Caries, oral health behaviour and satisfaction with teeth in children from 2 to 12 years of age

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Contents

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LIST OF PAPERS

Paper I Wigen TI, Baumgartner CS, Wang NJ.
Identification of caries risk in 2-year-olds.
Community Dent Oral Epidemiol 2018;46:297-302.
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Paper II Baumgartner CS, Wang NJ, Wigen TI.
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Paper III Baumgartner CS, Wang NJ, Wigen TI.
Self-reported satisfaction with teeth and associated factors in 12-year-olds.
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INTRODUCTION

The public dental services in Norway are by law entitled to provide regular and individualized oral health care to children and adolescents from birth to the calendar year in which they turn 21 years (Norwegian legislation 1984). All treatment is free of charge for children below 19 years of age. Children are called for the first regular dental examination in the dental services when they turn 3 years old (Norwegian legislation 1984; Misvær and Lagerløv 2013).

Before 3 years of age, oral health is integrated in the scheduled health checks at health centres. Health nurses shall, according to national guidelines contribute to early establishment of appropriate oral health behaviour including information to parents about oral health behaviour and inspection of children's mouth. The health centres should ensure that children are referred to the dental services when needed (Norwegian Directorate of Health 2004).

The majority of children are not examined by dental personnel before the age of 3 years and some children have developed caries before their first appointment in the dental services (Wendt et al. 1991; Kühnisch et al. 2016). Collaboration between the dental services and health services is necessary to fulfill the recommendations regarding young children´s oral health (Løken et al. 2016). The dental services ensure that employees at the health centres have sufficient knowledge to implement recommendations related to oral health (Norwegian legislation 1984).

Oral health in children

Dental caries is the most common preventable disease in childhood (Selwitz et al. 2007; Koch et al. 2017). This may lead to physical, psychological and emotional, behavioural and social problems and may adversely affect future oral health (Pitts et al. 2017). Caries can influence both oral and general health including children's quality of life (Filstrup et al. 2003; Sheiham 2006). Oral health is part of general health and well-being and contributes to development of healthy children and adolescents (Sheiham 2006). Caries affect teeth of people at all ages and involve both primary teeth and permanent teeth. Although the prevalence of caries has declined in developed countries during recent decades, oral health

promotion and oral disease prevention including control of early childhood caries is still necessary to prevent future caries development (Kassebaum et al. 2017; Marthaler 2004).

Up to the age of 12 years, most parents take care of children's oral health (Christensen 2004). After this age, children enter adolescence and gradually become responsible for own oral health and well-being (Broberg and Klingberg 2017). Research in adolescents shows association between dental caries, quality of life, social concern and satisfaction with teeth. During early life children have their own experiences with dental health and dental care that may influence their satisfaction with teeth and quality of life (Ekbäck et al. 2008).

Dental caries

Caries etiology

The cause of dental caries is multifactorial and complex. Historically, researchers have focused on biological and dietary effects on children's oral health to explain caries development. Keyes (1962) founded the basis for most models described over the past 40 years. He used the host-agent-environment model to describe the occurrence of dental caries. Dental caries only occurs when the three factors (direct causes), bacteria, tooth and sugar are present simultaneously (Keyes 1962). In recent years, there has been a broader focus on exploring children's oral health outcomes using a conceptual framework, which incorporates psychosocial and environmental predictors as well as the above-mentioned factors (Crall et al. 1990; Wendt et al. 1995; Fisher-Owens et al. 2007). These frameworks generally classify conditions associated with disease into five broad domains: genetics and biology, social environment, physical environment, health influencing behaviours and medical care (Fisher-Owens et al. 2007). These background variables are relevant to explain why some children develop caries lesions despite outspread use of fluoride and comprehensive information about caries prevention.

To visualize the different factors (macro- and micro-levels) which may influence caries development, various caries models have been developed and gradually modified (Eriksen and Bjertness 1991; Fejerskov 2004). Recent models are based on concentric rings:

the Fejerskov and Selwitz models with direct causes of dental caries surrounded by knowledge, attitudes, behaviour and socio-economic status (SES) related variables (Fjerskov 1997; Selwitz et al. 2007) and the Fisher-Owens model with direct causes (diet, bacteria, host teeth), surrounded in turn by community, family and child-level "influences" (Figure 1) (Fisher-Owens et al. 2007). These models give a description of how environmental factors can be considered the driving forces triggering the caries process, described by Keyes' triad to develop (Keyes 1962).

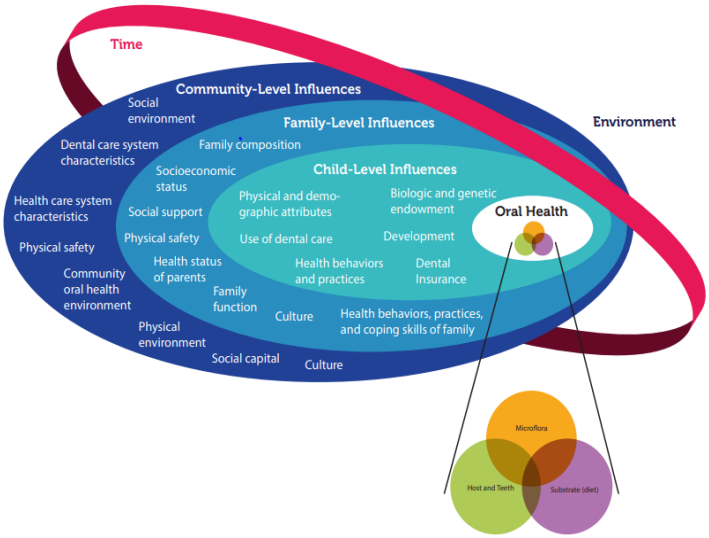

Figure 1. Caries model depicting environmental factors that can affect caries development in children (Fisher-Owens et al. 2007).

Early childhood caries

Early childhood caries (ECC) is prevalent around the world, but in particular growing in low- and middle-income countries in parallel with changing diet and lifestyles. ECC is the early onset of caries in young children often with fast progression, which can ultimately result in complete destruction of primary teeth. An epidemiological definition of early childhood caries is the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled surfaces in any primary tooth of a child under the age of 6 (Drury et al. 1999; Tinanoff et al. 2019). Due to the frequent consumption of carbohydrates, especially sugars, and inadequate to absent oral hygiene in small children, ECC shows an atypical

pattern of caries attack, particularly on smooth surfaces of upper anterior teeth (Wyne 1999).

The aetiology of ECC is complex, and the disease progresses more rapidly than caries in the permanent dentition (Peyron et al. 1992; Mejàre et al. 2001). ECC is strongly influenced by health behaviours and practices of children and families, mostly mothers and/or caregivers. In addition, structural factors and poor socioeconomic conditions have an important impact on the development of ECC and may lead to inequalities which are increasing in low- and middle-income countries (Thomson 2016; Otero et al. 2015). If left untreated, caries can cause pain, loss of function and may affect the child's general health, growth, development, sleeping, playing, self-esteem and worsen the child's oral health-related quality of life (OHRQoL) (Meyer et al. 2018; Acs et al. 1992). Moreover, ECC is also a global public health burden, medically, socially and economically.

In many countries, a substantial number of children require general anaesthesia (GA) for the treatment of caries in their primary teeth which leads to considerable costs and social implications (Thomson 2016).

Caries prevalence

When reporting caries in a population, the method of how caries lesions were registered may influence the caries prevalence estimates (Alves et al. 2018), reported caries experience and severity of dental caries (Amarante et al. 1998; Ismail 2004).

As mentioned above, caries prevalence in most of the industrialized countries has declined in recent decades (Norderyd et al. 2015; Koch et al. 2017) but persists as a highly global health problem that affects individuals during life course (Sheiham 2005; Kassebaum et al. 2017; Pitts et al. 2019). Concurrent with general oral health improvements, the distribution of dentin caries is reported to be increasingly skewed, where a minority of children carries the burden of caries (Skeie et al. 2005; Wigen and Wang 2010).

Depending on the population studied, results have shown that up to 80% of 3-5-year-olds (Wendt et al. 1991; Grindefjord et al. 1996; Koch et al. 2017; Anderson et al. 2021), 20-40% of 5-6-year-olds (Leroy et al. 2012; Monaghan et al. 2014; Anderson et al. 2021) and 30-

70% of 12-year-olds had developed caries (Koch et al. 2017; Leroy et al. 2012; de Almeida et al. 2003; Vernazza et al. 2016; Almerich-Silla and Montiel-Company 2007).

The proportion of caries-free children has increased in all Nordic countries and in all age groups between 2005–2017, except for 6-years olds in Sweden where caries has increased since 2011. Among 12-year olds, it varied from 56% in Finland (2015) to 79% in Denmark (2017) (Norwegian Directorate of Health 2018) (Figure 2). In Norway, the reported proportions of 5- and 12-year-old children with dentin caries experience has decreased from 50% in 1985 to 20% in 2020 among 5-year-olds and from 81% in 1985 to 39% in 2020 among 12-year-olds (Statistics Norway[a] 2020; Statistics Norway[b] 2020). In Sweden, the dentine caries prevalence in 6- and 12-year-olds has been reported to be 24% and 31% respectively (Swedish National Board of Health and Welfare 2021). Caries prevalence is higher if initial caries lesions (enamel caries) are included in the results. It must be mentioned that there is an underrepresentation of caries-free children in the figure, and this may vary between countries. Children with caries tend to be examined more often and are therefore overrepresented compared to caries-free children, who are called for examination more rarely. There are however drop-outs and how their status would affect the figure is unknown.

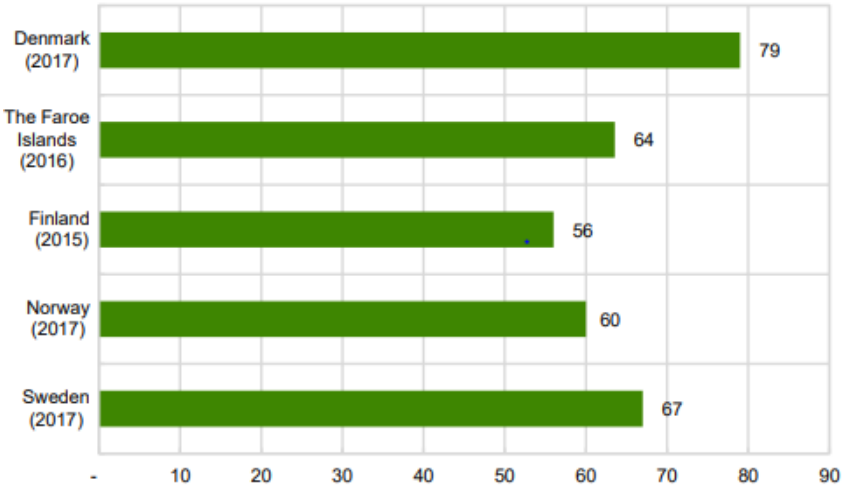

Figure 2. Proportion (%) of 12-year-old children with no dentine caries. Ministry of Health and Care Services "The Nordic project" (Norwegian Directorate of Health 2018).

None of the Nordic countries report or register enamel caries systematically. Enamel caries has a higher chance of requiring operative dental treatment in the future and indicates a need for non-operative treatment (fluoride brushing, fissure sealant etc). Including enamel caries (D_{1-2}) when collecting data would give a more accurate picture of oral health status and should be considered in the future for all countries, including the Nordic countries (Skeie and Klock 2014; Norwegian Directorate of Health 2018).

Caries prevalence, including initial caries lesions, has been reported to be 31% and 39% in Swedish 5-and 10-year-olds (Norderyd et al. 2015). There are few studies of the caries situation and oral health behaviours among children younger than 3 years of age. In Scandinavia, it is reported that 3-50% of children had already developed caries at 2-3 years of age (Skeie and Klock 2014; Hultquist et al. 2021; Anderson et al. 2021).

