive N' Kicking Programme in Sheffield
BiB	Born in Bradford Cohort Study
BiB1000	Born in Bradford 1000, sub-study of the Born in Bradford Cohort Study
BMI	Body Mass Index
CDC	Centre for Disease Control and Prevention, US
CFI	Comparative Fit Index
CSDH	Commission on the Social Determinants of Health of the World Health Organisation
dfs	Decayed, filled and sealed primary teeth
DFS	Decayed, filled and sealed permanent teeth
dft	Decayed and filled primary teeth
DFT	Decayed and filled permanent teeth
dmfs	Decayed, missing, filled and sealed primary teeth
DMFS	Decayed, missing, filled and sealed permanent teeth
dmft	Decayed, missing and filled primary teeth
DMFT	Decayed, missing and filled permanent teeth
GA	General anaesthetic
ICDAS (II)	International Caries Detection and Assessment System (II)
IOTF	International Obesity Task Force
MAR	Missing at random
MCAR	Missing completely at random
MI	Multiple Imputation
MICE	Multiple imputation by chained equation
ML	Maximum Likelihood
MNAR	Missing not at random

mvn	Multivariate normal distribution
NCDs	Non-communicable diseases
NHS	National Health Service, UK
NICE	National Institute for Health and Care Excellence
RMSEA	Root Mean Square Error of Approximation
SIT	Structured Interaction Task
SEM	Structural Equation Modelling
SES	Socioeconomic status
WHO	World Health Organisation
WMC	Weight Management Centre

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1. INTRODUCTION

Childhood obesity is one of the most serious public health challenges of the 21st century (World Health Organisation, 2020a). In recent years, the prevalence has increased at an alarming rate among developing and developed countries alike (World Health Organisation, 2020a). Childhood dental caries is also a major public health problem globally with dental caries in adults and children being the most widespread noncommunicable disease (NCD) (World Health Organisation, 2020c). The link between childhood dental caries and overweight/obesity has previously been investigated through primary studies (Goodson et al., 2013, Denloye et al., 2016, Honne et al., 2012, Qadri et al., 2015, Marshall et al., 2007) and review papers (Hooley et al., 2012a, Hayden et al., 2013, Ribeiro Silva et al., 2013, Li et al., 2015, Manohar et al., 2019, Angelopoulou et al., 2019, Paisi et al., 2019). The latter are discussed more in depth in the following chapter. Previous findings on this topic are inconsistent; some studies have reported a significant inverse relationship between dental caries and overweight/obesity (Goodson et al., 2013), others have found a direct link between the two conditions (Kesim et al., 2016, Honne et al., 2012), whilst others have not found an association between dental caries and overweight/obesity (Qadri et al., 2015, Denloye et al., 2016). The uncertainties reported in previous research suggest the need for a more comprehensive and in-depth approach to investigate the relationship between childhood dental caries and overweight/obesity in order to enhance our understanding on their determinants and as a result, propose potential effective intervention strategies to tackle both health conditions.

This thesis is structured as follows:

Chapter Two presents the definitions, prevalence and consequences of dental caries and overweight/obesity in children. The chapter also introduces a narrative review on existing theoretical models and frameworks on social determinants of health, which lead to the development of a conceptual framework for overweight/obesity and dental caries in children. The chapter finishes with a discussion of previously published review papers on the association between overweight/obesity and dental caries followed by the research aim and objectives.

Chapter Three outlines the justification of the research methods used in this PhD thesis, including the mixed method design.

Chapter Four describes the qualitative study of this PhD conducted with parents of children participating in the Alive N' Kicking programme (ANK) in Sheffield, including the background, methods, results and discussion.

Chapter Five describes the quantitative study of this PhD. The chapter reports the background of the BiB study, methods section, including data linkage, data imputation and SEM, results and the discussion of the findings.

Chapter Six is the overall discussion of the PhD research and includes limitations of the research and recommendations for future studies.

2. LITERATURE REVIEW

This chapter starts with a description of overweight and obesity during childhood, their prevalence and associated illnesses, followed by the description of dental caries in children and its prevalence as well as the impact of dental caries on oral health related quality of life[1]. The chapter will then outline the definition and historical development of the social determinants of health in a narrative review, discussing relevant theories and frameworks. This is followed by the development of an adapted framework for the determinants of overweight/obesity and dental caries in children. The chapter will then discuss previous systematic reviews and meta-analyses that have been published to date on the link between childhood overweight/obesity and dental caries. Finally, the chapter ends with the rationale for this PhD.

2.1. Childhood overweight and obesity

Overweight and obesity has been defined by the World Health Organisation (WHO) as excessive or abnormal fat accumulation that may impair health (World Health Organisation, 2016a). Overweight and obesity follow the same definition and only differ in terms of weight measurement threshold. Therefore, in this thesis overweight/obesity will refer to both overweight and obesity.

Worldwide there has been an increase in overweight/obesity rates among girls (5-19 years) from 5 million in 1975 to 50 million in 2016, accounting for an increase from 4% to 16%, respectively (World Health Organisation, 2016a). A similar increase has been observed among boys (5-19 years), from 6 million in 1975 to 74 million in 2016, accounting for an increase from 4% to 19%, respectively (NCD Risk Factor Collaboration, 2017, World Health Organisation, 2016a). Overall, 73% of the increase in overweight/obesity numbers has been due to a real increase in overweight/obesity and not due to the global growth of the human population (NCD Risk Factor Collaboration, 2017). Today, globally more people are obese than underweight in all regions, except sub-Saharan Africa and Asia (World Health Organisation, 2016a). If the current trends continue, by 2022, the number of overweight and obese

[1] "A multidimensional construct that reflects (among other things) people's comfort when eating, sleeping and engaging in social interaction; their self-esteem; and their satisfaction with respect to their oral health" FDI - WORLD DENTAL FEDERATION. 2020. *Oral Health and Quality of Life* [Online]. Available: https://www.fdiworlddental.org/resources/policy-statements-and-resolutions/oral-health-and-quality-of-life [Accessed March 10 2020].

children and adolescents will surpass the number of children and adolescents being moderately and severely underweight in the world (NCD Risk Factor Collaboration, 2017).

Recent findings of the UK Government's National Child Measurement Programme (school year 2017-2018) concluded that overweight/obesity rates in England have increased since the last survey among schoolchildren in year 6 (10-11 years of age) from 20% (school year 2016/2017) to 20.1% (school year of 2017/2018). The rates have remained similar at 9.5% for children in the school reception year (4-5 years of age) (NHS, 2018). Therefore, one fifth of the year 6 children can be considered obese. If the overweight children were included, more than one third (34.3%) of year 6 children were considered either overweight or obese in England in the school year of 2017/2018 (NHS, 2018).

The essential cause of overweight/obesity is the imbalance between energy intake and energy expenditure (World Health Organisation, 2016a). However, this imbalance is often associated with multiple factors, such as inadequate diet and lack of physical activity that are related to environmental and societal characteristics (World Health Organisation, 2016a). Swinburn developed the concept of *obesogenic environment*, defined as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting overweight/obesity in individuals or populations" (Swinburn et al., 1999, p. 564). Environmental factors may expose inhabitants to inadequate dietary intake and sedentary behaviour, such as the lack of supportive policies in agriculture, urban planning and health (World Health Organisation, 2016a). In addition, the exposure to a new environment, for example the start of school and thereby a possible change in dietary and physical activity habits (NCD Risk Factor Collaboration, 2017, Hemmingsson, 2018), and increased exposure to food advertising through television or other media (Jago et al., 2005), or distress within the family can negatively influence dietary behaviour and may increase a child's risk of developing overweight/obesity (Biehl et al., 2014, Hemmingsson, 2018).

Additionally, overweight and obesity during childhood are common risk factors for many chronic diseases in later life, including diabetes, cardiovascular diseases, musculoskeletal disorders and some types of cancers (World Health Organisation, 2016a). During the early years of childhood, parents are primarily responsible for their child's food intake and physical activity. Therefore, family environment plays a crucial role in the development and prevention of child's overweight/obesity (Pyper et al., 2016).

During childhood, obese children often experience breathing difficulties and have an increased risk for hypertension, insulin resistance, fractures and psychological effects, due to obesity (World Health Organisation, 2016a). Overweight/obesity is also associated with adverse social impacts such as discrimination, bullying and social exclusion during childhood (Loring and Robertson, 2014). Furthermore, childhood obesity is associated with a higher chance of obesity, premature death and disability in adulthood (World Health Organisation, 2016a).

Overweight/obesity is most commonly measured through the body mass index (BMI), which is calculated using the following formula: BMI = weight (in kg) / height² (in m) (World Health Organisation Europe, 2019). Cut-off scores for BMI categories have been developed by various institutions among others the WHO, the International Obesity Task Force (IOTF) and the Center for Disease and Prevention (CDC). These cut-off scores differ slightly from each other, due to demographic differences across populations. According to the WHO, the BMI cut off scores classify adults into the following categories: underweight (BMI < 18), normal weight (BMI 18-24.9), overweight (BMI 25-29.9), and obese (BMI ≥ 30) (World Health Organisation, 2016a).

BMI in children and adolescents calculated using the ratio between height and weight, additionally the cut off scores for overweight/obesity classifications are sex and age specific (World Health Organisation Europe, 2019, World Health Organisation, 2016a). BMI for children is therefore often referred to as BMI for age, percentiles or z-scores. The z-score is calculated as follows: z-score (or SD-score) = (observed value - median value of the reference population) / standard deviation value of reference population (World Health Organisation, 2010b). The different BMI cut off scores for children have been developed by the WHO, CDC and IOTF (World Health Organisation, 2010b, Centers for Disease Control and Prevention, 2019, International Obesity Task Force, 2019).

The BMI is the most common method to determine overweight/obesity in epidemiological studies (World Health Organisation Europe, 2019). This is mainly due to the feasibility of fieldwork for data collection and costs in large population studies. However, measurement bias (BMI over and underestimation) might occur as the BMI measure does not distinguish between lean and fat body mass (World Health Organisation Europe, 2019).

Following the description of overweight/obesity, its prevalence and associated diseases, the following section will discuss the prevalence, risk factors and associated diseases of childhood dental caries.

2.2. Childhood dental caries

The WHO describes dental caries as a result of the development of a microbial biofilm also called dental plaque that is formed around the tooth surface that converts free sugars from foods and drinks into acids that demineralise tooth enamel[2] and dentine[3] over time (World Health Organisation, 2018).

Worldwide, 60%-90% of schoolchildren are affected by dental caries (World Health Organisation, 2016b). It is estimated that 486 million children worldwide suffer from dental caries in primary teeth (World Health Organisation, 2018). The prevalence is higher in low- and middle-income countries, due to urbanisation, low access to fluoride, heavy marketing of sugar and poor access to dental care centres (World Health Organisation, 2018).

In the UK, in 2012 and 2013, dental caries was the most common reason for hospital admission among children aged between five to nine years (UK Government, 2017a). However, the prevalence of cavitated caries in children in the UK has significantly decreased in recent years (Masood et al., 2019). In addition, just under one in four children has dental caries before starting school (UK Government, 2017a).

Through an inflammation of the dental pulp, dental caries may cause toothaches either through continuous or occasional sharp pain (NHS, 2019, Rention, 2011). In later stages, dental caries can result in tooth loss and systemic infection (World Health Organisation, 2018). Dental caries further impacts oral health-related quality of life. In children, they may lead to a decrease in concentration in school activities and missing school days due to dental pain (Public Health England, 2017b, World Health Organisation, 2018), difficulties in eating foods as well as sleeping difficulties due to pain (Gilchrist et al., 2015). Dental caries may also increase bullying due to miscoloured or missing teeth (Barasuol et al., 2017).

[2] Enamel, in anatomy, the hardest tissue of the body, covering part or all of the crown of the tooth in mammals. Enamel, when mature, consists predominantly of apatite crystals containing calcium and phosphate. Enamel is not living and contains no nerves ENCYCLOPAEDIA, B. 2019. *Enamel | tooth* [Online]. @britannica. Available: https://www.britannica.com/science/enamel-tooth [Accessed]..

[3] Dentine, in anatomy, the yellowish tissue that makes up the bulk of all teeth ENCYCLOPAEDIA BRITANNICA. 2019. *Dentin | anatomy* [Online]. @britannica. Available: https://www.britannica.com/science/dentin [Accessed]..

Dental caries can be measured using a variety of clinical measurements (Doifode et al., 2018). Of them, counting the number of decayed (d), missing (due to caries only) (m) and filled (f) teeth (t) (dmft) or surfaces (s) (dmfs) is the most used dental index employed to assess experience of dental caries. Various combinations of the abbreviations exist either spelled in capital letters for permanent teeth and in small letters for primary teeth.

Following the description of both conditions that are the central elements of this PhD, the following section will outline the historical development of the social determinants of health, including key concepts, governmental documents and frameworks.

2.3. Definition and historical development of the social determinants of health

In the past, health conditions were often studied separately and the understanding of the occurrence of health conditions was mainly studied from a biological perspective since social conditions were not widely recognised as determinants of health.

Thomas McKeown, a professor of social sciences at Birmingham University during the establishment of the British National Health Service (NHS), was possibly the first academic to use the term "social determinants[4] of health" (Glouberman and Millar, 2003), which the WHO defined as "the conditions in which people are born, grow, live, work and age" (2017a). McKeown strongly believed that a large number of influences, such as better economic conditions, besides medicine and traditional public health influenced the improvements of overall standards of living and nutritional status (Glouberman and Millar, 2003, Colgrove, 2002). He argued that these influences should be considered in the development of health policies (Glouberman and Millar, 2003). His research was criticised in the 60's and 70's mainly by demographic and economic researchers, criticising McKeown's view on the dismissal of the importance of medical interventions (Colgrove, 2002). Later his research got overturned on the basis of empirical grounds (Colgrove, 2002). Quantitative techniques used by other researchers became more sophisticated

[4] A determinant differs from a risk factor, which the WHO defines as "any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease or injury. Some examples of the more important risk factors for ill health are underweight, unsafe sex, high blood pressure, tobacco and alcohol consumption, and unsafe water, sanitation and hygiene" WORLD HEALTH ORGANISATION. 2017b. *WHO | Risk factors* [Online]. World Health Organisation. Available: https://www.who.int/topics/risk_factors/en/ [Accessed].

and McKeown was criticised having used aggregated data, misinterpreted his own data and biasing his interpretation of evidence due to his own priori assumption on the limited value of medical interventions (Colgrove, 2002). However McKeown's theory has, despite the criticism, been widely used within public health research and health policymaking (Colgrove, 2002). This is mainly due to his research posing a fundamental question, which is still relevant today: Is the population's health better served by targeted interventions to the individual or the community or by broader measures redistributing the social, political and economic resources? (Colgrove, 2002).

In 1974, the Minister of National Health and Welfare of Canada published a report on the health and welfare of Canadians (Lalonde, 1974). The Lalonde Report is considered one of the first reports that extensively discussed the so-called traditional view of medicine and health services provision and its limitations as well as the importance of lifestyle and environmental aspects on the prevention of illnesses (Hancock, 1986; Lalonde, 1974). The Lalonde Report recognised that the health care system is not the most important factor in determining people's health status (Hancock, 1986). Critiques highlighted how the report dealt with lifestyle and the environment as relevant determinants of the health status at population level (Hancock, 1986). The report described individuals helpless against the environment and "the assignment of blame to the individual, not simply for their own actions but for the inactions of government, was strongly criticised" (Hancock, 1986, p. 98). Later, Labonté and Penfold criticised dealing with the determinants of health individually rather than as interactive variables (Hancock, 1986). The authors suggested the origins of disease are found in the social structures and improving population health would require a collective social change (Hancock, 1986). Even though negatively criticised at that time in Canada, the report served as a starting point for further public health movements combining health and social structures in Europe and other parts of the world (Hancock, 1986).

The Alma Ata Declaration, published in 1978, was the first international declaration highlighting the importance of primary health care to reduce health inequalities between and within countries (Karolinska Institutet, n.a.). The declaration was the output document of an international conference held in Alma Atta, USSR. The conference itself was considered a ground-breaking as the final document linked the rights-based approach to health and primary health care as a strategy to improve populations health

(Karolinska Institutet, n.a.). However critics highlighted that implementing primary health care is a process which requires a conceptualisation of context, culture, politics, economics and social concerns, which made it difficult for many countries and stakeholders to follow the advice of the Alma Atta declaration (Rifkin, 2018).

Two years after the Alma Atta conference, the United Kingdom Department of Health and Social Security published the Black Report in 1980, named on behalf of the chairman of the working group on inequalities in health and president of the Royal College of Physicians, Sir Douglas Black (UK Department of Health, 1980). The report identified in detail the unequal distribution of ill health and mortality rates within the British population and suggested that social inequalities have been widening instead of shrinking in the UK since the establishment of the NHS in 1948 (Gray, 1982). The report further proposed that the social inequalities of health do not result from a failure of the health care system, but rather from material social inequalities, such as inequalities in housing, education, diet and employment (Gray, 1982). Very few copies of the report were distributed in that time and thus very few people were able to read the report due to the disowning of the findings and recommendations in the report by the secretary of state for social services (Gray, 1982). Both, the Lalonde Report and the Black Report are seen as the fundamental documents of contemporary efforts to identify and address socially-determined health inequalities (Karolinska Institutet, n.a.).

As a follow-up to the Alma Ata Conference in 1978, the first international conference on health promotion was held in Ottawa, Canada in 1986 (Karolinska Institutet, n.a.). The Ottawa Charter was released calling for the reduction in health inequalities according to five main action points: building health public policy, creating supportive environments for health, strengthening community action for health, developing personal skills and re-orientating health services (World Health Organisation, 2016d). The charter was part of the WHO initiative to achieve health for all by the year 2000 (Karolinska Institutet, n.a.). Similar to the original Alma Atta conference, critics highlighted that targets had been developed from a western point of worldview, lacking the inclusion of cultural traits especially those of indigenous and communities from developing countries, making it difficult for stakeholders to comply with suggestions (McPhail-Bell et al., 2013).

In 1999, Sir Michael Marmot published the first report on the social determinants of health (Marmot and Wilkinson, 2005). The report was commissioned by the WHO and it was conducted by members of the international centre for health and society at the University College London. The aim of this report was to summarise the current knowledge on the social determinants of health into ten "solid facts", giving policy makers, politicians and public a better overview on the evidence on this topic (Marmot and Wilkinson, 2005). However, criticism on the research having been conducted in a specific population of civil servant workers with the majority being men, which might have prevented the findings to be generalised towards the general population has been brought forward. Further, questions on the definition of equity in health arose, highlighting that the definition might be dependent on culture, values and norms and therefore be a normative concept, which has not been recognised in the report (Schofield, 2007). Still, each of the ten "solid facts" were followed by a book chapter of evidence on social determinants of health (Marmot and Wilkinson, 2005). The first edition of the book was an immediate success, being translated into more than 20 languages and use in the policy process in many countries (Marmot and Wilkinson, 2005). Even though the concepts within the book are underlined with a vast amount of evidence, policy recommendations in the last chapter, lacked appropriate evidence (Schofield, 2007). The evidence presented highlighted the existence of an association between a social determinant and a health outcome, although lacked the evidence on the mechanisms of how the social determinants created the unwanted health outcome (Schofield, 2007).

After several countries had acknowledged the importance of reports such as the Lalonde report (1974), the Ottawa charter (World Health Organisation, 2016d), and the first report on the social determinants of health by Marmot and Wilkinson (2005), the WHO launched the initiative called the Commission on the Social Determinants of Health (CSDH) renewing the international interest in the social aspects of health in 2005. The commission, led by Prof Marmot, aimed to produce evidence and to support countries and global health partners in addressing the social factors leading to ill health and health inequities (Karolinska Institutet, n.a.).

The CSDH developed the framework on the social determinants on health (Figure 1, p. 25). The framework was developed to show the influence of social, economic and political mechanisms as well as

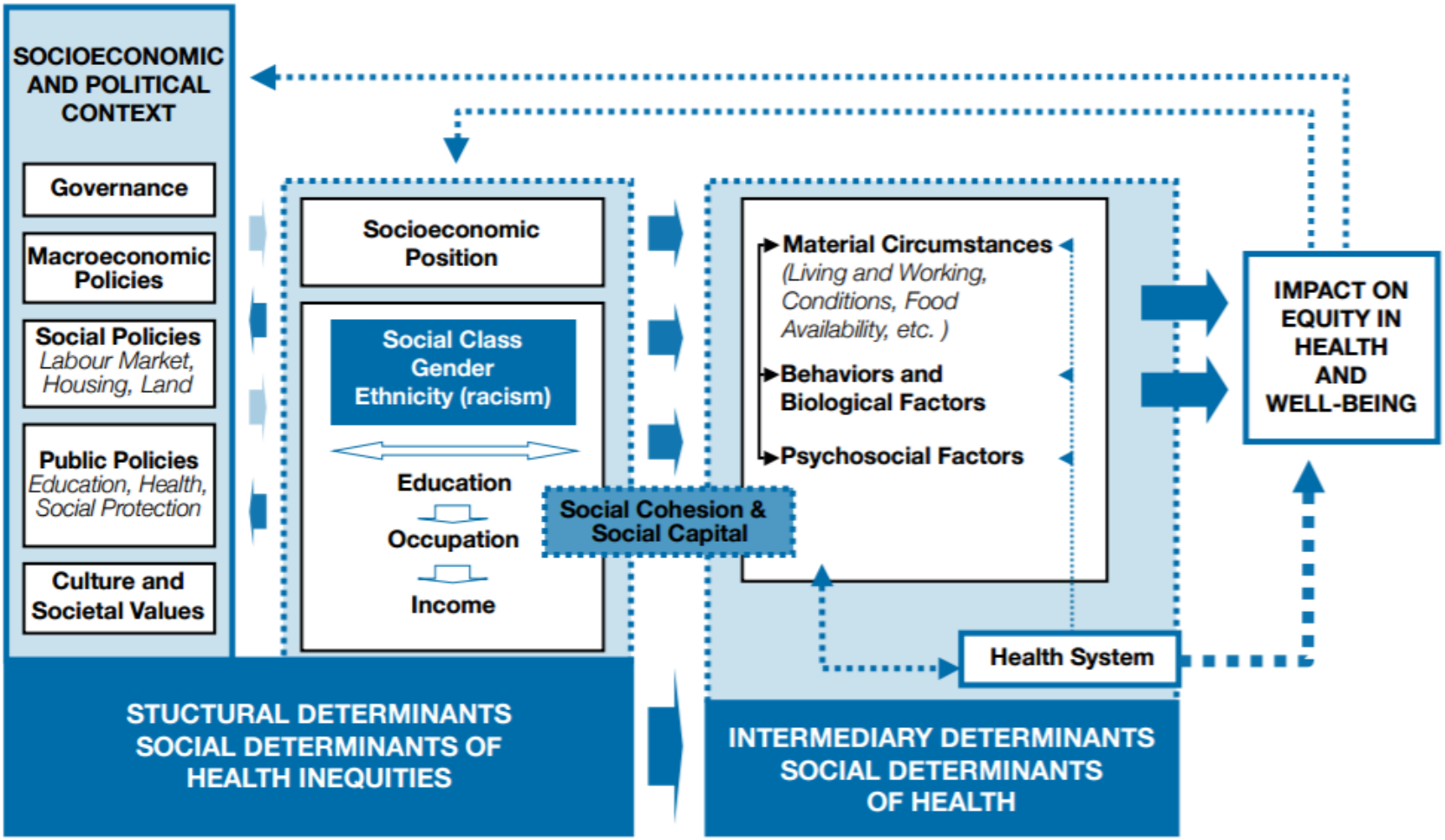
income, education, occupation, sex, race/ethnicity and other factors on health (World Health Organisation, 2010a). Vulnerability and exposure to health-compromising conditions are differently experienced by people according to their social status (World Health Organisation, 2010a). For example, illness can reduce one's employment opportunities and therefore reduce income and epidemics can even affect the functioning of the social, economic or political system (World Health Organisation, 2010a). The framework has been developed from previous models by conceptualising the health system as a social determinant of health (World Health Organisation, 2010a). In the framework, socioeconomic and political contexts include the economic, social and political mechanisms that maintain social hierarchies, including the labour market, the educational system, political institutions and other cultural and societal values (World Health Organisation, 2010a). Socioeconomic status (SES)[5] as well as social class, sex, ethnicity, education, occupation, and income form along with the socioeconomic and political context described earlier, the structural determinants of health inequalities (World Health Organisation, 2010a). The WHO (2011) describes the structural determinants as the most important component of the framework as they produce stratification within society through SES within hierarchies of power, prestige, and access to resources. The underlying social determinants of health inequities shape health outcomes through intermediary determinants of health, such as living and working conditions (material circumstances), physical activity, tobacco and alcohol consumption (behavioural and biological factors) and social support, coping styles (psychosocial factors) (World Health Organisation, 2010a).

Even though originally developed to support local and international initiatives aiming to reduce inequities in health, the WHO CSDH also recognised that better health contributes to other societal priorities such as education, productivity and economic development (World Health Organisation, 2011). Therefore mutual benefits are created by improving health and tackling the social determinants (World Health Organisation, 2011). Still, limitations of the framework include the relationship of causality between different determinants, for example psychological factors and occupation may occur bidirectionally instead of one-directional (Figure 1, p. 25). Further, it has been highlighted that even though, the WHO framework on

[5] *"Socioeconomic status is the social standing or class of an individual or group. It is often measured as a combination of education, income and occupation"* AMERICAN PSYCHOLOGY ASSOCIATION. 2017. *Socioeconomic Status* [Online]. Washington, DC: American Psychology Association. Available: http://www.apa.org/topics/socioeconomic-status/index.aspx [Accessed April 27 2017]..

social determinants of health has been used and adapted in different studies, both in the field of dental caries and overweight/obesity (Alwadi and Vettore, 2017, Vettore and Aqeeli, 2015, Fisher-Owens et al., 2007, Scribner et al., 2017, Baker et al., 2018), practical tools such as implementation guidelines for countries and governments to work with the proposed framework are lacking (Nayar and Kapoor, 2009).

Figure 1: The commission on the social determinants of health conceptual framework (World Health Organisation, 2010a)



Whereas the conceptual framework of the CSDH is not specific to any disease, other researchers have developed frameworks for the social determinants of specific illnesses and diseases. Frameworks specifically for the social determinants of overweight/obesity have been developed previously and the most comprehensive and theoretically sound will be discussed in detail in the following paragraphs (Davison and Birch, 2001). Additionally, the well-known and most comprehensive framework on the social determinants of oral health in dental research (Fisher-Owens et al., 2007) will be discussed. Even though the framework of Fisher-Owens was originally developed to investigate the social determinants of oral health, the framework includes all determinants of dental caries development. Subsequently, it was decided to use this framework as a guidance for this research. The Fisher-Owens framework will be discussed in the next section of this thesis, prior to the framework on the social determinants of overweight/obesity.

2.4. The social determinants of oral-health (Fisher-Owens et al., 2007)

Fisher-Owens and colleagues (2007) published a framework for the social determinants of oral health (Figure 2, p. 30). The aim of the framework was to stimulate the discussion on the determinants of children's oral health and to provide a framework for research and policy making to improve children's oral health (Fisher-Owens et al., 2007). The Fisher-Owens framework is similarly structured to the WHO framework (World Health Organisation, 2010a, Fisher-Owens et al., 2007). This section describes and discusses the social determinants of oral health according to the structure of the three levels, the child-, the family-, and the community-level of the Fisher-Owens framework. In a later section of this research, some of the determinants will be further discussed in detail and in relation to the development of a framework on the social determinants of overweight/obesity and dental caries.

The child-level determinants focus on the direct determinants of oral health of the child, including biological and genetic endowments, physical and demographic determinants, childhood development, dental insurance, use of dental care and health behaviours and practices (Fisher-Owens et al., 2007). The biological and genetic endowment includes reduced salivary flow and previous experience of dental caries in primary teeth (Fisher-Owens et al., 2007, Crall and Forrest, 2017). The physical and

demographic determinants include sex, age and height and weight of the child (Fisher-Owens et al., 2007). It may be, for example that a certain age-group or sex are an indicator of poor oral health (Lukacs and Largaespada, 2006, Centers for Disease Control and Prevention, 2018). Additionally, health behaviours and practices, such as low frequency of toothbrushing or bottle drinking before going to bed containing sweet liquids may be risk factors to oral health and specifically dental caries (Fisher-Owens et al., 2007, World Health Organisation, 2016c). Of the remaining child-level determinants, childhood development is focused on early childhood experiences, which affect the child's well-being, for example, frequency and duration of breastfeeding (Tham et al., 2015, Public Health England, 2019). The use of dental care can be related to a number of determinants, including whether or not the child accesses dental services, and whether dental care is problem-orientated or prevention-orientated (Fisher-Owens et al., 2007). Dental care also relates to the provision of fluoridated pastes and fissure sealants (Fisher-Owens et al., 2007). Dental insurance focuses on whether or not dental care for children (those under 18 years of age) is free at the point of need or based on an insurance-based system (Fisher-Owens et al., 2007). Some of these determinants are discussed in greater detail in a later section of this thesis (Section 2.7.1).

These child-level attributes may also be influenced by family-level factors according to the Fisher-Owens framework (2007). The family-level determinants include family composition, SES, social support, physical safety, health status of parents, family function, culture and health behaviours, practices and coping skills of family (Fisher-Owens et al., 2007). In relation to socioeconomic determinants, numerous studies have found a relationship between low SES and dental caries (Hooley et al., 2012b). Children who grow up in a low SES household (family level) may consequently have parents with less knowledge in oral health. Those parents may, due to the lack of oral health related knowledge, insufficiently demand their children to brush their teeth, which may lead to insufficient toothbrushing behaviour of the child (child level) (Mattheus, 2010, Skeie et al., 2006). These children are therefore at higher risk of developing oral health related diseases, including dental caries.

Determinants such as culture (e.g. diet and language), family composition, and parental health behaviours and parental health status at the family level, shape the development of the child and influence the oral health related choices of the child (Fisher-Owens et al., 2007). Parental health behaviours, for example

the frequent consumption of unhealthy foods, directly impacts their children's health behaviour, through for example role modelling (Mobley et al., 2009, van Ansem et al., 2014). Also parental oral health status is linked to those of their children, with children, whose parents have experienced dental caries, having a higher risk of developing dental caries than children whose parents have not experienced dental caries (Paglia et al., 2016, Hooley et al., 2012b). Additionally, family function and family support, for example may act as preventive factors for oral health issues (Berger and Font, 2015, Duijster et al., 2014a). The family-level determinants are further discussed in Section 2.7.2. of this PhD thesis.

And lastly, the framework includes the community level, which contains the determinants social and physical environment, dental and health care system characteristics, physical safety, social capital, culture and the community and oral health environment (Fisher-Owens et al., 2007). The dental and health care characteristics, include for example access to dental and health care (Fisher-Owens et al., 2007). Children with no access to dental health care, due to a remote location of living or for example due to no dental insurance coverage and no financial means for dental care, are at higher risk of developing dental caries than those children with limited access to dental health care (Hooley et al., 2012b). Subsequently, the community oral health environment, which contains for example the occurrence and frequency of prevention campaigns and access to healthy foods has an impact on the awareness of oral health and acts as a beneficiary towards children's oral health status (Petersen and Kwan, 2004). These community-level determinants influence the family-level ones (Fisher-Owens et al., 2007). A lack of physical safety in the community, might make physical access to oral health facilities difficult and it is further linked to violence and trauma (Fisher-Owens et al., 2007). This may negatively influence the oral health behaviours and practices of the family including those of the child (family and child level).

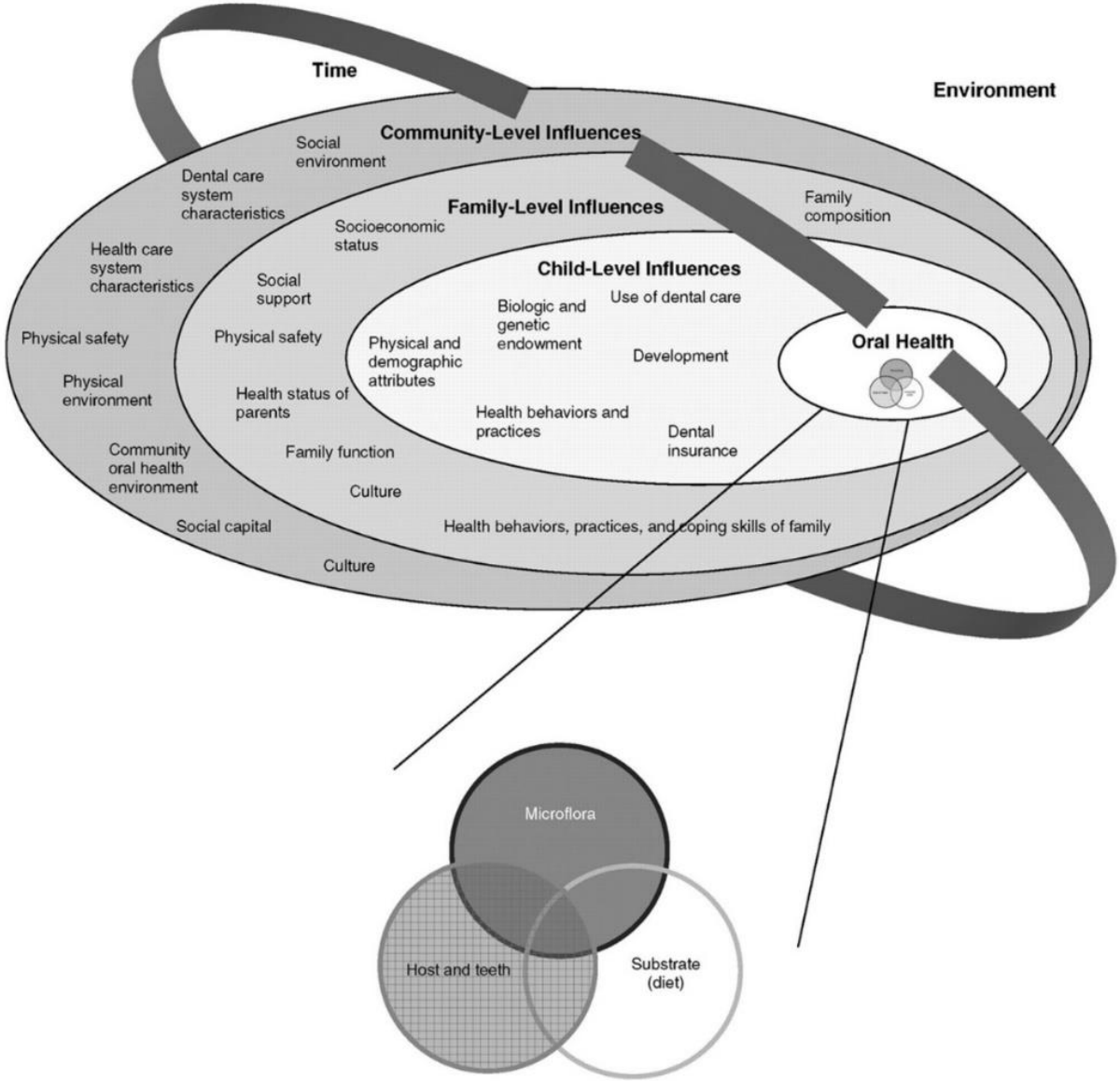
The framework recognises the importance of children's families' and communities' development over time and the dynamic of determinants in this evolving system (Fisher-Owens et al., 2007). This social determinants framework is one of the most cited in the oral health research literature (Casamassimo et al., 2009, Hooley et al., 2012a, Ismail et al., 2009). However, a number of critiques of the framework have been raised. For example, Duijster and colleagues (2014a) criticised the lack of direct pathways between child, family and community levels as well as between different determinants within each level. Fisher-

Owens and colleagues (2007) suggested that the intended purpose was not to propose hypothetical pathways concerning the direction of the relationships between the components. Instead, the framework was intended to provide an over-arching 'map'. In other words, the framework would have had to include too many paths, which would have made the framework unclear and the risk of neglecting pathways would have been too high (Fisher-Owens et al., 2007). Fisher-Owens and colleagues (2007) chose a "middle way" in designing the framework without causal paths instead of proposing a web of paths, by including too many paths or limiting the framework by including only some of them and thus failing to account for confounding factors. Further criticisms include the absence of the potential role of cultural aspects at both family and community levels (Riggs et al., 2014). Culture may have a very different and complex effect on other attributes such as, dietary choices, physical activity, and use of dental services (Hilton et al., 2007, Fisher-Owens et al., 2007). Nevertheless, the explicit lack of mechanisms within the Fisher-Owens framework may also be seen as a strength so that the framework that can be applied or adapted in different contexts and circumstances.

Interestingly, whilst the Fisher-Owens framework was originally developed for the social determinants of oral health, most of the research studies that have applied the framework did so in relation to dental caries (Riggs et al., 2014, Xiao et al., 2019). These authors have simply applied this generic framework to understand the development of dental caries as an important and broad component of oral health. Given this, and because there are few caries-specific frameworks, the Fisher-Owens framework has been adapted in the present research and used for the development of a framework on the determinants of childhood dental caries and overweight/obesity.

The next section will discuss a framework that was developed to explain and illustrate the social determinants of childhood overweight/obesity. This framework on overweight/obesity was then used - in combination with the previously discussed frameworks - to develop an adapted framework on the social determinants of childhood dental caries and overweight/obesity, which will be discussed in Section 2.7.

Figure 2: The adapted version of the social determinants of health by Fisher-Owens and colleagues (2007)



2.5. Ecological model of predictors of childhood overweight/obesity (Davison and Birch, 2001)

Following the previous section on dental caries, highlighting the social determinants of oral health by Fisher-Owens (2007), another social determinant framework was developed specifically for childhood overweight/obesity. In 2001, Davison and Birch developed a framework called the "ecological model of predictors of childhood overweight" (Davison and Birch, 2001) (Figure 3, p. 36). The WHO defines overweight/obesity essentially as an imbalance between energy intake and energy expenditure, which is influenced by multiple determinants (World Health Organisation, 2016a). The framework of Davison and Birch (2001) highlights these determinants, which influence the development of overweight/obesity. This framework is set up very similar to the previously discussed one of Fisher-Owens, in the sense that the determinants, here called predictors of childhood overweight/obesity are divided into three levels, the child characteristics and child risk factors, the parenting styles and family characteristics, and community, demographic and societal characteristics. The different levels, even though named slightly differently in this framework compared to the Fisher-Owen's framework, contain the determinants for overweight/obesity development in children. The following paragraphs will highlight and discuss these three different levels and their determinants, starting with the child characteristics and child risk factors, followed by the parenting styles and family characteristics and lastly the community, demographic and societal characteristics.

The child characteristics and risk factors include age, sex, dietary intake, sedentary behaviour, physical activity and family susceptibility to weight gain. Many studies and reviews have been published investigating the determinants of childhood overweight/obesity (e.g. Perkins and DeSousa, 2018, Zeiher et al., 2016, Mazarello Paes et al., 2015, Hawkins and Law, 2006).

Age and sex are important determinants of children's overweight/obesity. Age and sex should be considered when calculating the BMI of children and adolescents (age 0-18), since they are still growing, and height and weight ratios differ between age groups and sex. Therefore, different health advisory bodies, such as the WHO as well as the CDC have developed charts for the identification of overweight/

obesity in children (World Health Organisation, 2010b, Centers for Disease Control and Prevention, 2019). The relationship of age and sex with overweight/obesity will be further discussed in section 2.7.1. of this thesis.

The frequency and pattern of dietary intake are directly related to overweight/obesity development. As mentioned earlier, overweight/obesity derives from an imbalance in energy intake and energy output (World Health Organisation, 2016a). Therefore, high caloric diets (e.g. high sugar and fat) are attributable factors in the development of overweight/obesity (World Health Organisation, 2014c). High energy intake is not a risk factor alone as low physical activity and sedentary behaviours play a vital role in the development of overweight/obesity (World Health Organisation, 2014c).

A recent systematic review on sedentary behaviour including 13 previous systematic reviews reported moderately strong evidence on the association between screen time and greater obesity among children and young people (Stiglic and Viner, 2019). Almost all reviews included studies conducted in developed countries, with a majority of them being conducted in the USA (Stiglic and Viner, 2019). The age of participants ranged from 0 to 18 years. Overweight/obesity were measured using BMI while screen time was self-reported or observed, and included any type of screens (e.g. tablets, mobile phones, TVs) (Stiglic and Viner, 2019).

Low levels of physical activity have also been associated with overweight/obesity in children (e.g. Dhar and Robinson, 2016, Laguna et al., 2013). The WHO (2015) defines physical activity as energy expenditure and has made recommendations on the amount and intensity of physical activity, which healthy children should undertake on a daily basis to improve general health and muscle fitness. The recommendations consist of 60 minutes of moderate to vigorous physical activity on a daily basis for children between the ages of five to 18 years, for any gender, ethnic group and SES background (World Health Organisation, 2015).

Family's susceptibility (e.g. parental overweight or obesity) as a determinant of children's weight status is part of the child characteristics and child risk factors section of the framework (Davison and Birch, 2001).

There is evidence that children from obese mothers have a higher risk of developing obesity during early childhood than from normal weight mothers (e.g. Whitaker, 2004, Josey et al., 2019, Rooney et al., 2010).

The second level of this framework, the parenting styles and family characteristics level, includes the following determinants for childhood overweight/obesity: child feeding practices, types of foods available in the house, parental nutrition knowledge, parental dietary intake, parental food preference, parental weight status, parental encouragement of child activity, parental physical activity, parental monitoring of child TV viewing, and peer and sibling interactions (Davison and Birch, 2001).

Feeding practices for example are referred to as the type of feeding style. There are a variety of assessment tools for feeding practices (Hughes et al., 2012). According to Hughes and colleagues (2012), parents may be authoritative, authoritarian, indulgent and uninvolved in their feeding style. These four types of feeding styles derive from a calculation of scores from a questionnaire, previously answered by the parents. Measurement for parental feeding style will further be described in Section 5.3. of this thesis.

Types of foods available in the house directly indicate the quality of children's food consumption (e.g. healthy and unhealthy diet) (Ranjit et al., 2015, Santiago-Torres et al., 2014). Furthermore, the type of foods available at home indicates parental nutritional knowledge and family economic resources (Alkerwi et al., 2015, Drewnowski et al., 2014, Drewnowski and Darmon, 2005). The low costs of energy dense foods and the higher costs of "healthy" nutritional foods result in a social disparity between lower and higher SES population groups (Drewnowski and Darmon, 2005). However, food availability at home itself does not influence the development of dental caries and overweight/obesity in children. Parental role modelling shapes children's health behaviours as highlighted in the Fisher-Owens framework in section 2.4. of this thesis (Mobley et al., 2009, van Ansem et al., 2014, Lazarou et al., 2008). Although role modelling is not directly mentioned as a determinant of childhood obesity in the Birch and Davison framework (2001), parental dietary intake, parental food preference, parent activity patterns, parent preference for activity, are highly related to the role modelling behaviour of the parent (Lazarou et al., 2008, Birch and Davison, 2001, Davison et al., 2003). Children from parents with unhealthy role modelling behaviours such as reduced physical activity and an unhealthy diet, will most likely copy these behaviours. Therefore, their risk of developing overweight/obesity and dental caries is increased. The role

of parental role modelling in relation to dental caries and overweight/obesity development will be further addressed in section 2.7.2. of the thesis.

Other factors of parenting also influence the development of overweight/obesity and dental caries in children. Davison and Birch (2001) highlight parental encouragement of child activity and parent monitoring of child TV viewing as two more parenting factors in their framework. Parental encouragement of child physical activity is highly important to reduce overweight/obesity (Tate et al., 2015a). A cross-sectional study involving 423 pairs of parent and his/her child aged 8-14 years concluded that high parental encouragement of parents who engage in low levels of moderate to vigorous physical activity was associated with an increase in moderate to vigorous physical activity among their children (Tate et al., 2015a). Parent and child daily physical activity levels were measured for a period of seven days using activity monitor accelerometers. Parental perceived influence on child physical activity was also assessed. This study provides evidence that parental and child physical activity are positively associated to each one (Tate et al., 2015a).