Caries diagnostic criteria

Several caries diagnostic criteria systems have been developed (WHO 1997, Nyvad and Baelum 2018) and used in the literature. Historically, the World Health Organization (WHO) has recommended that caries detection should be performed at the cavity level (WHO 1997) and epidemiological surveys have mainly focused on cavitated lesions to evaluate the prevalence of caries. Detection at the cavity level may underestimate caries prevalence in populations (Skeie and Klock 2014). The caries diagnostic system described and recommended by the WHO clinical criteria is still widely used (Agbaje et al. 2012). A drawback of only expressing caries prevalence as the mean DMFT is that high caries groups may remain undiscovered in the population and camouflage the skewed distribution. In order to target the still caries-susceptible individuals in these populations, two caries diagnostic criteria systems were recently developed, the International Caries Detection and Assessment System (ICDAS I) in 2002 which was modified to ICDAS II in 2007 (Ismail et al. 2007) and the Significant Caries Index (SIC) in 2000 (Bratthall 2000). The background for introducing the ICDAS criteria was to develop a simple, one standard, logical evidence-based clinical scoring system for caries detection and assessment of caries research, where caries was recorded at all stages from the earliest enamel lesion to an extensive cavity which involves at least half of a tooth surface or possible reaching the pulp. The SIC-index focuses on individuals with the highest caries scores in a population where caries distribution is

skewed (Bratthall 2000), and it reports the caries experience (= mean of DMFT) for one-third of the population with the highest caries score (experience). It is actually not an index, but rather a form of data presentation to give a better picture of caries situation in populations with skewed distribution. In 2020, the SiC among Norwegian 12-year-olds was 2,43 (Statistics Norway[c] 2020).

The national statistics describing the caries situation in children in Norway are based on the WHO criteria, and only lesions into dentine are reported, while the dental services use a 5-graded index to register both enamel- and dentine caries (Espelid et al. 1990; Amarante et al. 1998).

Caries risk indicators/factors

Variables directly or indirectly related to risk for disease are either named risk indicators or risk factors. Some confusion exists regarding this nomenclature and there is no consensus at the present time (Burt 2001). Some authors include environmental and behavioural as well as biological variables in the term risk factors (Beck 1998), while others have defined risk indicators as characteristics or exposures that co-exist with an increased possibility to develop a disease, while risk factors are characteristics or exposures playing an essential role in the development of a disease. Risk factors are part of the causal chain, and are identified in longitudinal studies (Beck 1998). Risk indicators are established in cross-sectional studies, in which correlations between various conditions and disease are investigated (Rothman 2012). A risk indicator may be a risk factor if validated in longitudinal studies (Beck 1998). Risk indicators are useful in identifying groups at risk (Antunes et al. 2018), while risk factors are more important when identifying individuals at risk. Caries risk factors are diverse. In a systematic review from 2004, 106 risk factors were associated with caries prevalence or incidence of caries in primary teeth (Harris et al. 2004). Several studies conclude that a combined weighting of several caries risk factors is better than using individual factors and that there is no reliable method, model, programme or technique for predicting future caries (Pienihäkkinen et al. 2004; Twetman 2016; Hultquist et al. 2021). Risk factors for ECC are known, and almost all are modifiable (Table 1).

Table 1. Overview of risk factors and underlying determinants of ECC.

Microorganisms
Maternal oral health
Oral flora
Poor oral hygiene and control of dental plaque
Saliva—quantity (reduced flow) and constituents (particularly variations in proteins present)
Teeth
Lack of fluoride exposure (nonuse and nonavailability of fluoridated toothpaste)
Genetic susceptibility/factors
Enamel defects (hypoplasia)
Diet
Breastfeeding - beyond 12 months, especially if frequent and/or nocturnal
Free sugars added to baby bottles
Free sugars in foods and drinks
Nutritional status of mother and infant
Social determinants: family, culture and environment factors
Premature birth/low birth weight
Poor parental education
Low socioeconomic status

Multitude risk indicators/factors can (also) be grouped into children, family and community influences (Fisher-Owens et al. 2007).

Child-level

Research on risk indicators for caries in preschool children have focused on child oral health behaviours associated with caries development in children, child-level influences (Figure 1). Visible plaque (Wendt et al. 1994; Declerck et al. 2008), early colonization by caries-related bacteria (Alaluusua and Malmivirta 1994), the presence of mutans streptococci (Grindefjord et al. 1995; Grindefjord et al. 1996; Pienihäkkinen et al. 2004; Warren et al. 2008), frequent intake of sugary drinks (Rodrigues and Sheiham 2000; Karjalainen et al. 2001; Declerck et al. 2008), age when starting tooth brushing (Kumar et al. 2016), sporadic tooth brushing (Peres et al. 2005; Twetman and Dhar 2015; Boustedt et al. 2020), illness and use of antibiotics (Wendt et al. 1996; Paunio et al. 1993) have all been associated with caries development in preschool children. Previous caries experience has been considered the best predictor of future caries development in children (Wendt et al. 1999; Leroy et al. 2012; Twetman et al. 2013; Mejàre et al. 2014). Presence of dental plaque and caries in early childhood has been reported to be associated with caries increment during preschool age (Wendt et al. 1999; Leroy et al. 2012; Kramer et al. 2014).

Family-level

In early childhood, family influences are important for child development. Caries development in preschool children has been associated with the family's socioeconomic situation and oral health behaviour (Harris et al. 2004; Leong et al. 2013). Children with immigrant background and children of parents with low educational level have been shown to have higher caries prevalence than other children (Grindefjord et al. 1995; Harris et al. 2004; Petersen et al. 2005; Skeie et al. 2006; Wigen et al. 2011).

Community-level

Neighborhood empowerment may play a role in explaining inequalities in caries prevalence in children (Pattussi et al. 2006). Children's oral health is assumed to be better in community that appreciate good oral health (Watt 2002). Cultural aspects and neighborhood may have implications on caries development in children (Adair et al. 2004). The way in which a dental care system is designed and amount of dental care available may affect oral health and caries development in preschool children (Christensen et al. 2010).

Caries prevention and oral health promotion

Caries risk indicators may increase the possibility to intensify preventive care to children with highest risk of dental caries (Mejàre et al. 2014). However, caries is a multifactorial disease making it demanding to predict which child is at risk of developing caries. Efficient prevention strategies depend upon the understanding of how caries develops, progresses and ability to identify caries risk children. There are two main strategies for addressing the issues regarding health promotion, a population-based strategy or a high-risk strategy. The problem is whether the optimal strategy to reduce the excessive burden of disease would be the population-based, high-risk strategy, or a combination of both. Conventional population-based interventions have been the golden rule in health promotion. The caries preventive strategies should be two-pronged, consisting of both a population approach and a high-risk (individual-centred) approach.

A population strategy should make it possible for all individuals to control own risk factors by offering standardized interventions (spending equal resources) on the whole population without considering the actual risk of disease development in the individual. The method is to inform about the disease and risk factors and to improve the individual's oral health knowledge, attitudes and behaviours thus to lower prevalence of disease. Examples of this approach may be via legislation (taxes, reduced availability), mass media oral health promotion campaigns and education (oral health information, anti-smoke campaigns etc.). These programs tend to be expensive but may be economic when calculated on a cost-per-person basis (Platt et al. 2016). In situations where most of the individuals are without risk of disease, efforts and resources may be wasted as preventive measures assessed to be beneficial for the community but offers marginal gains to each individual.

The search for efficient preventive policies led to the **high-risk-strategy**, which implies to spend more resources on those with the highest needs by identifying individuals being at risk of developing disease (Rose 1992). If caries prevalence in the population is low and caries experience is skewed, parts of the population can benefit from tailored and intensified interventions, and the high-risk approach may be beneficial (Platt et al. 2016).

Good oral health is not a matter of course for healthy children, not to mention those suffering from illness. **Oral health promotion** should therefore be integrated with general health promotion through a common risk factor approach (WHO 2007). While some

determining factors are conceived as being nonmodifiable risks, sugar reduction and oral hygiene are lifestyle and behavioural factors that can be addressed early in life and could lead to recommendations or policies for changes in practice. Promoting good oral health during childhood and adolescent is important in order to achieve good health throughout life (WHO 2016).

Oral health behaviours

There are few studies about caries and oral health behaviours in children younger than 3 years of age and how caries and caries progression influence children's well-being and life-course. This may prevent effective and early identification of children with caries risk and prevent caries with its adverse effects which may lead to negative impact on children's satisfaction with teeth later in life.

Behavioural science impacts dentistry, and their contribution to dental education, research, clinical practice, and oral health policy has been significant over the past half century (Cohen 1981). Over time behavioural sciences have expanded the understanding of oral health away from a disease focus to a broader biopsychosocial model of oral health (Lee et al. 2017). This has led dentistry away from a focus on treatment to oral health care across the life span.

Good oral health relates not only to individual behaviour but the behaviour of other actors: parents, caregivers, and oral health care providers. Children are dependent on their environment to establish favourable health behaviours (Christensen et al 2010; Poutanen et al. 2006), and young children's dental health relies on the parents' (and family) involvement (Åstrøm and Jakobsen 1998; Mattila et al. 2005; Wigen et al. 2011). Oral health behaviours established during early childhood are maintained and associated with oral health conditions later in life (Ouellette and Wood 1998; Alm et al. 2007; Isaksson et al. 2013). During childhood, children should gradually be able to take care of own oral health (Broberg and Klingberg 2017). It has been shown that parental influence persists and is reflected not only during childhood, but also through adolescence and into young adulthood (Åstrøm and Jakobsen 1998; Åstrøm 2004).

Fluoride is a key agent in reducing the prevalence and severity of dental caries (Marinho et al. 2012; dos Santos et al. 2013; O'Mullane et al 2016). For topical exposure, tooth brushing twice daily with fluoridated toothpaste is considered the basic oral self-care behaviour for maintenance of good oral health (Kumar et al. 2016; Isaksson et al. 2019), and is recommended for all individuals to prevent caries (Marinho et al. 2012; dos Santos et al. 2013; O'Mullane et al. 2016; Walsh et al. 2019; Toumba et al. 2019).

Parental tooth brushing behaviours are related to caries prevalence in children (Wigen and Wang 2010) and caries increment (Mattila et al. 2000; Skeie et al. 2008). The age of the child when the parents' start to brush the child's teeth is associated with caries development in children (Skeie et al. 2008). Tooth brushing with fluoridated toothpaste less than twice daily at 3 years of age has been shown to be associated with approximal caries experience at 20 years of age (Isaksson et al. 2019). This shows the importance of early establishment of regular tooth brushing habits by the parents. Studies by Alm et al. (Alm et al. 2012) and Broadbent (Broadbent et al. 2016) reported similar factors in early childhood to be associated with oral health status in adolescence and adulthood.

In terms of diet, fermentable carbohydrates (sugars and starches) are the most relevant common dietary risk factor for dental caries (Sohn et al. 2006; Sheiham et al. 2015) and periodontal disease, but their associated mechanisms differ (Chapple et al. 2017). Frequent sugar intake has been considered a major risk factor for caries development (Moynihan 2016), though studies including children and adolescents have shown contradictory results. Additional oral hygiene behaviours, such as flossing and interdental brushing, are widely recommended, although evidence is inconclusive (Sambuniak et al. 2011; Salzer et al. 2015; Worthington et al. 2019).

Satisfaction with teeth

It is well known that oral disease and disorders have negative impacts on people's oral functions, self-esteem, general well-being and social activities. Research in adolescents have shown association between dental caries, quality of life, social concern and satisfaction with teeth (Ekbäck et al. 2008).

Oral health is integral to overall health and well-being and contributes to development of healthy children and adolescents (Sheiham 2005). When entering adolescence, the child becomes less dependent on the parents' care and the relationship between children and parents may change as the child becomes more capable of managing her/himself. Peers often take over as role models regarding attitudes, beliefs and behaviours during this period, when both emotional and social development occurs (Broberg and Klingberg 2017). In many ways, adolescence is about becoming independent and creating an own identity, but the ability to consider the long-term consequences of one's own actions is not fully developed in the early part of this period (Broberg and Klingberg 2017). Children should be able to maintain their own oral health, but the possibility of doing so is dependent on already established behaviours (Christensen 2004).

There is a lack of consensus regarding the conceptual meaning of satisfaction. Empirical studies of how people define satisfaction are rare (Carlquist et al. 2018) and there are few empirical studies on the conceptual understanding or usage of the term "satisfaction" in children (Taylor et al. 2010). Satisfaction is a subjective term that includes all positive and negative experiences with teeth or oral health. Being satisfied with teeth includes for instance no pain, cavities, tooth discoloration and other issues related to oral health. Subjective well-being is usually measured with self-reports that evaluate teeth and oral health and one's own level of satisfaction (Diener 2000; Jokovic et al. 2005).

Several subjective oral health indicators have been developed, ranging from compound to single global indicators (Locker 1997). Single global oral health indicators are recognized to provide a summary of how people perceive their oral health and to be as useful as more complex oral health-related quality of life (OHRQoL) inventories (Kaplan et al. 2003). Asking individuals to rate their oral health on scales ranging from good to poor or from satisfaction to dissatisfaction has become standard practice in oral health surveys and in evaluation programmes (Kaplan et al. 2003). Single-item global indicators such as self-referred satisfaction, are simpler than multiple and multidimensional scales, and are powerful predictors (Locker and Gibson 2005). While studies about satisfaction with teeth exist among adults, there is a paucity of studies on satisfaction with teeth in children and early adolescence and how dental disease and dental health in early childhood influence satisfaction with teeth among 12-year-olds.

HYPOTHESES

Based on previous research and practice, it was hypothesized that:

- Inviting 2-year-olds for a first dental examination with individualized caries preventive advice would prevent caries between 2 and 5 years of age.

- Background characteristics had less influence on oral health behaviours and caries prevalence in young adolescents than previous results showed in preschool children.

- Experiences with teeth and dental treatment influence young adolescents' satisfaction with teeth.

AIMS

The main aim was to explore aspects contributing to identification of children with caries risk and caries' impact on satisfaction with teeth.

Specific aims were:

- To describe presence of plaque, caries, and oral health behaviours in 2-year-old children.

- To explore increments in caries experience from 2 to 5-years of age and to study whether national background, visible plaque, caries, and oral health behaviours at 2 years of age were associated with increments in caries experience.

- To explore frequency of tooth brushing, dental flossing, use of fluoride supplements and sugar snacking in 12-year-olds, and to study how these oral health behaviours were associated with background characteristics and caries prevalence.

- To explore self-reported satisfaction with teeth in 12-year-old children, and to study whether satisfaction was associated with child characteristics, oral health behaviours and previous experiences with oral health and dental treatment.

MATERIALS AND METHODS

Study design

The present thesis consists of three papers with longitudinal and cross-sectional design and two materials. An overview of paper, theme, design, and participants in the thesis is shown in Table 2.

Table 2. Theme, design, and participants in the thesis.

Paper	Theme	Design	Participants
I	Identification of caries risk in 2-year-olds	Longitudinal	2-5-year-olds (n=211)
II	Oral health behaviours in 12-year-olds. Association with caries and characteristics of the children?	Cross-sectional	12-year-olds (n=4779)
III	Self-reported satisfaction with teeth	Cross-sectional	12-year-olds (n=4725)

Materials

Longitudinal study

In total 495 2-year-old children from one dental clinic in Oslo were invited to participate, and 392 children were examined at 2 years of age. The clinic is situated in an area of Oslo where preschool children have higher caries prevalence than average in Norway. Between 2 and 5 years of age 181 children moved, and when the children turned 5 years old, 211 children were available for reexamination (Figure 3).

Cross-sectional study

The cross-sectional study consisted of 12-year-old children living in one Norwegian county. The children were invited for an oral examination in connection with routine dental examination. In total 7595 children were invited, and 4779 children were included. In Paper III, 54 children were excluded because of lack of data (Figure 3).

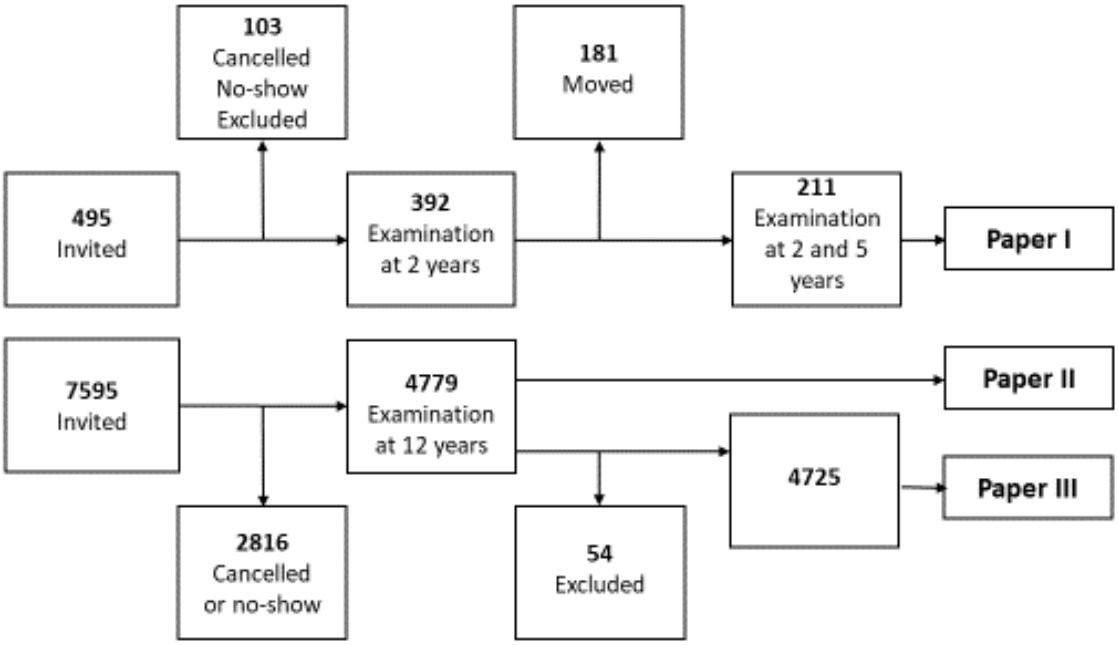

Figure 3. Flow-chart showing the participants included in the papers.

Methods

Data used in this thesis were collected by clinical oral examinations and questionnaires to parents and children (Appendix 1 and 2).

Clinical examination

Longitudinal study

The children were examined at the dental clinic at 2 and 5 years of age and the examination included individualized prevention.

Clinical examination at 2 years of age included registration of visible dental plaque and caries experience on all emerged teeth. At 5 years of age, clinical examination included bitewing radiographs when indicated in accordance with standard routines in the dental services. Dental students and hygienist students performed the examinations of children using established caries diagnostic methods used at the University of Oslo. Experienced dentists or hygienists verified all registrations.

Cross-sectional study

The clinical examination at 12 years of age included registration of caries and bitewings when visual inspection of approximal surface was impossible.

Written and oral information about the clinical caries criteria was given to and discussed with the examiners before data collection started. Agreement was examined using eight bitewing radiographs of permanent molars including 12 approximal surfaces in each radiograph. Intra- and inter-examiner agreements were calculated using Cohen's kappa. A "gold standard" was developed based on the second and third authors' registrations and compared with the examiners' registrations. Cohen's kappa values were categorized as substantial.

Questionnaire

Longitudinal study

At the examination at 2 years of age, parents completed a questionnaire, which included anamnestic information about child characteristics, oral health behaviours and sugar snacking (Appendix 1).

Cross-sectional study

The questionnaire at 12-years-age of was completed by the children, and contained sections on child characteristics, oral health behaviours and previous experiences (Appendix 2).

Variables

An overview of all independent and dependent variables used in Papers I to III are shown in Figure 4.

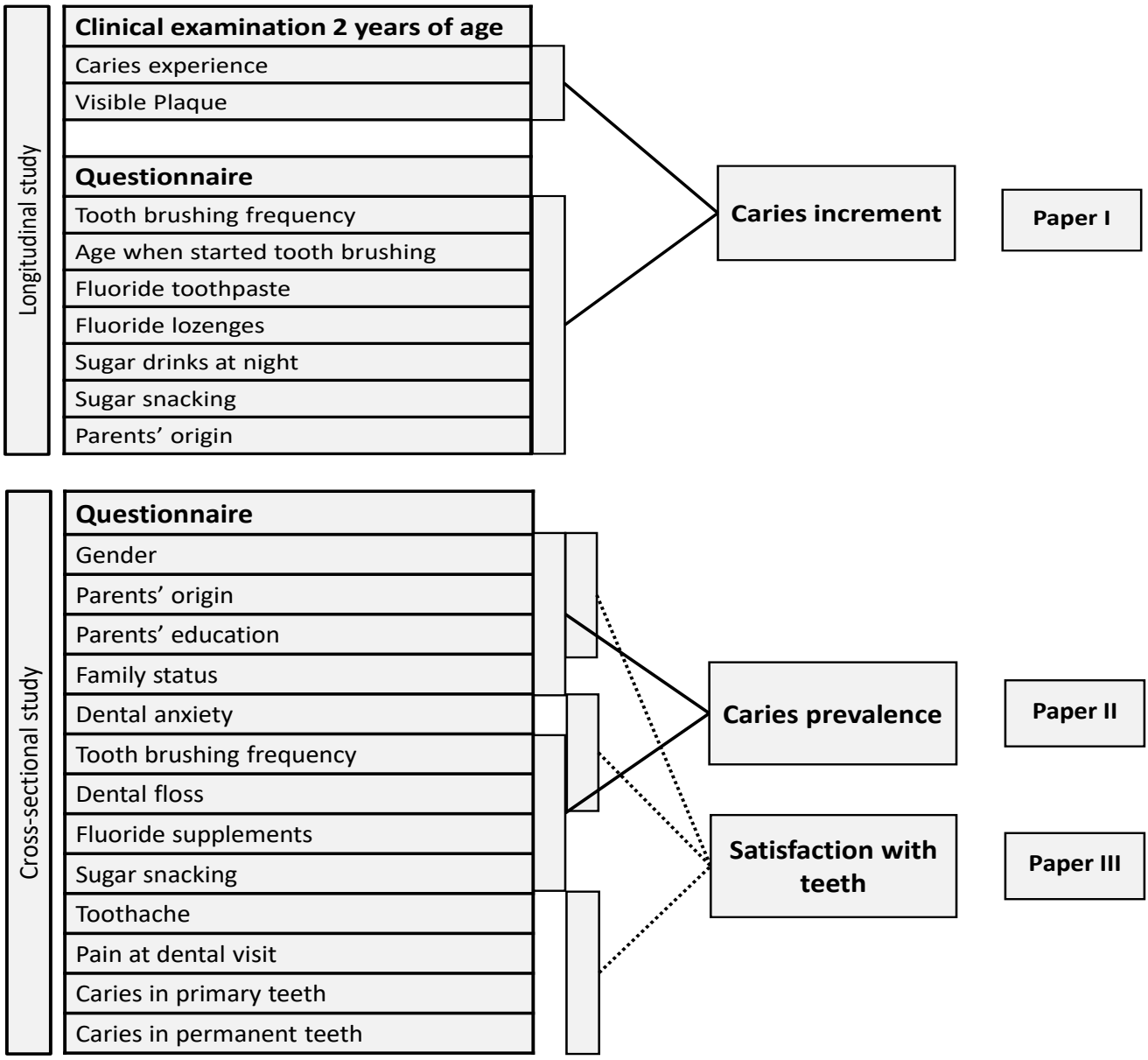

Figure 4. Overview of variables included in the papers. The bars on the right side of the figure mark variables included in the papers.

Caries increment

Caries increment between the age 2 and 5 years was the dependent variable in the analyses, described in Paper I (Figure 4).

All teeth with caries, both enamel caries and caries lesions extending to dentine, were analysed and named caries. Caries experience was reported as mean number of teeth with caries experience, and children were classified as having caries experience or not having caries experience. Caries increment was calculated as the difference in the number of teeth with caries experience at 2 and 5 years of age, and children were dichotomized as having or not having caries increment between 2 and 5 years of age.

Caries prevalence

Caries registered at 12 years of age was dependent variable in Paper II (Figure 4).
Caries was reported at tooth level. Caries lesions extending to dentine were recorded and named caries. Children were classified as caries-free and having caries.