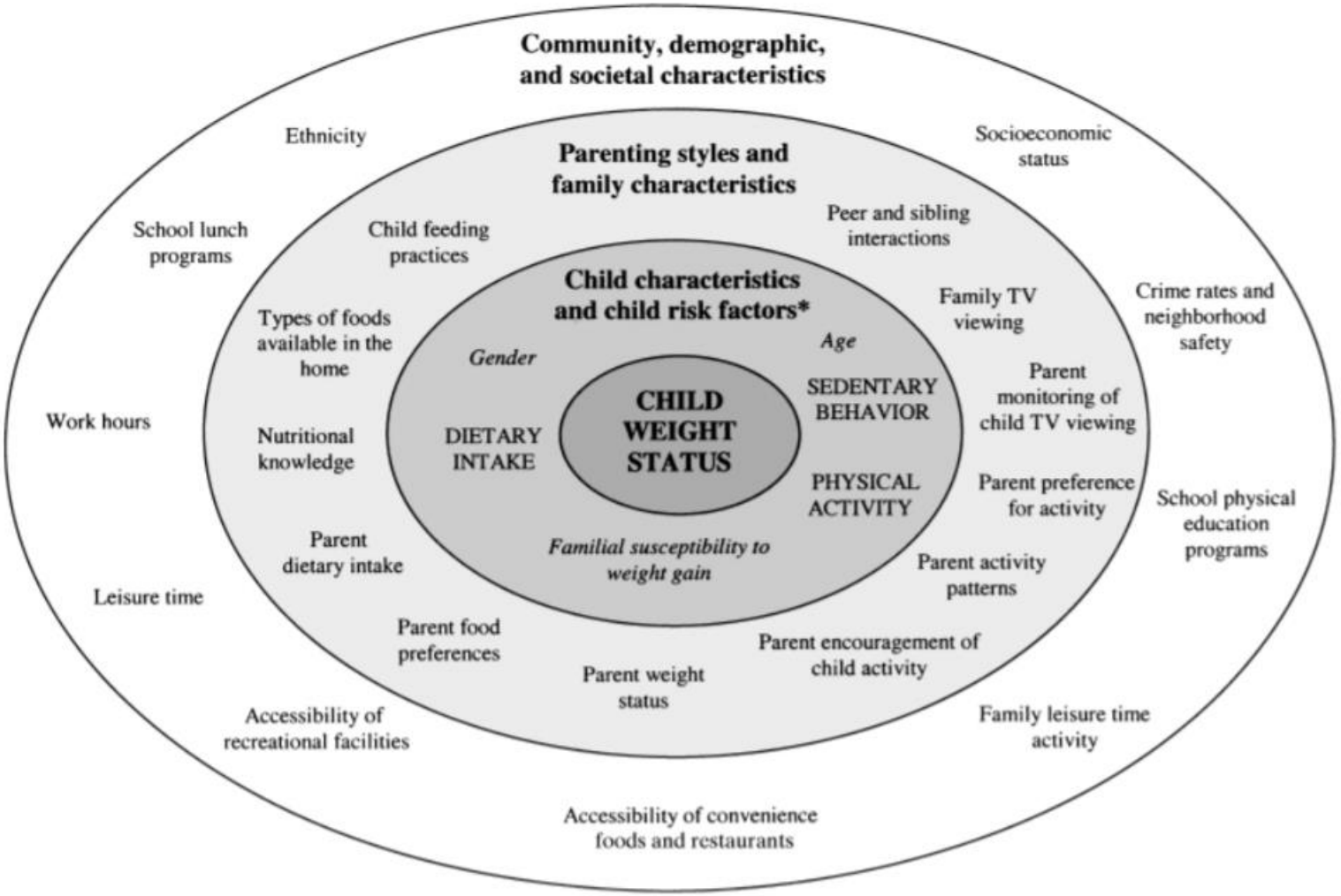
And lastly, the most distal component of the ecological model of predictors of childhood overweight/obesity framework consists of the community, demographic and societal characteristics (Davison and Birch, 2001). They include ethnicity, school lunch programmes, parental work hours, leisure time, accessibility of recreational facilities, accessibility of convenience foods and restaurants, family leisure time activity, school physical education programme, crime rates and neighbourhood safety and SES. Most of these determinants are interrelated. For example, low neighbourhood safety negatively influences children access to physical activity, since parents are less likely to allow their children to play outside if they live in an unsafe neighbourhood (Weir et al., 2006). Furthermore, children may be driven to school instead of walking to school due to insecurity in the neighbourhood, resulting in less physical activity of those children. Unsafe neighbourhoods are also often associated with less developed areas and low SES of the residents (Weir et al., 2006).

Easier access to convenience foods and fast food restaurants may further increase the risk of developing obesity (Xin et al., 2019). On the other hand, school physical activity programmes as well as school lunch programmes may prevent the development of childhood obesity (Miyawaki et al., 2018).

The ecological model of predictors of childhood overweight shows several similarities to the previously discussed framework on social determinants of oral health (Fisher-Owens et al., 2007). In many ways, the latter framework gives a detailed overview on the determinants involved in the development of childhood overweight/obesity.

The following section will outline the clustering of health behaviours and the common risk factor approach theories. Both concepts are strongly related to the previously discussed frameworks and supported the development of a combined conceptual framework on the predictors of childhood dental caries and overweight/obesity to guide the current PhD.

Figure 3: The ecological model of predictors of childhood overweight (Davison and Birch, 2001)



2.6. Clustering of health-related behaviours and the common risk factor approach

Both dental caries and overweight/obesity in children are influenced by multiple determinants, as discussed by the previous frameworks above (World Health Organisation, 2016b, World Health Organisation, 2016a, Fisher-Owens et al., 2007, UK Government, 2017b, Paglia et al., 2016, Davison and Birch, 2001). The clustering of health-related behaviours is a fundamental concept, which suggests that health related behaviours tend to cluster in children and in adults. Many chronic diseases are linked to clusters of health risk behaviours (Elsenburg et al., 2014, Alzahrani et al., 2014, Pearson et al., 2017, Spring et al., 2012). For example, health-compromising behaviours that increase the risk of dental caries include an unbalanced diet, with a high sugar-intake and poor oral hygiene (Public Health England, 2017b).

While clustering health behaviours may target one disease, the common risk factor approach proposes that few risk factors increase the risk for multiple diseases and the reduction of such diseases would be possible by tackling one or more common risk factors (Kumar and Y, 2017). For instance, a high sugar diet is considered a common risk factor for obesity and dental caries. Thus, reducing sugar intake of children may influence the decrease in childhood overweight/obesity, childhood dental caries and reduce the risk of metabolic diseases (World Health Organisation, 2016a, World Health Organisation, 2018). The common risk factor approach is considered more rational and effective public health strategy than those directed to specific diseases (Sheiham and Watt, 2000). The key principle of the common risk factor approach is to reduce several diseases at lower costs, greater efficiency and effectiveness by tackling few risk factors rather than adopting disease-specific approaches (Sheiham and Watt, 2000). Therefore, effective health promotion and preventive strategies should take common health-compromising behaviours into consideration (Petersen et al., 2008).

The next sections will describe the development of an adapted framework combining the social determinants of dental caries and overweight/obesity in children (Fisher-Owens et al., 2007, Davison and Birch, 2001, World Health Organisation, 2010a).

2.7. Development of an adapted framework on the social determinants of dental caries and overweight/obesity in children

The proposed adapted framework on the social determinants of dental caries and overweight/obesity in children (Figure 4, p. 40) is based on the common determinants of dental caries and overweight/obesity derived from the social determinants of oral health by Fisher-Owens and colleagues (2007) and from the ecological model of predictors of childhood overweight (Davison and Birch, 2001) (see Sections 2.3 to 2.7).

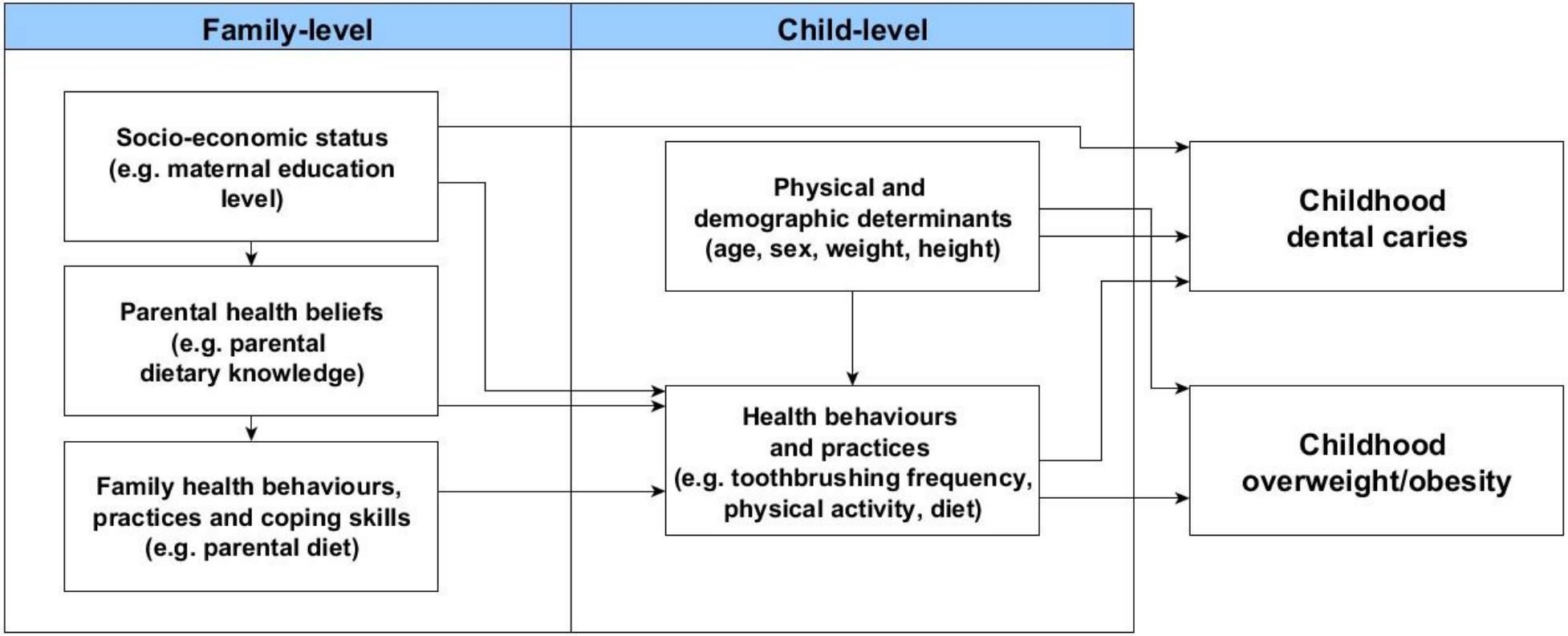
The original frameworks consist of three sections or levels: the child-level, the family-level, and the community- or social-level (Davison and Birch, 2001, Fisher-Owens et al., 2007). While the community- or social-level undoubtedly play an important role in understanding the development of dental caries and overweight/obesity in children, the child- and the family-level were the scope of this PhD thesis due to operational reasons, such as a limited amount of resources in terms of data on community-level determinants from the chosen population as well as a lack of time.

It was decided to group the predictors of overweight/obesity and dental caries into broader determinants (for example, health behaviours and practices which includes diet, physical activity) in the framework in order to increase the flexibility of the framework and to make it adaptable to different research settings. For instance, exploring the determinants of overweight/obesity and dental caries among distinct cultural groups or different countries may require the assessment of different determinants. The wide scope of the determinants of overweight/obesity and dental caries further reduces the risk of neglecting important determinants, making the framework applicable to a wide range of research. For example, health behaviours and practices in the child level may include determinants such as toothbrushing frequency and diet of the child however is not limited to those determinants.

In the following section, the adapted framework on the social determinants of dental caries and overweight/obesity in children will be described, according to child- and family-level. For each level, the determinants were chosen based on the current literature on the determinants of overweight/obesity and dental caries and will be presented and discussed in detail. It is important to highlight that the number of

determinants described in the adapted framework is not definite, and additional determinants may be added or adapted in any further research. The framework is described in accordance to the child-level followed by the family-level.

Figure 4: The adapted framework of the social determinants of dental caries and overweight/obesity in children from Fisher-Owens and colleagues (2007) and Davison and Birch (2001)



2.7.1. Child-level determinants

2.7.1.1. Physical and demographic determinants

The social determinants of oral health proposed by Fisher-Owens and colleagues (2007) include physical and demographic determinants in the child-level. The ecological model of predictors of childhood overweight dismembered these determinants into multiple factors, which are, age, sex, height and weight (Davison and Birch, 2001). In the adapted framework of this research these determinants were named physical and demographic determinants, following the ecological model of predictors of childhood overweight, in order to maintain a broad scope of the determinants of dental caries and overweight/obesity in children (Davison and Birch, 2001). This group of determinants include height, weight, age and sex and will be discussed in the following paragraphs based on current literature.

Height and weight

Height and weight are direct indicators of overweight and obesity since they are used to calculate the BMI fat measure which in turn allows the classification of individuals into underweight, normal weight, overweight and obese (World Health Organisation, 2016a, World Health Organisation Europe, 2019) (see Section 2.1).

Height and weight are not only important indicators for childhood overweight/obesity, but studies have shown that height is also a predictor for childhood dental caries (Peres et al., 2017, Nicolau et al., 2005). Peres and colleagues (2017) identified in a cross-sectional study including 400 6-year old children, randomly sampled from a birth cohort of 5249 live births in Pelotas, Brazil, that child's height deficit for age at 12 months was a risk factor for dental caries. Nicolau and colleagues (2005) confirmed this finding by investigating the relationship between height and dental caries among Brazilian adolescents in Cianorte, Brazil, were 652 of all 764 13-year-olds attending public and private school in the town participated in the clinical examinations and interviews. The authors concluded that taller adolescents had a protective effect on caries development (Nicolau et al., 2005). As height and

weight play a crucial role in the development of overweight/obesity, this variable was included in the adapted framework of this PhD thesis (Figure 4, p. 40).

Age

As described in the previous section, overweight/obesity in children cannot merely be determined by BMI as children are still growing (World Health Organisation Europe, 2019). Therefore, overweight/obesity in children is defined by BMI according to the child's age as described above. Age is even though a biological factor, which cannot be modified, included in the framework due to the influence on the manifestation of both overweight/obesity and dental caries (Leal Roberto et al., 2012). A systematic review on worldwide untreated caries including 192 studies on deciduous teeth in 74 countries and 186 studies on permanent teeth in 67 countries published between 1990 and 2010, found that the prevalence of untreated caries in deciduous teeth reached its peak at six years of age (Kassebaum et al., 2015). Age is therefore an important determinant for overweight/obesity and dental caries in children (Kassebaum et al., 2015).

Sex

Sex is a relevant aspect in the development of obesity (Wisniewski and Chernausek, 2009, Sweeting, 2008). As with age, it is a biological factor which cannot be modified, but is included in the framework due to its influence on both childhood overweight/obesity and dental caries. Girls are born with a higher percentage of fat mass than fat free mass in their bodies compared to new born boys (Wisniewski and Chernausek, 2009, Carberry et al., 2010). Sex is concerned with the biological differences (e.g. body composition) between girls and boys, whereas gender relates to values, attitudes and beliefs formed by society around behaviour (Sweeting, 2008). Although most differences in boys and girls are not solely deriving from biological differences (Sweeting, 2008), this research focused merely on sex as a determinant for both overweight/obesity and dental caries.

A study examined the overweight and obesity trends in children from 1974-2003 in England using data from the National Study for Health and Growth and the Health Survey, including 14587 white boys and 14014 white girls from the ages of 5 to 10 years (Stamatakis et al., 2005). An overall

increase of obesity among girls was identified as they had higher odds of developing obesity than boys (Stamatakis et al., 2005). This study also reported that obesity in children from lower income households increased more rapidly than among those from higher income households (Stamatakis et al., 2005). This finding is supported by a review that included 58 studies published between 1974 and 2008, involving children between the age from zero to 18 years (Wisniewski and Chernausek, 2009). Their findings on childhood gender differences in obesity highlighted that boys are more physically active than girls. The former have lower leptin levels while the latter have a greater fat mass and are more susceptible to family and environmental factors related to obesity (Wisniewski and Chernausek, 2009). Subsequently, the studies suggest that girls and women have a higher risk of developing obesity worldwide, however results may change depending on the specific study population (Wisniewski and Chernausek, 2009). Biological factors such as ethnicity and genes as well as social and environmental factors such as SES and cultural beliefs and habits should be taken into consideration in the different study populations when studying childhood overweight/obesity.

Differences in sex for adult dental caries have been found in previous studies, where women have higher rates of dental caries than men (Ferraro and Vieira, 2009, Lukacs and Largaespada, 2006). For example, Ferraro and Vieira (2009) published a review explaining the differences in caries development between men and women. Although not a systematic review, this paper summarises and evidence reasons for such differences. One biological explanation refers to differences in salivary flow between women and men (Ferraro and Vieira, 2009). Saliva plays a protective role in the oral cavity, such as on the remineralisation process and antimicrobial activities. However, saliva flow rates and composition has been shown to be less protective in women than in men (Ferraro and Vieira, 2009, Lukacs and Largaespada, 2006). On the contrary, the risk of developing childhood dental caries is higher among boys than girls (Shaffer et al., 2015, Margrit-Ann et al., 2018, Kalita et al., 2015, Acuña et al., 2019). More research is needed to explain the differences in childhood dental caries development. Cultural habits, such as easier access to sweets for boys, in societies, where boys receive preference over girls, may explain the difference (Shaffer et al., 2015, Kalita et al., 2015).

This section described the physical and demographic attributes that influence the development of dental caries and overweight/obesity in children, including age, sex, height and weight. These attributes should not be considered alone but are strongly linked to other predictors of childhood obesity and dental caries. For instance, toothbrushing behaviour and use of fluoride might mitigate the occurrence of childhood dental caries. Therefore, health behaviours and practices play an important role in the development of childhood dental caries and overweight/obesity. In the following section health behaviours and practices, including fluoride use and tooth brushing, physical activity and diet, are described and their role in the development of childhood overweight/obesity and dental caries are discussed.

2.7.1.2. Health behaviours and practices

This section will outline the health behaviours and practices that are determinants of overweight/obesity and dental caries within the child level of the adapted framework and include the use of fluoride toothpaste, tooth brushing, physical activity and diet.

Tooth brushing and fluoride use

Although tooth brushing behaviour is not relevant for the prevention of overweight/obesity it is included in this part of the study, as it is an important health behaviour for the prevention of dental caries. Tooth brushing behaviour should be considered in terms of toothbrushing frequency, duration, starting age and the use of toothpaste fluoride. Although fluoride is available in many ways, only fluoridated toothpaste will be considered in the present study. Frequent tooth brushing using fluoridated toothpaste is associated with fewer non cavitated caries and cavitated caries counts in preschool children (dos Santos et al., 2013). The UK government recommends the use of fluoridated toothpaste containing no less than 1,000 ppm for children up to three years of age (Public Health England, 2017a). Children at higher risk of dental caries development should use fluoridated toothpaste containing 1,350- 1,500ppm of fluoride (Public Health England, 2017a). Toothbrushing is generally associated with fluoride use as most toothpastes in the UK contain fluoride. Fluoride can also be taken through fluoride varnishes, fluoride pills or fluoride mouthwash (The British

Fluoridation Society, 2017). Fluoride varnish is effective to prevent dental caries in children and adolescents (Marinho et al., 2013). In some countries and areas, water fluoridation has been provided by the state or private water supply companies, implemented as a public health strategy to decrease dental caries (The British Fluoridation Society, 2017). Water fluoridation can decrease the burden of dental caries and reduce the dental caries disparities between low and high SES groups (Slade et al., 1996).

In order to ensure adequate dental hygiene and prevent dental caries evidence suggest twice a day toothbrushing (Public Health England, 2017a, Marinho et al., 2013). A systematic review and meta-analysis investigated the effect of toothbrushing frequency on the incidence and increment of carious lesions (Kumar et al., 2016b). The meta-analysis including 25 studies found that the incidence and increment of carious lesions among those with low frequency of tooth brushing was higher in deciduous than permanent dentition (Kumar et al., 2016b). The review further found, that infrequent toothbrushing (<2 times/day) was associated with higher incidence of carious lesions compared to frequent toothbrushing (≥2 times/day) (Kumar et al., 2016b). Most of the studies were conducted in developed countries (except 4 from Brazil and 1 from China) and there were no restrictions on the inclusion of participants, such as age (Kumar et al., 2016b). However, 17 of the 25 studies included infant or child populations (Kumar et al., 2016b).

Another scientific review aiming to identify risk factors for dental caries in deciduous teeth in children six years and under included 77 studies published between 1966 and 2002 without language restrictions found that toothbrushing with parental help was more effective on plaque removal and a more important preventive factor for caries occurrence than the daily toothbrushing frequency (Harris et al., 2004).

In terms of the starting age of toothbrushing, the NHS (2020) recommends parents to start brushing their children's teeth as soon as the first deciduous tooth erupts, which usually occurs after six months of age. The starting age of toothbrushing is significantly related to the prevalence of caries in deciduous teeth in children aged six years and under (Harris et al., 2004). Starting to brush children's

teeth after 12 months of age is significantly related to dental caries development (Al-Malik et al., 2001, Davies et al., 2003).

The next section will focus on physical activity and sedentary behaviour and its possible association with childhood overweight/obesity and dental caries.

Physical activity and sedentary behaviour

The WHO describes physical inactivity as the fourth leading risk factor for global mortality, causing 6% of deaths globally across the age groups (World Health Organisation, 2020d). Children's physical activity is a vital determinant of overweight/obesity development. Overweight/obesity has been described as a result of an imbalance between calorie intake and energy expenditure (World Health Organisation, 2016a). High calorie intake and low calorie expenditure lead to an increase in body fat (World Health Organisation, 2016a). The WHO recommends children to be physically active, which means to accumulate at least 60 minutes of regular, moderate- to vigorous-intensity activity each day (World Health Organisation, 2014d).

A study aiming to assess physical activity levels among children and adolescence was conducted in randomly selected schools across England, engaging 130,000 pupils between the ages of 5-16 years in the academic year 2018/2019 (Sport England, 2019). Data on activity levels indicate that 29% of all schoolchildren (2.1 million children between the ages of 5-16 years) are engaging in physical activity for less than 30 minutes a day (Sport England, 2019). This is less than the current recommendation, which is at least 60 minutes of exercise a day (Sport England, 2019). The increase in physical inactivity and sedentary behaviour over the recent decades is also partly due to an increase in prolonged sedentary screen time among children (World Health Organisation, 2019b).

Recent studies have explored the link between physical inactivity and overweight/obesity (Vincent et al., 2003, Dhar and Robinson, 2016, Shofan et al., 2011, Molnar and Livingstone, 2000). An increase in physical activity was associated with lower odds of obesity in 9-11 year-old children (Shofan et al., 2011, Katzmarzyk et al., 2015). The goal in fighting childhood overweight/obesity is a balance between energy intake and energy output that could be maintained over the years (World Health

Organisation, 2014d). However, overweight/obese children tend to engage in less physical activities than those with normal weight, which makes it more difficult for them to lose weight (Planinsec and Matejek, 2004, Molnar and Livingstone, 2000, Vincent et al., 2003).

Screen time including television watching has become a major part of contemporary life for children and adolescents (Stiglic and Viner, 2019). An increased time of television viewing a day decreases the time that could be spent being physically active (Zhang et al., 2015). Other screens may include smart phones, tablets, computers and videogames. However, screen time does not only reduce the time of being physically active as it is often also linked to the consumption of unhealthy foods (Zhang et al., 2015).

A meta-analysis by Zhang and colleagues (2015) including 14 cross-sectional studies and 106,169 subjects aiming to evaluate the association between television watching and childhood obesity, suggests that increased television watching is associated with an increased risk for childhood obesity. This finding is possibly explained by the fact that television watching is commonly accompanied by the consumption of snacks high in sugar, salt and fat food (Hobbs et al., 2015). These findings are in agreement with previous results showing the association between television viewing and higher BMI. Yet, such association was only observed when the former was combined with reduced physical activity and inadequate diet (Jago et al., 2005). Similar findings were reported by a recent WHO European Childhood Obesity Surveillance Study, where screen time was associated with a higher energy intake, such as high consumption of fat, free-sugars and salty foods (Bornhorst et al., 2015). The authors suggested that self-monitoring of food intake while engaging with an additional activity (such as watching television) decreases, meaning children being unaware of the amount of food they eat, while watching television (Bornhorst et al., 2015). Zhang and colleagues (2015) suggested that childhood obesity prevention programmes should aim to reduce television time as well as to reduce other sedentary activities.

The consumption of high sugar snacks while watching television adds to the above highlighted imbalance of energy intake and energy expenditure and creates a greater risk for dental caries development (Hayden et al., 2013). There is little evidence on the potential relationship between

sedentary behaviour and dental caries among children. A study in China investigated such relationship among adolescents aged 12, 14 and 17 years using data from the National Physical Fitness and Health Surveillance Study (Zeng et al., 2014). This study included a total of 3568 adolescents from the Guangxi province. Initial recruitment of the national survey was conducted through stratified cluster sampling method, were in the first stage five administrative areas were randomly selected, then in the second stage, 48 schools primary, secondary, high schools and colleges were randomly selected from each selected area, in the third stage two classes from each grade from each selected school were randomly selected (Zeng et al., 2014). Finally, all students in the selected classes were recruited as study subjects. For this study, all 12, 14 and 17 year olds having participated in the national survey were selected to participate and underwent dental examination by one of four experienced dental examiners and conducted a self-reported questionnaire on behavioural and demographic characteristics (Zeng et al., 2014). Results suggest a positive association between the duration of television viewing per day and dental caries among Chinese adolescents (Zeng et al., 2014). The longer the adolescents watched television, the higher the DMFT score (Zeng et al., 2014). The authors suggest that even though the underling mechanisms of this association are not yet fully understood, adolescents who watched television for longer were more exposed to advertising messages that predominantly promoted unhealthy foods and were more likely to consume sweetened beverages and snacks (Zeng et al., 2014). This study indicates how television viewing could influence dental caries in children. However, age and television programmes as well as advertisement regulations may look very different in the UK compared to China. A study in the UK on the clustering of health behaviours in children, with data deriving from the Sport, Physical Activity and Eating Behaviour: Environmental Determinants in Young People Study in which 2064 students between the ages of 9-10 years, took part in was conducted between April and July 2007 (Elsenburg et al., 2014). The data was collected by a combination of trained research staff and self-reported questionnaires by the parent/guardian (Elsenburg et al., 2014). The authors found evidence of clustering of screen viewing with unhealthy food consumption (Elsenburg et al., 2014). However, the temporal sequence between screen viewing and unhealthy food consumption could not be established due to the cross-sectional design of the study (Elsenburg et al., 2014). Therefore, the interpretation of their results should be considered with

caution and longitudinal studies are needed to draw conclusions for this association among children in the UK.

The following section will further elaborate on diet and its association with overweight/obesity and dental caries.

Diet and malnutrition

Malnutrition is considered an umbrella term consisting of three components: undernutrition, over-nutrition and nutrient imbalance (World Health Organisation, 2016e). This section will focus on malnutrition according to over-nutrition, which includes overweight and obesity as well as other diet-related non-communicable diseases such as heart disease, stroke, diabetes and cancer (World Health Organisation, 2016e).

Overnutrition as a result of poor diet in combination with insufficient physical activity, as previously described, can significantly influence the development of overweight and obesity in children and adults (World Health Organisation, 2016a). The WHO acknowledges the high intake of highly processed and energy-dense food, high in fat and sugar (e.g. butter, oils, fried foods) as the essential causes of overweight/obesity (World Health Organisation, 2016a, World Health Organisation, 2007). Over the recent years, a global shift in diet towards an increased consumption of fatty and sugary foods, low in vitamins, minerals and other healthy minerals has been reported (World Health Organisation, 2014c). The figures from the National Diet and Nutrition Survey of 2014-2016 in the UK support these trends in children's dietary pattern, highlighting that children in the UK consume higher amounts of sugar than officially recommended (UK Government, 2018). The study found that sugar represents 13.5% of the daily calorie intake of children aged from 4 to 10 years; whereas official recommendations suggest a maximum of 5% of daily calorie intake (UK Government, 2018).

The frequency of intake and the total amount of free sugar intake has been recognised by the WHO as the main cause of dental caries (World Health Organisation, 2016b). The regular consumption of sugary drinks is an important determinant of early childhood dental caries (Almasi et al., 2016, Paglia et al., 2016). Children who frequently consume sugar-sweetened beverages or carbonated soft drinks

have a higher risk of developing dental caries than those who consume milk or fruit juices (Almasi et al., 2016, Sohn et al., 2006). Following the World Oral Health Report in 2003, the WHO has linked dietary factors to dental caries (World Health Organisation, 2003).

Type, frequency and amount of diet is affected by multiple environmental and individual factors such as the purchaser's food preference, SES, cost and availability of food, and industrialisation of agricultural production, agricultural, tax and food policies as well as marketing and advertising of food products (Mobley et al., 2009, Caswell and Yaktine, 2013). Therefore, diet is influenced by child-level and family-level factors (Mobley et al., 2009). As stated previously, the scope of the current PhD research is on family- and child-level determinants only.

In the child- and family-level multiple studies have been conducted why children take certain food decisions and how these food likings have come to be. Noble and colleagues (2000) conducted a study with 123 children between the ages of 9-11 randomly selected from the school registry children of 14 primary schools in south east England, investigating children's perception of the healthiness of foods and their understanding of the relationship between food and health. The authors found that the understanding of the relationship between foods and nutrients was only occasionally evident and that there was an inverse relationship between the preference for foods among children and their perception on the healthiness of these. Foods chosen for a healthy meal were more frequently not those foods chosen for the preferred meal (Noble et al., 2000). Fitzgerald and colleagues (2010) conducted focus group discussions with 29 randomly selected Irish children and adolescents from three age groups (9-10, 13-14 and 16-18 years of age) investigating children's perceptions on factors that influenced their food choices. Children were recruited from randomly selected Irish primary and secondary schools from the list of schools published by the Irish Department of Education and Science. The authors confirmed previous findings by finding that children reported a preference for unhealthy foods, without understanding the concept of healthy eating (Fitzgerald et al., 2010). Weber Cullen and colleagues (2000) conducted focus-group discussions with Afro- Euro and Mexican American 9-12 year old children and their parents from a local school district in Texas, which agreed to participate and assisted with the recruitment of classes, aiming to assess social and environmental influences on children's healthy food choices. The authors concluded that the accessibility in the

household for example cut up fruit and vegetables increased the child's consumption of such (Weber Cullen et al., 2000). Additionally, the authors found that families went out to eat at least twice a week and that a low availability of foods low in fats and high in fruit and vegetable content were available on the menus. This lead to a consumption of unhealth foods (Weber Cullen et al., 2000). This means, given their importance, future studies should include the wider societal factors of diet when studying the determinants of childhood dental caries and overweight/obesity.

The next section highlights the family level influences, starting with SES.

2.7.2. Family-level influences

2.7.2.1. Socio-economic status

Low SES children are often found to have a higher dmft/DMFT rate than children from a higher SES background (Verlinden et al., 2019, Enjary et al., 2006, Kumar et al., 2016c, Masood et al., 2019). SES indicators such as maternal level of education (Skeie et al., 2006, Van den Branden et al., 2012, Enjary et al., 2006), family income (Tusek et al., 2011), awareness on dental care (Mattheus, 2010, Verlinden et al., 2019), availability and access to dental care services (Mattheus, 2010), social environment (Fontanini et al., 2015) have been associated with higher dental caries and poorer oral health status among children and adolescents.

Kumar and colleagues (2016c) conducted a systematic review, including 48 studies published in English and between the years 2000 and 2015, aiming to identify the effects of various parent-related characteristics such as SES on dental caries in the permanent dentition of children between the ages of six to 12 years. SES was measured through a variety of indicators throughout the studies included parental education, family income and parental occupation (Kumar et al., 2016c). The authors conclude that all studies included in the review indicate that children belonging to lower SES families experience greater caries than those that belong to higher SES families (Kumar et al., 2016c). Children of higher educated, professional and high income parents were at lower risk for dental caries compared to those of lower educated, manual working and low income parents (Kumar et al., 2016c).

However, the link between SES and dental caries may be context specific, depending for example on the country's socioeconomic development, access to dental care within national health care system, and access to dental care insurance. For example, in a study in Thailand investigating dental caries increment among children at 24 months and 36 months of age suggested that a strong association between higher maternal level of education and child's dental caries (Peltzer et al., 2014). The possible explanation for this finding could be that high maternal education was related to long working hours. During the working hours of the mother, the child is frequently under the grandmother's supervision (Peltzer et al., 2014), where sugary food (e.g. treats and sweets) and drinks (e.g. soft drinks) might be more easily available.

There have been some important discussions about the inverse relationship between SES and dental caries in developing countries (Hooley et al., 2012a, Schwendicke et al., 2015, Popoola et al., 2013).

Schwendicke and colleagues (2015) conducted a systematic review on the association of dental caries and SES, including 155 studies and a meta-analysis with 92 of these studies. All studies were published between 2000 and 2013. Cross-sectional, pro and retrospective cohort studies and case-control studies were all included in this review. The majority of studies were conducted in developed countries (88 studies), followed by developing countries (44 studies) and underdeveloped countries (22 studies). Various designs were used to assess dental caries and SES, however, caries had to be assessed clinically and SES individually or household level instead of by neighbourhood or area level for studies to be included in this review. Both, studies of adults and children were included in this systematic review. In their meta-analysis the authors found that dental caries was significantly associated with own or parental educational background, income and occupational background, confirming the previous findings (Schwendicke et al., 2015). However, the authors also found that this association was significantly higher in developed countries highlighting a more unequal distribution of dental caries than in developing countries. Even though dental care facilities are universally available in most developed countries, access might only be granted to a limited few, usually those with higher income (Schwendicke et al., 2015).

In developing countries on the other hand dental caries prevalence is more equally distributed between high and low SES background, meaning that dental caries is as prevalent among high income people as among low income people. Possible explanations for the higher incidence of dental caries among high SES people may include easier access to sugary and fatty foods by families from higher SES groups, due to higher economic resources (Popoola et al., 2013).

Similarly to dental caries, most of the contemporary research findings concluded that low SES is linked to overweight/obesity (O'Dea and Dibley, 2010, Jin and Lu, 2017). Shrewsbury and Wardle (2012) published a systematic review of cross-sectional studies aiming to identify the association between SES and adiposity in school-aged children in developed countries. The review included 45 studies published between 1990 and 2005 and included participants between the ages of 0-18 years. All studies were conducted in developed countries, with most studies being conducted in the United Kingdom, followed by Germany and the United States (Shrewsbury and Wardle, 2012). Overweight/obesity was measured using BMI in 41 studies (Shrewsbury and Wardle, 2012). SES was predominantly measured at household level, including parental education (n = 26), parental occupation (n = 14), indices of family income (n = 11), and composite SES measures (n = 5) (Shrewsbury and Wardle, 2012). Results indicated that SES was inversely associated to overweight/obesity in most studies, indicating that lower SES children had higher overweight/obesity levels than children from higher SES background (Shrewsbury and Wardle, 2012). The strongest inverse SES predictor of overweight/obesity was parental education (Shrewsbury and Wardle, 2012). However, the review included studies that were not designed to identify the association between SES and overweight/obesity and those may therefore not find such an association (Shrewsbury and Wardle, 2012). A further limitation is that studies did not include characteristics on the non-responders, leaving a possibility for SES related non-response bias (Shrewsbury and Wardle, 2012). A meta-analysis could not be conducted due to the variety of SES measures and definitions of overweight/obesity (Shrewsbury and Wardle, 2012).

Another systematic review explored the mechanisms by which SES may influence childhood overweight and obesity (Mech et al., 2016). Thirty studies published from 2003 to 2011 and a total of 192,479 participants up to eight years old were analysed (Mech et al., 2016). The review highlighted

the different underlying factors of overweight/obesity in low and high SES populations, and suggested that targeted preventive programmes are needed for both high and low SES populations (Mech et al., 2016). Possible predictors were categorised in four categories: 1. Child system factors, including children's birth weight, TV watching, eating behaviours and breastfeeding; 2. Parent system factors, including parent weight status, maternal TV viewing mother's age, smoking during pregnancy, feeding styles, depressive symptoms and alcohol consumption; 3. Household system factor, including family's ethnicity, single-parent households, parents' employment status and child-care attendance; and 4. Social system factors. The latter was only investigated in one study and included neighbourhood poverty and found that in low SES families parental obesity and maternal depressive symptoms were risk factors for childhood overweight and obesity, whereas in high SES families permissive parenting style and long maternal working hours were identified as risk factors for childhood overweight and obesity (Mech et al., 2016). One limitation of this study, however, was the range of SES measurements included, making it difficult to draw conclusions and to compare among studies (Mech et al., 2016). Further parental attitudes and health beliefs were understudied, leaving a gap in the parental influences on the understanding of the relationship between SES and childhood overweight/obesity (Mech et al., 2016).

Both reviews provide a good insight in the possible association between SES and overweight/obesity in children, however more homogeneous methodological approaches are needed, especially in the definition of determinants, in order to create better systematic reviews and possible meta analyses in the future.

The following section discusses the potential influence of parental health beliefs on the development of childhood overweight/obesity and dental caries.

2.7.2.2. Parental health beliefs

Parents' knowledge, attitudes, motivations, beliefs and behaviours play an important role in the children's behaviours and as a consequence in the development of their health. Parental health beliefs have been found to be a meaningful aspect for a number of different health outcomes in children

(Narine et al., 2013, Van den Branden et al., 2012, Lazarou et al., 2008, Amin and Harrison, 2009). Health beliefs and how they influence behavioural change have been discussed extensively and a number of models have been developed (La Morte, 2019). One of the best-known models is the Health Belief Model developed in the 1950s and later adopted by scientists at the United States Public Health Service (La Morte, 2019, Hollister and Anema, 2004). The model was first developed to understand why people failed to adopt preventive strategies or why elderly people failed to comply with screening tests for disease detection (La Morte, 2019). Over the years this model has been adapted to specific diseases and illnesses, including overweight/obesity and dental caries (Hollister and Anema, 2004, Garrett-Wright, 2010).

As discussed earlier, due to the control parents have on their child's diet and physical activity, including parents in the prevention of child's overweight and obesity is paramount (Garrett-Wright, 2010). Parent's perception of their child's weight status is a crucial aspect in the adapted version of the Health Belief Model as successful preventive strategies of childhood obesity are linked to parental awareness of the disease (Garrett-Wright, 2010). Programs focusing on the reduction of overweight/obesity in children are more likely to be unsuccessful if parents do not recognise that their child is overweight or obese (Garrett-Wright, 2010). However, parents of overweight or obese children often underestimate their children's weight, since parent's perception of the disease is linked to the likelihood of taking positive action on behalf of the child (Garrett-Wright, 2010). Further aspects described in the model, such as SES and health literacy of the parents influence the health beliefs of the parents, which will be discussed later in this chapter (Garrett-Wright, 2010).

According to the Health Belief Model, parents tend to believe that their child may be susceptible to dental caries, that their child's primary teeth are important to protect, and that dental caries can be prevented (Hollister and Anema, 2004). Furthermore, parents must be willing to prevent any risks of dental caries development in their children, such as foods containing sugar, and have strong self-efficacy to prevent dental caries by regular toothbrushing (Hollister and Anema, 2004). Children from families who are less likely to consider dental caries a serious disease and those who perceive themselves as least able to establish and maintain regular tooth brushing for their child are eight times more likely to develop dental caries (Pine et al., 2004a). The Health Belief Model describes the

importance of self-efficacy knowledge on a health-related topic in order to change behaviour (Hollister and Anema, 2004).

A systematic review carried out by Hooley and colleagues (2012b) assessed parental influence on the development of childhood dental caries among zero to six year old children and included 55 studies of both longitudinal and cross-sectional designs, published between 2006 and 2011. Studies were conducted in both developing and developed countries. The authors found that permissive and indulgent parental attitudes, especially in regards to the child's diet were associated with childhood dental caries (Hooley et al., 2012b). Further, parental health beliefs and attitudes influenced childhood dental caries development, were children of parents with a poor attitude towards and a lack of knowledge on dental hygiene, healthy diet and oral health were at higher risk of developing dental caries (Hooley et al., 2012b). Additionally the authors found that the diet children are exposed to in their early years develops their taste preference, which has an influence on their long term dietary behaviour, which is largely defined by parental attitudes and knowledge (Hooley et al., 2012b). Studies in the review did not investigate the differences between culture and its potential influence on the results (Hooley et al., 2012b), which might have created a better understanding of the findings. Further, studies have mainly investigated feeding styles and social determinants and little is still known about the beliefs and attitudes of parents (Hooley et al., 2012b).

The next section discusses family health behaviours, practices and copying skills including parental health behaviours, family composition, different parenting styles and parental role modelling in relation to childhood overweight/obesity and dental caries.

2.7.2.3. Family health behaviours, practices and coping skills

Parental health behaviours

Parental health behaviours are linked to parents' health beliefs, health knowledge, as well as their education and SES (Skeie et al., 2006, Van den Branden et al., 2012, Mattheus, 2010). Behavioural patterns and health beliefs of the parents play an important role in children's health behaviour (Pine et al., 2004, Lazarou et al., 2008, Xu et al., 2015). During younger childhood, parents are the primary

role models of their children as compared to adolescent when peers and friends moderate parental influences (Videon and Manning, 2002). Thus, parents represent the major influence on their child's behaviour (i.e. food choices, physical activity), and therefore they are the main influences on their child's overall health status (Mobley et al., 2009, van Ansem et al., 2014). As role models, parents can influence and encourage their child to eat a balanced or unbalanced diet, by regularly providing them at meals and eating them (Mobley et al., 2009, Lazarou et al., 2008). The regular parental consumption of sugary foods and snacks may encourage and reinforce the children to follow this behaviour that can lead to an increased risk of dental caries development, overeating and weight gain (Mobley et al., 2009, Lazarou et al., 2008).

Parental health behaviour may also be linked to dental caries development. A cross-sectional study assessed the relationship between family factors and children's toothbrushing frequency throughout the day (Trubey et al., 2015). The study found that parents brushed their children's teeth significantly more often in the morning that in the evening. This may be due to cosmetic and fresh breath related reasons (Trubey et al., 2015). Parents living in lower socioeconomic areas were more likely to not brush their child's teeth in the morning and in the evening than those living in higher SES areas (Trubey et al., 2015). Furthermore, having a more stable day-to-day routine in the morning was associated with a stronger habit to ensuring their child's toothbrushing in the morning and evening (Trubey et al., 2015).

These studies suggest that stable day-to-day routines in regard to oral hygiene and encouragement of parents towards these behaviours may support children's health behaviours positively.

Family composition

Biehl and colleagues (2014) found that from children participating in the nationally representative Norwegian child growth study of 2010, overall children of divorced parents were more likely to be overweight or obese than those who live in households with non-divorced parents, even after controlling for maternal education level, family's country background and current area of residence. This has been confirmed elsewhere (Schmeer, 2012, Arkes, 2012) and can be explained by the

differences in routine and process between children living with both parents and those living in two-parent households (Mauskopf et al., 2015, Yannakoulia et al., 2008). According to Mauskopf and colleagues (2015) preadolescents from divorced parents consumed sugar-sweetened beverages more frequently and had breakfast less frequent than those from married parents. Family routine was the only variable that explained the link between family structure and risk of child's overweight/obesity (Mauskopf et al., 2015). However in another study, living arrangements and parental marital status were not identified as risk factors for dental caries for pre-schoolers (Tiberia et al., 2007).

Parenting style and role modelling

Parenting style may consist of several determinants. Feeding style for example may be considered as a parenting style and may have direct influences on overweight/obesity and dental caries in young children.

A case-control study of de Jong-Lenters and co-workers (2014) assessed parenting practices and parent-child interaction based on the Social Interaction Learning Model to explore the relationship between parenting practices and dental caries in children aged 5-8 years. The authors reported a relationship between parenting practices and childhood dental caries. Parenting practices such as encouragement, positive involvement and problem-solving were associated with caries-free children (de Jong-Lenters et al., 2014). Children who were encouraged and engaged in physical activities were more likely to meet physical activity guidelines (Pyper et al., 2016). Parents performing physical activities with their children act as a role model (Xu et al., 2015). Increased physical activity is an important behavioural determinant of childhood overweight/obesity (Pyper et al., 2016, World Health Organisation, 2020a).

Kuczynski (1987) found that inconsistent, ambiguous and highly demanding parenting styles evoke non-compliance and resistance against the preferred behaviour in children. Assessing disciplinary behaviour is however difficult depending on the study setting, as disciplinary behaviour can only be observed following problematic behaviour of the child and these behaviours may not show in for example a study environment (de Jong-Lenters et al., 2014).

Few favourable parenting practices such as making plain water available, avoiding negative modelling and having a lack of awareness on the negative advice on daily soft drink/prepacked fruit juice consumption are often observed among mothers from low SES (Pinket et al., 2016). Further aspects on the importance of SES on the determinants of dental caries and overweight/obesity have been discussed in Section 2.7.2.1.

Amin and Harrison (2009) developed a model to describe parental behavioural change after a child had experienced dental general anaesthesia (GA). It highlighted the importance of facilitators and barriers to dental health behaviour (Amin and Harrison, 2009). One of the recognised barriers was the lack of appropriate knowledge on the harmful impact of sugary foods on their child's teeth (Amin and Harrison, 2009). The authors stated that "only those families who took more responsibility seemed to be more confident about the control over their child's dental health and where furthest along a continuum of change and able to maintain positive behaviours over time" (Amin and Harrison, 2009, p. 124). Parents mentioned that family function and family pressure were possible barriers for good oral health (Amin and Harrison, 2009). Some mothers highlighted having difficulties in teaching healthy behaviours as other caregivers, who take care of their children while parents are at work, may have different norms in relation to healthy behaviours (Amin and Harrison, 2009). Sweets are often given to keep children quiet or to spoil them (grandparents) (Amin and Harrison, 2009).

Another aspect influencing children's health behaviour through parenting is parental stress. Jang and colleagues (2019) investigated in a systematic review of observational studies the relationship between parental stress and childhood obesity. The authors included 27 mainly cross-sectional studies, from which 18 were conducted in the USA and Canada, four in Australia and the remainder in Europe. The studies were published between 2007 and 2018 and included children between the ages of 2-17 years of age. The authors found a relationship between parental general stress and parenting role stress and obesity in children younger than 10 years of age (Jang et al., 2019).

Although this research focuses only on child- and family-level determinants, the following section briefly discusses food marketing, following the suggestions on the influence on screen viewing in combination with food advertisements on unhealthy diets.

Food Marketing

In 2016 traditional TV-watching time among children in the UK was lower than children's online media use for the first time according to the 2016 Childwise Report (Leggett, 2016). Children still watched traditional TV show programs but instead they watched those programs on tablets and mobile phones (Leggett, 2016). Following these recent trends, the UK government has approved new regulations to all non-broadcast medias, including print, cinema online and social medias, which became effective in July 2017. They included banning advertising of high fat, salt or sugar food and drink products in children's media (Committees of Advertising Practice, 2016). In recent years, food and drink marketing regulations for children have been a political discussion at regional, national and European level (EU Food Law, 2016). The WHO has developed a nutrient profile model aiming to assist governments to restrict food marketing to children (World Health Organisation Regional Office for Europe, 2015). The model was developed in collaboration with states members and it is based on the models that are currently in use in Europe for restricting marketing to children: the Danish, Norwegian and United Kingdom models (World Health Organisation Regional Office for Europe, 2015). According to the WHO Regional Office for Europe (2015, p.1), nutrient profiling is "the science of classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health".

Advertising, covering sugar or sugar containing products on television to children has been one of the main concerns of public health advocates in recent years (World Health Organisation, 2014b). A number of studies have identified the link between exposure to food advertisement and increase of food consumption after exposure (Longacre et al., 2016, Gatou et al., 2016, Sadeghirad et al., 2016).

Gatou and colleagues (2016) investigated the short-term influence of advertising of cariogenic food, including sugary and starchy foods (e.g. bread and rice) as well as sticky foods (e.g. fried fruits, cookies and chewy candies) on Greek children's dietary preferences. One hundred eighty-three Greek children from seven schools in Athens, were selected through a clustering sample procedure. Schools were identified through the area-based mean family income and two to three schools were randomly selected from each stratum (Gatou et al., 2016). All selected schools agreed to participate and all

children between the ages of 11 and 12 years attending those schools were recruited (Gatou et al., 2016). Children who agreed to participate were exposed to advertisements of sugary foods and non-food items in a counterbalanced design (Gatou et al., 2016). After exposure to food advertisements in comparison with the control group (non-food items), children with higher dmft selected more unhealthy foods than those with lower dmft (Gatou et al., 2016). In addition, obese children and those with higher rates of physical activity chose fewer unhealthy foods (Gatou et al., 2016). Gatou and colleagues (2016) listed the possible explanations for those findings, including response bias due to social desirability among obese children. The study suggested that children's short-term attention can be drawn to focus on unhealthy food choices rather than healthy ones by exposure to media advertisements (Gatou et al., 2016). Confirming previous findings this study included that children who were more exposed to advertising had a higher susceptibility to advertising messages than those who were less exposed to advertising (Gatou et al., 2016). This study also highlighted that children with greater dental caries experience were more responsive to sweetened foods advertisements (Gatou et al., 2016).

A meta-analysis involving 26 studies that included children between 2 - 18 years of age evaluated the impact of unhealthy food and beverage marketing on dietary preference and intake. The study concluded that preference for the intake of energy-dense, low-nutrition products in children increases shortly after being exposed to advertisements (Sadeghirad et al., 2016). The study further found that children under the age of eight have a higher caloric intake and more often selected unhealthy foods and beverages compared to their older peers, suggesting that younger children are more susceptible to the impact of food and beverage marketing in terms of quantity and quality of food consumed (Sadeghirad et al., 2016). Of the 26 studies included in the meta-analysis, 12 studies examined the impact of TV advertising, nine studies examined licensed characters/logos and six studies analysed advertisements in games (Sadeghirad et al., 2016). The findings were consisted across studies, identifying no differences between TV advertising and advertising on games (Sadeghirad et al., 2016).

Although TV advertising itself is not directly linked to childhood dental caries, the abovementioned discussion on the link between high intake of sugary foods while watching TV and dental caries might have similar mechanisms to the role of television watching and overweight/obesity (Gatou et al.,

2016). Nonetheless, further research exploring the pathways by which screen time influences dental caries is needed in order to draw appropriate conclusions.

A combination of various determinants, some of which were mentioned in the previous section, may influence overweight/obesity and dental caries development in children. The determinants discussed in this research are not definitive and further determinants may be added. The determinants mentioned in this chapter were chosen according to the scope of this research, based on their relevance in the literature and pragmatically, on the data available within the BiB study which is utilised in Study 2 of this PhD thesis. Both studies that comprise this PhD, the qualitative (Study 1) and the quantitative (Study 2), were guided by the conceptual framework adapted here. In Study 1, for example, the interview questions were based on the key determinants as outlined above and in the adapted framework; the selection of variables from the BiB study were derived from the framework. In this way, the framework served as a dynamic guide throughout the PhD process.

The next section focuses on existing studies that have explored the possible association between childhood dental caries and overweight/obesity.

2.8. Systematic reviews on the association between dental caries and overweight/obesity

There has been a great amount of research on the association between dental caries and obesity/overweight as separate conditions. More recently, however, researchers have begun to examine commonalities between the determinants of these two conditions in order to help facilitate understanding and potentially, common risk strategies to tackle increasing prevalence.

Four systematic reviews will be discussed in the following sections. These reviews were included in the PhD thesis prior to data collection and analysis and therefore influenced the study design of this PhD. The literature was subsequently updated as the thesis was prepared for submission and three additional systematic reviews were found. These three reviews will be discussed in a later section, in order to highlight the difference between evidence published prior to and after the current PhD data collection.

The four systematic reviews found prior to data collection were published between 2012 and 2015 and included studies that examined the association between overweight/obesity and dental caries in children and adolescents, between the ages of 0 to 20 years (Hayden et al., 2013, Hooley et al., 2012a, Ribeiro Silva et al., 2013, Li et al., 2015). These systematic reviews included a total of 107 primary studies, ranging from 14 to 48 studies per review paper. The high range of studies included in the scientific reviews is mainly due to differences in the inclusion criteria of primary studies between the scientific reviews. For instance, Hayden and colleagues (2013) only included studies published in the English language and also included a meta-analysis of 14 studies, whereas the other three reviews included all languages. The key characteristics of these four review papers are summarised in Table 1, p. 67-68. In the following sections similarities and differences between the results of these reviews are discussed.

2.8.1. Quality assessments of included studies

Different quality assessment systems were used to assess the methodological quality of the primary studies included in the previous reviews, which makes any systematic comparison across reviews difficult. Hooley and colleagues (2012a) used multiple quality indicators, including: sample selection strategy (stratification/cluster, convenience, and randomisation), procedures to control for cofounders, BMI measures (standardised or non-standardised) and dental caries measures (dental surgery, mirror and probe, parent report, visual inspection and calibration). In the systematic review of Hayden and colleagues (2013), the quality scores of the included studies were assigned based on the University of Wales Quality Assessment, ranging from 4.0 to 10.5. Silva and colleagues (2013) used the Downs and Black criteria to identify high-quality methodologies.

2.8.2. Measurements of childhood overweight/obesity and dental caries

Three of the four reviews included studies using both childhood dental caries and overweight/obesity as outcome measures. The fourth review, a review of longitudinal studies included a majority of studies using early childhood weight as the predictor for dental caries. These differences may have an

influence on the study outcomes. Due to these differences and due to the longitudinal nature, this systematic review will be discussed in a separate section.

Dental caries was mainly measured through different forms of the dmft/DMFT in the systematic reviews. For example, dft, dfs, def, dmft, dmfs, DFT, DMFT, DMFS.

Weight status was assessed through different measures in all four reviews, including standardised versus non-standardised BMI measures, the CDC growth charts as well as IOTF cut-off scores (see Section 2.7.1.1).

Differences in measurement of caries and overweight/obesity may account for some of the discrepancies across the studies' findings. For example Hayden and colleagues' systematic review (2013) concluded that obesity was positively associated with dental caries when the former was measured through BMI. However, the results were inconclusive when z-scores was used to assess obesity. As discussed earlier, BMI is considered an adequate and reliable measure in population studies, due to its cost efficiency. However, BMI does not differentiate between lean body mass and fat body mass. Some studies have used self-reported weight and height to calculate BMI values. Therefore, measurement bias due to social desirability may have occurred in those studies. Furthermore, not all studies included every classification of weight status. Underweight and severely underweight children were underrepresented in many studies, which may influence the findings. For example, Hayden and colleagues (2013) concluded that dental caries was more prevalent in obese children than in normal weight children. However, only studies whose participants were overweight/obese or normal weight were included (Hayden et al., 2013). In the systematic review of Hooley and colleagues (2012a), some studies considered underweight as a separate category whereas others grouped underweight and normal weight children in a single category, which may have influenced the results.

In terms of dental caries, studies that found no association were more likely to use field examination methods instead of dental examinations, allowing for an underestimation of dental caries rates (Hooley et al., 2012a). Initial caries was mainly excluded from studies that found a negative or no association

between BMI and dental caries, which may have led to underestimate the levels of dental caries (Hooley et al., 2012a).

2.8.3. Inverse association between overweight/obesity and dental caries

Studies that found an inverse relationship between dental caries and overweight/obesity, meaning that underweight was associated with dental caries, were mainly conducted in developing countries. For example, Hooley and colleagues (2012a) found the relationship between dental caries and BMI follows a U-shaped curve format. In this study, both high and low BMI were associated with dental caries (Hooley et al., 2012a). The inverse relationship was found in 11 studies, from which the majority were conducted in developing countries. Dental caries severity tended to be higher in studies that found an inverse relationship compared to those that did not (Hooley et al., 2012a).

An explanation for the inverse relationship may be that dental caries may prohibit individuals from consuming enough nutrients due to dental pain and therefore cause underweight. Further, Hooley and colleagues (2012a) indicated that chronic malnutrition in young children is associated with a higher risk of caries development in deciduous teeth. Chronic malnutrition occurs more often in developing countries than in developed countries. These findings are supported by Hayden and colleagues (2013) who suggest that an inverse relationship may be due to the generally poorer eating practices in developing countries. However, due to globalisation and the fast emerging food markets, obesogenic foods have reached non-developed countries, increasing the risk of non-communicable diseases related to diet in those countries (Boutayeb and Boutayeb, 2005).

2.8.4. Positive association between childhood dental caries and overweight/obesity

Some studies have found a positive relationship between dental caries and overweight/obesity, indicating that a higher BMI was associated with higher dental caries scores, and that possibly SES might be associated with the two. People of lower income are often associated with consuming diets high in sugar and fat, resulting in greater risk for caries and obesity development (Public Health England, 2017b, World Health Organisation, 2014a). Those studies that have found a positive relationship between dental caries and overweight/obesity were, as previously mentioned, mainly

conducted in developed countries. Further, these studies showed an underrepresentation of underweight children (Hooley et al., 2012a). This demonstrates problems in the analysis of the data, as underweight children might have been included in the normal weight category leading to a misinterpretation of the data or further, the association between dental caries and overweight/obesity might not have been adequately tested, leaving out underweight categories (Hooley et al., 2012a). Even though compared to developing countries, people living in developed countries, usually have better access to fluoride and health care facilities, those people also have an increased access to fermentable carbohydrates and a diet higher in sugar and fat content, leading to overweight/obesity and dental caries (Hooley et al., 2012a). Additionally, studies that were conducted in developed countries used more specific caries detection methods, allowing for the detection of initial caries. This may explain the number of studies finding a positive association between dental caries and overweight/obesity in developed countries compared to developing countries.

Future studies should include initial caries in the caries category and use identical diagnostic criteria among studies for both dental caries and overweight/obesity, in order to make comparisons easier. Additionally, only few studies have included other determinants that might influence the association between dental caries and overweight/obesity. Future studies should therefore include additional determinants that might influence the association between childhood dental caries and overweight/obesity. Determinants related to the family and parents, such as SES, diet and education level are crucial determinants when studying the development of dental caries and overweight/obesity in early childhood (Hooley et al., 2012a, Hayden et al., 2013).

2.8.5. A systematic review of longitudinal studies

One systematic review mentioned in Table 1 below in this section that has not been discussed yet is the review of Li and colleagues (2015). The review was excluded from the prior discussion, due to the purely longitudinal study design of the included studies. Longitudinal studies provide important scientific evidence that may shed light on the development of overweight/obesity and dental caries. However, findings from longitudinal studies are difficult to compare to those that used other study designs, as obese children might adapt their behaviour to reduce weight resulting in a change of BMI,

whereas dental caries scores will remain high, considering dental caries throughout the life course (Ribeiro Silva et al., 2013). Li and colleagues (2015) included 17 longitudinal studies published between 1995-2014 in their systematic review. The 11,625 included children were between the ages of 0-18 and the follow up period ranged from 1.8 years to 14 years after the first data collection. The studies included were published in the English language and the sample size ranged between 50 and 4207 participants. Eight studies were collected at local primary schools or hospitals and six studies derived from large community samples such as the European Heart Study, the Pelotas 1993 birth cohort in Brazil, the Avon Longitudinal Study of Parents and Children in South West England, and the NHANES III study (Li et al., 2015). Eleven studies reported overweight/obesity and dental caries as primary outcomes, whereas six studies evaluated them as secondary outcomes. Among all included outcomes, 14 studies used early anthropometric measures such as birth weight to predict later dental caries. Overall, the review reached inconsistent results due to nonuniformity in assessments, different ages and ethnicity of participants, and different procedure and measurement settings. In line with the findings of Hooley and colleagues (2012a), dental caries is associated with both high and low weight in children (Li et al., 2015). Also this review concluded that an inverse relation between overweight/obesity and dental caries was mainly found in developing countries (Li et al., 2015). Further, in this review, the lack of standardisation on the assessment of dental caries and overweight/obesity may also explain the inconclusiveness of this review. Dental caries and weight assessment were done by a variety of trained and non-trained staff and students and may have introduced measurement bias. Lastly, only few studies included other determinants such as dietary habits and oral health behaviours. This is in line with the limitations of the previously discussed reviews (Hooley et al., 2012a, Hayden et al., 2013, Ribeiro Silva et al., 2013). Li and colleagues (2015) found that authors of some of the studies included in the review expressed a growing interest in the long term association between dental caries and overweight/obesity in children and call for a more accurate model of relation which covers for example SEM.

Table 1: Characteristics of systematic reviews on the association between overweight/obesity and dental caries

Author, publishing date	Literature search period	Type of analysis and number of studies included (N)	Age of participants	Measurement categories	Types of research designs	Main findings
Li et al., 2015	1995-2014	SR[6] of longitudinal studies N=17	0-18 years	**Overweight/obesity** BMI (categories), waist circumference, waist-to-hip ratio, skinfold thickness, other nutritional status categories **Dental caries** deft, dfts/DFTS, dft/DFT, dmfs, dmfs in ICDAS codes 1–6, dmfs in ICDAS codes 3–6; DMFS, dmft/DMFT, DFMT of incisors and molars; dt/DT, and any other indices	7 cohort 7 case-control 2 cross-sectional nested in birth cohorts 1 with cross-sectional and longitudinal findings	Conflicting evidence, one third of the included articles found no association and more than a quarter reported conflicting results.
Hayden et al., 2013	1980-2010	MA[7] N=14	1-18 years	**Overweight/obesity** BMI or z-scores **Dental caries** Dft, dfs, def, dmft, dmfs, DFT, DMFT, DMFS	1 longitudinal 13 cross-sectional	Overall, a significant relationship between childhood overweight/obesity and dental caries was found.
Ribeiro Silva et al., 2013	2005-2012	SR N=28	6-20 years	**Overweight/obesity** BMI **Dental caries** dmft, DMFT/dmfs, DMFS	11 cross-sectional 1 case-control 1 prospective longitudinal	Not enough evidence was found regarding the association of childhood obesity and dental caries.
Hooley et al., 2012a	2004-2011	SR N=48	0-18 years	**Overweight/obesity** BMI **Dental caries** DMFT, ds, DFS/dfs, def, estimation, parent report	40 cross-sectional 6 prospective longitudinal 2 case-control 1 retrospective longitudinal	Conflicting evidence was found on the existence and nature of an association between childhood dental caries and BMI

[6] Scientific review
[7] Meta-analysis

2.8.6. Update on the reviews

This section gives an update on the literature review from January 2018 until November 2019. Three additional systematic reviews and two included meta-analysis were found investigating the relationship between anthropometric measures and dental caries in children. These studies are detailed in Table 2 in this section.

Angelopoulou and colleagues (2019) included 32 studies in the systematic review from which 12 qualified for a meta-analysis. The studies included had no date or language restrictions, but only included pre-school children six years and under, where the age range was from five months to six years of age. All studies were cross-sectional, published between 1982 and 2017 and conducted in 15 different countries. The median sample size of the included studies was 355. Eleven studies found that underweight children had a higher caries rates and nine studies indicated that overweight/obese children had higher caries rates. Eleven studies found a non-significant difference between overweight/obesity and caries rates. The meta-analysis indicated that overweight and obese preschool children were at greater risk of developing dental caries than normal or underweight children (Angelopoulou et al., 2019). However, due to the cross-sectional nature of the studies, results are considered of lower quality and have a relatively high risk of bias. The findings of the systematic review and the meta-analysis align with the findings of the previous reviews detailed in the previous section, indicating overall inconclusive results.

Manohar and colleagues (2019), as did Li and colleagues (2015) presented in Section 2.8.5, only included longitudinal studies in their systematic review and meta-analysis. Children aged six years and younger were included in their systematic review of nine studies and meta-analysis of six studies. For overweight/obesity BMI measurements were used for identification and for dental caries the dmft and the International Caries Detection and Assessment System (ICDAS). The International Caries Detection and Assessment System II (ICDASII) recognises early enamel lesions and categorises them according to their stage of development (Doifode et al., 2018). The method is globally recommended for dental health surveys (Doifode et al., 2018). Studies included in the review were cross-sectional. Six studies were conducted in high-income countries, two in upper middle income and one in a lower

middle-income country (Manohar et al., 2019). Six studies indicated significantly higher caries experience among children with overweight/obesity, one further study indicated similar but not significant results, and two studies found no significant differences (Manohar et al., 2019). Limitations of this review include an underrepresentation or exclusion of underweight children and that studies were almost solely conducted in developed countries. The results do, however, align with the reviews of Li and Hooley concluding that a positive association was mainly found in developed countries (Manohar et al., 2019, Hooley et al., 2012a, Li et al., 2015).

The third review of Paisi and colleagues (2019) included 86 studies although nearly all were rated as low quality, with results drawn mainly from the seven studies which were higher in quality. The studies included in the review were published between 1980 and 2014 and included studies published in English. Thirty nine studies were conducted in very high human development countries, 28 in high-, 14 in medium-and three in low human development countries (Paisi et al., 2019). Overweight/obesity was measured through various BMI measurements and dental caries was mainly assessed through visual examination of tooth surfaces using the WHO criteria. Twenty-six studies found a positive relationship, 19 found an inverse relationship and 43 found no association (Paisi et al., 2019). Of the seven studies which were higher in quality, five found no association between dental caries and BMI and two found a positive association. Those two were both conducted in India. These results differ from the other scientific reviews concluding that a positive association is mainly found in developed countries (Hooley et al., 2012a, Li et al., 2015). However, as mentioned in an earlier section, obesity rates have been found to increase due to a wider availability of diets high in sugar and fat in developing countries. Another possibility might be an increase in affluence in India which may provide people with greater means and economic flexibility in terms of food consumption (Paisi et al., 2019).

Table 2: Updated list characteristics of systematic reviews on the association between overweight/obesity and dental caries

Author, publishing date	Literature search period	Type of analysis and number of studies included (N)	Age of participants	Measurement categories	Types of research designs	Main findings
Angelopoulou et al., 2019	1982-2017	SR[8] N=32 MA[9] N=12	0-6 years	**Overweight/obesity** BMI **Dental caries** dmft, dmfs	Cross-sectional	The results of the systematic review were inconsistent however those of the meta-analysis suggested that overweight/obese children were at higher risk having early childhood caries.
Manohar et al., 2019		SR N=9 MA N=6	0-6years	**Overweight/obesity** BMI-for-age centiles (CDC), BMI z-scores, (WHO), BMI categories (IOTF), BMI as a continuous variable. **Dental caries** dmf, dmft, dmfs, defs, dfs	5 cohort 6 case-control	Low levels of parental education and parental low income were associated with both conditions. Children with overweight/obesity were more vulnerable to dental caries.
Paisi et al., 2019	1980-2014	SR N=7	1-18 years	**Overweight/obesity** BMI-for-age centiles and -z-scores **Dental caries** dmft/DMFT, dmfs/DMFS	Cross-sectional	Evidence for an association between overweight/obesity and dental caries in children was inconsistent.

[8] Scientific review

[9] Meta-analysis

2.8.7. Discussion of all reviews

To date (2012-2019) seven systematic reviews and meta-analysis on childhood overweight/obesity and dental caries have been carried out. The findings of these suggest a possible positive association between childhood overweight/obesity and dental caries in some studies (Tables 1 and 2, Section 2.8). Yet, a number of studies reported an inverse or non-significant relationship between the two conditions. An inverse relationship means that childhood dental caries was associated with underweight instead of overweight/obesity. This has been found especially in developing countries (Hooley et al., 2012a, Li et al., 2015). Dental caries might cause children to eat less due to pain which may lead, over time, to undernutrition. In those countries, dental pain due to dental caries might be experienced for longer periods due to limited access to dental care facilities, when compared to developed countries. At the same time, children that experience chronic malnutrition, for example due to nutrient shortage in some developing countries, are more prone to developing dental caries than those who are nutritionally healthy (Hooley et al., 2012a, Hayden et al., 2013). Dental caries severity has been found to be higher in studies that reported an inverse relationship compared to those that found a positive or non-significant association.

In addition, many previous studies have had an underrepresentation of underweight children, leading to a misinterpretation of the data, as the association of dental caries was not tested across the whole range of BMI scores (Hooley et al., 2012a). Further, in those studies where underweight children were underrepresented, it must be assumed that underweight was merged into the same category as normal weight since underweight children were not specifically excluded from the study population (Hooley et al., 2012a, Hayden et al., 2013). If underweight children were included in the normal weight categories and underweight children have higher rates of dental caries than normal and overweight/obese children as for example found in some studies (Mishu et al., 2013, Acs et al., 1992, Oliveira et al., 2008), included in the systematic reviews of Hayden and colleagues (2013), Hooley and colleagues (2012a), and Angelopoulou and colleagues (2019) then the normal weight categories will be inflated and cause either an association between normal weight and dental caries or inconclusive results. Therefore, the individual categorisation of all BMI categories is important for the

results and to enable a comparison between studies. Although the purpose of this study was to find an association between childhood dental caries and overweight/obesity and not underweight and therefore an underrepresentation of underweight children in the sample does not influence the possible association between overweight/obesity and dental caries.

Additionally, different measurement categories were found between the studies. For example, in studies in the review of Silva and colleagues (2013), some studies used the IOTF obesity classifications while others used percentiles developed by the CDC or other measurements. Similarly, this occurred for the assessment of dental caries. Some studies used dmft, other dmfs and some were assessed through interproximal radiographs or through surfaces or decayed teeth. Depending on the quality of the assessment, underrepresentation for example of dental caries could lead to inconclusive results. Differences in assessment make study comparisons difficult and appropriate obesity measurement and reporting need to be promoted (Ghesmaty Sangachin et al., 2018).

In term of other methodological differences most studies included in the reviews were cross-sectional, having not always assessed exposure prior to outcome and are therefore not able to conclude causality (Angelopoulou et al., 2019, Ribeiro Silva et al., 2013, Paisi et al., 2019), where Li and colleagues (2015) and Manohar and colleagues (2019) only included longitudinal studies in their systematic reviews. Longitudinal designs of the studies usually ensure a higher quality of the studies, as the relationship between risk factors and the development of the disease over time can be better evaluated than for example in studies with a cross-sectional design (Caruana et al., 2015). In the review of Li and colleagues (2015) seven studies predicted childhood dental caries by birthweight and/or birth height, from which only two found a positive association. Six studies predicted childhood dental caries by height and/or weight and found an inverse association when assessing dental caries by height and weight and by height only. Five studies used BMI as the predictor for childhood dental caries and results were less clear between the studies, were one study reported a positive association, one an inconclusive association and three others no association. Lastly, two studies used baseline dental caries as a predictor for BMI, and both found an inverse association. These findings show that when studies were designed similarly in terms of predictor and outcomes, results showed similarities. This is confirmed by the findings of the other systematic review of longitudinal studies. In the systematic

review of Manohar and colleagues (2019) dental caries was predicted by BMI in all included studies. Here, six out of the nine studies included in the meta-analysis reported that overweight/obese children had significantly higher dental caries experiences than children with normal weight (Manohar et al., 2019). This highlights the importance of similar study predictors and outcomes when comparing studies with one another.

Further sample sizes varied between the different studies, making comparisons between them difficult. For example, Rodriguez and colleagues (2015) only included 60 3-6 year old children in their study aiming to assess salivary flow, nutritional status and dental caries and findings that normal weight was associated with dental caries instead of overweight and obesity whereas Pikramenou and colleagues (2016) included 2180 children between the ages of 2.5 and 5.9 years. The authors found that overweight/obese children were more likely to have a higher dmfs than normal weight children (Pikramenou et al., 2016). Both studies were included in the review of Angelopoulou (2019) and indicate the range of study participants included.

Evidently, the sampling process of participants within the studies included in the reviews varied, leading to possible differences in study outcomes. For example in the review of Paisi and colleagues (2019) the included study of de Jong-Lenters (2015) sampled children between the ages of 5-8 at a referral centre for paediatric care in one town in the Netherlands, whereas Hong and colleagues (2008) used data from a national representative cohort study in the United States. These differences even though accounted for in the systematic review (Paisi et al., 2019) might partially explain the overall inconclusiveness in the findings.

In terms of determinants of childhood dental caries and overweight/obesity, only some studies included multiple determinants of the conditions. For example SES was included in some studies in the review of Hayden and colleagues (2013) (Oliveira et al., 2008, Wärnberg Gerdin et al., 2008), diet (Alm et al., 2008) and education level of the parent (Marshall et al., 2007) was included in Hooley and colleagues (2012a). It is therefore difficult to understand multiple predictors which may be common to both conditions and a need to understand the mechanisms behind the possible association of childhood dental caries and overweight/obesity has been proposed (Paisi et al., 2019). For example, in some

studies, age may be considered alongside feeding style, whilst in others, the researchers may have considered SES but not parental health status. This means it is difficult to understand the complexity of the factors which facilitate the development and maintenance of childhood obesity/overweight and caries.

The following section outlines the rationale for the PhD leading from the results of these reviews on childhood overweight/obesity and dental caries.

2.9. Rationale for the PhD

The review of the literature on the determinants of dental caries and obesity/overweight shows a large amount of research carried out on both conditions. The models and frameworks of health described in Chapter 2 summarised the shift from a biological viewpoint of disease to a more comprehensive approach on the social determinants of health models and to specific versions of the social determinants of health adapted to overweight/obesity and dental caries. They detail the multiple causes and impacts of each condition, as well as their growing prevalence worldwide.

With this in mind, many researchers have in recent years begun to explore the communalities between these two conditions. The outline of the systematic reviews to date that have explored these communalities suggest that further research is needed, using common assessment tools for both conditions and incorporating a wider range of determinants for both dental caries and overweight/obesity to better understand the current inconclusive findings (Li et al., 2015, Paisi et al., 2019). The above discussion on the review papers highlights the existing inconclusiveness and lack of consensus on the current debate on the possible association between overweight/obesity and dental caries (Hooley et al., 2012a, Paisi et al., 2019).

In addition, the differences in the study design, and the heterogeneities concerning the measurements and control for confounders among primary studies restrict the comparison between them. Thus far, most studies have included various anthropometrical scores to identify overweight/obesity and various caries assessment and identification tools. However, only a few studies have considered social determinants, such as SES, diet or family status when looking at the association between dental caries

and overweight/obesity (Li et al., 2015, Paisi et al., 2019). As suggested in these systematic reviews, there are likely to be a number of common determinants underpinning childhood dental caries and overweight/obesity.

Some of the frameworks that have been developed to understand the determinants of health were explored, and those relating to oral health and obesity were outlined and discussed. However, by taking each condition separately, it is not possible to understand the complexity underpinning the development and/or maintenance of overweight/obesity and caries in children (Li et al., 2015). As there is a lack of frameworks on childhood overweight/obesity and dental caries, the conceptual framework in Section 2.7 has been developed and has been used to guide the current research. The framework can be applied to understand the determinants which may potentially link these two conditions. The framework has been adapted from the social determinants of health framework which classifies determinants of health into four different levels: individual level, family level, community level and national level (World Health Organisation, 2010a). The main focus of this study is, however, on the child- and family-level influences only for pragmatic reasons (i.e. availability of data) and because children in the age group from birth to 11 years (the focus of the current PhD) are mainly found to be influenced by their family in terms of decision making around health-related behaviours (such as, sugar consumption, toothbrushing) (Pyper et al., 2016).

Some of the determinants such as diet (World Health Organisation, 2016b, World Health Organisation, 2016a, World Health Organisation, 2003), SES (Mattheus, 2010, Peltzer et al., 2014, Williamson et al., 2008a, Kumar et al., 2016a, Lima et al., 2016, Slade et al., 1996, O'Dea and Dibley, 2010, Jin and Lu, 2017), health beliefs and health behaviours of the parents (Lazarou et al., 2008) seem to influence both the development of overweight/obesity and dental caries in children. Other factors such as fluoride use (Tubert-Jeannin et al., 2011) or physical activity (Cinar et al., 2011, World Health Organisation, 2016a) influence either dental caries or overweight/obesity. Previous studies show inconsistent findings regarding the relationship of some determinants with overweight/obesity and dental caries, such as sleep duration (Li et al., 2017, Lee and Lee, 2017). As such the adapted conceptual framework aimed to identify some of the links between overweight/obesity and dental

caries in children that have already been investigated, but in addition also identifies determinants for which results are at present inconclusive.

Much of the research to date on the association between childhood dental caries and overweight/obesity have been quantitative, with few qualitative studies carried out. Yet, qualitative studies can create a better – more nuanced and detailed - understanding on the cultural and personal understanding of health and disease (Ulin et al., 2005) and may therefore be crucial in finding possible new determinants for childhood dental caries and overweight/obesity. In addition, given their added depth, qualitative studies on the association between childhood dental caries and overweight/obesity may help shed light on reasons for the inconclusive results of some quantitative studies to date.

The overall aim of this research was to examine common risk factors and determinants for overweight/obesity and dental caries in the family setting of children between the ages of 0 and 11 years of age. The first objective was to identify commonalities between available frameworks in the literature and to develop a new framework on the common determinants of childhood overweight/obesity and dental caries. The proposed conceptual framework outlined in Section 2.7 was used to guide both the qualitative and quantitative studies, which make up this PhD. The qualitative study (Study 1) aimed to explore parents' experience of their child's overweight/obesity and dental caries in more depth utilising semi-structured interviews. The interviews with parents focused on the determinants as outlined in the conceptual framework. The framework was also used to guide the analysis of the interviews, determining codes, and themes within and between interviewees. The quantitative study (Study 2) aimed to examine the determinants of childhood overweight/obesity and dental caries according to the proposed framework using longitudinal cohort data of the BiB study, dental GA data and data from the oral health survey of 5-year old children 2014/2015. The conceptual framework was used to guide the selection of variables (and subsequent measures) and the SEM analysis.

Utilising this adapted framework, the two studies within this mixed methods PhD research aimed to generate a more in-depth and comprehensive understanding on the possible association between overweight/obesity and dental caries in children.

3. METHODS

This chapter describes the benefits and limitations of quantitative and qualitative research designs, and the advantages and key features of the most widely used mixed method research designs. The justification and rationale of using the triangulation research design as a specific mixed method approach for this PhD is then discussed.

Mixed method studies have become increasingly popular in research in recent years (Conversations at QSR International, 2017) as they combine both qualitative and quantitative research techniques into a single study (Johnson and Onwuegbuzie, 2004). This, in turn, is suggested to increase understanding and strengthen the conclusions of the research (Schoonenboom and Johnson, 2017).

A mixed method design was employed to address the research aims and to meet the objectives of the PhD. By using a mixed method approach, the theoretical framework was tested through two separate albeit interlinked studies using qualitative and quantitative methods. In the qualitative study (Study 1, Chapter 4), semi-structured interviews were conducted with the parents of children between 5 to 11 years old who participated in the ANK programme in Sheffield. Personal experiences of parents were explored through open questions covering family beliefs and habits related to oral health and dietary behaviours, and physical activity related to their children's experience of obesity and dental caries. Framework analysis allowed the researcher to identify and add new variables into the theoretical framework. The quantitative study (Study 2, Chapter 5) tested the relationships of parental and child influences with BMI and dental caries in children using longitudinal data from the BiB Cohort Study (Born in Bradford, 2017). This data was linked to dental data of the same participants deriving from dental GA sessions and the oral health survey of five-year-old children 2014-15 and was analysed using SEM according to the theoretical framework.

Before explaining the mixed method approach in greater detail, it is important to understand the concepts of qualitative and quantitative research which are discussed below.

3.1. Concepts and descriptions of mixed method study designs

Qualitative research is inductive or bottom-up research that focuses on understanding a phenomena from a scientific point of view in which the investigators are interested in the meaning of certain topics and how people experience or make sense of certain situations (Ulin et al., 2005). There are different methods to collect qualitative data, including semi-structured interviews, focus-group discussions and observations (Ulin et al., 2005). The data is often gathered in an exploratory way using open questions, which means that the researcher is not guided by a pre-established hypothesis and does not follow a pre-established sequence of questions. In qualitative research, data collection guides the research and, as a consequence concepts and frameworks are developed, and possible hypothesis are generated (Ulin et al., 2005). Data is often obtained using a non-random and a non-representative sample as the main purpose of qualitative study is to understand participants' perspectives and not to generalise the findings to the population (Ulin et al., 2005)

Quantitative research on the other hand is done systematically by the researcher, who collects numerical or quantifiable data, which are usually analysed by statistical techniques (Verhoeven, 2008). Quantitative research is considered deductive research, using measurements to examine explanations or cause and effect associations (Peat, 2001). It is most often used to give a broad understanding of a certain topic through analysing large datasets (Peat, 2001). Quantitative data are commonly obtained through questionnaires (online, face to face, household, telephone), clinical (dental/medical) examinations, medical/dental files (secondary data), laboratory exams, among others (Verhoeven, 2008, Peat, 2001).

As a large quantity of determinants was needed for this research, secondary analysis was chosen as the quantitative research for this PhD. With this method, the researcher does not have an influence on the composition of the data, as data has already been collected (Verhoeven, 2008). However, the advantage of using secondary data in academia for analysis are saving time and financial resources (Verhoeven, 2008). For this PhD, time and financial restrictions limited the researcher to conduct primary data of a large number of determinants in a cohort of participants over time. Nevertheless, primary data, in the form of interviews was still collected in the qualitative study of this PhD.

Together, the quantitative data analysis of the secondary data and the qualitative data collection form a mixed method research design.

As can be seen, mixed method research designs – such as that employed in this PhD - incorporate aspects of both qualitative and quantitative methods and therefore shed light on a research problem from two different perspectives (Tashakkori and Teddlie, 2003). As such, the mixed method approach combines the strengths, presented earlier, of both quantitative and qualitative research to generate a greater understanding of a certain topic (Schoonenboom and Johnson, 2017).

There are different types of mixed method research designs. One of the key differences among them is the weighting difference between the qualitative and the quantitative part of the mixed method study, where one of them may be weighted higher than the other. Further, the temporal relationship between the two makes a difference in the design. The order in which the qualitative and quantitative study are conducted, either sequential or simultaneously has an influence on the type of mixed method design. The four major types of mixed method designs are (1) embedded, (2) explanatory, (3) exploratory and (4) triangulation (Creswell and Plano Clark, 2006). Each of the four mixed method designs can be subdivided into different research designs. In the following paragraphs, the four mixed method designs will be described followed by a paragraph highlighting the justification for adopting the triangulation design for this PhD.

3.1.1. The embedded design

In the embedded design, the qualitative or quantitative study is the dominant study, and the other type of study has a secondary role, which is mainly based on the previous data type (Creswell and Plano Clark, 2006). For example, when planning a clinical trial (e.g. quantitative design), a qualitative study may be embedded into the main research to examine patients' perceptions of the intervention. Therefore, the qualitative study only makes sense, if it follows from the clinical trial.

3.1.2. The explanatory design

The explanatory design is a two-phase design in which the qualitative findings are used to explain the results of a previously conducted quantitative study (Creswell and Plano Clark, 2006). Although this design might have similarities with the embedded design, the explanatory design is a more in-depth understanding of the study's findings. For example, significant or non-significant results are explored in the qualitative study. In the embedded design, the second study is not necessarily linked to the same outcome measure but rather to the existence of the previous study.

3.1.3. The exploratory design

The exploratory design is also a two-phase design where the researcher starts with a qualitative study and is then sequentially followed by a quantitative design (Creswell and Plano Clark, 2006). This research design is often used when measures or instruments are not yet available in the field or there is no guiding theory or framework (Creswell and Plano Clark, 2006). The design is used for example when frameworks are explored and designed through qualitative data and then tested with larger, quantitative datasets (Creswell and Plano Clark, 2006). In this design a greater emphasis is often placed on the quantitative data as the study starts with that (Creswell and Plano Clark, 2006). The chosen design for this PhD, the triangulation design will be elaborated on in the following section.

3.1.4. Triangulation

Of all four of the mixed designs, the triangulation method is the most commonly used (Creswell and Plano Clark, 2006). In the triangulation design, the qualitative and quantitative research methods are simultaneously conducted and the evidence generated from their findings are equally considered (Creswell and Plano Clark, 2006). It is therefore also considered a one-phase design in comparison with the previously discussed two-phase designs, both studies are done at the same time, in one-phase (Creswell and Plano Clark, 2006). Triangulation aims to bring together the differing strengths of qualitative and quantitative research designs (Creswell and Plano Clark, 2006). This design is used when a researcher wants to compare or validate quantitative results with qualitative data. The purpose is to come to a valid and well-substantiated conclusion about the problem (Creswell and Plano Clark,

2006). The strengths of the triangulation method are the high efficiency in terms of time, due to the concurrent data collection, as well as a reduction in bias, as results of one study cannot influence the design of the other (Creswell and Plano Clark, 2006).

There are four different variants of the triangulation design, namely the convergence model, the data transformation model, the validating quantitative data model, and the multilevel model (Creswell and Plano Clark, 2006). The following paragraphs will briefly describe the key characteristics of each type, before describing the chosen method for this research in more detail.

When using the data transformation model, the researcher collects and analyses the qualitative and the quantitative data separately. After the analysis, one data type is transformed into the other; qualitative data are being quantified or the other way around. For example, the themes of a qualitative study are being scored dichotomously in the quantitative data as e.g. present or not present (Creswell and Plano Clark, 2006). The quantified scores are then used within the quantitative analysis (Creswell and Plano Clark, 2006).

The validating quantitative data model may be used if researchers want to expand their quantitative survey for example and add an additional open ended questions to the survey (Creswell and Plano Clark, 2006). Both types of data are therefore conducted with one survey instrument and the data is analysed through quantitative methods. The additional open-ended question helps the researcher to validate their quantitative research findings with a quote of the participant for example (Creswell and Plano Clark, 2006).

The multilevel model investigates different levels within a system or study setting through separate methods (quantitative and qualitative), the findings will be merged to one overall interpretation (Creswell and Plano Clark, 2006). One example could be to investigate employee counselling services within a big enterprise. The researcher may opt to use qualitative data at the management level and quantitative level at the organisation level (Creswell and Plano Clark, 2006).

The most frequently used and traditional model is the convergence model, also called the concurrent triangulation design or convergent parallel design (Creswell and Plano Clark, 2006, Watkins and Gioia, 2015, Center for Innovation in Research and Teaching, 2018). The qualitative and quantitative

data are collected concurrently but analysed separately (Watkins and Gioia, 2015). The different results are compared and contrasted during the interpretation (Creswell and Plano Clark, 2006). This way of data analysis allows the researcher to use traditional analysis methods for both qualitative and quantitative methods in a separate way, ensuring a clear analysis structure. Further, this method is considered highly efficient in terms of time as both studies are conducted and analysed simultaneously (Creswell and Plano Clark, 2006). Some of the challenges include the different characteristics of the samples and different sample sizes of the qualitative and quantitative designs when combining the two studies and finding a strategy to come to conclusions in a meaningful way (Creswell and Plano Clark, 2006).

3.2. Justification of the triangulation research design

As discussed in Section 2.8, previous systematic reviews of quantitative studies have found inconclusive results on the association between childhood dental caries and overweight/obesity (Hayden et al., 2013, Hooley et al., 2012a, Ribeiro Silva et al., 2013, Paisi et al., 2019, Angelopoulou et al., 2019). Further, no previous qualitative reviews have been published on the determinants of childhood overweight/obesity and dental caries. Several qualitative studies have researched the determinants of either overweight/ obesity (Appleton et al., 2017, Walsh et al., 2017, Pocock et al., 2019, Mazarello Paes et al., 2015, Chatham and Mixer, 2019) or dental caries (Duijster et al., 2015), and evidence on the link between childhood overweight/obesity and dental caries is scarce.