Oral health behaviours

Oral health behaviours registered at 12 years of age were dependent and independent variables in Paper II and independent variables in Paper III (Figure 4).

Tooth brushing frequency was reported as twice daily, once daily, sometimes and never and dichotomized as twice daily (favourable) and once daily or less often (unfavourable).

The use of dental floss was reported as daily, several times a week, once a week and less often, and dichotomized as once a week or more often (favourable) and less often than once a week (unfavourable).

The use of fluoride lozenges and fluoride mouthrinses were reported as daily, sometimes and never. Lozenges and rinses were combined into one variable; fluoride supplements and dichotomized as using lozenges and/or rinses daily (favourable) and less often than daily (unfavourable).

Consumption of sugar-containing drinks and sugary snacks was reported as less often than once a week, once a week, several times a week or several times a day. Drinks and

foods were combined into one variable, sugar snacking and dichotomized as consuming sugary drinks and/or foods once a week or less often (favourable) and several times a week (unfavourable).

Satisfaction with teeth

Satisfaction with teeth at 12-years-of age was the dependent variable in the analyses, described in Paper III (Figure 4). Satisfaction with teeth was reported as satisfied, neither nor satisfied and dissatisfied, and the children were classified as being satisfied or dissatisfied with teeth.

Previous experiences

Previous experiences included toothache, pain at the last dental visit and caries in Paper III (Figure 4). Toothache was reported as no or yes. Pain at the last dental visit was reported as not at all, slightly or very painful, and dichotomized as no (not at all) or yes (slightly, very).

Statistical methods

Several statistical methods were used. Data were analysed using the Statistical Package for the Social Sciences (SPSS) for Windows (Armonk, NY, USA). In all papers, data was cross-tabulated and tested using Chi-Square statistics. Differences between means were tested with Mann-Whitney-U-test (Paper I).

The association between caries increment between 2 and 5 years of age and the presence of plaque, caries, oral health behaviours at 2 years of age and national background was explored using negative binominal regression analysis with caries increment between 2 and 5 years of age as the dependent variable (Paper I). Multivariable logistic regression analyses were conducted with children's oral health behaviours and dentine caries prevalence as the dependent variables in Paper II and satisfaction with teeth in Paper III.

Spearman's rank correlation was used to explore associations between the independent variables before bivariable and multivariable analyses were conducted (Paper I, II and III). Missing data in Paper I was replaced using multiple imputation to reduce loss of data in multivariable analysis.

Results were presented as frequency tables, means and standard deviations (SD) (Paper I), and odds ratios (OR), 95% confidence intervals (95% CI) and p-values (p) (Paper I, II and III). The level of statistical significance was set at 5%.

Ethical considerations

The children's parents received information about the study. Information about the purpose of the study and the voluntary participation, and that data would be treated confidentially was included. Informed written consent was obtained from alle parents. All participants had the opportunity to withdraw from the study whenever they wanted.

The longitudinal study (Paper I) was performed as part of the quality assurance system required by law in the public dental services in Norway. The cross-sectional study (Paper II and III) was approved by the Regional Committee for Medical and Health Research Ethics (REK) and the Norwegian Centre for Research Data (NSD). No financial support influenced the studies and the results.

SUMMARY OF RESULTS

In this part of the thesis, the main results from the three papers are presented. Detailed results, figures and tables, are presented in the original papers.

Paper I

The purpose of this study was firstly to describe presence of plaque, caries and oral health behaviours in 2-year-old children. Secondly, to measure increments in caries experience from 2 to 5 years of age and to study whether national background, visible plaque, caries and oral health behaviours at 2 years of age were associated with increments in caries experience.

The results showed that only a small proportion of the 2-year-olds had caries experience (5%). Children having caries experience at 2 years of age had on average 4.4 (SD 3.6) teeth with caries experience. The findings showed that more than half of the children (58%) brushed twice daily and tooth brushing was introduced when the child was 7 months or older in 61% of the children. Children with non-Western origin more often had caries, visible plaque and unfavourable oral health behaviour than children with Western origin ($p < 0.05$).

At the examination at 5 years of age were 29% of the children registered with caries. Children having teeth affected with caries at 2 years of age developed more caries between 2 and 5 years of age than children without caries experience at 2 years of age (2.4 vs 0.7, $p < 0.05$).

The results of the multivariable analysis showed that children who started tooth brushing late (OR 2.1, CI 1.1-4.2), children who brushed less than daily (OR 4.8, CI 1.6-13.9) at 2 years of age and children having one or both parents of non-Western origin (OR 5.4, CI 3.0-10.0) had a higher probability of having caries increment from 2 to 5 years of age than other children. The other oral health behaviours, visible plaque and caries experience at 2-years of age were not associated with increment in caries experience.

Paper II

The aim of this study was to explore frequency of tooth brushing, dental floss, use of fluoride supplements and sugar snacking in 12-year-olds, and to study how these oral health behaviours were associated with background characteristics and caries prevalence.

The results showed that the majority of the 12-year-olds (81%) brushed twice daily, 36% flossed once a week or more often, 39% used fluoride supplements daily and 48% consumed sugar between meals once a week or less often.

Children who brushed twice daily more often had other favourable oral health behaviours; flossed regularly, used fluoride daily and consumed sugar between meals less often than other children ($p < 0.05$). Furthermore, girls and children whose parents had long education more often had favourable oral health behaviours than other children; brushed more frequently, more often used floss, fluoride supplements and consumed sugary snacks less often than other children ($p< 0.05$).

In total, 40% of the children were caries-free, and 35% had caries extending into dentin. When adjusting for characteristics of the children and other oral health behaviours in the multivariable analyses, the results showed that children who brushed less than twice daily more often had caries than other children (OR 1.50, CI 1.29–1.74), while none of the other oral health behaviours were associated with caries prevalence. Having parents with non-Western origin (OR 1.40, CI 1.23-1.58) and parents with short (OR 1.40, CI 1.23-1.58) education was associated with a higher probability of having caries.

Paper III

The aim of this study was to explore self-reported satisfaction with teeth in 12-year-old children, and to study whether satisfaction was associated with child characteristics, oral health behaviours and previous experiences with teeth and dental treatment.

The findings showed that the majority of the children (68%) were satisfied with teeth. The results showed that 39% of the children had experienced toothache, 24% pain at last dental visit and 36% caries in primary teeth. The proportion of 12-year-olds with caries in permanent teeth was 60%.

Multivariable logistic regression analysis showed that children who reported dissatisfaction with teeth had higher probability of having experienced toothache (OR 1.6, CI 1.4-1.8) and pain at last dental visit (OR 1.4, CI 1.2-1.6) than other children. The probability to be dissatisfied with teeth was higher among children who were diagnosed with caries in primary teeth (OR 1.4, CI 1.2-1.7) and permanent teeth (OR 1.2, CI 1.0-1.4). Children who reported dental anxiety (OR 1.2, CI 1.1-1.4), brushed seldom (OR 1.6, CI 1.4-1.9) or used dental floss less than once a week (OR 1.2, CI 1.1-1-4) more often were dissatisfied with teeth than other children. Parents' origin and education were not associated with satisfaction with teeth in 12-year-olds.

DISCUSSION

Methodological considerations

This thesis consists of three papers with longitudinal and cross-sectional design and two materials. Both study designs are observational. This means that researchers record information about their subjects without manipulating the study environment.

The first material (Paper I) included data from 2-year-old children examined by dental students and dental hygienist students and monitored longitudinally at the student dental clinic at the University of Oslo. The second material (Paper II and III) included 12-year-old children examined by dental personnel from 22 dental clinics i one Norwegian county. The examination was performed in a fully equipped dental clinic using plane mirror and sharp probe after the teeth had been dried with air. Bitewings were taken in accordance with the dental services' standard routines. A strength of the studies was the good clinical conditions for the examinations.

Longitudinal study

In a longitudinal study, researchers conduct several observations of the same subjects over a period of time, sometimes lasting many years. The benefit of a longitudinal study is that researchers are able to detect developments or changes in the characteristics of the target population at both the group and the individual level. Longitudinal studies extend beyond a single moment in time. As a result, they can establish sequences of events. A challenge with longitudinal studies is loss to follow-up and selection bias. Participation in the study and follow-up may be higher among parents who were interested and engaged in their children's oral health than among those who did not want to participate. Other disadvantages are that longitudinal research is expensive and time consuming.

The study was performed in an area where children in the Norwegian context had high caries prevalence. Seventeen per cent of children invited to participate did not attend for the dental examination (at 2-years of age). Non-participants in this study were children that did not want to participate and children that missed their appointment.

It has been shown that nonattenders more often have caries experience than other children (Wigen et al. 2009). Although some children did not participate, those who did were

caries risk children, and the findings in this study can be generalized to other areas with similar caries prevalence in young children.

The reason for drop out between 2 and 5 years of age were that the children had moved from the area and had their dental examination at other dental clinics. We had no access to data from children who had their dental care at other dental clinics.

Among children examined at 2 and 5 years of age, those with non-Western origin and children who had caries at 2 years of age were overrepresented compared to children only examined at age 2 years. Thus, a higher proportion of caries risk children was included in the analyses of increment in caries experience. Selection bias may influence the level of variables but has been shown to a lesser extent to influence associations between the variables (Nilsen et al. 2009).

Cross-sectional study

A cross-sectional study design is used when the purpose of the study is to describe the population or a subgroup within the population with respect to an outcome and a set of risk factors (Paper II), or when the aim is to find the prevalence of the outcome of interest, for the population or subgroups within the population at a given timepoint (Paper III). Benefit of a cross-sectional study design is that it allows researchers to compare many different variables at the same time. Cross-sectional studies are relatively inexpensive, take up little time to conduct and there is no loss to follow-up. That's why researchers might start with a cross-sectional study to first establish whether there are links or associations between certain variables. Then they could set up a longitudinal study to study cause and effect. Cross-sectional studies are useful for public health planning, understanding disease aetiology, evaluate common practice and for the generation of hypotheses, yet limitations of this design exist. Cross-sectional studies may not provide definite information about cause-and-effect relationships. This is because such studies offer a snapshot of a single moment in time; they do not consider what happens before or after the snapshot is taken. Furthermore, such studies may be prone to bias such as non-response, selection and report; thus, it is difficult to make causal interference and associations and directions should be carefully interpreted (Sedgwick 2014; Sedgwick 2015).

The study material in Paper II and Paper III included a large group of 12-year-old children scheduled for recall examination in the dental services in 2014. One third of the invited children did not participate. Non-participation may cause selection bias as mentioned above. In the studied children, caries prevalence, parents' origin and educational level did not differ from the national average (Statistics Norway[c] 2021; Statistics Norway 2021[d]; Statistics Norway[e] 2021;). It is reasonable to assume that the results from the study were representative for the country in general.

Clinical examination

In the longitudinal study, the clinical data collection was performed by dental students and dental hygienist students at the dental student clinic of the University of Oslo. Experienced dentists or dental hygienists verified all registrations. The clinical data collection in the cross-sectional studies were performed by experienced dentists or dental hygienists in the dental services as part of the routine dental examinations of the children at the age of 12 years.

In these studies, all examiners had the same guidelines regarding caries registrations. The calibration of the dental personnel showed substantial intra- and interexaminer agreement according to the scale of Landis and Koch (Landis and Koch 1977). In spite of the large number of examiners, caries registration was indicated to be reliable (Dobloug et al. 2014). Bitewing radiographs were taken in adjunct to clinical examinations to help diagnose approximal lesions that would otherwise not have been detected (Espelid and Tveit 2001). National guidelines recommend bitewing radiographs from 4-years of age in those cases where inspection of the approximal surface is not possible (Norwegian Directorate of Health 2022).

It has been shown that the accuracy of the data reported and synthesised is dependent on the size and accuracy of the data included (Peres et al. 2020). It may be challenging to compare data and indicators between countries, since definitions, use of caries diagnostic criteria, examination methods, lack of examiner calibration and data sources may differ (Tinanoff et al. 2019). While some countries may have a dental register as the data source, another country may only have data from a survey for the same indicator. Structural differences in dental health services across countries may also partly explain differences between the countries when it comes to some indicators. In the Nordic

countries, dental services are only partly organized in the same way. The effect of these structural differences is complex, and these factors must be considered when interpreting data from different countries (Norwegian Directorate of Health 2018).