Therefore, following the aim of this study, to explore common risk factors and determinants for overweight/obesity and dental caries in the family setting of children, the first study of this PhD is a qualitative study involving semi-structured interviews with parents of children enrolled in the ANK programme in Sheffield, UK. Study 2 is a quantitative study using SEM to explore data from the longitudinal cohort study BiB which itself was set up to understand the determinants of childhood and adult disease (Born in Bradford, 2017).

Even though the studies were conducted in a sequence, the results of the qualitative study did not influence the research design of the quantitative study, which was conducted afterwards. The

sequential study design was merely due to the timing of ethical approval in this study. As both studies are equally considered and non-influential of one another, the triangulation convergent parallel mixed method design was chosen to meet the aims of this PhD (Center for Innovation in Research and Teaching, 2018). After the separate analyses of the two studies outlined in Chapters 4 and 5, the study findings will be discussed and compared in Chapter 6 and referred back to the conceptual framework developed in this PhD (detailed in Section 2.7, Figure 4, p. 40).

The following chapter describes the qualitative study of this PhD, including a separate method section, which will outline in detail the methodology used, followed by a description of the results, a discussion of the key findings and how they relate to previous literature in the field, followed by a brief conclusion.

4. STUDY I: EXPLORING PARENTS' EXPERIENCES OF THEIR CHILD'S WEIGHT AND DENTAL CARIES

4.1. Introduction

This chapter presents the qualitative study of this PhD. The chapter starts by introducing previous studies in the field followed by the rationale and aim of the study. Following this, the research design and methods are described including a description of the setting, sampling and recruitment procedures, data collection, and the ethical processes. Following the method, the analytic process is described, and the key findings are introduced. The chapter ends with a discussion of the findings. The final conclusions will be presented together with those of the quantitative study in Chapter 7 of this PhD thesis.

4.2. Research to date

Most of the research that has been conducted on overweight/obesity and dental caries in children today has already been presented and discussed in Chapter 2 of this PhD thesis. Therefore, this section only briefly summarises and brings together the main references in both fields.

Worldwide, overweight and obesity rates in children have significantly increased over the last decade (World Health Organisation, 2016a). In 2015, in the UK, every fifth child in reception (4 years of age) was either overweight or obese (UK Government Statistical Service, 2017). In addition, just under every fourth child in the UK at that age has current or treated dental caries (UK Government, 2017a). As previously discussed in Section 2.8, the relationship between overweight/obesity and dental caries has been investigated although the findings to date remain inconclusive (Hooley et al., 2012a, Hayden et al., 2013, Ribeiro Silva et al., 2013, Angelopoulou et al., 2019, Paisi et al., 2018, Manohar et al., 2019, Li et al., 2015). Several possible explanations for these inconclusive findings have been discussed in detail in Section 2.8.9. To briefly recap, measurement differences between the different studies may have been one of the main reasons. This is because whilst most of the studies have assessed the link between dental caries measured using the dmft index and weight, measured using

BMI, other studies have used a range of indices including dmfs, dfs and for body weight, waist circumference (Li et al., 2015). This has made a comparison between studies difficult. Further, an underrepresentation of underweight children, may have resulted in outcome bias in some of the studies, highlighting the possible link between overweight/obesity and dental caries and leaving out results on a possible association of underweight and dental caries (Hooley et al., 2012a). Furthermore, the majority of studies have been conducted cross-sectionally and in high-income countries. It is also interesting that all studies to date have utilised quantitative methods whilst it could be argued that qualitative approaches (e.g. interviews, focus groups, online forums) may be particularly useful for understanding – in detail - the links between weight and caries from the parent or child's perspective.

As parents have a great influence on their children's health during younger years, as described in detailed in Chapter 2, parents' experiences of possible common factors that are associated with overweight/obesity and dental caries within the life of the family should be explored in order to understand the possible inter-relationships, as well as any common determinants. To date, there has been some research conducted on parents' experiences regarding overweight/obesity and dental caries in children, however, thus far research has merely focused on either one or the other (Amin and Harrison, 2009, Appleton et al., 2017, Duijster et al., 2015). For example, Duijster and colleagues (2015) conducted interviews and focus group discussions with parents in the Netherlands, aiming to identify perceptions of parents as to the barriers and facilitators that influence oral health behaviours in children. It was concluded that many parents had sufficient knowledge about the correct tooth brushing techniques and required frequency and dental caries development, however, they reported a lack of help to implement dental caries preventive measures (Duijster et al., 2015). The authors suggested the need for training to enhance parenting skills and a focus on parental self-efficacy and belief in future preventive programmes (Duijster et al., 2015). Other studies have conducted similar research on overweight/obesity (Turner et al., 2012, Schalkwijk et al., 2015). For example, Schalkwijk and colleagues (2015) conducted semi-structured interviews with parents and their children (mean age 10 years) in the Netherlands to identify barriers and facilitators of making lifestyle changes (to lose weight) that parents and children faced within their social context (within family, school and amongst friends and peers). Parents reported struggling in adhering to recommendations for behavioural

changes that would benefit their children's health and often lacked the support of other family members. This suggests that as with caries prevention, parents had sufficient knowledge on the prevention of overweight/obesity however lack help in implementing these measures. The authors (Schalkwijk et al., 2015) further highlighted the importance of the wider social environment, outside of the direct family. Children mentioned that peers encouraged them to reach their goals, however, bullying often discouraged children to change their behaviours. Further, children mentioned a lack of parental support in behavioural change and inconsistency in rules at home (Schalkwijk et al., 2015). These findings further suggest a need in support for preventive and management strategies for overweight/obesity within the direct family setting and the wider social environment (Schalkwijk et al., 2015).

To date, there have been no studies utilising qualitative approaches to understand more about the factors within the family environment that influence both the development of overweight/obesity and dental caries in children - from the parents' perspective. Therefore, the present study aimed to explore parents' experience of the factors related to the development of overweight/obesity and dental caries in their children. The study was based on the conceptual framework outlined in Section 2.7, as such it was used to derive the interview questions and to drive the data analytic strategy. The parents invited to take part in the study were those of five to eleven-year-old children who participated in the ANK programme in Sheffield, UK. The following section describes the research design and methods of the study in detail.

4.3. Research design and methods

4.3.1. Qualitative research methods

In qualitative research there are three main data collection methods one needs to consider; interviews, focus groups and observations (Barrett and Twycross, 2018). All three methods are briefly discussed in the following section and a justification for the chosen method for this study - interviews - is outlined.

Focus group discussions are usually used for gathering information on collective views (Gill et al., 2008). For example, a study on oral health experiences among children with learning disabilities conducted by Yesudian and colleagues (2012) chose a focus group discussion as data collection method to stimulate discussion on oral health experiences with and among the children. Focus group discussions usually consist of 6-14 participants and the researcher (Gill et al., 2008). This setting allows the researcher to gain knowledge of multiple people at the same time, and therefore being the most efficient data collection method in terms of time (Barrett and Twycross, 2018). Focus groups further often enhance a deep-level of discussion, as many people are talking about the same issue and inspire each other to think about the topic from many angles (Barrett and Twycross, 2018). Participants often see this method setting as most relaxed compared to one-to-one interviews (Barrett and Twycross, 2018). However, focus group discussions also bare limitations. Quieter participants or participants who may not feel comfortable speaking about certain subjects in a group, may contribute less to the discussion than more dominant participants (Stewart and Shamdasani 2015). This may cause some members of the discussion not being able to express their full thoughts on the topic and may lead therefore to incorrect or biased interpretations of the resulting data (Stewart and Shamdasani 2015). Furthermore, focus group approaches can be very time consuming in both conduction and analysis (Barrett and Twycross, 2018, Gill et al., 2008).

Observations conducted in social science are mainly centred around child development, education, medical sociology and some psychological research (Ritchie et al., 2014). Even though observations are a valid research method on their own, observations in social science are rarely used as a central method within the research, but rather as an approach within the methodology (Ritchie et al., 2014). For example, observations may be conducted of participants within focus-group discussions (Stewart and Shamdasani 2015). Observations give researchers the possibility to capture a vast amount of data on non-verbal and verbal communication. The researcher further gains a first-hand picture on what is happening in the research field, by observing what is happening in the research setting (interviews, etc) (Barrett and Twycross, 2018). The following limitations of the observation method should be considered; (1) participants often change their behaviour once they know that they are being observed (Barrett and Twycross, 2018), this has often to do with the role of the observer within the studied

population, therefore (2) the researcher may collect data that is not reflective of 'true' behaviour (Mulhall, 2003) and (3) as it is in the case of the focus group discussion, the observational approach can be highly time consuming.

Lastly, the interview method, which is considered the qualitative method that gives the most direct and straightforward information on a research topic, as participants are asked personally and given quotes of participants gives a researcher less room for interpretation, compared to the observational method (Barrett and Twycross, 2018). Interviews are usually conducted in a one-to-one setting, private setting, allowing the researcher to ask direct questions on a possibly sensitive issue. Conducting interviews can be done in various ways and usually differs from one another in terms of structure. Interviews may me open or unstructured, where the researcher prepares one questions or statement that leads the whole interview. The interviewer and interviewee in this case guides the process of the interview. This method is often used if the interviewer is interested in a narrative or in the story of the interviewee or if very little is known about a subject (Gill et al., 2008). Structured interviews follow a tighter format of previously set interview questions and leave no room to add any additional questions any adaptation of the questions (Gill et al., 2008). This method will often produce quantitative data (DiCicco-Bloom and Crabtree, 2006) and is therefore sometimes considered easier to analyse due to its structured format, however leaves no room for freedom or flexibility (Barrett and Twycross, 2018, Gill et al., 2008). Finally, semi-structured interviews allow the researcher to explicitly ask about the topic being researched and at the same time leaving room for the interviewees to express their own experiences and comments in the discussion (Gill et al., 2008). Semi-structured interviews are most often used in healthcare and with its flexibility in terms of structure, allows the researcher to discover or explore information (Gill et al., 2008). Interviews, as do all other methods of qualitative require a lot of time in transcribing and analysing (Barrett and Twycross, 2018). Further, the interviewer needs to be careful in avoiding bias, possibly leading interviewees to preferred answers, by non-verbal signals or leading questions (Barrett and Twycross, 2018).

4.3.2. Justification of the chosen research method

All of the above presented methods have strength and limitations and should be carefully chosen based on the aim and the research question. For this research, the aim was as described in Section 2.9 to explore parents' experience of their child's overweight/obesity and dental caries. To meet this aim, it was felt that either focus-group discussions or interviews were a suitable tool to gather detailed information on parent's experience of these topics. Given that some information may be sensitive and parents may not wish to discuss these topics in a wider group because of, for example, shame or embarrassment (Sim and Waterfield, 2019), semi-structured interviews were chosen as the research approach. The interview setting gave parents a private space to talk about their concerns and experiences. Semi-structured interviews gave the researcher the possibility to clearly define some of the interview questions, which were directly related to the derived framework (see Section 2.7; Figure 4, p. 40). Whilst other questions were left open, in order to give parents, the opportunity to add information not covered but which they felt was relevant to their experiences, or that of their children.

4.3.3. Setting: The Alive N' Kicking (ANK) programme

The Weight Management Centre (WMC) is an organisation providing overweight/obesity and weight management services and training throughout the UK (Weight Management Centre, 2017). Commissioners such as Sheffield City Council, appoint WMC for different programmes on contracts of up to three years in overweight/obesity management, targeting both children and adults. The ANK programme is one of the programmes offered for children and adolescents who are overweight or obese (Alive and Kicking, 2017). There has been a growing demand for the ANK programme by local authorities and public health teams in recent years (Alive and Kicking, 2017). The WMC serves as a framework to train partners to deliver weight management programmes in their communities (Weight Management Centre, 2017). Commissioners need to fulfil a number of requirements such as providing the facilities and staff before technical training is provided to full-time and part-time staff, freelancers or volunteers (Weight Management Centre, 2017).

The programme, offered by the WMC and commissioned by the Sheffield City Council, is a 11-12-week weight management programme targeted at overweight and obese children and adolescents. ANK programme adheres to National Institute for Health and Care Excellence (NICE) guidelines (Alive and Kicking, 2017) and it is built upon the transtheoretical model (Prochaska and DiClemente, 1983), self-efficacy theory (Bandura, 1977) and protection motivation theory (Rogers, 1975) and uses a variety of behavioural change methods such as motivational interviewing (Alive and Kicking, 2017, Hall et al., 2012). The programmes objectives are to help "overweight children and young people and their families to reach and maintain a healthier weight (Everyone Health, 2019). The programme is specifically designed to provide age appropriate messages, activities and behavioural change strategies that will benefit the whole family" (Alive and Kicking, 2017). ANK consists of the following five components to increase physical activity and to improve the quality of diet; learning about healthy eating & nutrition, making small, easy changes to help benefit your family's health, food preparation sessions to learn to make fruit kebabs, smoothies and healthy wraps, to shop healthier by learning how to read food labels and finally activity sessions to learn that exercise can be fun, play new games and build your skills and confidence (Alive and Kicking, 2017).

The programme includes children and adolescents from five to 19 years of age. Separate programmes, which have been described in section 4.3.1.1 are delivered according to the following age groups: infants and juniors (5 – 11 years of age), seniors (12 – 15 years), and young persons (16+ years) (Everyone Health, 2019).

4.3.3.1. Infants and juniors (ages 5-11 years)

The 10-12-week infant and junior programme focuses primarily on the role and responsibility of the caregiver or parent combined with activities for the children (Alive and Kicking, 2017, Everyone Health, 2019). Parents and caregivers meet once a week for a 90-minute session covering topics such as healthy eating, sugary, drinks, food tasting, healthy school meals and reducing sedentary behaviours (Alive and Kicking, 2017, Everyone Health, 2019). The main aim of these sessions is to guide parents towards a healthy lifestyle for the whole family (Alive and Kicking, 2017, Everyone Health, 2019). Additionally, children can join the weekly physical activity hour for games and challenges (Alive and

Kicking, 2017, Everyone Health, 2019). The programme is structured to take 10-20 children/families with a minimum of two staff delivering the programme (Alive and Kicking, 2017). Results indicate that 4,742 families have completed the ANK programme in 13 different locations in the UK, including Bristol, West Sussex, Northamptonshire, and Sheffield (Alive and Kicking, 2017).

4.3.3.2. Seniors (ages 12-15 years)

In this part of the programme, the focus is more on the young person instead of the parent. The aim is to create greater responsibility for maintaining a healthy lifestyle for the young person therefore they are included in all activities and workshops related to weight management, nutrition and health together with their parents (Everyone Health, 2019). Next to the theoretical sessions, this programme also involves weekly drop-off sessions, where parents drop their children off to participate in group physical activity classes delivered by the programme (Everyone Health, 2019).

4.3.3.3. Young persons (16+ years)

This programme offers the young people full responsibility for their health choices. The programme offers theoretical classes on for example energy balance, snacking, school food and snacking and ends with a half hour physical activity class (Everyone Health, 2019). The classes are flexible and can be adapted to individual classes, small or bigger groups. The classes are often accompanied by an additional physical activity class throughout the week, but can be adapted to the needs of the adolescents (Everyone Health, 2019).

4.3.3.4. The Sheffield ANK programme

This section will describe the ANK programme offered in Sheffield based on the information the researcher gathered during the visits at the interview sites. Most information derives from conversations with the programme manager and the session leaders during the sessions. In Sheffield, only one programme of the ANK programmes is offered, which combines the infant and junior, senior and young people groups. The above age groups are combined due to a lack of participants for each age group. The majority of children who participate in Sheffield are between the ages of five to 13

years. The physical activity sessions are delivered by physical activity experts from the Why Weight Sheffield programme, a programme that offers city wide programmes on weight management (Weight Management Centre, 2017). While children attend physical activity sessions, nutrition sessions are delivered to their parents in a separate room. Those sessions are delivered by trained staff of Why Weight Sheffield. During most weeks, children are asked to participate in the information sessions for the first 15-20 minutes before starting their activity session. During other weeks, parents are asked to join the physical activity sessions to enhance physical activity within the whole family and to demonstrate parental support for their children.

The 10-12-week sessions are given 12 times a year. Usually four of those sessions are given during the same weeks at different days and different locations (Alive and Kicking, 2017). Throughout the year, three blocks of sessions are delivered. Every block comprises three to four separate sessions of 10-12 weeks. After completing the first block a new block of sessions starts. The locations of the sessions are chosen based on the number of referrals received and the place where the participants are living. In addition to the three blocks offered throughout the year, the programme offers three summer clinics. One summer session consisted of physical activity sessions for the children, and nutritional information sessions for the parents. This session lasted nine weeks in total. Further two sessions are offered during the summer sessions, each lasting five to six weeks. These sessions consist of 60-minutes physical activity for children and do not include nutritional information for parents (Everyone Health, 2019). Parents and their children who participated in the summer sessions were usually invited to return for the full-time September sessions.

Participants were informed about the programme through referrals from the school nurse or their local general practitioner across the city of Sheffield (Alive and Kicking, 2017). Some parents searched themselves for obesity management programmes for their children in their community or heard from friends, who have previously participated. Furthermore, the ANK programme is advertised at local community centres. New participants are encouraged to join and enjoy priority for spaces in the programme. Previous participants are invited to join again if spaces are available.

Parents were asked by the Why Weight Sheffield staff to fill out a form with general information about the child at the beginning of a block of sessions. The booklets contain questions on general health of children and any family related illnesses. The booklet was kept by ANK and was taken to every session to keep track of weight and height of children. Every session started with weighting and measuring the child to check their BMI. The classification of overweight and obesity used in the ANK programme and in this research are as defined by the WHO-UK (World Health Organisation Europe, 2019). Overweight/obesity status was above the 91st centile among all children, as this was the requirement to participate in the ANK programme.

4.3.4. Sampling, recruitment and data collection

4.3.4.1. Contact between the researcher and the programme

Throughout the research, the researcher was in close contact with the project manager of the programme. The data collection was conducted in Sheffield, UK. Prior to conducting the research, the researcher met twice with the project manager and programme officer of ANK in Sheffield on the 3rd of October, 2017 and on the 27th of February 2018 to discuss the aims of the research and the data collection procedures before obtaining approval to conduct the research within the ANK programme from the project manager. Further the researcher attended one session of the ANK programme on the 15th of November 2017 in order to become familiar with the structure of the programme. Children between the ages of five to 16 years attended the session in November 2017. They were involved in the 90-minute physical activity session guided by an ANK trainer. The session consisted of physical activity games such as tack, and softball, suitable and adapted to the participant's age groups. During the session, parents were talking to each other and watching their children.

4.3.4.2. Eligibility criteria

Participants were eligible to participate in the research if they met the following criteria: participants were parents or guardians of children between the ages of five to 11 years, which were enrolled in the ANK programme in Sheffield for the first time and had participated in no more than two weeks of the programme. Parents who had had other children enrolled in the programme previously were excluded.

If parents had more than one child enrolled in the programme, they were still eligible to participate, but they had to specify which child they were talking about in the interview and lastly, only one parent or guardian of a child was eligible to participate. Mother, father or guardian were equally eligible to participate.

4.3.4.3. Interview set-up

The interviews were conducted throughout three different blocks of sessions in 2018. The sessions were held at four different locations in each block. Three locations in Sheffield, (postcodes: S139BZ, S58XL, S56AG) were visited for recruitment and conducting the interviews as two sessions occurred simultaneously at different locations. Of the two ANK sessions occurring simultaneously, just one had the capacity of an extra room for interviews. Therefore, the location with room for interviews was chosen. A description of the rooms will be given in a later paragraph of this section.

The researcher started to recruit and conduct interviews in April 2018 for the first block, in June 2018 for the second block and in September 2018 for the third block.

During the first week of each block, the interviewer visited each location for the duration of the programme and spoke to the group of parents for the last ten minutes of the 90-minutes sessions to introduce the study and to hand out information leaflets for the study (Appendix I: Parental information leaflet). Prior to introducing the study in each session, the researcher visited the physical activity sessions for the children and talked to them and their parents to give them a chance to get to know the researcher. During the introduction, the researcher highlighted the purpose of the study, the reason for the need for their parental expertise on the topic, confidentiality, their option to withdraw from the interviews at any point in time and finally informed the parents about the £15 gift voucher they can receive at the end of the interview.

The parents were given a week to decide about their participation. During the first block of interviews, the interviewer introduced the study to the whole group of parents at the end of the first session and handed out the information leaflets as described above. The one-to-one conversations between parents and interviewer were changed after the first block of interviews. The adaptation occurred after

consulting the programme leader and the project manager because of confusion of parents who were not eligible to participate, either due to having previously participated in the programme or due to having children outside of the anticipated age range.

During the second and third blocks, children were firstly weighed and measured at their first session and the programme leader then informed the new and eligible families to the researcher. The researcher then approached the parents individually, introduced the study and provided the parents the information sheet. The parents were informed that they may not need to decide about their participation at that moment and that they were given a week to think about it, if they wanted to participate. This approach was important as one-to-one talks about the study might lead parents to consent-bias.

Throughout the following two weeks, the researcher visited during the full duration of the sessions. The researcher approached the parents who attended the session in the previous week and asked whether they would like to participate in the interview. The researcher highlighted their free choice in participation. If they agreed, the interview could occur in the same day or could be arranged for a future date. The researcher was able to conduct up to two interviews per 90-min session. If new parents arrived at the location during the second week of the sessions, the researcher approached these parents and introduced the study as previously described and gave them the possibility for an interview in the following week.

The interviews took place in private rooms furnished with a table and two chairs. Once in the interviewing room, the researcher informed the parent again about the study and asked, if he or she had any further questions. If no questions or concerns were raised, the researcher gave the parent the consent form to read and to sign (Appendix II: Parental consent form). After obtaining the participant's signature the digital voice recorder was switched on and the interview started. After the interview was completed the digital voice recorder was switched off and the parents were handed the £15 gift voucher as well as a thank you letter (Appendix III: Thank you letter). Finally, parents were asked to sign a receipt of payment for the researcher's records.

All participants who meet the inclusion criteria were invited to participate in the study. In order to avoid stigmatisation, it was decided not to purposely sample the participants based on previous or current occurrence of children's dental caries, dental pain, or dental restauration. Therefore, parents whose children did not experience dental caries, dental pain, dental restauration or dental restauration were also interviewed. Dental caries was later identified through parents reporting the occurrence of dental caries, dental pain, dental restoration or dental restauration, as self-reported dental pain is highly correlated to dental caries in children and adolescents (Slade, 2001). All interviews were included in the analysis regardless of an indication of dental pain, as the purpose of the interview was to find out about parents' experiences of the link between dental caries and overweight/obesity regardless of their child's dental caries status.

4.3.4.4. Sample size

The interviews were carried out within the first three weeks of the participants starting the ANK programme. Recruitment continued until data saturation was met, meaning that no new themes emerged from the interviews (Guest et al., 2006). Previous studies aiming to explore attitudes and beliefs towards dental caries or overweight/obesity through semi-structured interviews with parents, reached data saturation at 19 (Hall-Scullin et al., 2015) and 12 (Rodríguez et al., 2016) participants, respectively. Data saturation in this study was reached after 13 completed interviews including 15 children. Two mothers had two children each participating in the ANK programme therefore 15 children were included in the interviews with 13 parents.

4.3.4.5. Interview content

The interviews were semi-structured, allowing the researcher to guide the interviewee through a number of topics and at the same time allow the interviewee to tell their own story. Fourteen interview topics were developed based on the child-level and family-level factors within the conceptual framework (see Section 2.7, Figure 4, p. 40), in order to gain information on parental experiences with childhood dental caries and overweight/obesity.

The 14 topics, which can be found in Table 3 of this section, included seven topics from the child-level of the proposed framework and seven from the family-level (Section 2.7).

Of the topics from the child level, six questions were derived from the health behaviours and practices attributes, namely the history of child's dental caries (e.g. dental caries experience), the child's dental health behaviour (e.g. toothbrushing frequency), the child's dietary behaviour (e.g. frequency of sugar-sweetened beverage consumption), the child's physical activity (e.g. frequency of physical activities), the child's sedentary behaviour (e.g. hours spent in front of screens) and the child's sleeping patterns (e.g. hours/day spent sleeping). One additional theme concerned the physical and demographic attributes including the age and the BMI of the child.

Of the seven topics from the family-level, one derived from the SES attribute, namely the socio-economic influence on family health behaviour, four from the parental health beliefs attribute which were the influence of the social environment on food choices, the parental perception on solutions that could facilitate a healthier diet for children, parental perception on the relationship of overweight/obesity and dental caries and lastly parental perceptions on the overall health of their child. Two topics derived from the parental health behaviours, practices and coping skills attribute of the proposed framework. These two were the parental control over child's health behaviour (e.g. restrictions in screen time) and parental health behaviour (e.g. toothbrushing behaviour or physical activity patterns of parents).

Each of these topics, and questions can be seen in Table 3 below. The questions served as a guideline but did not necessarily have to be used in the interview. If the researcher felt that the interviewee did not cover certain aspects in their story, these questions helped to get the information needed to answer the research question.

Parents were asked to answer all questions retrospectively which means, answers had to be linked to behaviour that they practiced prior to their participation in the ANK programme. This was done to reduce the possible influence the ANK programme might have on health-related behaviours of parents

and children. Parents answered the questions based on their experience with their child's weight and possible dental caries experience.

Each interview lasted between 20 and 40 minutes. An additional five to 10 minutes was given for the introduction and signing the consent form at the beginning and conclusions at the end of each interview.

Table 3: Interview Topics and Questions

Topic	Questions
Demographics	Age of child, sex, class at school, height of child, weight of child (last weight), size of family and living situation, parents or guardians, number of siblings, postcode, occupation, ethnicity
Parental perception on the relationship of overweight/obesity and dental caries	In your opinion, do you think there is a link between dental caries and overweight?
History of child's dental caries	Thinking about the time before you started the ANK programme, please tell me a little bit about the health of your child's teeth.
	Is oral health something you talk about at home?
	Prior to starting the ANK programme, has your child ever experienced any pain in the teeth, mouth or jaws?
	Prior to starting the ANK programme, has your child ever had any difficulty eating some foods?
	Prior to starting the ANK programme, has your child ever had any difficulty drinking hot or cold beverages?
	Has your child ever had any dental fillings?
	Has your child ever had any teeth extracted?
Child's dental health behaviour	Before you started the ANK programme, what brand of toothpaste did your child use?
	How often does your child brush their teeth?
	Are there any examples of when your child does not brush their teeth?
	Does your child do anything else while brushing their teeth?
Child's dietary behaviour	Can you tell me how and with what you fed your child as an infant?
	Did you ever breastfeed your child?
	When did you stop breastfeeding your child?
	How long (months) did you exclusively breastfeed your child (without supplementing with other food?
	Did you formula feed your child?
	How long (months) did your exclusively formula feed your child (without supplementing with any other food)?
	What does your child drink during the day and in the evening?
	How often during a regular day, does your child eat?
	What does your child eat next to the three main meals?

Child's physical activity	What did a typical week look like in your family regarding physical activity before you started the ANK programme?
	Could you please describe some of the activities that you and your child do?
	How often do you do sport?
	What kind of sport do you do?
	How often does your child do sports?
	Do you do any sports together?
	What kind of activity does your child usually do after school or on the weekend?
Child's sedentary behaviour	Tell me a little about the use of screen time in your house before you started the ANK programme?
	How much screen time does your child have on a regular weekday, including computer, phone, television, and videogames?
	What are the rules around screen time in your house?
	How and how long does your child watch TV on a regular school day?
	How often and how long does your child watch TV on the average weekend day?
	How often and long do you watch TV on a regular weekday and on a weekend day?
	Do you have control over the screen time of your child?
	Would you like to have more control over your child's screen time?
	What makes it difficult for you to have control?
	What would help you to gain more control over your child's screen time behaviour?
Child's sleeping patterns	Tell me something about the sleeping times and patterns of your child, before you started the ANK programme.
	At what time does your child usually go to bed?
	At what time does your child wake up?
	Does your child sleep through the night?
	Does your child take any naps during the day? If yes, how long do they usually last?
Parental perception on child health	How would you describe the overall well-being of your child?
Parental control over child's health behaviour	Do you control your child's tooth brushing behaviour?
	Is there a fixed routine in place to look after your child's teeth?
	Who takes the final decision on food or drink choices your child or you?

Parental health behaviour	How often do you brush your teeth?
	Do you brush your teeth together with your child?
	Talk me through how you go around shopping in your house before you started with the ANK programme.
	Who is usually doing the grocery shopping at your house?
	Who decides on what to buy (meal planning)?
	Tell me a little about cooking in your house before you started the ANK programme.
	Who is responsible for cooking in your home?
	What influences meal choices made?
	Do you generally eat the same food as your child?
	Tell me about an average weekday in your family in terms of meals prior to starting the ANK programme?
	How often do you share meals together as a family?
	Where do you usually eat? (table, TV, etc.)
	What is your child's favourite meal?
	What do you usually drink during the day and in the evening?
	How often do you eat out?
Socio-economic influence on family health behaviour	To what extend does money influence your choices?
	Do you usually have enough food at home for a balanced meal?
Influence of the social environment on food choices	Before you started the ANK programme, what influenced the choice of food or drink your child consumed?
	Is your child's food choice influenced by any external influencers (friends, TV)?
Parental perception on solutions that facilitate a healthy diet of children	What suggestion would you give other parents to help keep control of their child's diet?

4.3.4.6. Data storage

Interview voice recorder files were uploaded and saved on the researcher's University of Sheffield Google Drive account immediately after conducting the interview. Further, the consent form and the voucher receipt were scanned and uploaded to the university's google drive account of the researcher. The original documents were stored in a lockable safe at the University of Sheffield of which the researcher and supervisors had access. After the transcription of the interviews, the transcripts were

uploaded onto the University's google drive account of the researcher. All research data generated by the study will be kept for five years before being destroyed.

4.3.4.7. Participant confidentiality

To ensure participant confidentiality all interviews were transcribed anonymously. In transcripts and publications, parents and children's identification were anonymised (e.g. mother of nine-year old girl). No information that could allow the identification of the participant was transcribed.

4.3.4.8. Investigator safety

The researcher conducted the interviews at the above-mentioned ANK programme facilities in Sheffield. The researcher informed both supervisors about her arrival including the address and the estimated leaving time of the interview locations by WhatsApp. Once the researcher left the location, another WhatsApp message was sent to both supervisors to confirm she had left the location. In case of not having contacted both supervisors, a call would have been made by either of the supervisors to the researcher.

4.3.5. Data analysis

After conducting the interview, the interviews were transcribed manually by the researcher using google docs and google voice recognition. Analysis of the interview data was conducted by framework analysis (Gale et al., 2013) which was based on the proposed framework (Figure 4, p. 40) outlined in Section 2.7.

Framework analysis is one of many options to analyse qualitative data (Gale et al., 2013). Compared to other common qualitative data analysis methods such as grounded theory (Martin and Turner, 1986) or narrative methods, framework analysis is not specifically linked to a certain research field and is a flexible tool that can be adapted to many types of analysis approaches that aim to generate themes (Gale et al., 2013). Different approaches in how to select themes and codes within the framework analysis exist and choices for a certain approach should be based on the research question to be answered (Gale et al., 2013). Themes and codes of the framework analysis may be established in a

deductive approach, inductive approach or in a combined approach (Gale et al., 2013). The deductive approach means that both themes and codes are pre-defined and based on previously conducted research and existing theories (Gale et al., 2013). The inductive approach lets the researcher generate and define themes and codes based on the interview transcripts (Gale et al., 2013). Often a combination of the two methods is used when the aim is to explore specific aspects of a topic, but also to leave room to discover new aspects of the participants experience (Gale et al., 2013).

As this research aimed to identify determinants of childhood overweight/obesity and dental caries that had previously been identified in the literature, but also to leave room to explore new determinants, the researcher chose a combined method. Themes and codes were therefore pre-defined, based on the proposed framework (Section 2.7, Figure 4, p. 40). This proposed framework is developed based on previously conducted literature and therefore combined determinants of both childhood dental caries and overweight/obesity development as described in detail in Section 2.7. The themes and codes can be found in Table 4 of this section. Newly defined themes and codes are highlighted in the table. Most of the codes were predefined, based on the previously developed framework, however some were developed during the analysis. Codes and themes were newly developed when reoccurring phrases did not fit within the predefined codes and themes. For example, the theme parental perception of the link between dental caries and weight was not predefined. This theme was already used as a topic in the interview question development as the researcher was interested in the possible link between the two conditions from the parent's perspective. Questions from this topic were analysed through a deductive approach as no information was found on parents' perspectives on the link between childhood dental caries and overweight/obesity. Therefore, no codes were previously defined.

All themes and codes were cross-checked by the research supervisors. All codes and themes are presented with examples in the result section of this study (Section 4.4).

Table 4: Predefined themes and codes

Themes	Codes
Parental perception of their child's oral health	1. Parents' understanding of dental caries development 2. Parents' influence on their child's oral health behaviour through their own personal experiences with oral health
Parental perception of their child's toothbrushing behaviour	The perception of parents on barriers and enablers of their child's toothbrushing behaviour Parental supervision while toothbrushing
Parental perception of barriers and enablers of their child's physical activity	Weather condition Screen time Safety of neighbourhood Parental time to take children somewhere to be physically active Parental role modelling – physical activity
Parental perception on the dietary behaviour of their child	Accessibility to food outside the family home Triggers to consume unhealthy food Parental role modelling – dietary behaviour Consumption of treats and sugar sweetened beverages
Parental perception of the link between dental caries and weight	Sugary foods and sugar sweetened beverages Toothbrushing

4.3.6. Ethical considerations

Ethical approval was obtained in January 2018. The ethical approval was given from the University of Sheffield Research Ethics Committee (reference number 016773), following the University of Sheffield Research Ethics Policy prior to contacting the parents and conducting the interviews. After ethical approval had been obtained, the ANK programme gave a final approval of the study before the interviews started.

4.4. Results

This section presents the results of the interviews. Table 5 highlights the descriptions of the participants. Thirteen parents participated in the interviews with a total of 15 children. For eight of the 15 children, parents reported that their child has had previous experience of dental caries at one point in their life. All children were classified as obese after calculating their BMI-z scores at the starting point of the programme.

Table 5: Description of participants

Parent information		**Child information**					
Interview #	Interviewee	Child #	Age	Sex	BMI	WHO weight classification	Dental caries[1]
1	Mother	1	11	Female	24.3	obese	yes
2	Mother	2	10	Female	27.1	obese	yes
3	Mother	3	9	Female	26	obese	no
4	Father	4	11	Male	27.2	obese	no
5	Mother	5	10	Male	26	obese	yes
6	Mother	6	11	Female	26.4	obese	no
7	Mother	7	11	Male	22.7	obese	yes
8	Mother	8	9	Female	25.6	obese	Yes
9	Mother	9	5	Female	30.1	obese	No
9	Mother	10	11	Female	27.2	obese	Yes
10	Mother	11	9	Male	26.7	obese	No
11	Mother	12	10	Male	24.8	obese	No
12	Mother	13	5	Male	22.1	obese	No
12	Mother	14	10	Male	27.9	obese	Yes
13	Mother	15	11	Male	25.3	obese	Yes

[1] Ever experienced dental caries in their life

The child's mother was interviewee in 12 out of 13 interviews as mothers were usually the ones attending the sessions with their children on a regular basis. For one interview the father had been interviewed. In only one session a child was present during the whole duration of the interview, as the mother did not want to leave the child alone at the physical activity session. This child was a younger brother (two years old) of the child who participated in the programme. The child sat in the same room but at a different table and was given a paper and pen to stay occupied during the interview. The researcher felt that the mother was not distracted by the child and answered all questions fully and honestly. In another interview, two children who participated in the programme were brought into the room, as the interview lasted longer than the physical activity session. The two boys were in the room for the last five minutes of the interview.

The following sections highlights the five themes which emerged from the transcribed data (additionally see Table 4 above for an overview of the themes).

4.4.1. Theme 1: Parental perception of their child's oral health

The first theme, parental perception on the state of the child's oral health, consisted of two codes, which were recurring during the interviews; (1) parents' knowledge on dental health and (2) the perceived (parent) susceptibility to dental caries (child). The codes were combined into one theme, which derived from the attribute "parental health beliefs" of the parental level influences of the previously developed framework (Section 2.7, Figure 4, p. 40).

4.4.1.1. Parents' understanding of dental caries development

This code consists was exemplified by quotes giving an indication on the knowledge parents have on dental caries development and prevention. One mother indicated that she grew up with organic food herself and she thought that the non-organic food consumption of her daughter, resulted in her poor oral health.

> *I don't think that I had so many problems as they have had as a child, but then my diet was probably different to theirs as well, because we were brought up on organic food."* (mother of 11-year old girl, obese and dental caries).

This quote indicates that the mother is concerned about the poor dental health of her daughter, but still trying to understand the underlying reasons for this development, possibly indicating not having enough knowledge on dental caries development and prevention.

Another mother indicated uncertainties around her daughter's teeth being overcrowded. Although she does not specifically mention dental caries, she highlights being insecure about her daughter's food consumption having caused the overcrowding.

> *"I've noticed now is her teeth are overcrowded. I don't know if that has to do with her intake of food or things like that."* (mother of 11-year-old girl, obese and no dental caries).

One mother suggested that family genes might be the reason for the state of her daughters' teeth.

> *"But the older three do constantly having work done on their teeth, but I don't know their dads' teeth were never good either, so I don't know if it is something that kinda runs through the family* (mother of 5-year old girl, obese and no dental caries).

These quotes suggest an insecurity about oral health development among parents, which might indicate a lack of knowledge on oral health and dental caries. Even though some of these quotes were around the intake of food, none of them mentioned sugar specifically. This indicates that parents might think about other risk factors than just sugar. Most quotes are, however, centred around the knowledge of sugar intake. One mother indicated that she was unaware of the sugar content of certain products.

> *"So many saying no added sugar but when you look at the calories in I mean, when I am reading them I am wondering why does it say no added sugar but it still say it got so many calories in it"* (mother of 11-year-old girl, obese, dental caries)

Although in this study only one parent mentioned food labels specifically, this possibly indicates the challenges parents face with store-bought products and reading nutrition labels.

Another mother was unaware that certain behaviours were particularly harmful for their children's teeth. She mentioned that if she would have known that sleeping with a bottle during infancy had a bad effect on her child's teeth, she would have never allowed this behaviour. She further specifically wished that she had received better information from the dentist during pregnancy.

> *"So, with the second child, obviously we had the experience [of caries with the first child] so there wasn't sleeping with the bottle or anything like that [with the second child]. So, it was just like let her [the first child] sleep with the bottle, with the drink, with the milk which was causing her tooth decay, which I didn't even realize then. So I think it is just good to know for parents good to know step by step, stage by stage, with feeding or whatever […] So I think the dentists should recommend these to the people as soon as they know them"* (mother of 10 year old boy, obese, no dental caries)

Another mother mentioned after the interview, that she sometimes wonders why so many young mothers give juice or sweetened tea in bottles to their children.

> *"Obviously I did not do that myself, but definitely do not give kids juice out of a bottle 100% to me that is just common sense so I definitely wouldn't do that and obviously a lot of people do not realise that if you have milk at night, it stains on your teeth and it dries and so maybe that would be something that I would mention to parents"* (mother of 10 year old boy, obese, dental caries)

These quotes highlight the lack of knowledge of parents on dental caries prevention in their children. This was further confirmed by the following two quotes, highlighting that children were given sugar to avoid discussions around food and to keep children quiet. This behaviour indicates that parents may not know the long-term consequences of high sugar intakes or may not judge them as being harmful for their child.

> *"When he first came to us, he wanted a two-litre bottle of Coke before he went to bed for the first few weeks, he would constantly ask for a bottle of Coke. […] And he still does [asks for it] from time to time, if he is really upset, he asks can I have some Coke and I'm like no you don't need to coke, come and have a cuddle instead you know. I know when he is upset first thing, he wants is Coke. Coke all the time. It's kind of his safety blanket you know."* (mother of 10-year old boy, obese, dental caries)

> *"The wrong people, they would feed the kids with sweets and everything just to keep them quiet"* (mother of 9-year old girl, obese, no dental caries)

However, even though unaware of the impact of certain behaviours most parents suggested that they knew the importance of frequent and good toothbrushing behaviour to reduce the risk of dental caries.

> *"When you eat sweets make sure that you brush your teeth properly. Don't leave anything behind"* (mother of a 10-year-old girl, obese and dental caries)

> *"Brushing before going to bed and first thing in the morning before breakfast is obviously insisted"* (father of a 11-year-old boy, obese, no dental caries)

These quotes indicate that parents knew about the importance of toothbrushing to prevent dental caries, however unawareness was found about possible other influences on dental caries development, as discussed above. The following section is in line with this one, indicating the perceived susceptibility to dental caries, that parents have about their children. This quote is similar to the

parental knowledge on dental caries development; however, susceptibility is concerned with either family traits or genes that might influence the development of dental caries.

4.4.1.2. Parents' influence on their child's oral health behaviour through their own personal experiences with oral health

The code "parents' influence on their child's oral health behaviour through their own personal experiences with oral health" was used when parents described the influence their personal experiences with oral health or dental caries had on how they cared about their children's teeth. It was mentioned that their own experience with dental caries had let them to be more careful with their children's teeth and to encourage their children to brush their teeth.

> *"I have shown them my teeth, I have shown them I have got false ones and I think that urges them a bit more, but I think the things that they are eating now her teeth have gotten better. She seems to be more urgent to do it [taking care of her teeth]. I think it is me changing as well. I think a lot of it is me"* (mother of 9-year-old girl, obese, no dental caries)

The mother of the 9-year-old girl, highlighted how her own behaviour change influenced her daughter taking better care of her own teeth. This shows how important role modelling, which is further discussed in a later section, is for children health behaviour. The mother of the 11-year-old boy, on the other hand is less concerned with her own health behaviour but rather highlights the importance of parenting skills. She is controlling her child's sugar food consumption and oral hygiene, having herself experienced an upbringing with no rules in relation to food consumption as a child, resulting in dental caries.

> *"Only on the basis of when I was young, we were allowed to eat whatever we wanted to eat and painfully taken with that comes along tooth pain. And the experience that I felt with that I can never forget that. So, when it came to them, it was very important to me, that that was kept on top of. And I still at my age now, I still struggle with my teeth now, because obviously they are never going to repair"* (mother of 11-year-old boy, obese, dental caries)

Another mother of a 9-year old girl, in line with the previous quote, highlights the importance of her own experience, promising to not let her child experience dental caries as she had.

> *"I know. Because mine are really bad. I promised them I won't let theirs get that bad."* (mother of 9-year-old girl, obese, no dental caries)

Following this theme, the next one focuses on the parents' perception around their child's toothbrushing behaviour.

4.4.2. Theme 2: Parental perception of their child's toothbrushing behaviour

The theme parental perception of their child's toothbrushing behaviour includes two codes, (1) the perception of parents on barriers and enablers towards their child's toothbrushing behaviour, (2) supervision of the child's toothbrushing by parents. Both codes derived from the literature and were extensively discussed in Section 2.7.1.

4.4.2.1. The perception of parents on barriers and enablers of their child's toothbrushing behaviour

The interviews suggested that parents knew the importance of oral health, however, they struggled to keep their children engaged in adequate toothbrushing behaviour. Parents mentioned that it is often difficult to enforce the children's twice-a-day toothbrushing behaviour.

"It is a bit difficult with the kids. Especially when you have a stubborn child" (mother of 9-year-old girl, obese and dental caries).