Questionnaires

The studies were based partly on questionnaires. The questions were easy to answer and made it more likely that participants responded compared to studies requiring for example biological specimens or several follow-ups. Despite of a lot of advantages, all questionnaire studies have limitations such as recall and report errors, nonresponses, misconceptions and errors like answering in a socially desirable way and over-report of favourable behaviours may occur (Sjöström and Holst 2002; Sanzone et al. 2013).

The questionnaires were not validated, but obvious external validity of data existed in these studies as questions were mainly related to daily routines. The questionnaires were considered to accurately reflect what they were supposed to measure, hence minimizing inaccurate and contradictory answers. In the longitudinal study, children receiving dental care at the student dental clinic at the University of Oslo were invited to their first dental visit at 2 years of age where their parents completed a questionnaire. While in the cross-sectional study children completed the questionnaire assisted by parents. The probability of recall and reporting error in these studies were considered limited as most questions were related to daily routine of oral health habits in young children, and we assume that response bias was limited.

The variables in both studies were dichotomized to simplify statistical analyses, interpretation and presentation of results (Royston et al. 2006). Reflections of reasonable cut points for dichotomization were made, bearing in mind that fine scale information would be lost. Fedorov et al. (Fedorov et al. 2009) have shown that dichotomization could lead to loss of information about variation between individuals and could reduce the test strength. We consider the loss of information limited as few participants selected the alternative category (Paper I, II and III).

In addition to the independent variables (Paper II and III), which are used in other studies, we included the dependent variable “satisfaction with teeth” in Paper III. In this study, a single-item question to measure satisfaction with teeth in children was used.

A number of socio-dental indicators have been developed and validated to assess functional, psychological and social outcomes of oral problems, ranging from single-item global indicators such as satisfaction/dissatisfaction with oral health status to complex inventories and scoring systems, such as the Oral Health Impact Profile (OHIP) and Oral Impacts on Daily Performance (OIDP) (Slade and Spencer 1994; Adulyanon and Sheiham 1997). Alongside the multi-item scales, single-item global indicators have been shown to be advantageous and have been widely used in oral health research (Locker and Gibson 2005). When operational costs tend to increase, single-item indicators might be appropriate and even practical for regular use. Evidence suggests strong correlations between single- and multi-item scales (Cunny and Perri 1991). Single-item global indicators such as self-reported satisfaction can be used as powerful predictors (Locker and Gibson 2005).

The single-item question used in this thesis has been used to measure satisfaction with teeth in adults and was modified from another study to suit use in children. The questionnaire was piloted before use, but not validated. Single-item questions have been shown to be valid (Locker 2008).

In this thesis, the term satisfaction with teeth and oral health included several components for instance no pain, cavities, tooth discoloration and other issues related to oral health. Satisfaction is a subjective term that includes all positive and negative experiences with teeth or oral health. The etymological concept of the English word “satisfaction” stem from Latin “satis” (enough) and “facere” (to make) (Stevenson 2010). The Norwegian word “fornøyd”, used in the questionnaire of Paper III overlaps considerably with the word “tilfreds” in everyday Norwegian vocabulary, and is similar to the English word “content”. The “-nøyd” of “fornøyd” is etymologically related to the Norwegian “nøye”, which historically refers to sufficing or making do. Via this word it is further related to the word “nok”, or the German “genug”, both meaning enough (de Caprona 2013; Wangensteen 2005). However, the term “satisfaction” (still) lacks a detailed definition consistently referred to in the literature (Carlquist et al. 2018) but is described as being a component of subjective well-being (Diener 2000).

Ethical condiserations

To consider the ethical principle, autonomy, and respect for the children's young age, informed written consent was obtained from the caregivers for all children. Adults such as researchers, parents, teachers, etc. often speak for children, but it is meaningful to hear children's voices directly. When they participate in research it is important that they are heard in what concerns them.

The children's parents received written information about the study and the 12-year-olds also received information adjusted to the age. The form included information about the purpose of the study, the voluntary participation, that they were free to discharge whenever they wanted, and that data would be treated confidentially.

No financial support influenced the studies and the results.

Main results

This thesis has shown that several risk factors were associated with caries prevalence (Paper I, II and III) and caries development from 2 to 5 years of age (Paper I). Furthermore, an important finding from this thesis was that negative experiences with oral health and dental treatment during childhood were related to satisfaction with teeth in early adolescence.

Caries prevalence

The results from the longitudinal study showed that only a small proportion of the 2-year-olds had caries experience and that children with caries experience had several decayed teeth (Paper I). This skew distribution, with many children at low risk and a smaller group at very high risk was in line with other studies (Skeie et al. 2005; Bankel et al. 2006; Hugoson et al. 2008; Congiu et al. 2014). This has implications for the planning of dental services for children, including estimating the quantities and types of dental personnel necessary. Increased knowledge regarding risk indicators for caries development in early childhood would help to identify children at risk of developing caries before clinical caries develops and prevent adverse effects associated with caries.

Oral health behaviours

The results from this thesis showed that tooth brushing less than twice daily was associated with caries increment in preschool children and caries prevalence at 12 years of age.

It is well established that fluoride is a key agent in reducing the prevalence and severity of dental caries (Marinho et al. 2012; dos Santos et al. 2013; O'Mullane et al. 2016). There are two ways to use population-based fluoride to prevent dental caries: systemic exposure and topical exposure. For topical exposure, tooth brushing twice a day with a fluoridated toothpaste is the most effective preventive measure for ECC (Marinho et al. 2012; dos Santos et al. 2013; O'Mullane et al. 2016; Twetman 2018, Boustedt et al. 2020), as it maintains adequate fluoride around the teeth for a greater proportion of the day (Marinho 2013). The toothbrush is probably the most convenient and accepted tool to bring fluorides into the oral cavity (Marinho et al. 2012). Such preventive measures have the potential to be cost-effective; toothpaste with fluoride is close to an ideal public health method that is convenient, inexpensive, culturally approved and widespread (Burt 1998) and improved

brushing skills can spill over to siblings and relatives. The adoption of stable health habits in childhood begins at home with parents and main caregivers, as they play an important role in forming the child's oral health behaviours. Regularly performed tooth brushing established early in life will often become a lifelong routine as previous behaviours predict future behaviours (Ouellette and Wood 1998; Wigen and Wang 2014). Adolescence is a transitional stage between childhood and adult, a turbulent time in life consisting of considerable development and change within biological, emotional and social systems (Csikszentmihalyi 2021). Adolescents are increasingly independent and during this period, they have to establish their own health behaviours and attitudes (Viner et al. 2012).

Age when introducing tooth brushing was related to caries increment, in addition to tooth brushing frequency. These results are consistent with findings in some previous studies which have reported that the age of the child when the parents' start to brush the child's teeth to be associated with caries development in children (Skeie et al. 2006; Vanobbergen et al. 2001; Wigen and Wang 2012). Providing oral health education to parents and caregivers on caries risk factors must be emphasized as such knowledge may reduce the risk of ECC (Vann et al 2010; Moynihan et al. 2019). Likewise, parents encountering difficulties to perform the tooth brushing should be offered empowerment and hands-on training by oral health personnel.

In this thesis, use of fluoride supplements was not associated with caries prevalence (Paper I, II and III) and caries development (Paper I). When daily fluoride from toothpaste is used, any additional effect of fluoride supplements remains uncertain (Twetman et al. 2004; Tubert-Jeannin et al. 2011; Mejare et al.2015). Fluoride varnishes, gels and foams can be professionally applied for caries prevention according to the child's individual risk (Marinho et al. 2013).

The multivariable analyses in this thesis showed no association between caries increment and dietary practices from 2 to 5-years of age and caries prevalence in 12-year-olds, but it is well known that the primary risk indicator for early childhood caries is exposure to sugars through the diet. Intake of free sugars has a negative impact on oral and general health, such as dental caries, weight gain, obesity and is associated with a lot of non-communicable diseases (WHO 2016, WHO 2017). An explanation for the low impact of sugar on caries in this thesis could be the protective factor of tooth brushing with fluoride-

containing toothpaste by neutralising the potential damage from high sugar consumption (Downer et al. 2008).

Although exposure to fluoride reduces the development of dental caries and delays the onset of the cavitation process, it does not completely prevent dental caries if implemented as an isolated action (WHO 2017). While some lifestyle risk factors, such as diet and tooth brushing can be addressed early in life, other factors such as genetics and socioeconomic status cannot easily be modified. It is therfore important to understand the causes of caries (Drury et al. 1999, Pitts et al. 2019) in order to implement effective preventive approaches.

Many mechanisms have been suggested to mediate the association between social conditions and caries experience, particularly in ECC. Caregivers have a central role for preventing early childhood caries because they provide the oral care for their children (Seow 2012), and parental socio-economic characteristics have been found to influence oral health in children (Inchley et al. 2016, Petersen et al. 2005) and oral health-related quality of life (Kumar et al. 2014). The results in this thesis confirmed that family characteristics (non-Western origin and parental short education) were associated with caries increment and caries prevalence. This was consistent with findings in previous studies where children with immigrant background and parental short education had higher caries prevalence and caries increment than other children (Skeie et al. 2004; Anderson et al. 2021). One explanation could be that parents with relatively lower education levels may ignore the oral health of their children (adolescents) and fail to intervene appropriately when an issue arises. Another explanation may be that parents with low education have problems to change behaviour after receiving information and find it difficult to put it into action. Even in Norway, where the aim is to remove health inequalities in children, and the dental service is comprehensive and individualized, parental education level, parental background and family status influences children's oral health behaviours are decisive for the development of caries in preschool children and caries prevalence in adolescents.

Satisfaction

There are few studies about the association between satisfaction with teeth and previous experiences with oral health and dental treatment in children. One study has shown that treatment of caries improved satisfaction with teeth, smile and appetite in children aged 6-7 years (Alkarimi et al. 2012), while another study found no association between parental satisfaction with the appearance of the child's teeth and caries (Woodward et al. 1996).

Results of these studies showed that the majority of the 12-year-olds were satisfied with teeth. Previous experiences with teeth and dental treatment were related to children's satisfaction with teeth (Paper III). The strongest indicator for being dissatisfied was previous experiences with toothache, pain at last dental visit and caries while parents' origin and education were less important.

Toothache may lead to more dental treatment and increased dissatisfaction with teeth. Toothache can be caused by different factors, for instance, dental treatment and oral conditions such as caries, dental abscess, dental trauma or tooth shedding. Adolescents who experienced toothache reported more often to be dissatisfied with oral health (Rebouças et al. 2018). Pain is regarded to be a strong part of the conditioning process leading to dental anxiety in children (Klingberg and Broberg 2007; Klingberg 2012).

More children with dental anxiety were dissatisfied with teeth than other children. It is well known that dental pain and complications of tooth decay, being female and young age are related to dental anxiety in children (Raadal et al. 2002; Stenebrand et al. 2013; Dahlander et al. 2019). Dental anxiety in children may cause behaviour management problems and is associated with poor dental health conditions (Klingberg and Broberg 2007). A study among adults has shown that individuals with severe dental anxiety were less satisfied with their teeth (Neto 2017). Results indicate that dental anxiety was related to 12-year-olds' satisfaction with teeth, and that dental personnel should minimize painful and aversive situations associated with dental treatment. Pain is a complex and subjective human experience and pain reported in the dental setting is influenced by a number of different factors (Dahlander et al. 2019). Dental treatments sometimes require injections or invasive procedures which are associated with reports of pain, feelings of lack of control and dental anxiety (Klingberg and Broberg 2007). Managing and preventing or reducing anxiety and stress related to dental treatment, as well as providing adequate pain relief and

anaesthetics, should be given high priority among dental professionals (Rønneberg et al. 2015).

Caries prevention

Caries prevention is a priority in oral health care in children, and efforts towards prevention of dental caries should be given higher priority than restorative treatment. The first primary tooth erupts at around six to eight months of age and all primary teeth are erupted by the age of 3 years. Caries prevention may be of different kind for each person and can be organized in different ways. To reduce inequalities in oral health, dentists, hygienists and dental nurses offer individual preventive oral care in the dental clinics. The intention is that children and parents evolve knowledge that leads to change negative oral health behaviours.