"We try and encourage but it's like, yeah I am done but it's like literally 5 seconds and [laughter] [so she tells him] lets go do them again" (mother of a 10-year-old boy, obese and dental caries)

"You know he is crying does not want to brush his teeth, making me like you know he is a drama queen in the morning. I just say, just use the oral liquid, the oral mouth wash, yes just use that one and then we can sort that out in the evening. It is easier to do that with him in the evening for some reason than in the morning." (mother of 10-year-old boy, obese, no dental caries)

Where specific reasons for the difficulties were not always highlighted, one reason for their children not to brush their teeth was tiredness. The last mother mentioned that evenings are easier for her to encourage her children to brush their teeth, other parents mentioned that evenings were more difficult, due to the children being tired.

"Usually even though they know they need to brush their teeth twice a day […] most of the time they only brush their teeth once a day before they sleep. And sometimes the young one you know when she is too tired or feels so sleepy, she feels too lazy to brush her teeth before she sleeps." (mother of 9-year-old girl, obese and dental caries)

"*She brushes twice a day in the morning and sometimes she gets away with it the at night. Laughter. But I do try to make her to do it at night as well.*" (mother of 10-year-old girl, obese and dental caries)

Other parents mentioned the difficulty for parents to supervise the toothbrushing due to the request of independency of their children, which is highlighted in the following section on parental supervision on the child's toothbrushing.

4.4.2.2. Parental supervision of the child's toothbrushing

Most interviewed parents indicated that they did not control their children's toothbrushing anymore. However, that they had spent some time doing so when they were younger.

> *"She has been alright now for a few years [brushing by herself], but when she was younger, I had to stand by her but she's ok now."* (mother of a 10-year-old girl, obese and dental caries)

> *"I used to brush them all the time I think until he was about on and off maybe nine 10 years of age. And now he brushes them himself"* (mother of 9-year-old boy, obese and no caries).

Even though having mostly stopped supervising their children's teeth, some parents mentioned that the poor quality of their children's tooth brushing behaviour makes them brush their children's teeth once in a while.

> *"Every now and again I used to brush them in between that but he does not always brush them very well sometimes he misses places so that is why I check on them."* (mother of a 9-year-old boy, obese and no dental caries)

However, some children rejected parental efforts in brushing their teeth. Parents indicated that children would not let them brush their teeth anymore nor let them supervise their brushing.

> *"Even so she does not let me do it for her myself. She doesn't want me. I tell her try to reach the different areas. It is a bit difficult with the kids.*" (mother of 9 year-old-girl, obese and dental caries).

Only one parent suggested a tool to overcome these barriers and to improve the quality of their children's toothbrushing behaviours. The mother mentioned the use of an electric toothbrushes as being helpful in encouraging her son to brush his teeth properly.

> *"And the vital important part […] was using electric toothbrushes or battery run toothbrushes, those more or less did the job for them. For them it was about keeping their brush in their mouth for two minutes and the job is more or less done for them"* (mother of 10-year-old boy, obese and dental caries).

Other parents highlighted that they did not make a discussion point of tooth brushing and insisted on twice daily tooth brushing.

> *"Brushing before going to bed and first thing in the morning before breakfast is obviously insisted"* (father of a 10-year-old son, obese and dental caries)

The following section focuses on the parental perception of their children's physical activity levels.

4.4.3. Theme 3: Parental perception on barriers and enablers of their child's physical activity

This theme includes the codes, (1) weather condition, (2) screen time, (3) safety of neighbourhood, (4) parental time to take children somewhere to be active, (5) and parental role modelling. Besides weather and safety of neighbourhood, all codes derived from the previously proposed framework.

4.4.3.1. Weather condition

The barriers for children's physical activity were mentioned frequently by parents and one of the most frequent answers was the bad weather. Parents whose children were not enrolled in physical activity classes such as football and hockey outside the school setting had difficulties in finding physical activities for their children during rainy or cold days. This code had not been defined prior to the analysis, but as the weather was mentioned frequently, it was included as a code in the analysis.

> *"I mean it does depend on the time of the year, in winter we tend to be a little bit more inside simply because when you are being out you are cold, you come home any you just snuggle up […]"* (mother of 5- and 11-year-old girls, (both obese and no dental caries and dental caries respectively).

"So, you know he does a lot of activities on the weekends, but if it's raining, yeah forget that he is just indoors on the computer." (mother of 11-year-old boy, obese and dental caries)

As mentioned in the last quote rainy days may also lead to time spent inactive in front of screens. The amount of time children spent on screens was another barrier perceived by parents. This code is discussed in the following section.

4.4.3.2. Screen time

Parents indicated that children are more interested in the TV or other screens rather than playing actively either outside or inside the house. There was no difference found between children with or without dental caries. One mother mentioned differences between her children though deepening on her children's personal interest, were two were more interested in the screens and one was the more active one.

"*The two [oldest and youngest] they are rather inactive so [middle] is active so they like to sit down, doing stuff like drawing or something watching TV and stuff, they don't like to do running, walking and they don't like that kind of stuff […]"* (mother of a 9-year-old boy [oldest son], obese and no dental caries).

Most of the interviewed parents indicated that their children were very much fond of spending a considerable number of hours per day behind screens, including on mobile phones, tablets, computers or televisions. Most parents indicated that their children would spend two or more hours a day behind screens on a regular school day.

"She doesn't come off it. […] she will grab my phone whenever she can […] but the TV constant if she's got time it'll be on" (mother of 11-year-old girl, obese and dental caries)

"He spends probably five to six hours a day, during the week. And weekend I would say doubled, depending on weather, [when raining] more yes." (father of 11-year-old boy, obese and no dental caries)

"As soon as we are back home, she puts the TV on but then I can't say nothing because she didn't have any her time." (mother of a 11-year old girl, obese and dental caries)

The last quote indicates how TV watching has become a socially accepted everyday activity, as the mother indicated she has no argument to restrict her daughter from watching, if she has not done so earlier on that day. However there seem to be differences in the number of hours a child spent behind screens. Some parents described their child as being addicted to or obsessed with screens, indicating that their children watch multiple hours a day.

"Before we came here, he was on the computer so any moment he finds even if it is 5 minutes, he is on something. If its if you take that one away, he will be looking for another one. So that's why I say he is very addicted […]. So, any minute he finds in spare time he is on it." (mother of 11-year-old boy, obese, dental caries).

"I think he has an obsession. Literally we try not to tell him stop playing that or give back the computer, so he has just one hour to play. We do not do that so as soon as he is in that room, he is playing lots of different games so that is good. He is not stuck with one, he is not sort of obsessed. No, it is lots of different ones." (mother of 10-year-old boy, obese and no dental caries)

The high number of hours spent behind screens, will limit the time which could be spent playing or being physically active for example outside. It seems apparent however, that if the weather is bad and if no incentives are giving by the parents to play or be physically active, children will prefer spending time behind screens over being outside. Some mothers confirmed this, by mentioned difficulties in getting their children off screens and to do something else.

"Yes, I was telling her for example you are watching now for one hour for example and that is enough, and she will say I just want to finish this episode and then I will stop it" (mother of a 9-year-old girl, obese and dental caries)

> *"Yeah, he will be either upstairs in his room or downstairs on the telly, but he is always glued to that. I am like [boy] it is a nice day, go play in the garden or something else, I kind of have to turn the telly off to get him out of the house or else he won't move. He would be quite happy sit there all day, if the telly was on all day."* (mother of 10-year old boy, obese and dental caries)

Parental role modelling in terms of screen time per day may have an effect on children's screen time behaviour. Some interviewed parents indicated to have the family TV running all day, which may suggest to children, as discussed earlier, a normality of watching multiple hours of TV daily and therefore increases children's screen time.

> "*We have the TV playing but a lot of the time it is the background noise"* (mother of 5 and 11-year-old girls, both obese and no caries and dental caries respectively)

> *"The TV constant not on tablets or phones but TV. they just sat there with me"* (mother of 9-year-old girl, obese and no dental caries)

However, other reasons such as the safety of the neighbourhood have also an influence on the physical activity level of the child. Increased screen time and the therefore low level of physical activity may be related to unsafe neighbourhoods. Some parents for example mentioned living in neighbourhoods with high crime rates, resulting in not letting their child be physically active outside of the house. This code is discussed in the following section.

4.4.3.3. Safety of neighbourhood

Further concerns were expressed by the parents with regards to the safety of neighbourhood. Parents mentioned not letting their children play outside without supervision due to unsafe neighbourhoods.

> *"I was talking to another lady out there and you don't let your kids out either on the street to play anymore because you feel they are too vulnerable, and it is not as safe […]"* (mother of 5 and 10-year-old boys, both obese and no dental caries, dental caries respectively).

Another mother mentioned that her son felt uncomfortable playing outside, due to the crime rate in their street.

> *"I think even he prefers staying indoors rather than playing, because a few other children were getting the police at their door because they were damaging people's cars and things like that. Just a bit of antisocial behaviour. And he saw that and even he said, he didn't want to go out and play with them. So, he doesn't really play outside when we are at home, I think is why I take him out to my sisters a lot. You know he does get to go out and play with people." (*mother of 11-year-old boy, obese and dental caries)

On the other hand, families living in households with a garden, quiet street, neighbouring families with children of similar ages and parks in close proximity mentioned that their children do like to play outside and that the parents feel comfortable letting the children play outside.

> *"We live surrounded by woods, so it is beautiful just walking up to [place] where I live"* (mother of 11-year-old girl, obese and dental caries)

> *"Yes, he goes to the garden regularly"* (father of 11-year-old boy, obese and no dental caries).

These quotes suggest that the neighbourhood plays an important role in the physical activity levels of children and that children from safer areas may have better access to being physically active outside.

4.4.3.4. Parental time to take children somewhere to be active

Young children will often have to be supervised when playing outside. Therefore, not only the safety of the neighbourhood and the possibility to play outside in the neighbourhood is important for childhood obesity prevention, but also parental time to supervise their children. Supervising children outside while they play is often restricted by lack of time from the parents. Some parents mentioned being too busy, either with household chores or due to working in multiple jobs or having multiple children, to join them in physical activities outside.

"So literally we do not have that many situations to go somewhere together." [both parents working on the weekend] (mother of 10-year-old boy, obese and no dental caries)

"She had a bike but never used it, you know going down to the park and stuff I don't have time […]" (mother of a 11-year-old girl, obese and dental caries)

These quotes suggest that parental time, especially when living in neighbourhoods were children may not play outside unsupervised, is crucial in increasing the time children spent engaging in physical activity.

In line with the former quotes, the code parental role modelling for physical activity is discussed in the following section.

4.4.3.5. Parental role modelling – physical activity

When time was made to do join the children outside, the time spent together doing physical activities, such as walking or playing in the park, was considered as an enabler to get the children active. Parents mentioned that their children were keen on doing something together than doing physical activities alone. Activities that were mentioned were walking, playing outside as well as paid activities such as swimming and boxing.

"*But yeah she's into her hula hooping and she's really good at it but that's only if I'm there*." (mother of an 11-year-old girl, obese and dental caries)

"When I do the garden obviously and you know when I put the washing out and yeah, but she'll follow me. Only come out if I'm there" (mother of 11-year old girl, obese and dental caries)

"During the week we do trying to get out as much as possible. Even just to the park we even hired bikes from there and had gone around the valley. So, we are quite active" (mother of a 5 and a 11-year-old girl, both obese and no dental caries, and dental caries respectively)

As highlighted in the quotes above, parental engagement in common physical activities with the children will get the children more engaged and active. Further parental role modelling in being physical active may encourage children more to be physically active as well. However, barriers such as a lack of time or unsafe neighbourhoods make parental engagement more difficult, possibly leading to less physical activity and higher overweight/obesity rates in their children.

4.4.4. Theme 4: Parental perception on the dietary behaviour of their child

Diet is one of the most prevalent and therefore the biggest theme when looking at obesity and dental caries. Codes included in this theme were (1) accessibility to food outside of the home, (2) triggers towards the consumption of unhealthy foods, (3) parental role modelling, and (4) the consumption of treats including sugar-sweetened beverages.

4.4.4.1. Accessibility to food outside of the home

Parents mentioned the sustaining a healthy diet of their children as challenging in multiple ways. Greater access to unhealthy food outside their home was mentioned as one of the biggest challenges in securing a healthy diet for their children. Parents mentioned that grandparents, friends or even the school provide the children with either unhealthy food options or presents the food to their children in inappropriate portion sizes. This leaves challenges as parents often did not feel that they had control over their children's choice of food intake and children often chose unhealthy options such as pizza or burgers.

> *"But his dad and his nana bought him some [candy] and I had to tell them, stop it, it is really bad for his teeth, he has a high sugar diet, he has acids and so them are not helping him […]"* (mother of a 11-year-old boy, obese and dental caries).

This quote highlights the influence relatives have on the sugar intake on children, however another mother also mentioned that non-relatives such as caretakers would feed children unhealthy food.

> *"The sweet things they're having and the people where I used to go to help me with my mental health, they were in a way the wrong people they would feed the kids with sweets and everything just to keep them quiet. And it wasn't good it was like all the attention it was me me me."* (mother of 9-year-old girl, obese, no dental caries).

Lastly two mothers mentioned the portion sizes and unhealthy food choices that were presented to their children at school. One mother also highlighted that her child would choose based on the desert option presented to him at school.

> "*I found out, because they did my placement at their school and she had school dinners and I was watching, and I looked at my daughters' portion […] and oh my god the portion size was massive."* (mother of an 11-year-old girl, obese and no dental caries)

> *"He will choose which one will have the best dessert basically [at school]. He looks at the desert and not the meal that's what he looks for. So yeah he is very influenced by that."* (mother of 10-year-old boy, obese and dental caries)

Another mother also mentioned her daughter's preference for unhealthy food, while she usually took packed lunches to school, she sometimes went for the fried food option, presented at school.

> *"I just asked her that what she wants to take, and she will tell me and then I put it in her lunch box. Then when she feels like she wants a small drink with dinner it's mainly like fried even the fish and chips or pizza she prefers that you know you got to get spoiled you know once a week"* (mother of a 10-year -old girl, obese, dental caries)

> *"Yeah. their school dinners. They always pick something out. They might treat on a pudding. But they make up for it when they come home, and they have to have a treat from time to time." (mother of a 9-year old girl, obese, no dental caries)*

These quotes suggest that unhealthy food choices outside of the family home create a challenge for parents to enforce healthy eating habits among their children. Children will opt for the most preferred food in terms of taste, which may often be the less healthy option as highlighted by one mother in the quotes above. This may be due to a limited knowledge of children on healthy food choices and why healthy food choices will benefit them. There were no differences found in these quotes, between children with or without having experienced dental caries.

In line with the previous quotes, triggers towards the consumption of unhealthy foods also derived from other sources than extended family or school.

4.4.4.2. Triggers towards the consumption of unhealthy foods

Other challenges mentioned were triggers to the consumption of unhealthy foods that children were exposed to during a regular day. One mother mentioned the media, TV and YouTube advertisements as challenging factors. Her child would ask whether she could try a certain type of food, previously seen on the media.

> *"For example, from YouTube (second child] always tells me that she saw for example such a type of food whether we can try it"* (mother of a 9-year-old girl, obese and dental caries)

Two parents highlighted the difficulty of shopping for food together with the children. They were often struck by all the branded labels and different food chains.

> "*Any driving you know you see KFC those are the close proximity of those, McDonalds and then you see taco bell and so yeah. […]"* (father of 11-year-old son, obese and no dental caries)

> *"Candy which is available everywhere as soon as you go shopping you know the children are much interested in buying these candies."* (mother of a 9-year old girl, obese and dental caries)

Two mothers also mentioned that their children were influenced by their friend's food preferences. The children would ask at home if they could eat the same food as their friends do.

> *"Cause of my sons, they are overweight, and I try not to give them fizzy drinks, chocolates, and stuff like that but they all the time complain that you are not giving us that, so like my friend is having this much, my friend is having is crisps and chocolates in his lunch box and you are not giving us, so yeah it is a little bit hard yeah"* (mother of 9-year-old boy, obese, no dental caries)

> *"He gets influences from when he goes and sees his friends the mom will cook something different and he will get influenced by that"* (father of 11-year-old son, obese and no dental caries)

These codes further confirm that external factors such as advertisement and food choices of friends and relatives increase the difficulty of enhancing a healthy diet among their children for parents. Children are influenced by these factors and wish for a similar diet. Several reasons may be related to that, children may not fully understand the importance of a healthy diet and may also have developed tastes that are more receptive towards sugary foods. As all findings, these are further discussed in the discussion section of this chapter.

4.4.4.3. Parental role modelling dietary behaviour

Parents identified role modelling as a key aspect related to a healthier lifestyle of their children. Children will only change their diet if the whole household is willing to do so. If the parents or an older sibling are allowed to eat unhealthy choices, it will become difficult for the child to understand and stick to a healthy diet. One mother criticized her own diet related eating habits at home and that their children simply incorporated those behaviours.

> *"I can tell them to drink water all day but then I don't drink water all day and you know if you are not prepared to do it […]."* (mother of 5- and 10-year-old boys, both obese and no dental caries and dental caries, respectively)

Parents mentioned that getting their children to eat something healthy was mainly due to their own preference. Parental role modelling in healthy dietary behaviour was considered very important as well

as supportive parenting. Parents mentioned the importance of encouraging their children to try something new or to eat some of their vegetables.

> *"So, I will tell him all sorts of things he will say is there swede in there you know you can get mashed potatoes with swede and he is like is that swede in there and I'll be like no it's just an orange potato mixed in there."* (mother of 10-year-old boy, obese and dental caries)

This mother further explained that, to get her son to eat his vegetables, she gives him a choice of multiple different ones. This may create the illusion to children that they are in charge and possibly enhance their health eating behaviour.

> *"He is very limited with his vegetables if I give him the option I normally do three different vegetables and I know he will eat all three of the vegetables, you know it is like I don't want them to be like well you can have a few of them just try a few of them you know I'm not mounting just a few and he will but he does have to be kind of coaxed into it"* (mother of 10 year old boy, obese and dental caries)

Sometimes parents also used an authoritative parenting style to get the child to eat something healthy.

> *"They are ok, they were picky with their vegetables and stuff, but my husband made them sit at the table. make sure you are finishing your vegetables. So, they have been very good with that."* (mother of a 10-year-old girl, obese and dental caries)

Another parent mentioned that since she started to pay attention to calorie intake on the different products being bought, she notices her daughter practicing the same behaviour. This highlights that parental role modelling has an effect on children and that they will adapt their parental behaviour.

> *"And I think that is what she saw me doing in the past 5-6 weeks [reading food labels] and now she's looking at every bottle"* (mother of 11-year old girl, obese and dental caries)

Many of the parents defined their children as picky eaters at family meals, meaning that the children only eat certain types of food. Most parents found very difficult to understand and did not have an explanation for their children's limited food preferences.

> *"It seems to be the same old kinda stuff getting cooked every time again, there is nothing new getting ventured in it […]and even once every two months that they have a take out, even that is very fussy"* (mother of 11-year-old girl, obese and dental caries)

Some parents cook separate meals for their children as they will not eat the family meal in the evening. This parental behaviour may suggest to children that eating something less healthy or different from the family is fine and that their wish will be accommodated, therefore parents might be indirectly enhancing picky eating.

> *"We tend to make what we all really just like to eat, but sometimes my son won't like that or my daughter I have to make something else for them. It is usually on one agreement so we all like that"* (mother of 10-year-old girl, obese and dental caries)

> *"He started to refuse eating more and more stuff. So, I got to the point that I did not know what to do with that anymore, […]. It literally started in his head, something like, he has always been weird with his eating to be honest. I just got to the point, where I you know I can't do it anymore with myself. […] we are eating different stuff, like veg, fruit."* (mother of 10-year-old boy, obese, no dental caries).

Another mother mentioned that her child, if there was no cooked alternative, opt for a yogurt or cereal. This indicated that the mother does not always admit to the child's wish in cooking something separate, however still allows for an alternative.

"She is quite fussy she's not too keen on my chicken Asian dish, Indian dish, she is more keen on the meat one but again she is not even bothered. If there is any alternatives like wraps, she is quite happy going for that than the curry […] I always have an Asian dish but whether they have that or not they don't always have that.[…] Sometimes I don't have an alternative and I will give it to her but she will be like oh mum and she will not finish it and probably only have like three spoons full and that's it. [As an alternative] noodles and I put sometimes I put peas in them yeah just something easy the alternative. Or she'll have a yogurt or cereal" (mother of 11-year old girl, obese, no dental caries)

One mother highlighted that she finds it important that her son tries the food and that she will not cook something different for him, however, allows him to eat bread when he will not eat enough during dinner time. Also, in this example the child is allowed to eat something different than the family.

"I cook for the family together, […] because whatever I cook, he will say I don't want to eat. There is no option either like that or cook this one for him or the rest of the family that they do not like eating so I will cook together and then he will try it a bit. […] Sometimes he takes bread, first I give him to try and if it is okay then he will continue as much as he likes but sometimes he takes one bite and he says he doesn't want this so then he take bread" (mother of a 9-year-old boy, obese, no dental caries)

Another mother stated that she did not agree in cooking separate meals, she will try to cook something that everyone likes, but allow family members to not eat foods they do not like from a meal.

"I try to do something which everybody likes. I don't want to do different items for different family members. […] I try to make them eat everything. Even if they do not like it I tell them, try it you know for example they do not like aubergine so if we do a dish with aubergine they will eat, it usually includes chicken, so they will eat the chicken and the potato and they will exclude the aubergine." (mother of 9-year old girl, obese, dental caries)

These quotes suggest that eating healthily as a family seems to be a challenge in most households who participated in this study. Most of the children that were part of these interviews were identified as picky eaters and parents struggled to change their children's eating behaviour.

4.4.4.4. The consumption of treats including sugar-sweetened beverages

Parents mentioned that they give their children treats on a regular basis. Some families consumed fizzy drinks or sweets more frequently than others, and all indicated that they allowed their children to consume either fizzy drinks or treats. The frequency of consumption of fizzy drinks or treats ranged from once a day to a couple of times a month and therefore differed between families.

> *"Then when she feels like she wants a small drink with dinner, it's mainly like fried even the fish and chips or pizza, she prefers that, you know, you gotta get spoiled, you know, once a week."* (mother of 10-year-old girl, obese and dental caries)

> *"When he is watching his PlayStation, he will snack in between […] I think he will go for crisps."* (father of 11-year-old-boy, obese and no dental caries)

Treats were often described as something necessary by the parents, highlighting the need to treat oneself every so often.

> *"I have got a lot of sugar free biscuits as well so I am trying to be aware and what they are doing but because as well you have to have that little snack you gotta have that treat, otherwise I mean sometime you just fancy that and I mean chocolate, if your body is saying have it why not"* (mother of 5 and 11-year-old girl, both obese and no dental caries, dental caries respectively)

> *"Snacks, literally only if you eat something healthy like dinner, breakfast something after you can have a sweet so this is like a treat."* (mother of 10-year-old boy, obese, no dental caries)

Children would either get a treat with their school lunch, provided by the school or packed in their lunch taken from home, or would get a treat after school or after dinner. Not all families would give

their children treats every day, but rather mentioned to go out for dinner once a week or every two weeks as a treat.

> *"And then weekends, we do have a treat, I am not going to say we don't, so we might have a MacDonald kids meal or whatever [oldest] did use to have an adult meal but I cut that right down, so we just have a kids meal, we don't have a desert. We don't have milk shakes, we have coke zero, so and then Sunday, if we are out and about, we will have a Sunday dinner somewhere. I don't cook a lot to be honest, just because I work until 7 twice a week, so."* (mother of 5- and 10-year-old boys, both obese and no dental caries and dental caries, respectively)

The word snack however was often described as the same as the word treat by other families. One parent also mentioned that parents are aware of the unhealthy attributes of treats, but they might not be able to restrict their child of that treat.

> *"I think they [other than her own children] have a lot of problems with oral health because of the sweets that they have, the high acids and e numbers that they have. […] No, they [other parents] must [have the knowledge on oral health]. I know that when I first said to [boy] oh can I have that, so children must like it you know it is sweet and it lasts for a long time. So maybe they do not want to put up with the tantrums. But I would rather have the tantrum. So maybe easier life. Or maybe they are just a bit naïve. Yeah, I don't know"* (mother of 11-year-old boy, obese and dental caries)

In this quote the mother specifically highlights the oral health issue in relation to food consumption, compared to the other two quotes of this section. Quotes in previous sections have highlighted the link between food consumption and oral health such as, bottle drinking (p.110) and food consumption and weight gain (p. 122). The following section therefore outlines parental perception on a possible link between weight and dental caries.

4.4.5. Theme 5: Parental perception of the link between dental caries and weight

The theme parental perception of the link between dental caries and weight, comprised two codes: (1) sugary foods and sugar sweetened beverages, and (2) toothbrushing.

The codes have been discussed in detail in Section 2.7.1.2 in the health behaviours and practice section of the child level attributes in the proposed framework.

4.4.5.1. Sugary foods and sugar sweetened beverages

When parents were asked about a possible link between weight and dental caries, answers between parents varied. Some parents mentioned that they were not sure of a link, as their children had weight issues, but no dental caries.

> *"I am not sure. Because their teeth are healthy, I am just struggling with the weight. They are overweight. So, I am not sure, I can't say whether that is related or not."* (mother of 9-year-old boy, obese, no dental caries)

> *"Don't really know. Because if they tend to like cut down on the sugary stuff they keep up their weight and keep their teeth more healthy. The chocolates, the fizzy drinks, the Junk food"* (mother of 10-year-old girl, obese, dental caries)

This last quote shows the insecurity of the mother, possibly through experience, cutting down on sugar food had helped to improve dental health but not to decrease weight. Other parents indicated that there was a clear link, mainly pointing towards sugary foods and sweetened beverages influencing the development of both.

"Yes, I think it should be like that because I have experience with my daughter, and she had problems because she was loving to sleep with the bottle. So she had very early, I don't know how that is called, her tooth was brown, and we had to remove all her top teeth because it was such a bad infection and I didn't know with a young child, like she is one year old or two years old that I had to go to the dentist." (mother of 10-year-old boy, obese, no dental caries)

"Sweets, chocolates fizzy pop. Fizzy pop definitely [the link between the two]" (mother of 11- year old girl, obese and dental caries)

"If you have an unhealthy meal, sugar food, sugary things and things like that, surely over time it is going to affect your teeth. Is going to impact the way your teeth be like." (mother of 11-year-old girl, obese and no dental caries)

Sugary foods were mentioned by most parents in relation to the development of overweight/obesity and dental caries, however not all parents said that there was a clear link. Most parents said that sugar influences the development of both, but adequate toothbrushing can prevent dental caries. Therefore, the next section contains quotes of parents saying that toothbrushing influenced the link between dental caries and overweight/obesity development. Most parents however also point towards diet in the relationship of the two conditions.

4.4.5.2. Toothbrushing

Some parents indicated that there was a link, due to a sugary diet, but toothbrushing could prevent dental caries.

> *"I would say probably yes, just because my kids do, or my oldest one especially eats a lot of sweets and crisps and chocolates and things like that, ice creams. […] he did have one tooth taken out because he had a tiny winy whole in it. I think that was really about the amount of sugar that he was eating, and he wasn't brushing very well. […] I would say there is a link."* (mother of 5- and 10-year-old boys, both obese and no dental caries and dental caries, respectively)

> *"I think that was really about the amount of sugar that he was eating, and he wasn't brushing very well."* (mother of 10-year-old boy, obese and dental caries)

One mother, even though also highlighting the high sugar diet of her child, did not see a link even though her son did have dental caries experiences. She mentioned, as did other parents, that toothbrushing can prevent dental caries. If good toothbrushing was practiced, she thought that there was no link between the two.

> *"I don't actually. I think if a child brushes their teeth regularly and if it brushes them well. I don't think it is that much of a relationship. It does intervene with dental health I know that, but only to a certain degree. So, […] he has acid coming into his mouth. Plus, he has a high sugar diet, but he brushes his teeth. […] So, I think in relation to overweight and having a high sugar diet, cleanliness is also involved in this"* (mother of 11-year-old male, obese and dental caries)

The differences in answers on whether a link is seen or not, may be due to the different interpretation of the question. The mother who gave the last quote might have focused on the overall outcome, possibly meaning that a sugary diet can influence overweight/obesity development as well as dental caries, however in the end the child must not necessarily experience dental caries, if the teeth are brushed properly. Therefore, she might have answered that there was no link. Interestingly her son however did experience both, dental caries and obesity, influenced by a sugary diet.

Another mother mentioned that toothbrushing was important, and if toothbrushing was not done adequately, there could be a link.

> *"I think if you don't look after your teeth and clean them regularly there can"* (mother of 5 and 11-year-old girl, both obese and no dental caries, dental caries respectively)

One mother highlighted that her daughter had not gotten dental caries through a diet high in sugar but rather due to eating too many fruits containing acids and not brushing her teeth very well.

> *"I think if you don't look after your teeth and clean them regularly there can. But I had an incident with [3rd child] […] it makes her teeth rot and actually quite a few had to come out because when they are children, they have them taken out because they were rotting […]. It wasn't because she was eating a lot of rubbish or drinking a lot of rubbish it was the citrus fruit. But like I said what she should have done was really brush her teeth regularly, probably more so than everybody else. It probably sometimes does have a link, but it can also depend on how you look after your teeth as well. I mean I know a lot of people that eat sugary stuff and they have perfect teeth, so they clean them all. I think it can depend on how you look after your teeth."* (mother of 11-year-old girl, obese, dental caries)

The quotes reveal that overall parents did think that there was a link between dental caries and overweight/obesity, however that the relationship could be mitigated by adequate dental toothbrushing. Eight of the 15 children had experienced dental caries, according to their parents. Toothbrushing might have had an impact in preventing dental caries as not all the obese children participating in the ANK programme who were exposed to a high sugar diet had experienced dental caries, however as toothbrushing was not assessed in this study, it cannot be concluded that toothbrushing was the reason as to why some children did not experience dental caries whilst others did. The relationship is discussed further in the next section.

4.5. Discussion

The link between dental caries and overweight/obesity in children has previously been investigated in a number of studies which have predominately utilised cross-sectional surveys (Hooley et al., 2012a,

Ribeiro Silva et al., 2013, Hayden et al., 2013, Li et al., 2015, Angelopoulou et al., 2019, Manohar et al., 2019, Paisi et al., 2019). The aim of this study was to explore parents' experience of their child's overweight/obesity and dental caries in more depth utilising semi-structured interviews. The interviews were framed around the adapted framework outlined in Section 2.7, but parents were also free to speak about any other factors that were relevant to the study topic in order to gain as much detailed information as possible. Thirteen interviews were subsequently conducted with parents of obese children participating in the ANK obesity management programme in Sheffield, UK.

This section discusses the relevant findings of this qualitative study beginning first with a discussion of oral health and toothbrushing, dietary behaviour, and physical activity. Following this section, there is a discussion of two themes that emerged from the interviews but were not originally in the adapted theoretical framework; these were weather and safety of the neighbourhood. The final section considers the link (or not) between overweight/obesity and dental caries as discussed by the parents in this qualitative study.

4.5.1. Dental caries and toothbrushing

When children in this study had dental caries, parents seemed to feel the necessity to further search for an origin of the disease, besides a lack of adequate toothbrushing. They mentioned genes or a diet high in acid containing fruits as possible causes. The search for cause in relation to health beliefs has been explored in depth in relation to a number of different dental and non-dental conditions and often relates to a lack of knowledge on the condition (Gupta et al., 2010, Yen et al., 2004). These findings have been confirmed, by Pine and colleagues (2004), who conducted an international study on 2.822 children (mean age 4 years, SD 0.6) investigating dental caries experience and its possible relation to familiar cultural beliefs as highlighted in Section 2.7.1. This study found that parental health beliefs and parental knowledge favourable to dental caries prevention play an important role in the prevention of childhood dental caries (Pine et al., 2004). Similarly, Duijster and colleagues (2015) conducted focus-group discussions with 39 parents of 7-year old children of Turkish and Moroccan background in the Netherlands, recruited from paediatric dental centres in the Netherlands, to identify parents' perceptions of barriers and facilitators that influence adherence to key behaviours, including twice

daily tooth brushing with fluoride toothpaste and reducing the consumption of sugary foods and drinks in children. The authors also explored parents' views on limitations and opportunities for professional support to promote children's oral health. Parents in their study indicated that they had received conflicting information on sugary foods and fruit intake from health care professionals, which made parents insecure on what was best for their children (Duijster et al., 2015).

Although Duijster and colleagues' study focused on specific ethnic minorities, and therefore results might be specific to this particular target group, a lack of knowledge and a wish for better information from health professionals has been found in other studies, and indeed was discussed by one parent in their interview for the current study. More parents, however, did not mention the origins of dental caries, possibly suggesting a lack of knowledge. A lack of knowledge on (dental) health is often linked to unhealthy behaviour and in the case of childhood dental caries to the lack of sufficient satisfactory toothbrushing behaviour (Skeie et al., 2006, Mattheus, 2010) and a diet high in sugar (World Health Organisation, 2016c, Fisher-Owens et al., 2007). This was not confirmed by the current interviews, as most of the other parents suggested that they knew the importance of frequent and good toothbrushing behaviour to reduce the risk of dental caries and is in line with previous findings in the literature as described in Section 2.7.2.2.

Nevertheless, the current study did not investigate at what time in point parents learned about the importance of frequent and good toothbrushing. If parents learned about this only after their first child had experienced dental caries, this might explain why they reported difficulties dealing with their child's unwillingness to brush their teeth, even though parents indicated that they recognised the importance of good nutrition and frequent toothbrushing (Amin and Harrison, 2009, Vermaire et al., 2010). These findings are further discussed and linked to overweight/obesity in the overall discussion in Chapter 6 of this thesis.

4.5.2. Barriers and enablers of children's physical activity

In this study, the parents talked about a number of factors that were associated with the physical activity levels of their child. Two factors, which are discussed in the next section, were the weather

conditions which had an impact on the amount of time the child spent outside being active as well as the safety of the neighbourhood. In line with the adapted theoretical framework, parents highlighted that their children spent a large amount of their free time behind a screen. Some parents even went as far as calling it an obsession and an addiction. They indicated that most of their children would rather sit in front of the TV instead of playing outside. It has been confirmed that increased time spent in front of the television decreases time spent physically active among children (Zhang et al., 2015, Fang et al., 2019) and is associated with an increased BMI (Jago et al., 2005, Fang et al., 2019, De Coen, 2014, Stiglic and Viner, 2019). Some parents mentioned that their children were more interested in being physically active when their parents joined them in those activities. This is in line with previous research indicating that parental role modelling has a positive influence on children's physical activity pattern (Davison et al., 2003). However, parents mentioned that time was often an issue for them to take their children somewhere to be physically active.

4.5.3. Children's dietary behaviour

In terms of diet, increased screen time has previously been linked to an increase in consumption of foods high in sugar and fat (Zhang et al., 2015, Hobbs et al., 2015). Parents participating in the interviews in this study, had not been asked specifically about the snack consumption of their children in front of screens. Yet, many of the parents mentioned that their child would go for a treat while watching TV. There has been literature confirming the link between screen time and overweight/obesity in children. As discussed in Section 2.7.1.2. a meta-analysis by Zhang et al in 2015 including 14 cross-sectional studies and 106,169 subjects found that increased television watching is associated with an increased risk for childhood obesity (Zhang et al., 2015). This might be due to television watching often being accompanied by the consumption of snacks high in sugar, salt and fat food (Hobbs et al., 2015).

Another issue mentioned by parents in the interviews were children's unhealthy food choices and options that they are given outside of the home (Weber Cullen et al., 2000). Parents highlighted that children would opt for the unhealthy option rather than the health one. This is most likely due to taste and possibly habit of opting for the unhealthy choice (Hooley et al., 2012b, Weber Cullen et al., 2000,

Noble et al., 2000). Parents highlighted that children that have previously eaten a lot of unhealthy food found it more difficult to change to the healthier options, which has been confirmed by previous literature (Weber Cullen et al., 2000). Also, children may not understand the benefit of the healthy food options (Noble et al., 2000). Lastly, children may need a reinforcing environment and could find it challenging to maintain a healthy diet if extended family or friends trigger them to follow unhealthy choices (Amin and Harrison, 2009). This supports previous studies referred to in Section 2.7.2.3.

4.5.4. Additional themes arising from the interviews

As outlined in the section above, the findings of the interviews with parents indicated support for many of the concepts within the developed framework (Section 2.7, Figure 4, p. 40). In addition to these, two new codes emerged from the interviews, weather conditions and safety of neighbourhood, both of which were within the theme relating to parent's beliefs around the barriers and enablers of their child's physical activity. Interestingly, weather is usually defined as an external determinant of health and is therefore typically placed in the socio-environmental level of the social determinants of health (Office of Disease Prevention and Health Promotion, 2020, Maziak et al., 2008) outside of the child and family level of such frameworks, including the framework of this PhD. Nevertheless, previous literature has examined the association between the weather and childhood overweight/obesity. Harrison and colleagues conducted a longitudinal cohort study investigating the association between rainfall and physical activity among initially 9-10 year old children in Norfolk, UK (Harrison et al., 2015). The children were recruited through the SPEEDY study (University of Cambridge, 2020) and wore accelerometers on ≤7 days for three occasions in the summers of 2007, 2008 and 2011 (Harrison et al., 2015). Weather data was obtained from two local weather stations (Harrison et al., 2015). This study found that among primary school children, increased rainfall was associated with decreased physical activity (Harrison et al., 2015). Similar results were found in a systematic review of 37 studies, published between 1980 – 2006, investigating the association between season and weather to physical activity in eight countries (Tucker and Gilliland, 2008). Twelve of these studies investigated the relationship of physical activity and weather among children and adolescents, 3-18 years of age through either self-assessment, parental assessment or using technology

to track physical activity levels at different days during the week using a calorimeters (Tucker and Gilliland, 2008). The authors concluded that physical activity levels decreased during the cold winter months, but in some warmer regions in the US, physical activity also decreased during hot summer months (Tucker and Gilliland, 2008). These studies confirm the findings of this research that rainy weather and cold weather decreases physical activity levels among children. Designers of future prevention programmes should take weather conditions into account and provide indoor space for children to be physically active in winter months (Tucker and Gilliland, 2008).

The second new code that originated from the analysis of the interviews with ANK participants in Sheffield was the safety of the neighbourhood. As above, the safety of neighbourhood is usually seen as an external determinant of health (World Health Organisation, 2010a); again, as with the weather, outside of the child and family level determinants that the current PhD was focussed upon. The safety of neighbourhood has been discussed previously in past research on childhood overweight/obesity and dental caries (Weir et al., 2006, Fisher-Owens et al., 2007). Whereas safety of neighbourhood or often called physical safety is often linked to fewer physical activity in weight research, in dental caries research it is typically linked to dental trauma from either unsafe playgrounds or violence (Fisher-Owens et al., 2007).

In the present research, however, concerns of parents were linked to physical activity rather than to dental health. These findings fit with previous studies. For example, An and colleagues (2017) conducted a systematic review of 22 prospective cohort studies and meta-analysis of eight studies on the impact of neighbourhood safety on physical activity of children aged 17 and younger. The studies were conducted in seven developed countries, USA (11), Australia (4), Canada (2), UK (2), Germany (1), the Netherlands (1) and Vietnam (1). Study populations ranged from 171 to 12,701 with a mean of 3,447 (An et al., 2017). Children were between the ages of 0-17 years of age, with the majority (15 studies) between 4-11years of age and were followed for a medium of 4.5 years. Neighbourhood safety measures were measured subjectively by parents or children themselves in 16 studies, only two studies used objective measures such as neighbourhood crime rates and road conditions and four studies used both, objective and subjective measures. Weight related behaviour was measured by most

studies through questionnaires and by three studies through accelerometers. Further, BMI outcomes were calculated using objectively measured height and weight status in most studies (An et al., 2017). The authors concluded from the meta-analysis that children living in unsafe neighbourhoods had a modest increase in BMI-z score and a reduction in weekly physical activity duration, but not with an increased risk in overweight/obesity development (An et al., 2017). This review confirms the findings of this research, concluding that physical activity levels decrease in unsafe neighbourhoods, however also highlights that it is not physical activity alone that can predict obesity, which has also previously been confirmed (World Health Organisation, 2014c).

4.5.5. Dental caries and overweight/obesity: Any link?

In this, one of the first qualitative studies on overweight/obesity and dental caries to be conducted, parents did talk about a link between these two conditions in their children. The common link discussed by parents was that their child's diet was one high in sugar. Parents talked about sugary foods and drinks influencing both dental caries and overweight/obesity development. A consumption of a diet high in sugar has previously been associated with both, dental caries and overweight/obesity (World Health Organisation, 2018, World Health Organisation, 2014a, Paglia et al., 2016, Almasi et al., 2016).

However, in the previous literature, whilst a high sugar diet has been identified as a risk factor for both overweight/obesity (World Health Organisation, 2014a) and dental caries (World Health Organisation, 2018), findings of previous literature on other common risk factors were less conclusive. As previously mentioned in Section 2.8 and 2.9, those reviews that have examined the link between dental caries and overweight/obesity found inconclusive results, mainly due to differences in study design, study location and measurement differences of overweight/obesity and dental caries. Another reason for this might be the limited determinants of dental caries and overweight/obesity included in those reviews, as discussed in more detail in Section 2.8.

The parents interviewed took their experiences from social and family factors that influence dental caries and overweight/obesity development over time. Suggesting that, in accordance with the

literature, a diet high in sugar can influence the development of dental caries and overweight/obesity, toothbrushing however can disrupt the association. The quotes from the interviews of this study suggest that knowledge on dental caries prevention plays an important part in parents answers on the link between the two. Parents knew about the negative influence sugar and the preventive influence toothbrushing has on their child's dental health. Parents might allow children to eat sugary foods, as they know that toothbrushing can prevent dental caries. Most parents highlighted the importance of toothbrushing, and that dental caries could be prevented through good toothbrushing behaviour, and therefore obese children do not necessarily need to experience dental caries according to the parents. The literature confirms that toothbrushing with fluoridated toothpaste is considered an important aspect in dental caries prevention (Tubert-Jeannin et al., 2011, Lima et al., 2016, Chankanka et al., 2011, Marinho et al., 2013) and also that parental health behaviours in establishing and maintaining regular toothbrushing behaviour of their child can be favourable for preventing dental caries (Pine et al., 2004). However, this research did not assess at what point in time parents gained knowledge on dental caries, toothbrushing and sugary foods. One parent mentioned that she wished she had known that milk bottle drinking at night had a negative influence on her child's teeth for her first child. This seems to suggest that not all parents knew about the relationship between toothbrushing, dental caries and sugary foods from the time of becoming a new mother.

Even when parents knew about the importance of good oral hygiene, it was mentioned that good toothbrushing among their children was difficult to accomplish for them. They found it difficult to enforce regular toothbrushing behaviour in their child, as children were resistant to be controlled brushing their teeth and often too tired to brush them in the evenings. Similar results were reported by a Dutch qualitative study on toothbrushing behaviours among children (Duijster et al., 2015). Parents in the Dutch study mentioned difficulties in enforcing regular toothbrushing behaviour (Duijster et al., 2015). However, the literature, as discussed previously, suggests that toothbrushing with parental help leads to or a more effective plaque removal (Harris et al., 2004). The difficulties that parents' experience could be due to inconsistency in parenting behaviour towards a toothbrushing routine, possibly indicating that parents were not always aware of the importance of good toothbrushing behaviour and only started to enforce toothbrushing at a later age of the children. The literature

underlines this issue, finding that children from families who were less likely to consider dental caries a serious disease and those who perceive themselves as least able to establish and maintain regular tooth brushing for their child are eight times more likely to develop dental caries (Pine et al., 2004).

Interestingly though, throughout the interviews, parents only looked at dental caries and mentioned toothbrushing being able to disrupt the possible relationship between dental caries and overweight/obesity. None of the parents mentioned a possible disrupter of the relationship from the overweight/obesity perspective, such as physical activity or a low calorific diet. The effects of increased physical activity and a healthy diet on overweight/obesity has been studied extensively and was discussed in Section 2.7.1 of this thesis. It may be these issues were not discussed due to the characteristics of the study population. That is, all parents interviewed had children that were obese, and only some experienced dental caries. Therefore, obesity may be a given in this particular study population and dental caries seemed to be the condition that was preventable. It would be interesting to study this in more detail in another population; perhaps those young people who are overweight/obese who also all have clinically assessed dental caries.

4.6. Conclusion

In this Chapter, the qualitative study aiming to explore the potential common link between weight and caries through interviews with parents of obese children in Sheffield found support for the limited previous findings to date in this area. That is, the important role of a diet high in sugar. There were, in addition, a number of other common factors discussed by parents that could be seen to link the two – whether directly or indirectly (i.e. through another variable). For example, weather, safety of the neighbourhood, screen time. What these findings suggest is that the common determinants of obesity and dental caries will be a complex inter-play of child- and family-level. This is discussed further in the final discussion chapter of the thesis (Chapter 6), together with the strengths and limitations of this study.

5. STUDY II: DETERMINANTS OF DENTAL CARIES AND OBESITY IN CHILDREN

5.1. Introduction

This Chapter presents the quantitative study of this PhD. The section starts by introducing previous studies in the field followed by the rationale and aim of the study. Following this, the research design, methods and analysis are described after which the key findings are introduced. The section ends with a brief discussion of the findings and a conclusion. The final discussion and conclusions are presented, together with those of the qualitative study, in Chapter 6 and 7.

5.2. Research to date

The relationship between childhood dental caries and overweight/obesity has been discussed in detail in Chapter 2. From the literature reviewed in Chapter 2, previous systematic reviews have found inconclusive results on the relationship between childhood dental caries and obesity. The possible reasons for these discrepancies were discussed, including the omission of important determinants for obesity and dental caries in the majority of previous studies (e.g. SES, diet). Following a review of the literature, an adapted framework for the social determinants of childhood dental caries and overweight/obesity was developed – based on those proposed by Fisher-Owens and colleagues (2007) and Davison and Birch (2001). The second study of this thesis was designed to test this adapted framework using a quantitative approach. The study aimed, as described in Section 2.9, to examine the determinants of childhood overweight/obesity and dental caries according to the proposed framework using longitudinal cohort data of the BiB study, dental GA data and data from the oral health survey of 5-year old children 2014/2015. The conceptual framework was used to guide the selection of variables (and subsequent measures) and the SEM analysis.

5.2.1. Finding suitable secondary data

A suitable dataset with meaningful variables was needed to populate and test the proposed framework. Potential datasets were searched, including different longitudinal cohort studies within the UK and abroad. The following search criteria were applied: (1) the dataset should include variables that could be operationalised to test as far as possible the adapted framework, including valid measures for dental caries (e.g. dmft) and overweight/obesity (BMI), (2) the dataset should include variables representing key individual and social determinants of overweight/obesity and dental caries that had been identified in the literature, (3) the dataset should contain longitudinal data.

Finding a dataset that fulfilled the above criteria was challenging since most datasets of longitudinal health data do not meet all the above-mentioned requirements. Academic collaboration with the BiB cohort study to use the BiB1000 dataset seemed an ideal scenario, as dental caries data of participants had been collected previously (Raynor, 2008). This dataset, which is described below (see Section 5.2.2.1), did not include dental data originally. However, through a collaboration with Leeds Dental Institute at the University of Leeds, dental data of the participants were obtained and linked with the BiB1000 dataset. The dental data collection and collaboration with the University of Leeds will be described in Section 5.2.2.2. Researchers from the University of Leeds were already, prior to this PhD, interested in linking the two datasets and had therefore obtained consent for data linkage from the participants of the BiB1000 cohort study.

Data for the current study derived from three different data sources. All participants of this study took part in the BiB cohort study (Raynor, 2008). Some of the participants of the BiB study had also undergone dental GA (n = 1,071) or had participated in the oral health survey of five-year-old children 2014-15 (n = 354) (Public Health England, 2014b) and had agreed to data linkage. The BiB study as well as the dental GA dataset and the oral health survey of five-year-old children 2014-15 dataset are described in detail below.

5.2.2. Description of the data sources

5.2.2.1. The Born in Bradford Cohort Study

The BiB Cohort Study is a multi-ethnic longitudinal birth cohort study that collected information on health and well-being of over 13,500 children and their parents residing in Bradford, UK (Born in Bradford, 2017, Wright et al., 2013). The study included children who were born between 2007 and 2013 at the Bradford Royal Infirmary (Born in Bradford, 2017, Wright et al., 2013). Women were recruited between the 26th and 28th weeks of their gestational period at the Bradford Royal Infirmary (Born in Bradford, 2017). Mother, children, and their families have been followed from pregnancy through the childhood to investigate the social and environmental influences on health and diseases (Born in Bradford, 2017, Wright et al., 2013). The data has been used to analyse the causes of childhood illnesses and cognitive and social development of this cohort, and to develop new strategies to improve the health of the families (Born in Bradford, 2017).

Data collected in the BiB study includes DNA data, maternal depression, children's wellbeing, growth and obesity patterns, asthma, allergies, family use of green spaces, heart diseases, diabetes, risk factors for genetic disorders and vision problems, measurement of physical activity, motor co-ordination, and data on diet and household income, among others (Born in Bradford, 2017).

The BiB study contains many sub-projects gathering data throughout the different stages of the life course (Born in Bradford, 2017). The present study has used data from the BiB1000 dataset as well as the mother's baseline data (Born in Bradford, 2017). The latter included information on socio-demographic and family circumstances, as well as mother's weight and height (Born in Bradford, 2017). Mother's baseline data was collected after BiB study recruitment, which occurred between the 26^{th} and 28^{th} weeks of the gestational period (Born in Bradford, 2017).

The BiB1000 dataset contains information on sociodemographic, developmental and clinical measures of 1763 children that were obtained at five different time points: at 6, 12, 18, 24 and 36 months after birth (Born in Bradford, 2017). The questionnaires of each time point did not always include the same questions since they were chosen according to the children's age and development stage of the child.

The mothers completed the BiB1000 questionnaires partly through individual interviews by a BiB researcher and partly by self-completion.

Additional data needed for this study, which was not available in the BiB1000 dataset, but was available within the overall BiB study was made available to the researcher by the BiB team and included in the current study. This included data on children's demographics, such as the child's sex, social deprivation status as well as a table comprising weight and height measurements of the child at different time points including their age in months at each point of measurement. This data was compiled by BiB researchers throughout the different waves of the BiB study. As not all children participated in all appointments of growth measurement throughout the years in the BiB study, there was variability in the amount of data available for each child. Therefore, the BMI for each child was calculated using the growth measurement closest to their dental GA appointment or in the case of children who did not undergo dental GA, closest to their completion date of the oral health survey of five-year-old children 2014-15.

5.2.2.2. The dental GA dataset

The collaboration with the Leeds Dental Institute allowed the researcher to gain access to dental GA data of 1071 participants of the BiB study. The Leeds Dental Institute runs as a partnership between the University of Leeds and the Leeds Teaching Hospitals NHS Trust. The Institute is a referral centre offering specialised treatments for patients with referral from dentists or GDPs (Institute, 2019). The collaboration between academics from the School of Clinical Dentistry at the University of Sheffield and Dr Peter Day, from the University of Leeds and the Leeds Dental Institute, gave the researcher access to the routinely collected GA data of 1,071 patients, who had previously taken part in the BiB1000 study. All GA treatments were provided by NHS hospitals in Bradford. Research ethics were obtained, and the research protocol is available upon request. The GA dataset provided this study with data on each tooth of the child, consisting of coded data from 0-4 for each of the teeth. A tooth was coded as 0 if no treatment was performed, 1 if the tooth was extracted, 2 if the tooth was filled, 3 if the tooth was fissure sealed and 4 if the tooth was crowned. This information was later, in accordance with the research team from the University of Leeds, translated into decayed teeth (Code 1) and

healthy teeth (Code 2) in order to be comparable with the dmft data from the oral health survey of five-year-old children 2014-15. The dmft index is composed of the total number of decayed, missing and filled deciduous teeth registered through dental clinical examinations. All extracted, filled or crowned teeth (1, 2 or 4 above) resulted from dental caries and therefore were coded as decayed teeth (Code 1). All teeth that were fissure sealed (4) or had undergone no treatment (0) were coded as 2 (healthy teeth). The number of teeth coded as decayed was added up to calculate dmft in order to be comparable with the dmft obtained from the oral health survey of five-year-old children 2014-15, which is described in the next section.

5.2.2.3. The oral health survey for 5-year-old children 2014-2015

The oral health survey for 5-year-old children was conducted in the school year 2014/2015. The survey is part of the Public Health England Dental Public Health Epidemiology Programme and is coordinated and carried out by Public Health England (Dental Public Health Intelligence Team, 2016). This was the third national oral health survey for 5-year olds. The surveys were conducted at mainstream primary schools in England and included 111,500 children who were 5 years old when the survey was conducted (Dental Public Health Intelligence Team, 2016).

Demographics (NHS number, full name, date of birth and address) of the children participating in the oral health survey were registered before undergoing a short dental examination to collect dmft. Ethical approval and parental consent was obtained prior to the data collection (Day et al., 2018).

Three hundred twenty-four children participated in the BiB Study and in the oral health survey of five-year-old children 2014-15. For 316 of those children consent was given for data linkage. Prior to this study, the participants data of the oral health survey of five-year-old children 2014-15 and the BiB data was linked using NHS numbers (Day et al., 2018). Pseudo anonymisation software was used to encrypt the NHS numbers and then link without sharing the original NHS numbers from either dataset (Day et al., 2018).

5.2.3. Access to the data

A first meeting to discuss a possible collaboration with the BiB cohort study was held between Dr Peter Day, Professor Sarah Baker, Dr. Mario Vettore and Magdalena Uerlich on the 27th of July 2017 in Sheffield, UK and was organised by Dr Peter Day and Professor Sarah Baker. Dr Peter Day has strong relations with the BiB Cohort study and clarified the different aspects of accessing data. He initiated the meeting with the project manager of the BiB cohort study, Dr Rosie McEachan. This meeting took place in Bradford, UK at BiB Institute on August 10th, 2017. Professor Sarah Baker, Professor Peter Day and Dr. Mario, Dr Rosie McEachan and Magdalena Uerlich attended the meeting. Prior to the meeting Magdalena Uerlich sent a short project summary to the project manager Dr Rosie McEachan. During this meeting the objectives of the study as well as the feasibility and the steps for data accessibility were discussed.

The dataset was accessed after signing the collaboration agreement. The data was sent in raw format to the primary researcher in an encrypted format.

Further guidance on the data was given throughout the PhD process by the statistician Dr. Gilian Santorelli by email, phone and through face-to-face meetings at the Bradford Research Institute.

The data dictionaries as well as the original questionnaires of all waves of the cohort are freely accessible through the BiB website (Born in Bradford, 2017).

5.3. Research method

5.3.1. Cleaning of the dental dataset

As outlined above, the dental data derived from two different sources. The two dental data sets were linked to the BiB1000 data set according to the individuals' NHS numbers by an administrative clerk who was trained up by a senior nurse in the Bradford District Care NHS Foundation Trust, who run the dental electronic records for the Bradford Community Dental Service. The research protocols for the data linkage of both studies are available upon request.

A researcher and dentist from the University of Leeds, Mrs Lucy Brown and the primary researcher double-checked and cleaned the dataset afterwards. The primary researcher was not given access to any personal dental data of the BiB participants. The data cleaning took place at the Westbourne Green Community Hospital in Bradford, where patient data could be accessed through an NHS computer in a locked office. Lucy Brown accessed the data through an NHS computer and checked the data with the primary researcher, who accessed a password protected laptop checking the anonymised dental data. The anonymised dataset was checked with the NHS patient data. The data of the two datasets was compared according to the following variables:

1. NHS patient number
2. Date of birth of the child
3. Sex of the child
4. Date of dental GA
5. Dental GA data of the child (number of decayed, missing, filled, crowned teeth)

The primary researcher had, at no moment in time, access to any personalised patient data. Both, the primary researcher and Lucy Brown had meetings over eight days in June and July 2018 in Bradford to check the patient data (see Table 6 for dates and locations of the data cleaning meetings). The primary researcher gained access to the hospital and University of Leeds under the supervision of Lucy Brown and Professor Peter Day through an honorary contract, previously signed.

Table 6: Dates and locations of the meetings for data cleaning

Dates	Location of meeting
25.6.2018	Westbourne Green Community Hospital, Bradford
02.07.2018	Westbourne Green Community Hospital, Bradford
04.07.2018	Westbourne Green Community Hospital, Bradford
16.07.2018	Westbourne Green Community Hospital, Bradford
17.07.2018	Westbourne Green Community Hospital, Bradford
18.07.2018	Westbourne Green Community Hospital, Bradford
24.07.2018	Westbourne Green Community Hospital, Bradford
31.7.2018	Westbourne Green Community Hospital, Bradford

5.3.2. Data linkage of the dental and BiB data

Each of the BiB1000 datasets containing data from the questionnaires was received as a separate dataset in SPSS format, resulting in five BiB datasets, one for each questionnaire. The dental GA dataset and the oral health survey of five-year-old children 2014-15 dataset were also in two separate datasets. The variables sex, date of birth of the child, growth measures, including height, weight and BMI of the child and deprivation status were received from an additional dataset. The latter dataset was combined by Gillian Santorelli, the statistician at BiB, after those additional variables had been requested by the primary researcher. These variables came from various sources within the BiB cohort. The variables had been requested, as the BiB1000 dataset did not include data on sex and deprivation. In addition, data on height and weight were often available only at birth.

The PersonID variable consisted of an individual five-number code, identifying each participant throughout the five surveys. The PersonID was randomly generated prior to the start of this study and it was used throughout the BiB study to identify a specific participant. The code ensures anonymity and the researcher was not able to identify the NHS number of the specific participant.

After checking for duplicates in the PersonID variable, the datasets were merged using the PersonID variable as a linking variable. The dental GA dataset included a few duplicates in PersonID, as some

of the children had already had multiple GAs and each GA appointment was registered as a new case using the same PersonID. All GA appointments were coded as either first, second or third appointment and therefore allowed the researcher to differentiate between them. The second and third GA appointments were deleted from the file and only the first one was maintained in the dataset in order to compare dmft among all children. Afterwards, the datasets were linked to generate a single SPSS file based on the variable PersonID.

After combing the datasets, missing data was coded as 99 or 999 for all variables depending on the values of the variables. Cases without complete dental data either from the dental GA or the oral health survey of five-year-old children 2014-15, and those without data from the BiB dataset were deleted. The selected variables for this study are described in Table 7 in Section 5.4.3 of this research.

5.3.3. Variable selection

The variables of the datasets were selected based on the Fisher-Owens (2007) and Davison and Birch (2001) theoretical frameworks (Section 2.7) and on data availability from the previously described combined dataset. Some variables of the BiB1000 study were recoded to match with variables of the proposed framework. For example, the variable diet in the proposed framework was populated by multiple variables of the BiB1000 data set, such as fruit and vegetable consumption, fatty food consumption, and amount of food consumed. Variables of the BiB1000 study were chosen from all follow-up periods (6, 12, 18, 24 and 36 months of age). This was due to the variation on data availability of each questionnaire and the information needed to populate the proposed framework. By combining the information from all questionnaires, the proposed framework could be populated.

The variables included in the study are described below following the order of the proposed framework as family-level (see Table 7) and child-level (see Table 8), and the two outcome variables (see Table 9).

5.3.3.1. Family – level variables

Table 7: Family-level variables

Variable name	Source	Question in BiB questionnaire	Original categories and adaptations made	Description of variable	Type of variable	New Categories
Deprivation status	BiB source	This information derived from a variety of sources and was already given in a recoded format to the researcher.	No adaptations made	The variable describes the SES of the family the child grows up in. The variable derives from latent class analysis previously conducted with BiB data by Fairley and colleagues (Fairley et al., 2014).	Categorical	1) least deprived and most educated 2) employed and not materially deprived 3) employed but no access to money 4) receiving benefits but coping 5) most deprived
Mother's alcohol consumption	BiB1000 24 months	Have you drunk alcohol since giving birth	1) yes once a week or more 2) yes occasionally 3) no 4) I don't remember	The variable describes if the mother consumed alcohol after giving birth	Categorical	1) yes 2) no
Mother's age at birth	BiB1000 datasets	Age of mother (months)	The age at birth was calculated from the reported age of the mother at the time of the 6-, 12-, 18-, 24- and 36-month questionnaires	The variable indicates the mother's age at birth in months	Categorical	1) under 25 2) between 25 and 29.9 3) 30 and above
Child breastfeeding	BiB1000 6 months	Was (child's name) ever breast fed?	No adaptations made	The variable describes if the child was breastfed at any point after giving birth.	Categorical	1) yes 2) no

Variable name	Source	Question in BiB questionnaire	Original categories and adaptations made	Description of variable	Type of variable	New Categories
Parental psychological wellbeing	BiB1000 18 months	Outcome derived from the General Health Questionnaire (GL Assessment, 2019).	Validated questionnaire (GL Assessment, 2019). The scores of 28 questions were summed up.	The variables assesses somatic symptoms, anxiety and insomnia, social dysfunction and severe depression The higher the score, the worse psychological distress (GL Assessment, 2019)	Continuous	n/a.

Variable name	Source	Question in BiB questionnaire	Original categories and adaptations made	Description of variable	Type of variable	New Categories
Caregiver's feeding style	BiB1000 24 months	A validated questionnaire (Hughes et al., 2012)	Validated questionnaire. Two dimensions are derived through seven child-centred and 12 parent-centred feeding directives measured on a 5-point Likert scale (ranging from never to always). Child-centred feeding directives are those that promote child autonomy (e.g., reasoning, complimenting, and helping the child to eat). Parent-centred feeding directives at-tempt to control children's eating through external pressure (e.g. demands, threats, and reward contingencies). Using median splits, a cross-classification of high and low scores on the two dimensions identifies four feeding styles: authoritative (high responsiveness, high demandingness), authoritarian (low responsiveness, high demandingness); indulgent (high responsiveness, low demandingness), and uninvolved (low responsiveness, low demandingness) (Hughes et al., 2012).	Measures the feeding pattern of parents and identifies four feeding styles: authoritative (high responsiveness, high demandingness), authoritarian (low responsiveness, high demandingness); indulgent (high responsiveness, low demanding-ness), and uninvolved (low responsiveness, low demandingness) (Hughes et al., 2012)	Categorical	1) authoritarian 2) authoritative 3) indulgent 4) uninvolved

Variable name	Source	Question in BiB questionnaire	Original categories and adaptations made	Description of variable	Type of variable	New Categories
Ethnicity	Baseline questionnaire and other BiB sources	This information derived from a variety of sources and was already given in a recoded format to the researcher.	No adaptations made	This variable describes the ethnicity of the child	Categorical	1) White British 2) Pakistani 3) Other

5.3.3.2. Child – level variables

Table 8: Child-level variables

Variable name	Source	Question in BiB questionnaire	Original categories and adaptations made	Description of variable	Type of variable	Categories
Physical activity of the child	BiB1000 24 months	Taken your child to places where he/she can be physically active?	The variable had 6 categories: 1) never, 2) 1-3 times, 3) once a week, 4) 2-4 times a week, 5) 5-6 times a week, 6) every day. The categories were reduced to three	The variable describes how often the child has been taken somewhere to be physically active	Categorical	1) never 2) once a month up to once a week 3) twice a week up to 7 times a week
Sex	BiB source	This information derived from a variety of sources and was already given in a recoded format to the researcher.	No adaptations made	Sex of the child	Categorical	1) male 2) female
Daily TV hours during weekday of the child	BiB1000 24 months	Over the last months, on average how many hours per day does (child's name) watch TV or DVDs?	Question was asked four twice, 1) weekday before 6pm, 2) weekday after 6pm. Categories 1) none, 2) less than 1 hour, 3) 1-2 hours, 4) 2-3 hours, 5) 3-4 hours, 6) more than 4 hours. The hours were combined and categorised according to a 24-hour day	The variable indicates the hours of TV the child watches during a 24-hr weekday	Categorical	1) none 2) up to 1 hour 3) 1-2 hours 4) 2-3 hours 5) more than 3 hours

Variable name	Source	Question in BiB questionnaire	Original categories and adaptations made	Description of variable	Type of variable	Categories
Frequency of drinking sugar-sweetened drinks child	BiB1000 36 months	Questions derived from a children's food frequency questionnaire, sugary drinks such as pure fruit juice and fizzy drinks. The categories ranged from never to more than 7 times a day.	Previous categories were combined based on frequency distribution of data. Previous rarely or never - 1-2 times a month became 1) very low consumption of sugary drinks. Once a week – more than 7 times a week became 2) medium to high consumption of sugary drinks	The variable describes the frequency of drinking sugar-sweetened beverages over the period of 2-3 months	Categorical	1) very low consumption of sugary drinks 2) medium to high consumption of sugary drinks
Emotional and behavioural wellbeing of the child	BiB1000 36 months	Outcomes derived from the strength and difficulties questionnaire (SDQ). The SDQ consist of 5 scales, emotional problems, conduct problems, hyperactivity, peer problems and prosocial scale, each containing 5 situations, e.g. many fears, easily scared, which parents need to score from 1) not true, 2) somewhat true, 3) certainly true	Scores of each scale were added up. The scores were mostly given as follows: 1) not true was scored as 0, 2) somewhat true as 1, 3) certainly true as 2. This is a standardised questionnaire (Goodman, 1997).	The score of the validated questionnaire indicates the results of a brief emotional and behavioural screening of the child. A higher score indicates a less normal situation	Categorical	1) close to average 2) slightly raised 3) high 4) very high
Hours of sleep child/day	BiB1000 24 months	How many hours on average does (child's name) sleep in 24 hours? This includes any naps in a baby chair/buggy etc? a) Day, between 6 am and 6 pm b) Night, between 6 pm and 6 am	The sum of hours of sleep per night and hours of sleep per day.	The score indicates the hours a child sleeps per 24 hours	Categorical	1) less than 10 hours per 24h 2) between 10-12 hours per 24h 3) 12,5 – 14 hours per 24h 4) more than 14 hours per 24h

5.3.3.3. Outcome variables

Table 9: Outcome variables

Variable name	Source	Question in BiB questionnaire	Adaptations	Description of variable	Type of variable	Categories
Dental caries	GA dataset and oral health survey of five-year-old children 2014-15 (Dental Public Health Intelligence Team, 2016)	GA data was received as follows: each tooth was coded from 0-4; 0 if no treatment was performed, 1 if the tooth was extracted, 2 if the tooth was filled, 3 if the tooth was fissure sealed,4 if the tooth was crowned (see Section 5.2.2.2) oral health survey of five-year-old children 2014-15: the dmft was a given variable (see Section 5.2.2.3)	GA data: All teeth extracted, filled or crowned (1, 2 or 4 above) were as a result of dental caries and where therefore coded as decayed (Code 1). All teeth that were fissure sealed (4) or had undergone no treatment (0) were coded as 2 (healthy teeth). oral health survey of five-year-old children 2014-15: dmft scores >0 were recoded into 1) decayed and scores of 0 were recoded into 2) healthy	The categories indicate if a child has experienced dental caries or if the teeth are caries free	Count ranging from 0-21 teeth affected by dental caries	n.a.
Overweight or obesity of child	Different questions within the BiB dataset (Wright et al., 2013)	BMI-z scores (see Section 2.7.1.1.) The cut-off points for children are as follows: <-3SD: sever thinness >-3SD, <-2SD thinness >-2SD, <1SD normal weight >1SD, <2SD overweight >+2SD obesity	n/a	The variable indicates the weight status in relation to height and age of children	Categorical	1) severe thinness 2) thinness 3) normal weight 4) overweight 5) obese

5.3.4. Missing data

Of the 15 variables included in the analysis (14 for the parsimonious model (Figure 5, p. 169) (Table 7-9), 6 variables had complete data in both the parsimonious (Figure 5, p. 169) and the original model (171 cases). Nine variables had missing data (8 for the parsimonious model) ranging from 18% to 36% of missing data. Table 10 presents the number of missing observations for each of the 15 variables.

Table 10: Included variables in the data analysis

Variable description	**Missing data value**	**Percentage of missing data**
Weight status of the child	0/171	0%
Deprivation status	0/171	0%
Dental caries of the child	0/171	0%
Ethnicity	0/171	0%
Sex of the child	0/171	0%
Mother's age at birth	0/171	0%
Breastfed child	30/171	18%
Caregivers feeding style	30/171	18%
Hours of sleep per day child (excluded in parsimonious model)	31/171	18%
Physical activity of the child	30/171	18%
Daily TV hours during weekday of the child	32/171	19%
Parental psychological wellbeing	35/171	20%
Emotional and behavioural wellbeing child	35/171	20%
Frequency drinking sugar-sweetened beverages child	38/171	22%
Maternal alcohol consumption	61/171	36%

Missing data is usually classified into three types: (i) missing completely at random, (ii) missing at random, and (iii) not missing at random (Pedersen et al., 2017, Institute for Digital Research and Education, 2019, Garcia-Laencina et al., 2009, Sterne et al., 2009).

1. *Missing completely at random (MCAR)* occurs when the probability that a variable is missing is independent of the variable itself and any external influences (Garcia-Laencina et al., 2009). This scenario occurs seldom as the assumption that a variable is missing completely random is a strong assumption (Institute for Digital Research and Education, 2019).
2. *Missing at random (MAR)* follows the assumption that missingness cannot be predicted by the true values (Institute for Digital Research and Education, 2019). The missingness itself is independent but the pattern of missingness is traceable (Garcia-Laencina et al., 2009). If another variable in the dataset, but not the variable itself can predict the missingness of this variable it is considered MAR (Institute for Digital Research and Education, 2019). MAR is seen as a less restrictive assumption than MCAR (Institute for Digital Research and Education, 2019).
3. *Missing not at random (MNAR)* is classified as a variable that predicts missingness itself, one example would be income, as very high income populations are more likely to decline answering questions regarding their income (Institute for Digital Research and Education, 2019). IF MNAR occurred valuable information is missing and no general method of handling missing data is available (Garcia-Laencina et al., 2009).

The data in this dataset was classified as MAR. The missing data did not occur completely at random as missing data is mostly linked to participants missing a questionnaire at one or more of the time points of data intake. No data of this dataset is missing at MNAR.

5.3.5. Data imputation

There are several ways to deal with missing data. The easiest approach is complete case analysis. All incomplete cases are deleted before analysis. This method may only be used if the dataset is large enough to allow cases being deleted without having an impact on the statistical power of the dataset.

This method may also only be used if the data is MCAR. Otherwise bias may be considered an issue (Institute for Digital Research and Education, 2019). This dataset accounted too much missing data and therefore complete case analysis was not an option.

Another common method is maximum likelihood estimation (ML). ML assumes that the data is normally distributed and therefore works best with continuous variables only. However, as most of the variables used in this research were not continues, multiple imputation (MI) was chosen as a method to deal with missing data instead of ML. MI creates a number of different, plausible imputed datasets and appropriately combines the results from each of them (Sterne et al., 2009). The observed data is used to estimate multiple values that reflect the uncertainty around the true value (Institute for Digital Research and Education, 2019). When choosing MI one of the first choices that need to be made is the choice of distribution one wants to impute their variables under (Institute for Digital Research and Education, 2019). When imputing multiple variables at the same time, the Markov Chain Monte Carlo procedure, which assumes that all the variables of the imputation model have a joint multivariate normal distribution (mvn), is used most often in social research (Institute for Digital Research and Education, 2019, Allison, 2002). The algorithm used in this case is called the data augmentation algorithm and replace the missing data by drawing from the conditional distribution, mvn (Institute for Digital Research and Education, 2019).

Another method that may be used when working with categorical and or ordinal variables is multiple imputations by chained equations (MICE). This method is designed for non-normal distributed data such as categorical and ordinal variables. The MICE command imputes every variable separately using its own imputation model, and therefore is capable of handling different variable types (Royston and White, 2011).

However, the mvn method is the most researched and most theoretically sound if the sample is large enough (Institute for Digital Research and Education, 2019). Therefore, researchers suggest using the mvn method even when the normality assumption is violated (Allison, 2002). Most likely, when using the mvn method, the imputed data for categorical variables will be greater or smaller than some of the original categories within the variable (Allison, 2002). In the past, recommendations for rounding off

the data, that is greater or smaller than the original categories have been made (STATA CORP LLC). Some studies have suggested that rounding will make the results invalid (Allison, 2002). Unless the fraction of cases in any one category is very small, imputation without rounding, approaches valid results (Allison, 2002). As categories in this research have been formed based on case distribution, not one category produces small amounts of cases and therefore the imputation without rounding was used.

MI has three phases:

1. The imputation phase where data is imputed, and missing data is replaced by the dataset.
2. The analysis phase, where each of the datasets is being analysed using statistical analysis for example a linear regression analysis.
3. The pooling phase where the parameter estimates of each dataset are combined for inference (Institute for Digital Research and Education, 2019).

5.3.6. Multiple Imputation and structural equation modelling

Phase two of the MI process refers to linking the imputed datasets with a statistical method. In this case, SEM was chosen as the statistical method to test the theoretical model. This method was developed by geneticist Sewall Wright in 1921 and has its roots in path analysis (Hox and Bechger). SEM is used to test models and frameworks. One of the strengths of SEM compared to other methods is the ability to specify and estimate complex models, including those with latent and intervening variables between the independent and dependent variables (Hox and Bechger). The standard procedure when dealing with missing data in SEM is maximum likelihood (ML) with missing values. However, ML will not be used in this research for the reasons discussed earlier.

SEM is not compatible with MI in most common statistical software. This is mainly due to the reason that MI was designed to get point estimates by creating multiple datasets. Testing for model fit is therefore not possible as there is not one model/dataset, but multiple models/datasets that are being created through MI as described in phase one of MI. STATA users have created a way to link an imputed dataset with SEM as the statistical analysis of choice. This bypass gives indicative results for

SEM outcomes. However, it is not possible to run any fit indexes after the SEM command has been given. This is again due to not having one but many datasets through MI. The STATA commands used in this research are described below.

1. mvdecode (varlist), mv (99), or mvdecode (varlist), mv (999)

Missing data was coded into 99 or 999 depending on the variable.

2. mi set mlong

The data was converted to multiple imputed data in the marginal long style as this is the most memory efficient way of saving data in STATA.

3. mi register imputed (varlist)

Here the variable list that will include imputed data is defined. This is the variable list with all variables that have missing data.

4. mi impute mvn missing = nonmissing, add (40)

This step will impute the data. All variables with missing data were added as well as all data without missing data. The complete dataset will guide the imputation process. The dataset will be multiplied by 40, giving 41 datasets in total with the original data and the other 40 with imputed data. There is no rule on how many datasets should be included in the imputation. However, the more datasets are imputed the fewer the power fall off (Graham et al., 2007). The recommended number of imputed datasets for 30% missing data is 20 and for 50% of missing data is 40 imputed datasets (Graham et al., 2007). This research has 30-40% missing data and therefore it was chosen to reduce the power fall off as much as possible and use the 40 imputed datasets.

5. sem, standardized

Through this command, the standardised variables are produced to examine the effect of the independent variables on the dependent variables. The standardised outcomes are presented in Table 12 and Table 13 below.

6. estat gov, stats (all)

Model fit was tested with the imputed dataset before SEM was completed. This was done, since fit indices could not be created after SEM was applied to the imputed data, as MI in STATA produces multiple models. Therefore, the fit indices used served as an indication and do not represent those related to the final model produced in this research. The fit indices aimed for where the root mean square error of approximation (RMSEA) ≤0.05 and the comparative fit index (CFI) > 0.9. These indices were used as an indication only.

7. mi estimate, cmdok: sem

The mi estimate prefix is used to analyse multiple imputed datasets. The cmdok function allows unsupported estimation commands to run. SEM was run after MI had been applied. As STATA does not link MI to SEM, for reasons discussed earlier, a cmdok function was added. This function has been used previously in combination with SEM (Dorta and StataCorp).

5.4. Results

5.4.1. Descriptive data

As can be seen in Table 11 below, of the 171 children included in the analysis, 136 children had undergone a GA treatment. In this group, the children had an average age of 5.7 years at the time of their GA treatment, ranging between 2.3 and 6.6 years. Of the 35 children who participated in the oral health survey of five-year-old children 2014-15, the mean age was 5.4 years, ranging between 4 and 6 years. Children were between 0 and 5 years old at the time of anthropometric measurement with a mean of 3.88 years. In total 23.4% of the children were overweight/obese, including 9 participants of the oral health survey of five-year-old children 2014-15 and 31 of the GA sample. The average dmft was much higher (not unexpectantly) in the GA sample than the oral health survey of five-year-old children 2014-15 (9.1 and 0.9 dmft respectively). Overall, 46.2% of the studied sample was composed of male children.

Table 11: Demographic characteristics of the participants

Variables	Dental data		BiB (N = 171)	Total (N = 171)
	Dental GA (N = 136)	Oral health survey of five-year-old children 2014-15 (N = 35)		
Age children (years), mean (range)	5.7 (2.3 – 6.6)	5.4 (4 – 6)	3.88 (0-5)	n.a.
Weight status of child, N (%)				
Severe thinness	0	0	n.a.	0
Thinness	6 (4.5%)	0	n.a.	6 (3.5%)
Normal weight	99 (73%)	26 (74.3%)	n.a.	125 (73.1%)
Overweight	25 (18%)	8 (22.8%)	n.a	33 (19.3%)
Obese	6 (4.5%)	1 (2.9%)	n.a.	7 (4.1%)
dmft: mean (SD) range	9.1 (3.9) 2-21	0.9 (1.8) 0-8	n.a.	mean: 7.4
Sex, N (%)				
Males	68 (50%)	11 (31.4%)	n.a.	79 (46.2%)
Females	68 (50%)	24 (65.6%)	n.a.	92 (53.8%)

n.a. = not applicable

Table 12 shows the amount and percentage of dental caries and the BMI (in categories) of the participants. No participant was in the BMI category of severe thinness, six where thin and all of the six had decayed teeth, 125 were of normal weight, from which most had decayed teeth (n=109). Thirty-three were overweight, with most of them having decayed teeth (n=27) and seven were obese with six having dental caries. 23.4% (40/171) of the study population was either overweight or obese and the majority of these children 82.5% (33/40) had decayed teeth.

Table 12: Dental caries and BMI in study participants

		Dental caries		
		Decayed teeth	Healthy teeth	**Total**
BMI (in categories)	Severe thinness	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Thinness	6 (4.1%)	0 (0.0%)	6 (3.5%)
	Normal weight	109 (73.6%)	16 (69.6%)	125 (73.1%)
	Overweight	27 (18.2%)	6 (26.1%)	33 (19.3%)
	Obese	6 (4.1%)	1 (4.3%)	7 (4.1%)
Total		148	23	171

Table 13 and Table 14 present the family- and child-level characteristics. Both were calculated using the original data, before MI and therefore include a maximum of 171 children without missing data.

More than half of the children (57.4%) were from families receiving benefits or deprived families. In addition, the majority of the sample was of Pakistani origin (60.2%). Most of the mothers of these children (72.7%) did not drink alcohol since giving birth. Sixty-two percent of the mothers were under 25 years of age at the time of birth. Of the 141 mothers who answered the question about breastfeeding, 65.2% breastfed their child at least once. The parental psychological wellbeing determinant derived from the general health questionnaire indicated that 88.2% of the parents scored below the cut-off score indicating a “normal” psychological state, and 11.8% indicated to show some type of distress. The outcomes of the caregivers feeding style indicated that the majority of parents used an authoritative feeding style (48.9%), actively encouraging their child to eat with supporting behaviours, followed by an indulgent feeding style (34.8%), which also consists of supporting behaviours from the parents, but fewer eating demands than the authoritative style.

Table 13: Family-level characteristics of the children

Variable	Categories	Frequency	Percentages
Deprivation status	Least deprived and most educated	23	13.5
	Employed and not materially deprived	23	13.5
	Employed, no access to money	27	15.8
	Benefits but coping	62	36.2
	Most deprived	36	21.0
Alcohol consumption mother	Yes	30	27.3
	No	80	72.7
Mother's age at birth	Under 25 years of age	62	36.2
	Between 25-30 years of age	60	35.1
	Older than 30	49	28.7
Breastfed child	Yes	92	65.2
	No	49	34.8
Parental psychological wellbeing	normal health (threshold 23)	120	88.2
	worse condition/distress	16	11.8
Caregivers feeding style	Authoritarian	2	1.4
	Authoritative	69	48.9
	Indulgent	49	34.8
	Uninvolved	21	14.9
Ethnicity	White British	54	31.6
	Pakistani	100	60.2
	Other	14	8.2

As can be seen from Table 14, nearly half of the children were females (53.8%). Most of the children were taken out to be physically active twice a week up to seven times a week (45.4%) followed by once a month to once a week (43.3%). Nearly half of the children did not watch either television at all or up to one hour a day (49.5%). Parents of 64.7% of the children said that their child had a low consumption of sweetened drinks which, in this study, was defined as never or one to two times a month. The majority of children slept between 10-14 hours a day (85.8%). In relation to emotional and behavioural wellbeing of the children, 48.5% of the children were scored by their parents within the normal range for their age. However, of the sample, 19.2% were reported to have been scored much lower than normal, indicating behavioural and emotional distress.

Table 14: Child-level characteristics of the participants

Variable	Categories	Frequency	Percentages
Physical activity	Never active	16	11.3
	Once a month to once a week	61	43.3
	Twice a week to 7 times a week	64	45.4
Sex	Male	79	46.2
	Female	92	53.8
Daily TV hours during weekday of the child	None	17	12.3
	Up to one hour	52	37.2
	1-2 hours	31	22.3
	2-3 hours	26	18.7
	More than 3 hours	13	9.5
Frequency drinking sugar-sweetened beverages child	Very low consumption	86	64.7
	Medium to very high	47	35.3
Emotional and behavioural wellbeing child	Close to average	66	48.5
	Slightly decreased	29	21.3
	Low	15	11.0
	Very low	26	19.2
Hours of sleep per day	Less than 10 hours	10	7.1
	Between 10-12 hours	60	42.9
	12.5-14 hours	60	42.9
	More than 14 hours	10	7.1

5.4.2. Fit indexes

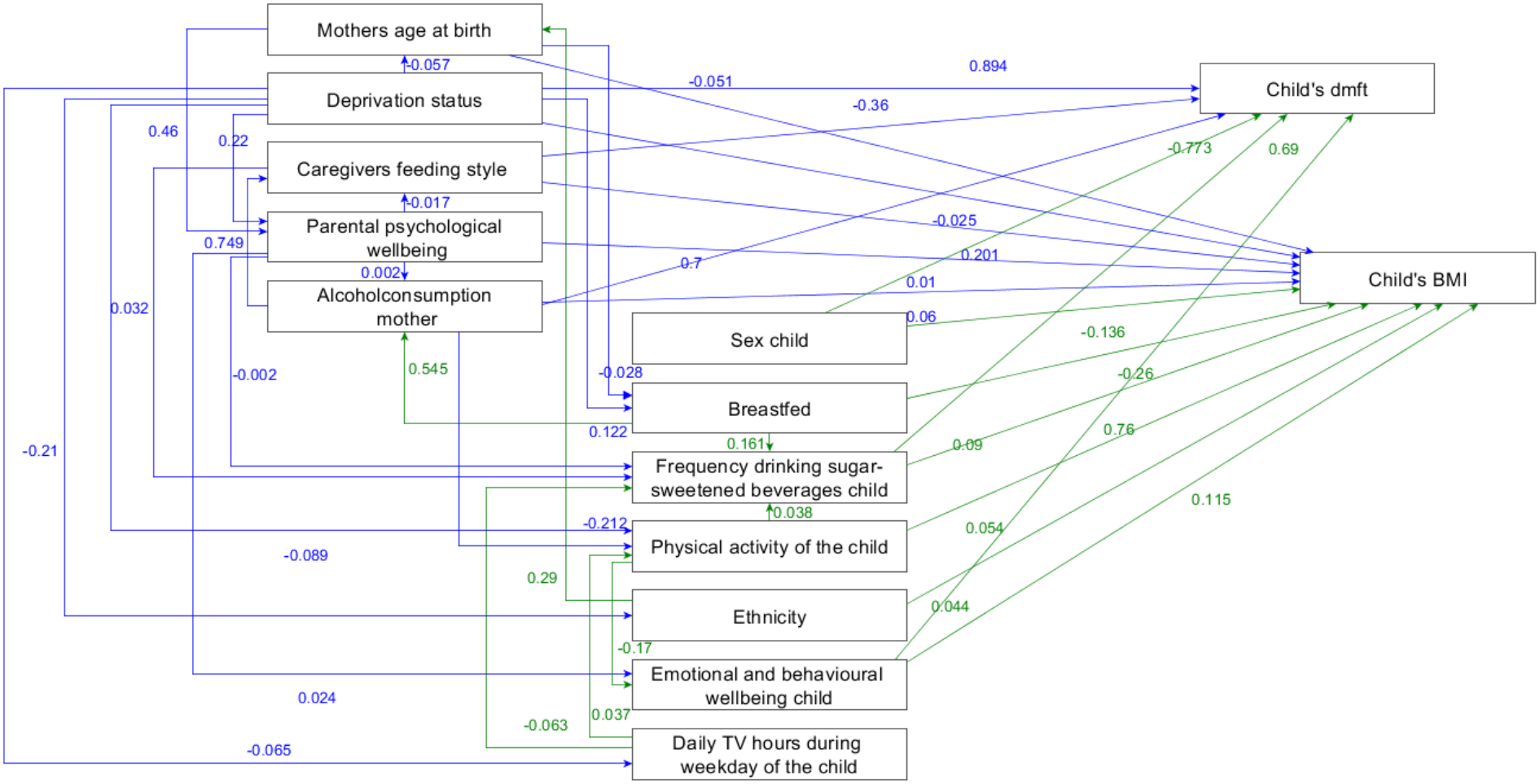
As described more briefly in the methods section, SEM in combination with imputed data is not supported by STATA, therefore, the cmdok function was used. Once the cmdok function has been used and results from the SEM had been produced, it was impossible to run any fit indexes or standardised models. This is mainly due to STATA not producing one but multiple models. Therefore, the researcher opted to produce estimation fit indexes by running the fit indexes with the imputed data and SEM without using the mi estimate function. This results in STATA seeing the data as a normal dataset and not as an imputed dataset. Therefore, all 4651 imputed cases are seen as separate cases. Both, the fit indices and the standardised effects should therefore be seen as an indication and not as a true value for the final model of this research.

The adequacy of the model was assessed using two fit indices and thresholds: the CFI > 0.90 and RMSEA < 0.06 (Hu and Bentler, 1999). After data imputation the dataset counted 4651 cases. The CFI was 0.926 and RMSEA was 0.053, which suggests the model was acceptable fit to the data, meeting both of the *a priori* criteria. Only little research has been conducted on using fit indices for models from SEM and multiple imputed datasets (Enders and Mansolf, 2018). The fit indices should therefore, especially in datasets with a large amount of missing data be used with caution (Enders and Mansolf, 2018).

5.4.3. Parsimonious model

The variable "hours of sleep per day per child" was not associated with any other variables. Therefore, this variable and non-significant links were removed from the model, which was re-estimated to obtain a statistically parsimonious model (Figure 5, p. 169). Figure 5 reports the non-standardised direct effects of the final model using the cmdok function. Standardised effects of SEM cannot be estimated when using MIs. Thus, the coefficients between variables refer to the original measurement units of the variables and are therefore not comparable with each other as different measurement units were used. For example, deprivation status predicts child's dmft with a non-standardised ß-coefficient of 0.894 ($p < 0.001$). This means that a low deprivation status (higher score = more deprived) was associated with a higher dmft of the child. Further, a higher frequency of sugar-sweetened beverage consumption of the child was associated with a higher dmft of the child (ß = 0.687, $p < 0.001$). The non-standardised estimates are not comparable between them. Thus, the beta values do not inform whether deprivation status or the frequency of consuming sugar-sweetened beverages of the child has the greater impact on the child's dmft, as compared to the standardised values. It was decided to present the parsimonious model with the non-standardized betas, since it was not possible to calculate standardised betas.