While all children are recommended to use fluoride toothpaste, only caries risk-children are recommended to use fluoride supplements. For caries prevention, the majority of the attention was placed on the frequency of consumption of free sugars, infant feeding practices, poor removal of dental plaque and the low availability of fluoride.

Addressing the cause (free sugars) of early childhood caries is essential in preventing and reducing dental caries (WHO 2017). Reasons for caries-inducing behaviours lie in the family such as their own experiences, circumstances and lifestyles. However, the family (or caregivers) are subjected to strong cultural, economic and marketing influences which shape beliefs, attitudes and behaviours (Skeie et al. 2006). Creating supporting environments in which families live is an important element of oral health promotion.

A wide range of risk factors is associated with caries in children and adolescents from underprivileged and low socioeconomic status. Oral health has been recognized as an essential component of general health and quality of life. Hence both oral disease prevention and oral health promotion should be included as an integral part of chronic disease prevention and general health promotion programs.

Various behavioural models, theories, techniques and methods have been developed and are increasingly used to change behaviour with respect to oral health with varying degrees of success (Asimakopoulou and Newton 2015; Werner et al. 2016; Norwegian Directorate of Health 2022).

Clinical implications

Although all children in Norway are recalled regularly from 3-years of age for individualized oral health care, socioeconomic inequalities in oral health behaviours and caries prevalence still exist. Identifying children at risk of developing caries before this age may open possibility of targeting preventive oral care to children at risk of developing caries and their families.

Health professionals who have contact with young children, have to focus on parents with short education, non-Western origin and those who are unable to or find it difficult to brush their children's teeth twice daily. These parents' need special attention and help to change unfavourable health behaviours.

Establishing favourable brushing routines at eruption of the first tooth seems to be the most effective preventive oral health behaviour. The dental services should encourage parents to initiate tooth brushing as soon as the first tooth erupts, and tooth brushing twice daily with fluoride toothpaste should be continued to maintain good oral health during childhood and early adolescence.

Satisfaction with teeth in children is influenced by previous experiences with teeth and dental treatment, and satisfaction is a part of oral health-related quality of life and will influence future oral health. Previous experiences with teeth and dental treatment should be considered when planning and conducting dental treatment. The dental services should focus on reducing negative experiences with oral health og dental treatment.

Future research

In this thesis, risk indicators for caries increment from 2 to 5 years of age, caries in early adolescence and factors related to satisfaction with teeth in 12-year olds were identified.

It is necessary to understand better why some parents' have difficulties to implement received information about oral health behaviours, and obstacles blocking tooth brushing twice daily of children younger than 2 years of age.

Future research should focus on organization of dental services to children to be able to prevent caries in the youngest children. Further development of interprofessional collaboration should be emphasised to identify children with caries risk as soon as possible so preventive efforts can be initiated.

Further monitoring of caries development, oral health behaviour and satisfaction with teeth in the 12 year olds during adolescence and into early adulthood will provide valuable knowledge on these topics. We know that there is some caries increment during adolescence, but have limited knowledge on how oral health behaviour changes and influence caries development.

Oral health-related quality of life (OHRQoL) has been defined as an individual's perception of how functional, psychological, and social aspects, together with pain and discomfort, affect personal well-being (Inglehart and Bagramian 2002). The extent of the impact of negative previous experiences on satisfaction with teeth and oral health could be studied by OHRQoL measures and appropriately incorporated into oral healthcare and global oral health policy. Future research should also consider how increasing body press and its negative impact on well-being and quality of life affect satisfaction with oral health during childhood and adolescence.

CONCLUSIONS

The main aim of this thesis was to explore aspects contributing to identification of children with caries risk and caries' impact on satisfaction with teeth.

The studies showed that

- Half of the 2-year olds brushed twice daily. Children with caries at 2-years of age developed more caries during preschool age than other children.
    - Tooth brushing frequency, age starting tooth brushing and family background was associated with caries increment.
    - The individualized caries prevention given to the studied children was not sufficient to prevent caries increment, indicating that present caries preventive routines were not sufficient.

- The majority of 12-year old children brushed teeth twice daily and these children had less often caries than other children. The other oral health behaviours did not reduce the probability of having caries.
    - Background characteristics had influence on oral health behaviours and caries prevalence, but association were weaker than the results from younger children.

- Most 12-year-olds were satisfied with teeth. Self-reported satisfaction with teeth in 12-year-old children was associated with previous experiences with oral health and dental treatment.
    - Previous experiences with toothache, pain at last dental visit and caries was the strongest predictor for being dissatisfied with teeth, while factors such as parental origin and education had less influence on whether the 12-year-olds were satisfied or dissatisfied with their teeth.

REFERENCES

Acs G, Shulman R, Ng MW, Chussid S. The effect of dental rehabilitation on the body weight of children with early childhood caries. Pediatr Dent 1992;21:109-113.

Adair PM, Pine CM, Burnside G, Nicoll AD, Gillett A, Anwar S, et al. Familial and cultural perceptions and beliefs of oral hygiene and dietary practices among ethnically and socio-economical diverse groups. Community Dent Health 2004;21:102-111.

Adulyanon S, Sheiham A. Oral impact on daily performances. Measuring oral health and quality of life. Chapel Hill, University of North Carolina, Department of Dental Ecology, 1997. p.151-160.

Agbaje JO, Lesaffre E, Declerck D. Assessment of caries experience in epidemiological surveys: a review. Community Dent Health 2012;29:14-19.

Alaluusua S, Malmivirta R. Early plaque accumulation - a sign for caries risk in young children. Community Dent Oral Epidemiol 1994;22:273-276.

Alkarimi HA, Watt RG, Pikhart H, Jawadi AH, Sheiham A, Tsakos G. Impact of treating dental caries on schoolchildren's anthropometric, dental, satisfaction and appetite outcomes: a randomized controlled trial. BMC Public Health 2012;12:706.

Alm A, Wendt LK, Koch G, Birkhed D, Nilsson M. Caries in adolescence - influence from early childhood. Community Dent Oral Epidemiol 2012;40:125-133.

Alm A, Wendt LK, Koch G, Birkhed D. Prevalence of approximal caries in posterior teeth in 15-year-old Swedish teenagers in relation to their caries experience at 3 years of age. Caries Res 2007;41:392-398.

Almerich-Silla JM, Montiel-Company JM. Influence of immigration and other factors on caries in 12- and 15-yr-old children. Eur J Oral Sci 2007;115:378–383.

Alves LS, Susin C, Damé-Teixeira N, Maltz M. Impact of different detection criteria on caries estimates and risk assessment. Int Dent J 2018;68:144-151.

Amarante E, Raadal M, Espelid I. Impact of diagnostic criteria on the prevalence of dental caries in Norwegian children aged 5, 12 and 18 years. Community Dent Oral Epidemiol 1998;26:87-94.

Anderson M, Dahllöf G, Warnqvist A, Grindefjord M. Development of dental caries and risk factors between 1 and 7 years of age in areas of high risk for dental caries in Stockholm, Sweden. Eur Arch Paediatr Dent 2021;22:947-957.

Antunes LAA, Ornellas G, Fraga LS, et al. Oral health outcomes: the association of clinical socio-dental indicators to evaluate dental caries in preschool children. Cien Saude Colet 2018;23:491-500.

Asimakopoulou K, Newton JT. The contributions of behaviour change science towards dental public health practice: a new paradigm. Community Dent Oral Epidemiol 2015;43:2-8.

Åstrøm AN, Jakobsen R. Stability of dental health behavior: a 3-year prospective cohort study of 15-, 16- and 18-year-old Norwegian adolescents. Community Dent Oral Epidemiol 1998;26:129-138.

Åstrøm AN. Stability of oral health-related behaviour in a Norwegian cohort between the ages of 15 and 23 years. Community Dent Oral Epidemiol 2004;32:354-362.

Bankel M, Eriksson UC, Robertson A, Köhler B. Caries and associated factors in a group of Swedish children 2-3 years of age. Swed Dent J 2006;30:137-146.

Beck JD. Risk revisited. Community Dent Oral Epidemiol 1998;26:220-225.

Boustedt K, Dahlgren J, Twetman S, Roswall J. Tooth brushing habits and prevalence of early childhood caries: a prospective cohort study. Eur Arch Paediatr Dent 2020;21:155-159.

Bratthall D. Introducing the Significant Caries Index together with a proposal for a new global oral health goal for 12-year-olds. Int Dent J 2000;50:378-384.

Broadbent JM, Zeng J, Foster Page LA, Baker SR, Ramrakha S, Thomson WM. Oral health–related beliefs, behaviors, and outcomes through the life course. J Dent Res 2016;95:808-813.

Broberg AG, Klingberg G. Child and adolescent psychological development. Pediatric dentistry: a clinical approach (third ed.) / (ed) Göran Koch, Sven Poulsen, Ivar Espelid, Dorte Haubek, Wiley-Blackwell 2017. p. 15-27.

Burt BA. Definitions of risk. J Dent Educ 2001;65:1007-1008.

Burt BA. Prevention policies in the light of the changed distribution of dental caries. Acta Odontol Scand 1998;56:179-186.

Carlquist E, Nafstad HE, Blakar RM. Understanding Satisfaction: an analysis of the meaning potential of the word “satisfaction” in everyday Norwegian language. J Happiness Stud 2018;19:939-959.

Chapple IL, Bouchard P, Cagetti MG, Campus G, Carra MC, Cocco F et al. Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. J Clin Periodontol 2017; 44 Suppl 18:39-51.

Christensen LB, Twetman S, Sundby A. Oral health in children and adolescents with different socio-cultural and socio-economic backgrounds. Acta Odontol Scand 2010;68:34-42.

Christensen P. The health-promoting family: a conceptual framework for future research. Soc Sci Med 2004;59:377-387.

Cohen LK. Dentistry and the behavioral/social sciences: an historical overview. J Behav Med 1981;4:247-256.

Congiu G, Campus G, Sale S, Spano G, Cagetti MG, Lugliè PF. Early childhood caries and associated determinants: a cross-sectional study on Italian preschool children. J Public Health Dent 2014;74:147-152.

Crall JJ, Edelstein B, Tinanoff N. Relationship of microbiological, social, and environmental variables to caries status in young children. Pediatr Dent 1990;12:233-236.

Csikszentmihalyi M. Adolescence. Encyclopedia Britannica, 20 Feb. 2021, https://www.britannica.com/science/adolescence. (cited 18 July 2022).

Cunny KA, Perri M. Single-item vs multiple-item measures of health-related quality of life. Psychol Rep 1991;69:127-130.

Dahlander A, Soares F, Grindefjord M, Dahllöf G. Factors associated with dental fear and anxiety in children aged 7 to 9 years. Dent J (Basel) 2019;7:68.

de Almeida CM, Petersen PE, Andre SJ, Toscano A. Changing oral health status of 6- and 12-year-old schoolchildren in Portugal. Community Dent Health 2003;20:211-216.

de Caprona Y. Norsk etymologisk ordbok. Oslo: Kagge forlag; 2013.

Declerck D, Leroy R, Martens L, Lesaffre E, Garcia-Zattera Mj, Broucke SV, et al. Factors associated with prevalence and severity of caries experience in preschool children. Community Dent Oral Epidemiol 2008;36:168-178.

Diener E. Subjective well-being. The science of happiness and a proposal for a national index. Am Psycho 2000;55:34-43.

Dobloug A, Grytten J, Holst D. Dentist-specific variation in diagnosis of caries - a multilevel analysis. Community Dent Oral Epidemiol 2014;42:185-191.

dos Santos AP, Nadanovsky P, de Oliveira BH. A systematic review and meta-analysis of the effects of fluoride toothpastes on the prevention of dental caries in the primary dentition of preschool children. Community Dent Oral Epidemiol 2013;41:1-12.

Downer MC, Drugan CS, Blinkhorn AS. Correlates of dental caries in 12-year-old children in Europe: a cross-sectional analysis. Community Dent Health 2008;25:70–78.

Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH. Diagnosing and reporting early childhood caries for research purposes. J Public Health Dent 1999;59:192-197.

Ekbäck G, Åstrøm AN, Klock K, Ordell S, Unell L. Self-perceived oral health among 19-year-olds in two Swedish counties. Swed Dent J 2008; 32:83-94.

Eriksen HM, Bjertness E. Concepts of health and disease and caries predictors: a literature review. Eur J Oral Sci 1991;99:476-483.

Espelid I, Tveit AB. A comparison of radiographic occlusal and approximal caries diagnoses made by 240 dentists. Acta Odontol Scand 2001;59:285-289.

Espelid I, Tveit AB, Mjör IA, Eriksen HM, Fjelltveit A, Øiestad V. Indekser for registrering av okklusalkaries og approksimalkaries. Nor Tannlegeforen Tid 1990;100:658-663.
Fedorov V, Mannino F, Zhang R. Consequences of dichotomization. Pharmaceut. Statist 2009;8:50-61.

Fejerskov O. Changing paradigms in concepts on dental caries: consequences for oral health care. Caries Res 2004;38:182-191.

Fejerskov O. Concepts of dental caries and their consequences for understanding the disease. Community Dent Oral Epidemiol 1997;25:5-12.

Filstrup SL, Briskie D, da Fonseca M, Lawrence L, Wandera A, Inglehart MR. The effects on early childhood caries (ECC) and restorative treatment on children's oral health-related quality of life (OHRQOL). Pediatr Dent 2003;25:431-440.

Fisher-Owens SA, Gansky SA, Platt LJ, Weintraub JA, Soobader MJ, Bramlett MD, et al. Influences on children's oral health: a conceptual model. Pediatrics 2007;120:510-520.

Grindefjord M, Dahllöf G, Nilsson B, Modéer T. Prediction of dental caries development in 1- year-old children. Caries Res 1995;29:343-348.

Grindefjord M, Dahllöf G, Nilsson B, Modéer T. Stepwise prediction of dental caries in children up to 3.5 years of age. Caries Res 1996;30:256-266.

Harris R, Nicoll AD, Adair PM, Pine CM. Risk factors for dental caries in young children: a systematic review of the literature. Community Dent Health 2004; 21: Suppl-85.

Hugoson A, Koch G, Helkimo AN, Lundin SA. Caries prevalence and distribution in individuals aged 3-20 years in Jönköping, Sweden, over a 30-year period (1973-2003). Int J Paediatr Dent 2008;18:18-26.

Hultquist AI, Brudin L, Bågesund M. Early childhood caries risk assessment in 1-year-olds evaluated at 6-years of age. Acta Odontol Scand 2021;79:103-111.

Inchley J, Currie D, Young T. WHO. Growing up unequal: gender and socioeconomic differences in young people's health and well-being. HBSC study (2013/2014 survey), Available from: https://www.euro.who.int/en/publications/ abstracts/growing-up-unequal.-hbsc-2016-study-2013/2014-survey. (cited 26 July 2022).

Inglehart MR, Bagramian R. Oral health-related quality of life. Quintessence Pub; 2002.

Isaksson H, Alm A, Koch G, Birkhed D, Wendt LK. Caries prevalence in Swedish 20-year-olds in relation to their previous caries experience. Caries Res 2013; 47:234-242.

Isaksson HG, Koch G, Alm A, Nilsson M, Wendt LK, Birkhed D. Parental factors in early childhood are associated with approximal caries experience in young adults: a longitudinal study. Community Dent Oral Epidemiol 2019; 47:49-57.

Ismail AI, Sohn W, Tellez M, Amaya A, Sen A, Hasson H et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Community Dent Oral Epidemiol 2007;35:170-178.

Ismail AI. Diagnostic Levels in dental public health planning. Caries Res 2004;38:199-203.

Jokovic A, Locker D, Guyatt G. What do children's global ratings of oral health and well-being measure? Community Dent Oral Epidemiol 2005;33:205-211.

Kaplan RM. The significance of quality of life in health care. Qual Life Res 2003;12:3-16.

Karjalainen S, Soderling E, Sewon L, Lapinleimu H, Simell O. A prospective study on sucrose consumption, visible plaque and caries in children from 3 to 6 years of age. Community Dent Oral Epidemiol 2001;29:136-142.

Kassebaum NJ, Smith AGC, Bernabe E, Flemin TD, Reynolds AE, Vos T, et al. Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990–2015: a systematic analysis for the global burden of diseases, injuries, and risk factors. J Dent Res 2017;96:380–387.

Keyes PH. Recent advances in dental caries research. Bacteriological findings and biological implications. Int Dent J 1962;12:443-464.

Klingberg G, Broberg AG. Dental fear/anxiety and dental behaviour management problems in children and adolescents: a review of prevalence and concomitant psychological factors. Int J Paediatr Dent 2007;17:391-406.

Klingberg G. Dental anxiety and behaviour management problems in paediatric dentistry--a review of background factors and diagnostics. Eur Arch Paediatr Dent 2012;9:11-15.

Koch G, Helkimo AN, Ullbro C. Caries prevalence and distribution in individuals aged 3-20 years in Jönköping, Sweden: trends over 40 years. Eur Arch Paediatr Dent 2017;18:363-370.

Kramer AC, Skeie MS, Skaare AB, Espelid I, Ostberg AL. Caries increment in primary teeth from 3 to 6 years of age: a longitudinal study in Swedish children. Eur Arch Paediatr Dent 2014;15:167-173.

Kühnisch J, Ekstrand KR, Pretty I, Twetman S, van Loveren C, Gizani S et al. Best clinical practice guidance for management of early caries lesions in children and young adults: an EAPD policy document. Eur Arch Paediatr Dent 2016;17:3-12.

Kumar S, Kroon J, Lalloo R. A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral healthrelated quality of life. Health and Qual Life Outcomes 2014;12:12-41.

Kumar S, Tadakamadla J, Johnson NW. Effect of toothbrushing frequency on incidence and increment of dental caries: a systematic review and meta-analysis. J Dent Res 2016;95:1230-1236.

Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-174.

Lee JY, Watt RG, Williams DM, Giannobile WV. A new definition for oral health: implications for clinical practice, policy, and research. J Dent Res 2017;96:125–127.

Leong PM, Gussy MG, Barrow S-YL, de Silva-Sanigorski A, Waters E. A systematic review of risk factors during first year of life for early childhood caries. Int J Paediatr Dent 2013;23:235-250.

Leroy R, Bogaerts K, Martens L, Declerck D. Risk factors for caries incidence in a cohort of Flemish preschool children. Clin Oral Invest 2012;16:805-812.

Locker D, Gibson B. Discrepancies between self-ratings of and satisfaction with oral health in two older adult populations. Community Dent Oral Epidemiol 2005;33:280-288.

Locker D. Concepts of oral health, disease and the quality of life. In: Slade GD, editor. Measuring oral health and quality of life. Chapel Hill, Dept. of Dental Ecology, School of Dentistry, University of North Carolina, 1997. p. 11-23.

Locker D. Validity of single-item parental ratings of child oral health. Int J Paediatr Dent 2008;18:407-414.

Løken SY, Wang NJ, Wigen TI. Health nurses' experiences and attitudes regarding collaboration with dental personnel. BMC oral health 2016;16:66.

Marinho VCC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev 2013;(7):CD002279.

Marinho VCC. Cochrane reviews of randomized trials of fluoride therapies for preventing dental caries. Eur Arch Paediatr Dent 2012;10:183-191.

Marthaler TM. Changes in dental caries 1953-2003. Caries Res 2004;38:173-181.

Mattila ML, Rautava P, Aromaa M, Ojanlatva A, Paunio P, Hyssälä L et al. Behavioural and demographic factors during early childhood and poor dental health at 10 years of age. Caries Res 2005;39:85-91.

Mattila ML, Rautava P, Sillanpää M, Paunio P. Caries in five-year-old children and associations with family-related factors. J Dent Res 2000;79:875-881.

Mejare I, Axelsson S, Dahlen G, Espelid I, Norlund A, Tranaeus S et al. Caries risk assessment. A systematic review. Acta Odontol Scand 2014;72:81-91.

Mejare I, Klingberg IG, Mowafi FK, Stecksén-Blicks C, Twetman S, Tranæus SH. A systematic map of systematic reviews in pediatric dentistry-what do we really know? PLoS One 2015;10: e0117537.

Mejare I, Stenlund H, Julihn A, Larsson I, Permert L. Influence of approximal caries in primary molars on caries rate for the mesial surface of the first permanent molar in swedish children from 6 to 12 years of age. Caries Res 2001;35:178-185.

Meyer F, Enax J. Early Childhood Caries: epidemiology, etiology, and prevention. Int J Dent 2018;22:1415873.

Misvær N, Lagerløv P. Håndbok for helsestasjoner. Oslo: Kommuneforlaget; 2013.

Monaghan N, Davies GM, Jones CM, Neville JS, Pitts NB. The caries experience of 5-year-old children in Scotland, Wales and England in 2011-2012: reports of cross-sectional surveys using BASCD criteria. Community Dent Health 2014;31:105-110.

Moynihan P, Tanner LM, Holmes RD, Hillier-Brown F, Mashayekhi A, Kelly SAM et al. Systematic review of evidence pertaining to factors that modify risk of early childhood caries. JDR Clin Trans Res 2019;4:202-216.

Moynihan P. Sugars and dental caries: evidence for setting a recommended threshold for intake. Adv Nutr 2016;7:149-156.

Neto MVG. Dental anxiety in northern Norway. Epidemiologic assessment of dental anxiety in the Troms County. The THONN-study; Thesis 2017. Available from: https://hdl.handle.net/10037/15518. (cited 26 July 2022).

Nilsen RM, Vollset SE, Gjessing HK, Skjærven R, Melve KK, Schreuder P et al. Self-selection and bias in a large prospective pregnancy cohort in Norway. Paediatr Perinat Epidemiol 2009;23:597-608.

Norderyd O, Koch G, Papias A, Kohler AA, Helkimo AN, Brahm CO et al. Oral health of individuals aged 3-80 years in Jonkoping, Sweden, during 40 years (1973-2013). Swed Dent J 2015;39:57.

Norwegian Directorate of Health. Kommunenes helsefremmende og forebyggende arbeid i helsestasjons og skolehelsetjenesten Veileder til forskrift av 3. april 2003 nr. 450. (Guide to regulation on the municipality's health promotion and prevention work in the health centres and school health service) 2004. Report No.: IS-1154.

Norwegian Directorate of Health. Quality indicators in oral health care. A Nordic project. Proceedings in 2012-2018, an update 2018. Report No.: IS-2799.

Norwegian Directorate of Health. Tannhelsetjenester til barn og unge 0-20 år (National guideline for the dental health service for children and adolescents 0-20 years) 2022. Available from: https://www.helsedirektoratet.no/retningslinjer/tannhelsetjenester-til-barn-og-unge-020-ar. (cited 26 July 2022).

Norwegian Directorate of Health. Tenner for livet. Helsefremmende og forebyggende arbeid (Teeth for life. Health promotion and health prevention) 1999. Report No.: IS-2659.

Norwegian legislation (Act related to dental health services). Lovdata 1984. Lov om tannhelsetjenesten. LOV-1983-06-03-54: Available from: http://lovdata.no/dokument/NL/lov/1983-06-03-54. (cited 26 July 2022).

Nyvad B, Baelum V. Nyvad Criteria for Caries Lesion Activity and Severity Assessment: a validated approach for clinical management and research. Caries Res 2018;52:397-405.

O'Mullane DM, Baez RJ, Jones S, Lennon MA, Petersen PE, Rugg-Gunn AJ et al. Fluoride and Oral Health. Community Dent Health 2016;33:69-99.

Otero G, Pechlaner G, Liberman G, Gurcan E. The neoliberal diet and inequality in the United States. Soc Sci Med 2015;142:47-55.

Ouellette JA and Wood W. Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. Psychol Bull 1998;124:54-74.

Pattussi MP, Hardy R, Sheiham A. The potential impact of neighborhood empowerment on dental caries among adolescents. Community Dent Oral Epidemiol 2006;34:344-350.