Figure 5: Parsimonious model of the adapted framework of the social determinants of dental caries and overweight/obesity in children indicating the direct effects non-standardised ß-coefficients



Notes: All betas were statistically significant. Blue lines derive from family level determinants, green lines from child-level determinants.

5.4.4. Determinants of childhood overweight/obesity and dental caries (direct effects)

As for the fit indices, described above, STATA did estimate the standardised effects prior to the cmdok function, but not after. This means that standardised effects were generated from the imputed dataset including all 4651 cases instead of the final 171. Therefore, the fit indices, and standardised effects do not represent the final model, however, they were generated from the same data and therefore they were included in this thesis.

Table 15 presents the significant relationships (standardised betas) between the predictors and childhood weight status and dental caries. These estimates were therefore computed using the 4651 cases, prior to the final SEM model (cmdok function).

Six predictors were significantly associated with both BMI and dental caries (see Figure 5, p. 169 and Table 15). No alcohol consumption of the mother after giving birth, higher frequency of the child drinking sugar-sweetened beverages, emotional and behavioural difficulties of the child and being male were significantly associated with both childhood overweight/obesity and dental caries. Social deprivation showed different effects on childhood weight and dental caries since greater levels of deprivation were significantly associated with lower weight, but deprivation predicted a higher dental caries score (dmft). In addition, caregivers uninvolved or indulgent feeding style was associated with a higher BMI category and with a lower dental caries score (dmft).

Table 15: Determinants for childhood overweight/obesity and dental caries in children (standardised effects)

Variable	**BMI category** 1. severe thinness 2. thinness 3. normal weight 4. overweight 5. obese		**Dental caries** continuous score (dmft) from 0-21 indicating teeth affected by dental caries	
	ß	**95% CI**	**ß**	**95% CI**
Alcohol consumption mother after giving birth 1) Yes (at least once) 2) No (never)	.055	.026, .084	.075	.042, .109
Frequency drinking sugar-sweetened beverages of the child 1) very low consumption of sugary drinks 2) medium to high consumption of sugary drinks	.084	.058, .111	.074	.047, .100
Emotional and behavioural wellbeing of the child Sequential, higher score = less normal situation	.241	.216, .266	.189	.163, .215
Caregivers feeding style score 1) authoritarian 2) authoritative 3) indulgent 4) uninvolved	.288	.263, .313	-.061	-.090, -.032
Sex child 1) Male 2) Female	-.115	-.140, -.090	-.077	-.104, -.050
Deprivation status 1) least deprived and most educated 2) employed and not materially deprived 3) employed but no access to money 4) receiving benefits but coping 5) most deprived	-.056	-.083, -.029	.237	.210, .264

Note: All p-values were <0.0001, standardised effects were derived using all of the imputed dataset (4651 cases) prior to the cmdok function.

5.4.5. Significant determinants for childhood overweight/obesity (direct effects)

No other variables were significantly associated with dental caries. However, five other variables were linked just to weight status (Table 16). Mothers with a higher maternal age at birth and mothers who

did not breastfeed were linked to lower weight of their children. Parents scoring higher on the general health questionnaire, indicating lower parental psychological wellbeing and parents of Pakistani or other ethnicities were more likely to have children with overweight or obesity. Parents who took their children out more frequently for physical activities were more likely to have overweight or obese children.

Table 16: Additional significant variables for childhood overweight/obesity (standardised effects)

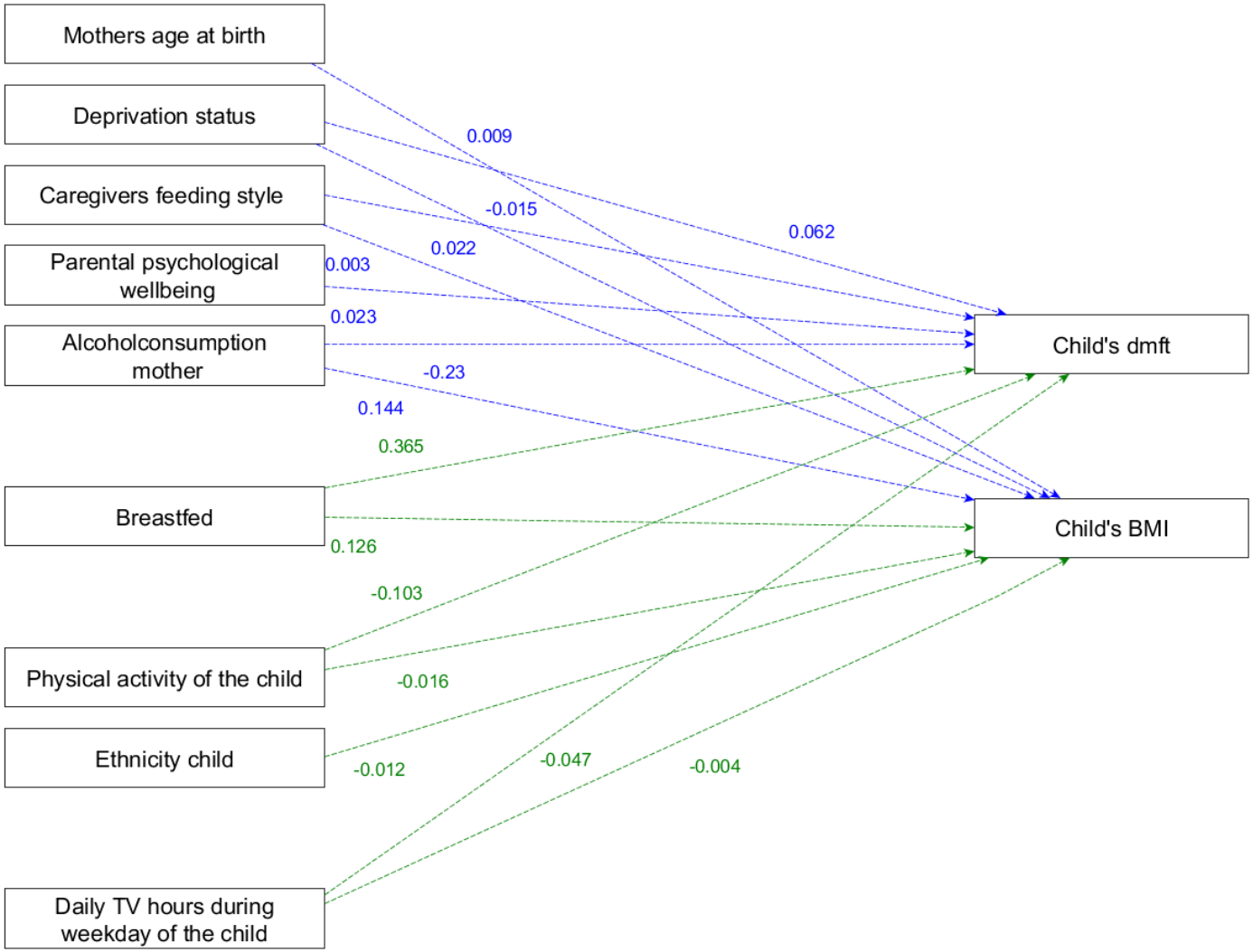
Variable	**BMI category** 1) severe thinness 2) thinness 3) normal weight 4) overweight 5) obese	
	ß	**95% CI**
Mothers age at birth Sequential, higher score = older age	-0.07	[-.095, -.041]
Breastfed 2)	-0.23	[-.256, -.199]
Parental psychological wellbeing Sequential, higher score = psychological distress	0.19	[.165, .215]
Ethnicity 1) White British 2) Pakistani 3) Other	0.47	[.179, .076]
Physical activity of the child 1) never 2) once a month up to once a week 3) twice a week up to 7 times a week	0.07	[.042, .093]

Note: All P-values were <0.0001, standardised effects were derived using all of the imputed dataset (4651 cases) prior to the cmdok function.

5.4.6. Significant indirect pathways

In addition to the direct effects detailed above, there were a number of significant indirect effects between the child- and family-level determinants and dental caries and weight categories as presented in Figure 6, p. 174. These significant pathways indicate the indirect relationships of child-level determinants and family-level determinants with childhood dental caries and weight status. There were seven indirect paths between the determinants and child dmft. Of them, four paths were between family-level determinants and dmft (SES, feeding style, general health, alcohol consumption) and three between the child-level determinants and dmft (whether breastfed, physical activity, hours of daily TV). Eight indirect paths between determinants and BMI were statistically significant. Of them, four were related to the family-level determinants (mothers age at birth, SES, feeding style, mother's alcohol consumption) and four to the child-level ones (whether breastfed, physical activity, ethnicity, hours of daily weekday TV). The 15 total indirect pathways are described in more detail according to the specific indirect pathways as shown in Tables 17 – 31. The tables report the ß of the total effects of the pathways and the specific pathways between variables. The individual betas for each single pathway are not described due to the high number of pathways.

Figure 6: Significant indirect pathways of the adapted framework of the social determinants of dental caries and overweight/obesity in children



Note: All ßs were statistically significant. Blue lines derive from family level determinants, green lines from child-level determinants.

5.4.6.1. Indirect paths between determinants and dmft

As highlighted in Figure 6, p. 174 seven determinants were indirectly linked to dmft. The specific indirect pathways related to dmft are detailed in Tables 17-23. The indirect pathway on the influence of deprivation status on dmft are depicted in 49 specific paths (Table 17). For example, deprivation status predicted child's dmft through mothers age at birth, parental psychological distress and the caregivers feeding style. Thus, low deprivation status was associated with a higher age at birth of the mother, which was linked to a higher level of parental psychological distress, which was associated with a lower involvement of the caregiver in terms of the feeding style which was then linked to a lower dmft. Deprivation status was also indirectly linked to child's dmft through mothers age at birth, child's breastfeeding and the frequency of the child drinking sugar-sweetened beverages, which influenced the child's dmft. This means that low deprivation status predicted high maternal age at birth, which in turn was associated with the child being breastfed, which was associated with a lower consumption of sugar-sweetened beverages of the child, which was associated with a lower dmft of the child.

Table 17: Indirect pathways deprivation status → Child's dmft

ß of total indirect effect deprivation status → Child's dmft (total indirect effect: ß = 0.062)
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Caregivers feeding style → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Caregiver's feeding style → Child's dmft
Deprivation status → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Caregiver's feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Mother's age at birth → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's dmft

ß of total indirect effect deprivation status → Child's dmft (total indirect effect: ß = 0.062)
Deprivation status → Mother's age at birth → Breastfed → Alcohol consumption mother → Child's dmft
Deprivation status → Mother's age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Mother's age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Mother's age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Deprivation status → Mother's age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Breastfed → Alcohol consumption mother → Child's dmft
Deprivation status → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Deprivation status → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Parental psychological wellbeing → Caregivers feeding style → Child's dmft
Deprivation status → Parental psychological wellbeing → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Parental psychological wellbeing → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Parental psychological wellbeing → Alcohol consumption mother → Child's dmft
Deprivation status → Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Parental psychological wellbeing → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Deprivation status → Parental psychological wellbeing → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Daily TV hours during weekday of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Daily TV hours during weekday of the child → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Daily TV hours during weekday of the child → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Caregivers feeding style → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft

ß of total indirect effect deprivation status → Child's dmft (total indirect effect: ß = 0.062)
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Breastfed → Alcohol consumption mother → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Deprivation status → Ethnicity child → Mother's age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft

There was one indirect path between caregiver's feeding style and child's dmft via frequency of drinking sugar-sweetened beverages (see Table 18). This path means that an uninvolved feeding style was linked to a higher frequency of drinking sugar-sweetened beverages of the child which predicted a higher dmft of the child. Eight specific paths were found between general health of the parent and the child's dmft (see Table 19). For example, as can be seen in Table 19, parental psychological distress was linked to caregiver's feeding style, which was associated with the child's frequency of drinking sugar-sweetened beverages which then predicted the dmft of the child. Thus, a parent with lower psychological distress was more likely to have an uninvolved feeding style, which influenced greater frequency of sugar-sweetened beverage consumption of the child and in turn the child had a greater dmft.

Table 18: Indirect pathways caregivers feeding style → Child's dmft

ß of total indirect effect caregivers feeding style → Child's dmft (total indirect effect: ß = 0.022)
Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft

Table 19: Indirect pathways Parental psychological wellbeing → Child's dmft

ß of total indirect effect parental psychological wellbeing → Child's dmft (total indirect effect: ß = 0.023)
Parental psychological wellbeing → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft
Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's dmft
Parental psychological wellbeing → Emotional and behavioural wellbeing of the child → Child's dmft
Parental psychological wellbeing → Alcohol consumption mother → Child's dmft
Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Parental psychological wellbeing → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Parental psychological wellbeing → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Parental psychological wellbeing → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft

There were four indirect paths between maternal alcohol consumption and the child's dmft (Table 20). Alcohol consumption of the mother was associated with the caregivers feeding style which was predictive of the frequency of the child drinking sugar-sweetened beverages, which was then linked to the child's dmft. This meant that no alcohol consumption was predictive of an uninvolved feeding style which was associated with a higher consumption of sugar-sweetened beverages of the child, which was linked to a higher dmft.

Table 20: Indirect pathways alcohol consumption mother → Child's dmft

ß of total indirect effect alcohol consumption mother → Child's dmft (total indirect effect: ß = 0.006)
Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Alcohol consumption mother → Caregivers feeding style → Child's dmft
Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft

In Table 21 for example, child's breastfeeding was associated with a higher frequency of drinking sugar-sweetened beverages of the child which predicted the child's dmft. This meant that children, which were not breastfed had a greater frequency of sugar-sweetened beverages intake, which

predicted a higher dmft of the child. Six indirect pathways were found between breastfeeding of the child and the child's dmft (Table 21).

Table 21: Indirect pathways breastfed → Child's dmft

ß of total indirect effect breastfed → Child's dmft (total indirect effect: ß = 0.365)
Breastfed → Frequency drinking sugar-sweetened beverages child → Child's dmft
Breastfed → Alcohol consumption mother → Child's dmft
Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's dmft
Breastfed – Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's dmft

Table 22 and Table 23 indicate the indirect pathways between physical activity of the child, hours of daily TV watching of the child and child's dmft, respectively. In Table 22 physical activity of the child predicted the emotional and behavioural wellbeing of the child, which was linked to the child's dmft. Therefore, lower levels of physical activity were associated with emotional and behavioural difficulties of the child, which predicted a higher dmft of the child. The indirect pathways between hours of daily TV watching of the child and the child's dmft are displayed in Table 23. For example, daily hours of TV watching during weekdays of the child was linked to the frequency of the child drinking sugar-sweetened beverages which was associated with the child's dmft. This meant that a child that watched more hours of daily weekday TV was more likely to drink sugar-sweetened beverages less frequently and therefore had a lower dmft.

Table 22: Indirect pathways physical activity of the child → Child's dmft

ß of total indirect effect physical activity of the child → Child's dmft (total indirect effect: ß = -0.103)
Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft

Table 23: Indirect pathways hours of daily TV child → Child's dmft

ß of total indirect effect Daily TV hours during weekday of the child → Child's dmft (total indirect effect: ß = -0.0471)
Daily TV hours during weekday of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft
Daily TV hours during weekday of the child → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's dmft
Daily TV hours during weekday of the child → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's dmft

5.4.6.2. Indirect paths between determinants and child's BMI

Eight indirect pathways have been found between the determinants and child's BMI. Of them, four were between family-level determinants and child's BMI and four between child-level determinants and child's BMI. Table 24-31 present the indirect pathways between the determinants and child's BMI. The total indirect effects are presented in the first row in each table. For example, as can be seen in Table 24, mother's age at birth has been indirectly linked with child's BMI through 19 pathways. For example, in the first pathway mother's age at birth was associated with parental psychological well-being, which predicts the child's BMI. So, a greater age of the mother at the child's birth was predictive of a lower level of parental distress, which was associated with a higher BMI of the child.

Table 24: Indirect pathways mother's age at birth → Child's BMI

ß of total indirect effect mother's age at birth → Child's BMI (total indirect effect: ß = 0.0089)
Mothers age at birth → Parental psychological wellbeing → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Caregivers feeding style → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child →Frequency drinking sugar-sweetened beverages child → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Mothers age at birth → Parental psychological wellbeing →Emotional and behavioural wellbeing of the child → Child's BMI
Mothers age at birth → Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's BMI
Mothers age at birth → Breastfed → Child's BMI

Mothers age at birth → Breastfed → Alcohol consumption mother → Child's BMI
Mothers age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's BMI
Mothers age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Child's BMI
Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Mothers age at birth → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's BMI

The 45 indirect pathways between deprivation status and child's BMI are displayed in Table 25. As an example, deprivation status was linked to the general health of the parent which was associated with the child's BMI. A higher deprivation status predicted greater distress among parents which was associated with a higher BMI of the child.

Table 25: Indirect pathways deprivation status → Child's BMI

ß of total indirect effect deprivation status → Child's BMI (total indirect effect: ß = -0.0152)
Deprivation status → Parental psychological wellbeing → Child's BMI
Deprivation status → Parental psychological wellbeing →Caregivers feeding style → Child's BMI
Deprivation status → Parental psychological wellbeing →Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Parental psychological wellbeing →Alcohol consumption mother → Child's BMI
Deprivation status → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Child's BMI
Deprivation status → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child →Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Child's BMI
Deprivation status → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Physical activity → Child's BMI
Deprivation status → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status →Ethnicity → Child's BMI
Deprivation status → Ethnicity → Mother's age at birth → Child's BMI
Deprivation status → Ethnicity → Mother's age at birth → Parental psychological wellbeing → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Caregivers feeding style → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child →Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing →Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Alcohol consumption mother → Child's BMI

ß of total indirect effect deprivation status → Child's BMI (total indirect effect: ß = -0.0152)
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status → Ethnicity → Mothers age at birth → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Daily TV hours during weekday of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Daily TV hours during weekday of the child → Physical activity of the child → Child's BMI
Deprivation status → Daily TV hours during weekday of the child → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Daily TV hours during weekday of the child → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status → Breastfed → Child's BMI
Deprivation status → Breastfed → Alcohol consumption mother → Child's BMI
Deprivation status → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's BMI
Deprivation status → Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Breastfed → Alcohol consumption mother → Physical activity of the child → Child's BMI
Deprivation status → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Deprivation status → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Deprivation status → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's BMI

Table 26 and 27 present the indirect pathways of caregivers feeding style (Table 26) and alcohol consumption (Table 27) with child's BMI. Uninvolved caregivers feeding style was associated with a higher frequency of drinking sugar-sweetened beverages, which was linked to higher child's BMI (Table 26). An example of an indirect pathway between alcohol consumption of the mother and child's BMI is the pathway through caregivers feeding style. Alcohol consumption of the mother predicted an authoritarian feeding style, which was associated with lower BMI of the child (Table 27).

Table 26: Indirect pathways caregivers feeding style → Child's BMI

ß of total indirect effect caregivers feeding style → Child's BMI (total indirect effect: ß = 0.0030)
Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI

Table 27: Indirect pathways alcohol consumption mother → Child's BMI

ß of total indirect effect alcohol consumption mother → Child's BMI (total indirect effect: ß = 0.1444)
Alcohol consumption mother → Physical activity of the child → Child's BMI
Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Alcohol consumption mother → Physical activity of the child →Frequency drinking sugar-sweetened beverages child → Child's BMI
Alcohol consumption mother → Caregivers feeding style → Child's BMI
Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI

Table 28-30 show the indirect pathways of child's breastfeeding (Table 28), child's physical activity (Table 29) and daily TV hours during weekdays of the child (Table 30) and child's BMI. Seven indirect paths were found between breastfeeding and child's BMI. For instance, child's frequency of drinking sugar-sweetened beverages mediated the link between breastfeeding and child's BMI. Lack of breastfeeding was associated with a higher frequency of drinking sugar-sweetened beverages of the child and the latter was predictive of a higher child's BMI. In terms of physical activity, low physical activity was linked to a higher score in the strengths and difficulties questionnaire of the child, indicating that the child had a low emotional and behavioural wellbeing, which was associated with a higher child's BMI (Table 29). Higher daily TV hours during weekdays of the child was predictive of the child drinking sugar-sweetened beverages less frequent, which lead to a decreased BMI of the child (Table 30).

Table 28: Indirect pathways breastfed → Child's BMI

ß of total indirect effect breastfed → Child's BMI (total indirect effect: ß = 0.1264)
Breastfed → Alcohol consumption mother → Child's BMI
Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's BMI
Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Breastfed → Alcohol consumption mother → Physical activity of the child → Child's BMI
Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Breastfed → Frequency drinking sugar-sweetened beverages child → Child's BMI

Table 29: Indirect pathways physical activity of the child → Child's BMI

ß of total indirect effect physical activity of the child → Child's BMI (total indirect effect: ß = -0.0159)
Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Physical activity of the child →Frequency drinking sugar-sweetened beverages child → Child's BMI

Table 30: Indirect pathways daily TV hours during weekday of the child → Child's BMI

ß of total indirect effect daily TV hours during weekday of the child → Child's BMI (total indirect effect: ß = -0.0045)
Daily TV hours during weekday of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Daily TV hours during weekday of the child → Physical activity of the child → Child's BMI
Daily TV hours during weekday of the child → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Daily TV hours during weekday of the child → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI

Table 31 presents the 20 indirect pathways between ethnicity and the child's BMI. For instance, ethnicity was associated with child's BMI through mother's age at birth. This means that being from non-white British ethnicity was predictive of a higher age of the mother when giving birth, which was linked to a lower BMI of the child.

Table 31: Indirect pathways ethnicity child → Child's BMI

ß of total indirect effect ethnicity child → Child's BMI (total indirect effect: ß = -0.0120)
Ethnicity child → Mother's age at birth → Child's BMI
Ethnicity child → Mother's age at birth → Parental psychological wellbeing → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Caregivers feeding style → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Physical activity of the child →Frequency drinking sugar-sweetened beverages child → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing →Emotional and behavioural wellbeing of the child → Child's BMI
Ethnicity child → Mothers age at birth → Parental psychological wellbeing → Frequency drinking sugar-sweetened beverages child → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Alcohol consumption mother → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Alcohol consumption mother → Caregivers feeding style → Frequency drinking sugar-sweetened beverages child → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Frequency drinking sugar-sweetened beverages child → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Alcohol consumption mother → Physical activity of the child → Emotional and behavioural wellbeing of the child → Child's BMI
Ethnicity child → Mothers age at birth → Breastfed → Frequency drinking sugar-sweetened beverages child → Child's BMI

5.5. Discussion

5.5.1. What are the common determinants of overweight/obesity and dental caries?

Six common determinants of childhood overweight/obesity and dental caries, through direct effects were identified in this research. These include maternal alcohol consumption, the child's consumption frequency of sugar-sweetened beverages, behavioural and emotional development of the child, sex, deprivation status and caregivers feeding style. The following sections discuss each of the six determinants by comparing direct and indirect associations as well as contrasting these findings with evidence form existing literature.

The first common determinant between the two outcomes was maternal alcohol consumption after birth. The association between lack of alcohol consumption post-partum and high child's BMI and dmft was an unexpected finding. Postpartum alcohol consumption of the mother has been studied less often than alcohol consumption during pregnancy. This association might be explained by both the high deprivation status and ethnic background of the BiB study population. Postpartum alcohol consumption has been associated with deprivation status in for example, the study of Laborde and Mair (2012) who compared new mothers (aged 18-48, with the youngest child in the household ≤ 1 year and pregnant in the last 5 years) drinking behaviour to other women (women who did not have a child in the household ≤ 1 year and had not been pregnant in the last 5 years), using a randomised and representative sample of 28,537 adult women living in California. Even though, overall, new motherhood prevented alcohol consumption, alcohol consumption was higher among those with high income and high education (Laborde and Mair, 2012). These results might suggest that socio-economically deprived women who have recently given birth may be less likely to consume alcohol in the postpartum period in the BiB study population. The BiB study population was also largely composed of Pakistani participants and therefore cultural habits regarding alcohol consumption might have influenced the present results. Pakistani has been found to be the ethnic group with the highest percentage of non-drinkers (89% of men and 95% of women) when compared to other ethnic groups living in England (Becker et al., 2006). Both ethnicity and deprivation might, therefore, help interpret

the association between a lack of alcohol consumption and both dental caries and BMI in children. This association could also be explained through the indirect association of caregivers feeding style and frequency of drinking sugar-sweetened beverages of the child. The indirect association (see Tables 17 & 31) suggests that no alcohol consumption in this population was associated with an uninvolved feeding style of the parents, which was predictive of a higher frequency of the child drinking sugar-sweetened beverages and, in turn, a higher dmft and a higher BMI of the child.

The second common determinant of child's dental caries and BMI was frequency of drinking sugar-sweetened beverages of the child. This study confirmed previous findings on the association of high frequency of sugar sweetened beverage consumption with child overweight/obesity (World Health Organisation, 2019a, Luger et al., 2018, Hu, 2013) and child dental caries (Almasi et al., 2016, Paglia et al., 2016, Sohn et al., 2006). Only frequency of drinking sugar-sweetened beverages was assessed in this study. Therefore, it is difficult to evaluate the total caloric intake of each child since the amount of sugar consumption was not assessed. Frequency of drinking sugar-sweetened beverages was assessed through food frequency questionnaires completed by the parents of the child. The dietary assessment used in this study is further discussed in the final chapter of this PhD (Chapter 7).

Emotional and behavioural wellbeing of the child was also related to child dmft and BMI, suggesting that mothers reporting more emotional and behavioural difficulties with their child (Goodman, 1997) (e.g. emotional symptoms and hyperactivity symptoms) had children with greater BMI and higher dmft. Previous studies using the same questionnaire (Griffiths et al., 2011, Heerman et al., 2016, Sanders et al., 2015, Kelly et al., 2016), also found an association between childhood overweight/obesity and children's emotional and behavioural difficulties. The Millennium Cohort Study conducted in the UK (Kelly et al., 2016) examined 16936 children aged 3, 5, 7 and 11 years on BMI and psychosocial wellbeing. High BMI was linked to worse psychosocial wellbeing. Similarly, behaviours of 30-60-month-old children were compared between those with (n=60) and without (n=60) dental caries (assessed during the last 6 months by a dentist) using the child behaviour checklist (Williamson et al., 2008b). Behavioural problems consisting of different every day behaviours such as jealousy and sleep problems, stress and attention deficits were assessed and found to be significantly associated with dental caries (Williamson et al., 2008b). It has been suggested that

children with such behavioural issues might have lower compliance to dental hygiene and therefore have higher rates of dental caries (de Jong-Lenters et al., 2018).

The fourth common determinant of child dmft and BMI was sex. Male children had both higher BMI and more dental caries than female children. Previous studies suggest that girls are more likely to be overweight or obese than boys (Lundeen et al., 2016, Dearden et al., 2018, Izaki and Swaine, 2017, Wisniewski and Chernausek, 2009). Possible reasons for this finding include the greater levels of physical activity among boys (Wisniewski and Chernausek, 2009, Izaki and Swaine, 2017), and the genetic predisposition to gain weight among girls (Wisniewski and Chernausek, 2009). It is interesting to note that our finding on the link between sex and overweight/obesity was in the opposite direction to many previous studies - since boys had greater BMI. One possible explanation for the difference between our study and previous research might be the high percentage (60.2% of the sample) of Pakistani children in the studied population. Studies in Pakistan, investigating overweight/obesity prevalence among Pakistani children, concluded that obesity is more prevalent in boys than in girls due to cultural reasons (Mushtaq et al., 2011, Ahmed et al., 2013). According to Pakistani culture, for example, boys have more access to foods outside the home and girls are more restricted in terms of going outside and social mobility within society (Ahmed et al., 2013). These cultural reasons might be altered slightly through British cultural influences of the study population, however the Bradford population is special as it is home to the largest Pakistani community in England and makes 20.3% of the Bradford population (City of Bradford, 2020) and therefore it may be that some cultural habits have been retained.

In terms of dental caries, most research on the association between sex and dental caries in children concluded that boys have higher levels of dental caries than girls (Shaffer et al., 2015, Kalita et al., 2015, Harris et al., 2004, Margrit-Ann et al., 2018, Mamai-Homata et al., 2016). Our findings agree with previous research on the higher occurrence of dental caries among boys. One explanation for this, similar to the link between overweight/obesity and male gender, is that boys may have easier access to food outside home and snacks than girls (Kalita et al., 2015). Boys might be offered more sweets and are allowed to spend more time outside the house without supervision than girls. Additionally, a higher cultural importance might be placed on girls dental aesthetics compared to those of boys

(Shaffer et al., 2015), valuing healthy looking teeth over caries affected teeth and therefore ensuring better oral health prevention practices among girls. In a meta-analysis by Mamai-Homata and colleagues (2016), a higher exposure to fluoride among girls was found due to more frequent toothbrushing. However, the meta-analysis (containing 3 studies) included university students (aged 19-25) and the results might not be directly comparable to those for children.

Deprivation status was the fifth common determinant associated with a low BMI and high dental caries. Previous studies have reported that children living in deprivation have higher levels of dental caries (Verlinden et al., 2019, Enjary et al., 2006, Kumar et al., 2016c, Masood et al., 2019, Schwendicke et al., 2015). There are many potential explanations for this link. For example, it has been found that children from deprived families often have poor preventive oral health behaviours, due to for example low parental oral health literacy as well as limited access to preventive services (Verlinden et al., 2019). Their parents also often have limited potential teaching them appropriate preventive measures, for example brushing teeth at least twice a day or eating less caloric foods than those from better off socio-economic background (Verlinden et al., 2019, Christensen et al., 2010). Furthermore, these results may be due to ethnic diversities in terms of differences of foods consumption (Arora et al., 2017, Bedi et al., 2000). Arora and colleagues (2019) investigated among adults, whether there are ethnic differences related to oral health in the UK and whether these differences are explained by SES or lifestyle factors using the Adult Dental Health Survey of 2009. Out of 11,380 participants 94.6% were of white British ethnicity, 2.5% Indian, 1.5 % Pakistani/Bangladeshi and 1.7 % Black participants, which made the sample representative of England, Wales and Northern Ireland (Arora et al., 2017). The authors found that the non-white British people was more socio-economically deprived and generally rated their own oral health as poorer, compared to those of the white population (Arora et al., 2017). The non-white population had lower intake of sugary sweets and cakes. However, they added sugar to their drinks more frequently (Arora et al., 2017), which is a cultural difference in dietary behaviour to white British, which may contribute to the high dental caries in this population group. However, it is important to recognise that these results derive from an adult population and may be different in children. Schwendicke and colleagues (2015), as highlighted in Section 2.7.2.1, found in their meta-analysis of 92 studies

assessing the relationship between socioeconomic position and dental caries that in developed countries dental caries prevalence is more unequally distributed among children from different socio-economic backgrounds than in developing countries. The authors pointed out that greater availability of dental care facilities might not account for access to these facilities, which is often exclusively for those of higher socio-economic position and therefore the prevalence of dental caries might be higher among those of lower socio-economic position (Schwendicke et al., 2015). Schwendicke and colleagues (2015) highlighted possible indirect associations between socio-economic position and dental caries through access to personal preventive means such as toothpaste dental floss and low caloric sugar reduced diets as well as health literacy and behaviour such as tooth cleaning habits.

Previous studies have reported that higher deprivation status was associated with a high BMI (O'Dea and Dibley, 2010, Jin and Lu, 2017, Shrewsbury and Wardle, 2012). Interestingly, our results differ from previous findings, since low deprivation status predicted higher weight status in children. Mech and colleagues (2016) found in their systematic review investigating the underlying mechanisms by which SES influences childhood BMI, as highlighted in Section 2.7.2.1, that different underling factors influenced the development of BMI between high- and low-income population. For example, in low-SES families, maternal depressive symptoms were found to be a strong risk factor for children's overweight/obesity, whereas older maternal age was a protective factor for children's overweight/obesity (Mech et al., 2016). These factors were also found to be associated with children's overweight/obesity in this PhD thesis. For example, high deprivation status was indirectly associated with high child's BMI through increased parental distress (see Table 17). Further, low deprivation status was associated with an older maternal age at birth, which was associated with lower BMI of the children in this study. It seems plausible therefore that different factors might influence the development and/or maintenance of childhood overweight/obesity between high- and low-income populations (Mech et al., 2016).

Ethnicity might be a relevant factor that explains obesity/overweight in children. One study investigated racial/ethnic disparities in BMI and the odds of obesity/overweight in the UK and US using data on 5-year-old children from national representative cohort studies (Zilanawala et al., 2015). UK, Indian and Pakistani children had significantly lower BMI than white children, and Pakistani

children were 40% less likely to be obese than white ones (Zilanawala et al., 2015). Ethnic differences between Asian and other ethnicities in relation to children's BMI have also been found in the US. Asian children had a lower BMI than children from other ethnic backgrounds (Isong et al., 2018). However, in Isong and colleagues study, Asian children were part of the higher income population and therefore, different from the BiB population (Isong et al., 2018). Quite different to the US, between 2015-2018, 76% of the Pakistani population living in the UK were from the lowest two income quintiles (GOV UK, 2019). Therefore, discrepancies between this PhD's findings and previous results on the association between low SES and high childhood BMI might be due to the different socioeconomic conditions of the ethnic groups included in the present study. Additionally, different factors such as maternal BMI could influence the association. For example, adjustment for maternal BMI in the study of Zilanawala and colleagues (2015) attenuated the association between SES and children's BMI. Maternal BMI was not taken into consideration in this study, however other studies have confirmed that maternal obesity is a strong predictor for childhood obesity (Heslehurst et al., 2019, Higgins and Dale, 2012), possibly stronger than ethnicity or SES (Higgins and Dale, 2012).

The sixth common determinant was caregivers feeding style (family-level). In terms of childhood overweight/obesity, an uninvolved feeding style, (few demands of parents and unsupportive parental behaviour) was associated with higher weight status in children. Indirect pathways in this study between caregivers feeding style and dental caries or weight status were linked through the child's frequency of drinking sugar-sweetened beverages. In both cases, an uninvolved feeding style was predictive of a more frequent consumption of sugar-sweetened beverages of the child, which lead to a higher weight status and dental caries of the child. Previously, permissive parenting styles (uninvolved and indulgent) have been linked to unhealthy child dietary behaviours (Hennessy et al., 2012, Hoerr et al., 2009, Hughes et al., 2005) and to a higher childhood BMI (Hughes et al., 2005, Hennessy et al., 2012).

An uninvolved feeding style suggests that parents may let their children snack and choose high-energy dense foods (Hoerr et al., 2009, Hennessy et al., 2012). In previous studies the uninvolved feeding style is often linked to low SES (Hennessy et al., 2012, Hughes et al., 2005). In such families, due to financial restraints, food requests of their children may be the only request (compared to non-food

requested items) they can answer positively (characteristic of a permissive feeding style) (Hennessy et al., 2012). This is mainly due to the low costs of energy dense foods and the higher costs of healthy nutritional foods, resulting in a social disparity between lower and higher SES populations (Drewnowski and Darmon, 2005). Although, in this study feeding style was not directly associated with deprivation status, but rather linked to parental behaviour such as alcohol consumption of the mother and parental psychological wellbeing, where an authoritarian feeding style was predicted by maternal alcohol consumption and parental distress. However, as mentioned earlier, the BiB population is considered a population with high deprivation rates compared to the rest of the UK.

In regard to dental caries, an authoritarian feeding style (rule-based demands, regardless of child's preferences) was associated with dental caries. Previous research has found that encouraging and problem-solving (authoritative and indulgent) parenting styles were associated with caries-free children (de Jong-Lenters et al., 2014). In addition, restrictive parenting (authoritarian) styles led children to be resistant and non-compliant towards parentally given rules (Kuczynski, 1987). Additionally, high control of parents over children's food consumption led to the development of food fussiness in children, which was associated with dental caries and high BMI, due to a higher preference for unhealthy foods (Nembhwani and Winnier, 2020, Hughes and Papaioannou, 2018). These results confirm our findings that higher dental caries was associated with an authoritarian feeding style.

Previous findings and the results of this study on the association of childhood dental caries and BMI with feeding style suggests that the authoritative and indulgent parenting styles can promote both oral health and a healthy nutritional status. However, the two extremes, authoritarian and indulgent feeding styles are associated with either higher weight status or dental caries in children. This may suggest a U-shaped curve on the above-mentioned relationships related to parenting styles, indicating that both extremes (authoritarian and uninvolved) parenting styles may be negatively associated with a child's oral health and weight.

5.5.2. What were the additional determinants of overweight/obesity?

In addition to the common determinants of both outcomes, there were five additional predictors of childhood overweight/obesity, including mothers age at birth, parental psychological distress, non-Pakistani ethnicity, low physical activity of the child, and lack of child breastfeeding. Interestingly, there were no additional determinants of dental caries. No non-significant associations were found.

The first determinant of overweight/obesity was mother's age at birth, where a child born to a younger mother (younger than 25 years of age) was linked to a higher weight status of the child. Previous studies have indicated that maternal age was associated with childhood weight in a U-shaped form, suggesting that younger mothers (age below 25 years) and older mothers (age over 35 years) are at higher risk of having a child with obesity (Myrskylä and Fenelon, 2012, Barclay and Myrskyla, 2016) and underweight (Pearce et al., 2015). Pearce and colleagues (2015) investigated the social gradient of children being underweight in the UK. They found that early life circumstances explained the social gradients using a representative sample of 3-7-year-old children in the UK. Children of south Asian ethnicity were at higher risk of being underweight than those from other ethnicities (Pearce et al., 2015). The authors suggested that the high underweight rates in South Asian ethnic groups might result from inter-generational exposure to poverty, living in the most disadvantaged socioeconomic categories.

The second predictor of childhood overweight/obesity was parental psychological wellbeing. A higher score in the general health questionnaire of parents, which indicated higher parental distress, was related to childhood overweight/obesity. Thus, children whose parents had higher levels of psychological distress were at higher risk of overweight/obesity. This finding confirms previous studies and reviews that suggest that parents who experienced stress were more likely to have a child who was overweight/obese (Leppert et al., 2018, Tate et al., 2015b, Halliday et al., 2013, Lampard et al., 2013, Jang et al., 2019). Parental psychological wellbeing was also indirectly associated with BMI in children in this study. For example, higher parental distress was associated with decreased emotional and behavioural wellbeing of the child, which in turn was associated with increased BMI. Maternal stress and depression may result from multiple factors, such as economic distress that leads

to fewer availability of resources (Leppert et al., 2018, Halliday et al., 2013), living in unsafe neighbourhoods and the related safety concerns of children playing outside (Leppert et al., 2018), belonging to a racial or ethnic minority (Jang et al., 2019) and poor family functioning, including family conflict and poor communication (Halliday et al., 2013) as well as single parent households (Jang et al., 2019). Multiple factors on the influence of maternal stress on child's health have been highlighted, indicating that maternal stress might influence parenting behaviours such as less frequent meal preparation for the children, leading them to eat alternatives such as snacks and unhealthy foods (Tate et al., 2015b, Lampard et al., 2013), fewer restrictions on child's screen time (Lampard et al., 2013) and mothers providing fewer opportunities for the child to be physically active (Tate et al., 2015b), which can increase childhood overweight/obesity (Tate et al., 2015b, Lampard et al., 2013, Leppert et al., 2018, Halliday et al., 2013).

The third determinant was ethnicity since ethnicities other than white and Pakistani ethnicity was associated with a higher BMI in children. As discussed in Section 5.5.1., 5-year old Pakistani children in the UK had lower odds of obesity (Zilanawala et al., 2015). Similar results were found in the US, where children from Asian descents were less likely to be overweight/obese than children of other ethnicities (Zilanawala et al., 2015, Isong et al., 2018). Other studies found similar results as childhood obesity was less common among Asian ethnicities (Zilanawala et al., 2015, Lynch et al., 2000). Further studies are needed to understand the complex relationship between ethnicity and childhood overweight/obesity. Some explanations on the possible reasons for the association between ethnicity and childhood overweight/obesity have been suggested. Jain and colleagues (2012) highlighted that generational status of the mother was a predictor for childhood overweight/obesity since children who were born from mothers who were the first generation immigrants were less likely to develop overweight/obesity. This has suggested to be mainly due to parental acculturation. Acculturation means the change of attitudes and behaviours of the immigrant towards those of the host country and is often associated with negative consequences for migrants such as poorer mental health and possible weight gain (Delavari et al., 2013). Parental acculturation is a risk factor for developing childhood obesity among Chinese Americans (Jain et al., 2012). The authors suggest that this might be due to the adaptation of mainstream eating and television habits (Jain et al., 2012). Secondly the concept of

intersectionality should be acknowledged (Kapilashrami and Hankivsky, 2018). Different ethnic groups within a certain society might experience higher incidence of diseases than others, which is often associated with an interlinkage between factors such as cultural aspects towards health behaviours, SES, living areas, access to health care facilities and many others. The Pakistani population of this research for example belongs to the poorest ethnic minorities in the UK (City of Bradford, 2020).

The fourth determinant was low physical activity of the child; more physically active children were less likely to be obese than those who were more sedentary. This finding is in line with previous studies and reviews - as discussed in Section 2.7.1.2 (Hills et al., 2011, World Health Organisation, 2014d, Molnar and Livingstone, 2000, Shofan et al., 2011, Dhar and Robinson, 2016, Vincent et al., 2003, Poorolajal et al., 2020). The NHS and WHO recommend for children to engage in at least 60 minutes of physical activity a day (NHS Digital, 2019, World Health Organisation, 2020d). However, the newest statistics on childhood physical activity showed that only 18% of children between 5-18 years of age living in England meet this recommendation (NHS Digital, 2019). NHS Digital (2019) further points out that physical activity of children is linked to family affluence; children from least affluent families are less physically active, according to the results of this latest report on obesity in England. This was also found in this PhD, where an indirect association between deprivation status and BMI was mediated by physical activity. Children from deprived families were less physically active which was associated with higher behavioural and emotional difficulties of the child and, in turn, associated with higher BMI of the child. Physical activity and diet in England, drawn from various sources by the NHS, indicate that 39% of children from the least affluent families within England engage in less than 30 min of activities a day (NHS Digital, 2019). The results on the frequency of physical activity in this PhD, indicated that 11.3% of the studied population never engaged in any physical activity and 43.3% exercised regularly once a month up to once a week. Therefore, our findings confirm the latest statistics on childhood physical activity in England from the NHS. Furthermore, as highlighted earlier, the studied population are from low socio-economic background, which confirm the NHS results of the lower frequency of physical activity among underprivileged children.

The fifth determinant of weight status in this study was breastfeeding; lack of breastfeeding was associated with low weight status of the child. These findings are interesting as previous studies suggest that breastfeeding is a protective factor of childhood overweight/obesity (Yan et al., 2014). However, Poorolajal and colleagues (2020) found in their meta-analysis (199 studies including 1,636,049 participants) that breastfeeding is only protective towards childhood overweight/obesity when continued for more than four months, delaying the introduction of complementary foods which may lead to excess weight gain. Early weaning was also found to be a mediating effect between SES and childhood overweight/obesity in the systematic review of Mech and colleagues (2016). Unfortunately, the data used in the present study does not detail the length of breastfeeding and therefore the results could be explained to some extent by women breastfeeding for less than four months. Another possible reason might be linked to the low SES and Pakistani ethnicity of the studied population. The latest infant feeding survey, for example, published in 2010, indicates that Asian mothers, including Pakistani mothers were more likely to breastfeed their children after birth (95%) and 49% of Asians still breastfed their children up to at least 6 months of age (McAndrew et al., 2012). This is in line with findings of this study, where, as stated earlier, 65.2% of mother's indicated to have breastfed their child at one point, however the length of breastfeeding is not known. Further, breastfeeding is associated with overweight/obesity in this study. Financial hardship and the cost of formula milk may lead mothers to unsafe feeding practices (e.g. placing larger amounts of time between (breast)feedings) (All-Party Parliamentary Group on Infant Feeding and Inequalities, 2019). An indirect relationship between high deprivation status and lower BMI in this study was mediated by children not being breastfed. Unsafe feeding practices might lead to less feeding and undernutrition, which may offer some explanation for findings of this study, however feeding practice was not assessed in this study.

5.6. Conclusion

A number of studies have researched the link between childhood overweight/obesity and dental caries (Goodson et al., 2013, Hall-Scullin et al., 2018, Hooley et al., 2012a, Hayden et al., 2013), but little research has addressed the common determinants/predictors of the two conditions. In this Chapter, the

quantitative study aiming to examine the determinants of childhood overweight/obesity and dental caries according to the proposed framework using longitudinal cohort data of the BiB study, was presented. This study investigated the influence of 13, family- and child-level determinants for both obesity and dental caries in children using longitudinal data from both the BiB cohort study and linked dental data (dental GA data and data from the oral health survey of five-year-old children 2014-15). Of them, three child- and three family-level determinants directly predicted both child's BMI and dental caries. Four determinants, including lack of alcohol consumption of the mother after giving birth, high frequency of drinking sugar-sweetened beverages of the child, lower behavioural and emotional well-being of the child, and being male were positively associated with more dental caries and greater BMI in children. The remaining two significant family-level determinants, deprivation status and caregiver's feeding style, suggested that higher deprivation status directly predicted lower BMI and a higher dmft. An uninvolved feeding style was linked to higher BMI and a lower dmft of the child. These findings are further discussed in relation to the findings of the qualitative study (Study 1) in the final discussion chapter (Chapter 6) of the thesis, together with the strengths and limitations of this research.

6. DISCUSSION

6.1. Introduction

The aim of this research was to examine common risk factors and determinants for overweight/obesity and dental caries in the family setting of children between the ages of 0 and 11 years of age. The first objective was to identify commonalities between available frameworks in the literature and to develop a new framework on the common determinants of childhood overweight/obesity and dental caries. The second objective was to explore parents' experience of their child's overweight/obesity and dental caries in more depth utilising semi-structured interviews and the third objective was to examine the determinants of childhood overweight/obesity and dental caries according to the proposed framework using longitudinal cohort data of the BiB study.

In the initial phase of the PhD, an adapted conceptual framework on the determinants of childhood overweight/obesity and dental caries was developed based on two frameworks and models specifically developed for childhood obesity (Davison and Birch, 2001) or dental caries (Fisher-Owens et al., 2007) the and common risk factor approach (Sheiham and Watt, 2000) (see Section 2.6). Key aspects of this adapted framework were then firstly, explored in Study 1 (Chapter 4) which utilised semi-structured interviews with mothers of children attending the ANK programme in Sheffield, UK and secondly, in Study 2 (Chapter 5) tested in a longitudinal dataset BiB1000, which was combined with dental GA data and data of the oral health survey of 5-year old children in 2014/2015 of the children participating in the BiB study.

The discussion of these results is divided into the following sections. Section 6.2 considers the development of the conceptual framework and discusses the models used guiding this development. Section 6.3 highlights and compares the common child-level determinants of childhood overweight/obesity and dental caries from the qualitative and quantitative studies and discusses these outcomes in the light of previous systematic reviews on the topic. Section 6.4 highlights and compares the common family-level determinants of childhood overweight/obesity and dental caries from the qualitative and quantitative studies and discusses these in the light of results of previous systematic

reviews on the topic. Section 6.5 includes a brief discussion on factors found to play a significant role for childhood overweight/obesity only. Section 6.6 discusses additional possible determinants on childhood overweight/obesity derived from the interviews. Section 6.7 summarises the discussion points of the thesis and finally, Section 6.8 highlights the strengths and limitations of this research. The final chapter of the thesis (Chapter 7) summarises the conclusions and recommendations resulting from this PhD research and their possible use in policy and future research.

6.2. A conceptual framework on childhood overweight/obesity and dental caries

In order to get a better understanding of the determinants that influence the development of childhood dental caries and overweight/obesity, the first objective of the PhD was to provide a comprehensive conceptual model of the common determinants of childhood overweight/obesity and dental caries (Watt and Sheiham, 2012, Victora et al., 1997). To develop the conceptual model, it was necessary to adapt existing frameworks for each condition. Two frameworks specific to the determinants of childhood dental caries (Fisher-Owens et al., 2007) and to the determinants of childhood overweight/obesity (Davison and Birch, 2001) were chosen based on their comprehensiveness and theoretical soundness (see Section 2.3. – 2.6 for a thorough description and discussion of these frameworks). Both frameworks have been used extensively in the literature to date and present several determinants for either childhood overweight/obesity or childhood dental caries in the child-, family-, and community-level and have been discussed in detail in Chapter 2, Section 2.4 and 2.5 of this PhD.

The final conceptual framework can be seen in Figure 4, p. 40 in Section 2.7 of the thesis. It suggests the existence of common child- and family-level influences of childhood overweight/obesity and childhood dental caries. For example, the conceptual framework hypothesises that family SES (family-level) indirectly affects both conditions through children's health behaviours such as diet (child-level). The framework also proposes that child-level determinants, including demographics (e.g. age and sex), and health behaviours and practices (e.g. diet) may influence childhood overweight/obesity and childhood dental caries. Family-level determinants of both conditions include SES (e.g. maternal

education status), parental health beliefs (e.g. parental dietary knowledge) and family and health behaviours, practices and coping skills (e.g. parental diet).

The model was then empirically tested in two studies: the first a qualitative study with parents of 5-11-year-old obese children attending the ANK programme in Sheffield, UK. The second a quantitative study using linked data from the BiB cohort study with dental data of the same children deriving from dental GA data and the oral health survey of 5-year-old children 2014/15 in England. The results of both studies are discussed together below – firstly, the common child-level determinants of overweight/obesity and dental caries; followed by, the common family-level determinants.

6.3. The common child-level determinants of overweight/obesity and dental caries

In the linked dataset in Study 2 (quantitative study), three child-level determinants were found to be significant for both childhood dental caries and overweight/obesity: namely, frequency of drinking sugar-sweetened beverages, sex and emotional and behavioural well-being of the child. Given previous literature, the significant association between a higher frequency of consuming sugar sweetened beverages and dental caries as well as overweight/obesity was not surprising. There have been a number of previous studies reporting such a relationship (Schwendicke et al., 2016, Paes et al., 2015, Almasi et al., 2016, Paglia et al., 2016, Sohn et al., 2006, Luger et al., 2018, Hu, 2013). The findings from the present qualitative study with parents also reported similar results, with mothers talking about the link between childhood overweight/obesity and tooth decay mainly being due to their child's diet, and consumption of drinks and food high in sugar. Parents often reported that their child preferred foods such as sugary snacks and drinks, and that snacks – high in sugar and fat - were part of their children's daily food consumption. Interestingly, most parents did not indicate that they had difficulties in controlling the consumption of sugar-sweetened beverages of their children. Indeed, only one parent indicated that it was difficult to restrict their child drinking sugar sweetened beverages when they were not prepared to give the beverage up themselves. These results lend support to the importance of parental role modelling in preventing children from drinking sugar sweetened beverages (Davison et al., 2003). It appeared from the interviews that restricting sugar sweetened beverage

consumption was not prioritised by parents. This was in contrast to toothbrushing – parents often mentioned experiencing difficulties controlling their children's toothbrushing behaviour, which was seen as a preventive measure for tooth decay among parents. Parents talked about preventing their child from experiencing tooth decay even though a high sugar diet was consumed.

The second significant determinant common to both conditions was sex. Being male was related to childhood overweight/obesity and dental caries in the linked dataset, which has been discussed in depth in Section 5.5.1. One interpretation was that sex differences in the BiB population may be found due to cultural differences due to the high percentage of Pakistani children within the sample (Ahmed et al., 2013, Mushtaq et al., 2011). Sex differences in childhood overweight/obesity and dental caries have been reported in many countries (Sweeting, 2008, Zhang et al., 2018). One suggestion for this has been that boys often have priority over girls towards access to sweets and calorie rich foods in some cultures (Kalita et al., 2015). In the interviews conducted in Study 1, there was no discussion by parents of differences between boys and girls in relation to childhood overweight/obesity and dental caries. This was likely to be because parents typically only had one child attending the ANK programme.

The third significant determinant was a child's emotional and behavioural state; children with greater emotional and behavioural difficulties were more likely to experience overweight/obesity and dental caries. These findings support previous literature on childhood dental caries (Williamson et al., 2008b, de Jong-Lenters et al., 2018) and overweight/obesity (Griffiths et al., 2011, Kelly et al., 2016, Sanders et al., 2015, Heerman et al., 2016). It is not possible from the BiB data to detail what emotional and behavioural difficulties children were experiencing to understand more about how this relates to obesity or tooth decay. In terms of the interviews, one parent talked about how their child would consume sugar sweetened beverages to comfort them when feeling negative emotionally. However, other parents did not mention emotional or behavioural difficulties in relation to their children when interviewed.

6.4. The common family-level determinants of overweight/obesity and dental caries

In addition to the child-level determinants discussed above, three family-level determinants were found to be significant for both dental caries and overweight/obesity. These were the level of deprivation status, caregivers feeding style and maternal alcohol consumption. In terms of deprivation, a higher level of deprivation (least educated and most deprived) was associated with childhood dental caries and non-overweight/obese children in the linked dataset. Previous literature has reported the link between dental caries and high deprivation status (Verlinden et al., 2019, Enjary et al., 2006, Kumar et al., 2016c, Masood et al., 2019). With regard to overweight/obesity however, the present findings are not in line with other studies which have typically found that a higher deprivation status was linked to overweight/obesity. However, as discussed in Section 5.5.1, also here ethnic background may account for the different findings (Zilanawala et al., 2015, Isong et al., 2018). There are two potential correlated aspects that might explain our findings. First, the majority of the Pakistani people living in the UK belongs to the lowest two quintiles of income (GOV UK, 2019). Second, previous research suggests that Pakistani children living in the UK are 40% less likely to be obese than white children (Zilanawala et al., 2015).

None of the parents interviewed in Study 1 talked about the role of deprivation in relation to either tooth decay or their child's weight, and deprivation status was not assessed in the study. Sheffield, where the interviews took place has, however, been found to be more deprived than the average of all other local authorities in England (Broomhead et al., 2014). Certainly, in the UK data, childhood dental caries (Masood et al., 2019) and overweight/obesity (Stamatakis et al., 2005) have previously been linked to a higher deprivation status, suggesting similar outcomes are possible for the study population in Sheffield.

The second family-level determinant was caregiver's feedings style; an uninvolved caregiver's feeding style was associated with childhood overweight/obesity and an authoritarian feeding style with childhood dental caries. Uninvolved feeding styles have been found to lead to unhealthy eating behaviours in children (Hennessy et al., 2012, Hughes et al., 2012, Hoerr et al., 2009) and authoritarian feeding styles to resistance of children and fussiness in terms of food preferences

(Nembhwani and Winnier, 2020, Kuczynski, 1987). These findings suggest that both extremes might lead to childhood dental caries and overweight/obesity as discussed in Section 5.5.1.6. In line with this, most parents participating in the interviews described their children as being fussy eaters, which might have led to the children being overweight/obese. Highlighting that they often had to cook similar things every day or cook separately for the children as they would not eat what the rest of the family would eat (see Section 4.4. and 4.5). No interview questions were asked about parenting style and therefore the fussiness in eating behaviour could not be linked to parental feeding style per se. However, some parents mentioned that parental role modelling in terms of dietary behaviour might have had an influence on their child's dietary behaviour, which has been supported by previous literature (Lazarou et al., 2008, Mobley et al., 2009).

The third family-level determinant was postpartum alcohol consumption of the mother; a lower postpartum alcohol consumption was associated with dental caries and overweight/obesity in children in the BiB population. These unexpected findings were surprising and as discussed in further detail in Section 5.5. of this thesis, might be specific to the study population due to its high percentage of Pakistani participants. The Pakistani ethnic group living in England has been found to be those with the highest percentage of non-drinkers (Becker et al., 2006). However, alcohol consumption in the BiB study was only measured once, after giving birth, and the amount of alcohol was not considered. Maternal alcohol consumption was not assessed in the interviews and therefore no conclusions could be drawn. The association of dental caries and overweight/obesity with parental alcohol consumption therefore warrants further detailed investigation.

6.5. Additional significant determinants for childhood overweight/obesity

The previous discussion has highlighted the six significant child- and family-level common determinants to both conditions. There were five other determinants – outlined in the conceptual model – which were also found to be significant for childhood overweight/obesity in the BiB sample, but not for dental caries. They include child's ethnicity, childhood physical activity, being breastfed, maternal age at birth, and parental psychological wellbeing.

6.5.1. Child-level determinants

There were three child-level determinants significantly associated with overweight/obesity but not with dental caries in the linked dataset: child's ethnicity, childhood physical activity and being breastfed.

The first child-level determinant was ethnicity; being non-Pakistani ethnicity was associated with childhood overweight/obesity (see Section 5.5.2.), but not associated with childhood dental caries. The lack of association between ethnicity and dental caries might be due to the sampling of the population. The study population of the quantitative study consisted mainly of Pakistani ethnicity and the majority had undergone dental GA and was therefore considered to have dental caries. As highlighted earlier, ethnicity was not discussed during the interviews, therefore no conclusion can be drawn from the qualitative study.

The second determinant of childhood overweight/obesity was physical activity. Children who were taken by their parents more frequently to be physically active were less likely to be overweight/obese than those who were taken less often within the BiB population. Previous literature has confirmed an association between increased physical activity and lower levels of childhood overweight/obesity (Hills et al., 2011, Molnar and Livingstone, 2000, World Health Organisation, 2014a, Shofan et al., 2011, Dhar and Robinson, 2016, Vincent et al., 2003). Also, during the interviews, parents highlighted the importance of physical activity to prevent childhood overweight/obesity. There was no association between physical activity and dental caries. Previous studies have identified an indirect link between sedentary behaviour, such as TV watching, and dental caries due to a higher frequency of calories and sugary food intake. The latter increases the risk to dental caries (Alswat et al., 2016, de Nazaré Marreiros Tavares Silva et al., 2019), however this could not be confirmed in this study.

The third child-level determinant was breastfeeding. Children who were not breastfed had lower levels of overweight/obesity in the BiB population. This contradicts many national and public health promotion campaigns wherein breastfeeding is recommended to prevent childhood overweight/obesity (World Health Organisation, 2020b) and previous studies where breastfeeding was found to reduce the risk of developing childhood overweight/obesity (Yan et al., 2014). In this study, however, as

discussed in Section 5.5.2, these findings of the quantitative study are most likely to be linked to the generally lower number of overweight/obesity in children of Asian ethnicity (Zilanawala et al., 2015). Breastfeeding was also discussed in the interviews; mothers confirmed to have breastfed their children for at least some period of time but none of the parents mentioned breastfeeding in the context of dental caries or overweight/obesity prevention. This might indicate a lack of knowledge on the potential benefits of breastfeeding. Alternatively, it could also be that parents did not think about breastfeeding as children were aged between 5-11 years at the time of the interview. It may be that parents were focussed only on age-appropriate strategies to prevent overweight/obesity and dental caries. Interestingly, no association between breastfeeding and dental caries was found in the linked dataset. Yet, the link between breastfeeding and dental caries has been reported in previous research (Tham et al., 2015) and is the target of many early intervention strategies for preventing early childhood caries (Public Health England, 2014a).

6.5.2. Family-level determinants

There were two family-level determinants that were associated with overweight/obesity in the linked dataset but were not significantly related to dental caries. These were maternal age at birth, and parental psychological wellbeing. The first determinant, maternal age at birth, indicated that older mothers at the time of the delivery were more likely to have a child with a lower BMI during childhood. In this study, the majority of mothers who gave birth at the age of 30 years or above were of Pakistani ethnicity (73.5%). Of those mothers who gave birth under 25 years of age, only 45% were of Pakistani ethnicity. These outcomes are in accordance with recent findings from the Office for National Statistics (2019) where a higher proportion of non-UK born women were aged 30 and above during childbirth compared to UK born women. Furthermore, apart from Poland, Pakistan was the country where most non-UK born mothers living in the UK were born. A higher proportion of mothers who were born in the UK were under the age of 30 years at the delivery (47.4%) compared to mothers not born in the UK (36.4%) (Office for National Statistics, 2019). Children from Asian parents have been found to be thinner than children whose parents were from other ethnicities (Pearce et al., 2015). No association was found between mothers age and dental caries. This is contrary to previous studies

(Retnakumari and Cyriac, 2012, Zhou et al., 2012) that have found that children of younger mothers had more dental caries.

The second determinant was parental psychological wellbeing; a higher score in the parental health questionnaire, indicating that psychological difficulties among parents was associated with childhood overweight/obesity in children in the BiB population. As discussed in more detail in Section 5.5.2., parental self-efficacy influences parental behavioural choices and the choices they make for their children (Amin and Harrison, 2009). Studies have found that even though parents recognise the importance of good nutrition and regular toothbrushing, they have difficulties in dealing with their child's demands for snacks or unwillingness to brush their teeth (Amin and Harrison, 2009, Vermaire et al., 2010), which might be linked to parental stress. To encourage children to have a healthy diet and to adopt regular toothbrushing habits requires effort from the parents on a daily basis, which may partially explain the challenges to promote children's behavioural changes (Van den Branden et al., 2012).

Parents were not specifically asked about their mental health during the interviews. However, one mother mentioned that her poor mental health has influenced the dietary pattern of her child, through caregivers providing snacks and unhealthy food, which led to overweight/obesity within her family. These findings suggest that parental mental health may play a role in the development of childhood overweight/obesity; previously found in other literature (Leppert et al., 2018, Tate et al., 2015b, Halliday et al., 2013, Lampard et al., 2013). However, as highlighted by the interviewee, their child's weight was also influenced through the provision of foods high in sugar content by other people outside of the family (e.g. friends, grandparents, neighbours).

There was no association between parental health and dental caries in the linked dental data and BiB dataset; although previous research has reported childhood dental caries to be associated with poor parental health, such as stress and anxiety (Hooley et al., 2012b). This finding is interesting as previous literature highlights that stress and depression levels among South Asian mothers living in the UK are high, often due to intergenerational stress factors related to cultural differences between the home and British culture (Sonuga-Barke et al., 1998, Sonuga-Barke and Mistry, 2000). As the BiB

population has a very high percentage of Pakistani participants, stress related to cultural differences might be minimised due to the high density of Pakistani living together in the Bradford area. As highlighted earlier, dental caries in this sample was high, due to the sampling which was based on having had a dental GA. The combination of these two factors might explain the lack of association between parental health and dental caries.

6.6. Additional possible determinants from the interviews

Interestingly, during the interviews, there were two other determinants that were frequently mentioned by parents, which were not included in the BiB dataset and are outside of the child- and family-level determinants within the conceptual framework. These were the weather and the safety of the neighbourhood. In their interviews, parents mentioned that the weather would often restrict them in engaging their children in physical activities outside, such as walking to school instead of taking the car or playing in the garden or park. These discussions were had in relation to overweight/obesity. In their interviews, parents sometimes also highlighted that the safety of the neighbourhood restricted their children playing outside and being physically active. Parents mentioned these – the weather and safety - in relation to overweight/obesity prevention. These findings support previous literature which have suggested a link between the safety of neighbourhood (Weir et al., 2006), weather conditions (Harrison et al., 2015, Tucker and Gilliland, 2008) and childhood obesity.

Weather and safety of neighbourhood are usually conceptualised as socio-cultural level determinants in models of health (World Health Organisation, 2010a, Office of Disease Prevention and Health Promotion, 2020). As the conceptual framework developed and tested in this thesis only included child- and family-level determinants, these would not have been included. The finding that parents considered these as important in relation to their child's weight suggests that they should be considered further, both their availability and frequency of use. Parents mentioning these determinants, indicated the fictional boundaries of level categories often included in [oral] health research and conceptual models. Parental perception of important determinants will not be limited to only those written about in the literature, highlighting the importance of conducting qualitative and mixed method studies.

6.7. Summary

To summarise, the first objective of this research, to identify the commonalities between available theoretical frameworks in the literature and to develop a new framework on the common determinants of childhood overweight/obesity and dental caries, was met though the identification and analysis of the social determinants of oral health (Fisher-Owens et al., 2007) and the ecological model of predictors of childhood overweight (Davison and Birch, 2001). These two frameworks formed the basis of the adapted framework on the child- and family-level determinants for both conditions. An adapted framework on the social determinants of childhood dental caries and overweight/obesity was then developed (Figure 4, p. 40). The framework includes physical and demographic determinants such as age and sex, as well as children's health behaviours such as physical activity and diet at child-level. The family-level includes SES, parental health beliefs such as parental dietary knowledge, and family health behaviours. All included determinants derived from the Fisher-Owens (2007) and Birch and Davison (2001) frameworks, however the adapted framework excluded community- and national-level determinants, due to the capacity of the PhD timeframe.

The adapted framework guided the interviews of the qualitative study related to the second objective, to explore parents' experience of their child's overweight/obesity and dental caries in more depth utilising semi-structured interviews. Parents highlighted two potential determinants of childhood overweight/obesity which were not part of the adapted framework, namely weather and safety of neighbourhood. Both were reported in previous research (Harrison et al., 2015, Weir et al., 2006). The link to childhood obesity was only possible due to the setting where the sample was gathered since all parents had obese children. High sugar diet was a contributor to both dental caries and overweight/obesity in children as indicated by their parents. This has previously been confirmed in the literature (Almasi et al., 2016, Paglia et al., 2016, Liang et al., 2016) and is in agreement with the findings of the quantitative study of this research, which answered the third objective; to examine the determinants of childhood overweight/obesity and dental caries according to the proposed framework using longitudinal cohort data of the BiB study. The BiB data which was linked to dental caries data of the same population revealed six common determinants of childhood overweight/obesity and dental

caries; frequency of drinking sugar-sweetened beverages, sex, emotional and behavioural well-being of the child, level of social deprivation, caregivers feeding style and maternal alcohol consumption.

The following section outlines the strengths and limitations of this research.

6.8. Strengths and limitations

There were a number of conceptual and methodological strengths of the research carried out for this PhD. These included; the use of a comprehensive theoretical framework, a mixed method study design, the use of longitudinal data, using MI to overcome missing data, and the use of a comprehensive linked dataset rich in a number of child- and family-level determinants relevant to BMI and dental caries. In addition, in terms of the study population characteristics, the high deprivation status and diverse ethnic background of study participants in the BiB dataset (Study 2), allowed for a unique study setting.

One of the key strengths was that the research was guided by a comprehensive conceptual framework, which was developed and adapted from previously used frameworks and theories. Therefore, the research was theoretical driven, which increased the explanatory power and legitimacy of the study's findings (Collins and Stockton, 2018). The proposed framework was based on existing public health theories, such the common risk factor approach, as well as on existing specific frameworks of childhood dental caries and obesity (Fisher-Owens et al., 2007, Davison and Birch, 2001). Although the adapted framework is not a theoretical framework itself as it has not been widely accepted and tested (Dickson et al., 2018), it provides reference points for the understanding of the determinants of childhood overweight/obesity and dental caries (Ulin et al., 2005). The development of a conceptual framework can further be seen as an argument of why the topic one wishes to study matters and why the methods on how to study the topic are appropriate (Ravitch and Riggan, 2016). The conceptual framework was developed as no previously tested framework for both childhood obesity and dental caries existed. A conceptual framework further indicates the variables to be included in future research and how they are possibly related (Dickson et al., 2018). The use of the adapted framework to examine the common determinants of childhood dental caries and obesity in this study supported the qualitative

study of this PhD thesis by defining the open questions and on how to expand them during the interviews. In addition, the selection of the variables for the quantitative study as well as the relationships between them were based on the theoretical assumptions proposed by the adapted framework. Using a conceptual framework is also essential when employing SEM; a statistical technique that should always be based on an existing framework. In this framework, different relationships of the child- and family-level variables with dental caries and overweight/obesity have been identified. However, the framework did not consider the community- and national-level variables. Assessing those characteristics is now needed for a more comprehensive understanding of the determinants of childhood overweight/obesity and dental caries.

A further strength was the use of a mixed method study design (Schoonenboom and Johnson, 2017, Creswell and Plano Clark, 2006). This PhD research firstly provided an adapted comprehensive multi-determinant conceptual framework for childhood dental caries and overweight/obesity, which was then tested using a comprehensive dataset in lifestyle and dietary data (Gale et al., 2013) combined with dental data of the same children. An additional qualitative study enabled a more in-depth exploration of parents' perspectives on the possible determinants of childhood dental caries and overweight/obesity. For example, in this study parents identified two additional determinants of childhood overweight/obesity, which were not considered in the proposed conceptual framework and therefore were not tested in the quantitative study. The qualitative findings therefore add valuable information to the quantitative findings and suggest including further determinants in future studies. The mixed method design adopted in this PhD allowed the researcher to shed light on the common determinants of childhood overweight/obesity and dental caries since the qualitative and quantitative elements were complementary to enhance the knowledge on this topic through using two different methodological approaches (Tashakkori and Teddlie, 2003).

The secondary data (BiB data set and dental data) allowed the researcher to test the conceptual framework using a quantitative approach and then to compare the findings with previous studies. SEM was the statistical method chosen to test the framework. SEM is a robust method that allows the researcher to test complex relationships between variables that can be simultaneously assessed as independent and dependent variables following a theoretical model (Hox and Bechger, 1998). The

quantitative data used for testing the framework consisted of three different data sources as described earlier, including data from a longitudinal study. The reason to combine different datasets was the lack of a single dataset with the essential variables of the framework, namely dental and BMI data, as well as lifestyle/ dietary data of children. Combining data from different sources resulted in a dataset with missing data. The procedures to handle this problem will be discussed in the following paragraph. However, the data linkage resulted in a unique and rich dataset to examine the common determinants of childhood dental caries and overweight/obesity. The use of a comprehensive dataset to test the framework using SEM is a major strength of this study.

Through the dataset linkage process, missing data was inevitable and led to a much reduced sample size; resulting in a study with less precision and power than initially planned (Sterne et al., 2009). Missing data was due to firstly, the unavailability of dental data for some of the participants of the BiB study. Participants without dental data had to be excluded for the purpose of this study. Secondly, some participants with dental data had few BiB data available and therefore had to be excluded. This was mainly due to the fact that BiB data originated from a longitudinal study with different time points of data collection and some participants did not complete data collection during all six points in time. Thirdly, the type of data collected at the different time points differed, and some variables, for example diet, were only assessed twice and other variables, such as breastfeeding, were assessed in all six waves of data collection. Therefore, if a participant was not interviewed in both of these data collection points, no data on diet was available.

In order to account for the missing data, MI was performed, allowing the researcher to conduct the analysis despite the missing data (Sterne et al., 2009). MI was chosen over the more commonly used ML estimation as the latter method is only suitable for data that is normally distributed and therefore most likely continuous data. Most of the variables in this dataset were, however, categorical. Another strength of the MI method is obtaining unbiased estimates. Obtaining unbiased outputs suggest more accurate results, meaning that the findings are more likely to reflect the nature of the events. This occurs through the estimation of missing data, by combining the results of multiple imputed dataset and taking the average of these results as new values to replace missing data (Graham et al., 2007, Pedersen et al., 2017, Sterne et al., 2009). Nevertheless, even though some of the missing data was

accounted for, it must be acknowledged that using primary data (i.e. collected from study participants) would have been preferable compared to estimating missing data. This is because the former would result in a more accurate representation of the characteristics of the study population.

The qualitative study was conducted using interviews with parents of 5-11-year-old obese children in Sheffield. The semi-structured interview questions were guided by the conceptual framework, but also left room for parents to talk about and comment on additional determinants of childhood overweight/obesity and dental caries. Even though previous qualitative studies with parents explored the determinants of childhood overweight/obesity (Appleton et al., 2017, Schalkwijk et al., 2015) and childhood dental caries (Duijster et al., 2015, Amin and Harrison, 2009), as far as the researcher is aware this is the first qualitative study simultaneously assessing the potential determinants of the two conditions. Previous evidence suggests that parents have great influence on their children's health behaviours and health outcomes through their own health beliefs and behaviours (Narine et al., 2013, Van den Branden et al., 2012, Lazarou et al., 2008, Amin and Harrison, 2009), and were therefore chosen as the interviewees for this research. One-to-one interviews allowed parents to talk openly about sensitive and stigmatized issues related to this research such as childhood overweight/obesity and dental caries than for example focus-group discussions with other parents present (Sim and Waterfield, 2019).

The next paragraphs highlight some of the limitations of this research.

Despite the above-mentioned strengths of this research, a number of limitations should be noted. First, the conceptual framework only included the determinants from the child and family level. Second, the statistical method of MI in combination with SEM proposes possible statistical limitations. Third, the longitudinal dataset could not be used to its full potential, due to missing data. Fourth, the use of secondary data has a number of limitations. Fifth, sampling issues were noted in both studies due to sampling based on dental caries in the quantitative study and based on childhood obesity in the qualitative study. Finally, a limited number of cases were included in the quantitative study due to the linkage of the dental GA and BiB data. Each of these aspects are discussed below.

The development of a conceptual framework to guide this research has been described as one of the strengths of this PhD, however the framework lacks important determinants from the community level and national level. For instance, access to health care and national health policies are considered important determinants of health. These more distal determinants play an important role in the development of childhood obesity (Davison and Birch, 2001) and dental caries (Fisher-Owens et al., 2007). Davison and Birch (2001), for example, call the distal level community, demographic and societal characteristics, which include access to convenience foods and fast food restaurants. These have been shown to increase the risk of obesity (Xin et al., 2019) through for example middle level characteristics, such as parental food preferences, parenting styles and family characteristics. In the framework of Fisher-Owens (2007), the distal level refers to community-level influences and includes determinants called community dental health environment, which involves food prices and access to healthy foods, which influence children's oral health status (Petersen and Kwan, 2004). If characteristics at the distal level had been included in the adapted conceptual framework, childhood diet at the child level, which was measured according to the frequency of drinking sugar-sweetened beverages, could be influenced by one of the distal level determinants (at the national or international level). Such distal level determinants may include the globalisation of food systems, agricultural policies and large scale farming, cheap energy of fossil fuels and trade agreements, which have changed the dietary pattern of Western countries populations (Swinburn et al., 2019). These changes have facilitated access to non-traditional foods and increased the consumption of sucrose (Peres et al., 2019), including sugar-sweetened beverages, that can potentially influence the occurrence of both dental caries and overweight/obesity (Swinburn et al., 2019, Peres et al., 2019). In this thesis, however, these distal determinants were not assessed due to their unavailability in the dataset. As a result, the focus here was only on the child- and family-level determinants of dental caries and overweight/obesity in children.

Using MI and SEM can be considered an innovative approach to deal with missing data and longitudinal data (Enders and Mansolf, 2018). As highlighted earlier in this section, MI was chosen over ML as the estimation method as the variables were not normally distributed and due to the strength of the former method in producing unbiased estimates (Graham et al., 2007, Pedersen et al.,

2017, Sterne et al., 2009). However, MI and SEM has received little attention in public health research (Enders and Mansolf, 2018). MI is not supported in STATA, as further outlined in Section 5.3.6. Through incompatibility of MI and SEM the model fit could not be assessed and therefore, the findings should be interpreted with caution (Institute for Digital Research and Education, 2019). However, MI and SEM have been implemented in R and MPlus and the initial results indicated a good calibration compared with those obtained using the ML method (Enders and Mansolf, 2018). More studies using MI and SEM with different percentages of missing data and number of variables might be needed to draw definitive conclusions on the effectiveness of such methods (Enders and Mansolf, 2018).

As described above, as the dataset in Study 2 originated from the BiB cohort study, there were inconsistencies in the data collection and response rates over the time points of the cohort study which resulted in a considerable amount of missing data. This meant that even though BiB is a robust longitudinal cohort study, most variables could only be used from one point in time and changes over time were not assessed. Furthermore, the use of secondary data also meant that not all available variables were relevant for the objectives of this study (Cheng and Phillips, 2014). For example, there were several measures of physical activity such as number of minutes spent doing physical activity per day, and frequency that parents took the child somewhere to do physical activities. However, only one measure on physical activity assessed at one point in time (frequency that parents took children somewhere to be physically active) could be used in the analysis. This was mainly due to large amounts of missing data in other variables measuring physical activity. Similarly, mother's weight status was not taken into consideration in this study, although as highlighted in Chapter 2.5 and 5.5.1 of this thesis mother's weight status has previously been linked to children's birth weight and to childhood obesity (Whitaker, 2004, Josey et al., 2019, Rooney et al., 2010, Heslehurst et al., 2019, Higgins and Dale, 2012). This was due to a high number of missing cases (126 missing cases from 171 total cases). Additionally, previous studies have found that household constellation has an influence on the development of childhood overweight/obesity and dental caries (Mech et al., 2016, Schmeer, 2012, Plutzer and Keirse, 2011, Duijster et al., 2014b). For example, mother's high working hours lead to grandparents taking care of the children, who might have different health behaviours in relation to diet

. The number of household members was another variable that could not be included in the analysis of this study due to missing data (127 out of 171 cases missing). Additionally, even though the diversity of the sample concerning ethnic background and SES was highlighted as a strength of this research, the studied samples of both qualitative and quantitative studies are not representative for England and the UK (Wright et al., 2013) as discussed in more detail in Section 5.5.1.

Combining the BiB dataset with dental data produced a unique dataset, however by combining, it also reduced the number of participants significantly due to limited availability of dental data, resulting in a small overall sample size (n=171). Due to the availability of dental data and because the majority of dental data derived from dental GA data, the levels of dental caries of the sample of the quantitative study were much higher than those observed in children in the UK (GA sample: mean dmft: 9.1 and England representative oral health survey data used in this PhD: 0.9). Therefore, the participants in the combined dataset are not representative of the general population because of the overrepresentation of dental caries. Similarly, in the qualitative study, all study participants were parents attending the ANK programme, because they were either advised to do so or due to their voluntary intention to adopt behavioural changes to reduce the obesity of their child. However, since the aim of the study was not to investigate the prevalence of overweight/obesity and dental caries, but rather the common determinants of both diseases the possible high prevalence of both conditions should not affect the study results. Finally, in the qualitative study, since parents attended a management programme to reduce childhood obesity, their interviews might have been more focused around the determinants of obesity rather than dental caries.

The next section outlines the overall conclusions of this research as well as the recommendations for health policy and future research.

7. CONCLUSION AND RECOMMENDATIONS

In order to explore common risk factors and determinants for childhood overweight/obesity and dental caries in the family setting:

- A conceptual framework on the determinants of childhood overweight/obesity and dental caries was developed based on the social determinants of health (World Health Organisation, 2010a), the social determinants of oral health (Fisher-Owens et al., 2007) and the ecological model of predictors of childhood overweight (Davison and Birch, 2001).
- The framework was tested using data from the BiB study (Born in Bradford, 2017) and complemented by dental data from the same participants deriving from dental GA data and the oral health survey of 5-year-old children 2014/2015 (Public Health England, 2014b). Missing data was accounted for through MI and the framework was tested through SEM.
- The PhD was complemented by a qualitative study investigating family experiences of childhood obesity and dental caries based on the conceptual framework through interviews with parents of overweight/obese children living in Sheffield.

7.1. Summary of the findings

- From the literature review, it was clear that previous studies and systematic reviews have found inconclusive results on the association between childhood dental caries and overweight/obesity. The lack of common assessment tools and different methodological approaches might account for these findings. Further, only a few studies included multiple determinants – including both child- and family-level determinants – and therefore lacked many of those that are likely to be important (and common) to both conditions.
- The quantitative study of this PhD, which tested the adapted conceptual framework, found that three child-level determinants (frequency of drinking sugar-sweetened beverages, sex, and emotional and behavioural well-being of the child), and three family-level determinants (level of deprivation, caregivers feeding style, and maternal alcohol consumption) were associated with both childhood dental caries and overweight/obesity. Maternal non-consumption of alcohol after giving

birth, high frequency of drinking sugar-sweetened beverages by the child, behavioural and emotional difficulties of the child, and being male were associated with dental caries and overweight/obesity. A high deprivation status was associated with dental caries and a low deprivation status with overweight/obesity. An uninvolved caregiver feeding style was related with obesity whereas an authoritarian feeding style was associated with dental caries.

- The interview study with parents of children attending the ANK programme in Sheffield confirmed some of these findings in terms of the importance of a high consumption of sugary drinks for the occurrence of dental caries and overweight/obesity in children. In addition, the interviews added further depth to understanding of the determinants – with weather and neighbourhood safety being discussed by some parents as important factors related to physical activity and therefore overweight/obesity prevention. These two determinants were not part of the original interview schedule as they were not included in the family- and child-level determinants in the adapted conceptual framework – they are typically seen as part of the community-level within the social determinants of health framework (World Health Organisation, 2010a).

7.2. Implications for research

- Future research should test the adapted framework using longitudinal data incorporating multiple determinants and both childhood overweight/obesity and dental caries outcomes, in order to overcome the selection biases as discussed earlier. The framework should be tested, if possible, with different age groups of children to explore whether determinants are common in younger as well as older children and adolescents (e.g. 0-5, 6-12, 13-18 years) as highlighted in Section 2.7.1. In addition, this framework should be tested in populations with different levels of deprivation, ethnic groups, cultural populations, possibly even in different countries to identify possible differences between population groups.
- The conceptual framework should be further expanded to include community- and national-level determinants. As highlighted in the strengths and limitations section of this research, valuable information can be gained by including information from these levels. Future research involving countries that have implemented different health policies and programmes specifically to tackle

dental caries and overweight/obesity, might provide valuable information (Wright et al., 2017). Additionally, qualitative studies should be carried out to explore, for example, the family and child experiences regarding food policies and their impact on school meals, grocery prices and health (Krukowski et al., 2016).

- Further qualitative research should be carried out on the experiences of different family members such as children, siblings, parents and possibly grandparents with childhood dental caries and overweight/obesity to enhance the understanding of possible enablers and restrictors for healthier lifestyles in terms of dental caries and overweight/obesity.
- Further research should be conducted on improving targeted health promotion strategies for parents and children utilising a common risk factor approach to reduce both dental caries and overweight/obesity (see below).

7.3. Implications for practice

- Many governments are committed to reducing health inequalities and to improving people's health (Sadana and Harper, 2011). Combining strategies to tackle multiple health outcomes is not only cost-effective for governments but they also result in substantial health gains for the population (Cecchini et al., 2010, Hawe et al., 1997). For example, increasing awareness on healthy eating and physical activity will affect multiple health outcomes (Cecchini et al., 2010). Future prevention campaigns of childhood dental caries and overweight/obesity should target common determinants of the two conditions (Sheiham and Watt, 2000), such as emotional and behavioural well-being, the reduction in consumption of sugary drinks and possibly targeted interventions for boys. These strategies should emphasise the importance for behaviour change among individuals and in addition, the need to change the fundamental societal and health economic structures which underpin these two conditions. The latter should focus on the reduction of social inequalities that can potentially result in better population health and consequently reduce healthcare costs. A recent systematic review aiming to identify social media health campaigns to reduce sugar-sweetened beverage consumption (in English) and the social media platforms reported that social media campaigns against sugar-sweetened beverage consumption have been underutilized by

governments (Te et al., 2019). The authors concluded that social media campaigns have the capacity to reach large population groups, due to the increased use of social media among all age groups (Te et al., 2019). Social media campaigns aiming to promote protective behaviour against dental caries and overweight/obesity in children could be implemented using reasonable financial resources (Te et al., 2019) and could for example, target, based on the results of this PhD research, specifically male children.

- As was highlighted by some parents in the qualitative interviews, preventive knowledge on dental caries and overweight/obesity was lacking (Section 4.4.1), which suggests that the provision of such information should be provided as early as possible. This could be from, for example, health care workers such as the midwife, nurse, GP or (dental) paediatrician.
- Childhood dental caries and overweight/obesity prevention should be considered in already existing health policies in the UK, for example policies such as the Social Value act, which aim to improve health inequalities through targeting determinants such as deprivation, which influences both dental caries and overweight/obesity (GOV UK, 2014).
- Health promotion campaigns such as the National Healthy School Programme (Leeds City Council, 2020), aiming to improve children's diet to improve overweight/obesity levels could easily integrate oral health education and highlight the link between dental caries and overweight/obesity through diet (e.g. sugar-sweetened beverages).

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APPENDICES

Appendix I: Parental information leaflet (Study 1)

The University Of Sheffield.

Contact information:
Magdalena Uerlich
School of Clinical Dentistry
University of Sheffield
mfuerlich1@sheffield.ac.uk.
0114 271 7877

Parent/ Carer Information Sheet

We would like to invite you to take part in our research study. Before you decide on whether to participate in this study, I will explain why I carry out this research and what it would involve from your side.

I will go through this information sheet with you and answer any questions you may have at any point. Please, do feel free to also talk to other people about this study if you wish to do so.

What is the purpose of the study?
A lot of research has been carried out on children's weight, their diet, and sugar intake. There has also been a great of research on children's oral health, tooth decay and the link with diet and sugar. I am interested in finding out about your thoughts on what your child eats and their health behaviour and whether you see any links between overweight and your child's oral health.

The overall aim of this study is to explore your experiences within your family on what influences your child's diet, weight, and oral health.

Why have I been invited?
We have invited you as your child is between the ages of 5-11 years and for the first time enrolled in the Alive N' Kicking programme. We are aiming to talk to between 15-20 parents involved in the programme.

What will I have to do after I agree to take part?
If you agree to participate in this study, we would like you to sign a consent form, saying that you agree to take part in the study.

You may still withdraw from the study at any point and you do not need to explain your reasons for doing so.

I will conduct a short interview of about 30-45 minutes with you on your experiences of shopping and cooking in your family life, your child's diet, their sugar intake, their oral health, and oral hygiene. We will record the interviews, but all information you give will be anonymous, which means your name, or the name of your child will not be used.

What are the possible benefits of taking part?
Upon completion of the interview, you will receive a £15 shopping voucher. Your answers will be used to influence the development of future strategies to prevent overweight and tooth decay.

What are the possible disadvantages or risks of taking part?
There are no risks to you from taking part in the study.

What happens when the research stops?
After the interview, we will inform you by email or post about the findings of this research.

Please do not hesitate to contact me at any point in time, with any further questions.

Appendix II: Parental consent form (Study 1)

The University Of Sheffield.

Contact information:
Magdalena Uerlich
School of Clinical Dentistry
University of Sheffield
mfuerlich1@sheffield.ac.uk.

Name of parent involved in the interview:
Age and gender of child involved in the programme:

Oral and general health of children aged 5-11 years

Parent/Carer Consent Form

Put your initials in the boxes below if you agree with the statement

Please initial here

1. I confirm that I have read and understood the information sheet for the above study. I have had the opportunity to consider the information given, ask questions, and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, and without my participation in other research studies or legal rights being affected. ☐
3. I understand that digital sound recordings will be made, and that the purpose for which the material will be used has been explained in terms that I have understood. ☐
4. I understand that any information obtained will be used for research purposes only. This will include research publications. Anonymity and confidentiality will be preserved at all times. ☐
5. I agree to participate in this study. ☐
6. I agree to be contacted be contacted in relation to this study. ☐

Name	
Telephone number	

7. I agree to be contacted for any future research. ☐
8. Please provide your email address to receive the final results of this study:

Name of person taking consent	Date	Signature

Appendix III: Thank you letter for parents (Study 1)

The University Of Sheffield.

School of Clinical Dentistry
Claremont Crescent
Sheffield
S10 2ZZ

12/05/2020

Dear Parent/Guardian

This letter is being given to you as you have been taking part in our study on oral and general health of children aged 5-11 years, conducted at the Alive N Kicking programme location in Sheffield.

Please find enclosed your £15 gift voucher as a thank you. We are really grateful that you have taken part in our interviews as it is important for us to find out more about your views as a parent or guardian on weight gain and oral health of children.

Please sign and date the enclosed receipt and return it to me.

We will send you an email at the end of the study to tell you about what we have found out and what we think it means.

If you have any questions please contact me by email: mfuerlich1@sheffield.ac.uk.

Many thanks for your help in this study.

Yours sincerely,

Magdalena Uerlich
PhD Research Student