Paunio P, Rautava P, Helenius H, Alanen P, Sillanpaa M. The Finnish Family Competence Study: the relationship between caries, dental health habits and general health in 3-year-old Finnish children. Caries Res 1993;27:154-160.

Peres KG, Thomson WM, Chaffee BW, Peres MA, Birungi N, Do LG et al. Oral Health Birth Cohort Studies: achievements, challenges, and potential. J Dent Res 2020;99:1321-1331.

Peres MA, Latorre MRDO, Sheiham A, Peres KG, Barros FC, Hernandez PG, et al. Social and biological early life influences on severity of dental caries in children aged 6 years. Community Dent Oral Epidemiol 2005;33:53-63.

Petersen PE, Bourgeois D, Ogawa H, et al. The global burden of oral diseases and risks to oral health. Bull World Health Organ 2005;83:661-669.

Peyron M, Matsson L, Birkhed D. Progression of approximal caries in primary molars and the effect of Duraphat treatment. Scand J Dent Res 1992;100:314-318.

Pienihäkkinen K, Jokela J, Alanen P. Assessment of caries risk in preschool children. Caries Res 2004;38:156-162.

Pitts NB, Baez RJ, Diaz-Guillory C, Donly KJ, Feldens CA, McGrath C et al. Early childhood caries: IAPD Bangkok Declaration. J Dent Child (Chic) 2019;86:72-72.

Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F et al. Dental caries. Nat Rev Dis Primers 2017;3:17030.

Pitts WK, Seow N, Sharkov Y, Songpaisan, Twetman S. Early childhood caries epidemiology, aetiology, risk assessment, societal burden, management, education, and policy: global perspective. Int J Paediatr Dent 2019;29:238-248.

Platt JM, Keyes KM, Galea S. Efficiency or equity? Simulating the impact of high-risk and population intervention strategies for the prevention of disease. SSM - Popul Health 2016;3:1-8.

Poutanen R, Lahti S, Tolvanen M, Hausen H. Parental influence on children's oral health-related behavior. Acta Odontol Scand 2006;64:286-292.

Raadal M, Strand GV, Amarante EC, Kvale G. Relationship between caries prevalence at 5 years of age and dental anxiety at 10. Eur J Paediatr Dent 2002;3:22-26.

Rebouças AG, Cavalli AM, Zanin L, Ambrosano GMB, Flório FM. Factors associated with Brazilian adolescents' satisfaction with oral health. Community Dent Health 2018;35:95-101.

Rodrigues CS, Sheiham A. The relationships between dietary guidelines, sugar intake and caries in primary teeth in low income Brazilian 3-year-olds: a longitudinal study. Int J Paediatr Dent 2000;10:47-55.

Rose G. Prevention for individuals and the "high-risk" strategy. In: The Strategy of Preventive Medicine. Oxford University Press;1992:29-52.

Rothman KJ. Epidemiology Edn 2: an introduction. New York: Oxford University Press, Inc, 2012.

Royston P, Altman DG, Sauerbrei W. Dichotomizing continuous predictors in multiple regression: a bad idea. Statist Med 2006;25:127-141.

Rønneberg A, Strøm K, Skaare AB, Willumsen T, Espelid I. Dentists' self-perceived stress and difficulties when performing restorative treatment in children. Eur Arch of Paediatr Dent 2015;16:341-347.

Salzer S, Slot DE, Van der Weijden FA, Dorfer CE. Efficacy of inter-dental mechanical plaque control in managing gingivitis-a meta-review. J Clinical Periodontol 2015;42:92-105.

Sambunjak D, Nickerson JW, Poklepovic T, Johnson TM, P Imai, Tugwell P et al. Flossing for the management of periodontal diseases and dental caries in adults. Cochrane Database Syst Rev 2011;(12):Cd008829.

Sanzone LA, Lee JY, Divaris K, DeWalt DA, Baker AD, Vann JWF. A cross sectional study examining social desirability bias in caregiver reporting of children's oral health behaviors. BMC Oral Health 2013;13:24.

Sedgwick P. Bias in observational study designs: cross sectional studies. BMJ 2015;350: h1286.

Sedgwick P. Cross sectional studies: advantages and disadvantages. BMJ 2014; 348:g2276.

Selwitz RH, Ismail AI, Pitts NB. Dental caries. Lancet 2007;369:51-59.

Seow W. Environmental, maternal, and child factors which contribute to early childhood caries: a unifying conceptual model. Int J Paediatr Dent 2012;22:157-168.

Sheiham A, James WP. Diet and dental caries: the pivotal role of free sugars reemphasized. J Dent Res 2015;94:1341-1347.

Sheiham A. Dental caries affects body weight, growth and quality of life in preschool children. Br Dent J 2006;201:625-626.

Sheiham A. Oral health, general health and quality of life. Bull World Health Organ 2005;83:644.

Sjöström O, Holst D. Validity of a questionnaire survey: response patterns in different subgroups and the effect of social desirability. Acta Odontol Scand 2002;60:136-140.

Skeie MS, Klock KS. Scandinavian systems monitoring the oral health in children and adolescents; an evaluation of their quality and utility in the light of modern perspectives of caries management. BMC oral health 2014;14:43-43.

Skeie MS, Espelid I, Riordan PJ, Klock KS. Caries increment in children aged 3-5 years in relation to parents' dental attitudes. Oslo, Norway 2002 to 2004. Community Dent Oral Epidemiol 2008;36:441-450.

Skeie MS, Espelid I, Skaare AB, Gimmestad A. Caries patterns in an urban preschool population in Norway. Eur J Paediatr Dent 2005;6:16-22.

Skeie MS, Raadal M, Strand GV, Espelid I. Caries in primary teeth at 5 and 10 years of age: a longitudinal study. Eur J Paediatr Dent 2004;5:194-202.

Skeie MS, Riordan PJ, Klock KS, Espelid I. Parental risk attitudes and caries-related behaviours among immigrant and western native children in Oslo. Community Dent Oral Epidemiol 2006;34:103-113.

Slade GD, Spencer AJ. Development and evaluation of the Oral Health Impact Profile. Community Dent Health 1994;11:3-11.

Sohn W, Burt BA, Sowers MR. Carbonated soft drinks and dental caries in the primary dentition. J Dent Res. 2006;85:262-266.

Statistics Norway[a]. Dental status among 5-, 12- og 18-year-olds, by age 2020. Available from: https://www.ssb.no/en/statbank/table/13033/. (cited 17 July 2022).

Statistics Norway[b]. Dental status by age, contents, year and region 2020. Available from: http://www.ssb.no/en/statbank/table/04163/. (cited 17 July 2022).

Statistics Norway[c]. Dental health service. Key figures by region, statistical variable and year 2020. Available from: https://www.ssb.no/statbank/table/11985/. (cited 17 July 2022).

Statistics Norway[d]. Distribution of the immigrant population 2021. Available from: https://www. ssb.no/befolkning. (cited 17 July 2022).

Statistics Norway[e]. Educational attainment of the population 2021. Available from: https://www. ssb.no/en/statbank/table/09429/. (cited 17 July 2022).

Stenebrand A, Wide Boman W, Hakeberg M. Dental anxiety and symptoms of general anxiety and depression in 15-year-olds. Int J Dent Hyg 2013;11:99-104.

Stevenson A. Oxford dictionary of English, Edn 3, Oxford, Oxford University Press; 2010.

Swedish National Board of Health and Welfare: karies hos barn och ungdomar. Art. nr. 2021-12-7697. En lägesrapport för år 2021. Available from: http://www.socialstyrelsen.se/ publikationer. (cited 26 July 2022).

Taylor RL, Olds T, Boshoff K, Lane AE. Children's conceptualization of the term 'satisfaction': relevance for measuring health outcomes. Child: care, health and development 2010;36:663-669.

Thomson WM. Public health aspects of paediatric dental treatment under general anaesthetic. Dent J 2016;4:20.

Tinanoff N, Baez RJ, Diaz Guillory C, Donly KJ, Feldens CA, McGrath C et al. Early childhood caries epidemiology, aetiology, risk assessment, societal burden, management, education, and policy: global perspective. Int J Paediatr Dent 2019;29:238-248.

Toumba KJS, Twetman S, Splieth C, Parnell C, van Loveren C, Lygidakis N. Guidelines on the use of fluoride for caries prevention in children: an updated EAPD policy document. Eur Arch Paediatr Dent 2019;20:507-516.

Tubert-Jeannin S, Auclair C, Amsallem E, Tramini P, Gerbaud L, Ruffieux C, et al. Fluoride supplements (tablets, drops, lozenges or chewing gums) for preventing dental caries in children. Cochrane Database Syst Rev 2011;(12):CD007592.

Twetman S, Fontana M, Featherstone J. Risk assessment - can we achieve consensus? Community Dent Oral Epidemiol 2013;41:e 64.

Twetman S, Petersson LG, Axelsson S, Dahlgren H, Holm AK, Källestål C et al. Caries-preventive effect of sodium fluoride mouthrinses: a systematic review of controlled clinical trials. Acta Odontol Scand 2004;62:223-230.

Twetman S. Caries risk assessment in children: how accurate are we? Eur Arch Paediatr Dent 2016;17:27-31.

Twetman S. Prevention of dental caries as a non-communicable disease. Eur J Oral Sci 2018;126:19-25.

Twetman S, Dhar V. Evidence of effectiveness of current therapies to prevent and treat early childhood caries. Pediatr Dent 2015;37:246-253.

Vann WF Jr, Lee JY, Baker D, Divaris K. Oral health literacy among female caregivers: impact on oral health outcomes in early childhood. J Dent Res 2010;89:1395-1400.

Vanobbergen J, Martens L, Declerck D. Caries prevalence in Belgian children: a review. Int J Paediatr Dent 2001;11:164-170.

Vernazza CR, Rolland SL, Chadwick B, Pitts N. Caries experience, the caries burden and associated factors in children in England, Wales and Northern Ireland 2013. Br Dent J 2016;221:315-320.

Viner RM, Ozer EM, Denny S, Marmot M, Resnick M, Fatusi A et al. Adolescence and the social determinants of health. Lancet 2012;379:1641-1652.

Walsh T, Worthington HV, Glenny AM, Marinho VCC, Jeroncic A. Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst Rev 2019;(3):CD007868.

Wangensteen B. Bokmålsordboka (Dictionary of Norwegian Bokmål), Oslo, Kunnskapsforlaget; 2005.

Warren JJ, Weber-Gasparoni K, Marshall TA, Drake DR, Dehkordi-Vakil F, Kolker JL, et al. Factors associated with dental caries experience in 1-year-old children. J Public Health Dent 2008;68:70-75.

Watt RG. Emerging theories into social determinants of health: implications for oral health promotion. Community Dent Oral Epidemiol 2002;30:241-247.

Wendt LK, Hallonsten AL, Koch G, Birkhed D. Oral hygiene in relation to caries development and immigrant status in infants and toddlers. Scand J Dent Res 1994;102:269-273.

Wendt LK, Hallonsten AL, Koch G. Dental caries in one- and two-year-old children living in Sweden. Part I-a longitudinal study. Swed Dent J 1991;15:1-6.

Wendt LK, Hallonsten AL, Koch G. Oral health in preschool children living in Sweden. Part III - A longitudinal study. Risk analyses based on caries prevalence at 3 years of age and immigrant status. Swed Dent J 1999;23:17-25.

Wendt LK, Jonsell R. Illness and use of medicines in relation to caries development and to immigrant status in infants and toddlers living in Sweden. Swed Dent J 1996;20:151-9.

Wendt LK, Svedin CG, Hallonsten AL, Larsson IB. Infants and toddlers with caries. Mental health, family interaction, and life events in infants and toddlers with caries. Swed Dent J 1995;19:17-27.

Werner H, Hakeberg M, Dahlström L, Eriksson M, Sjögren P, Strandell A et al. Psychological interventions for poor oral health: a systematic review. J Dent Res 2016;95:506-514.

Wigen TI, Wang NJ. Caries and background factors in Norwegian and immigrant 5-year-old children. Community Dent Oral Epidemiol 2010;38:19-28.

Wigen TI, Wang NJ. Parental influences on dental caries development in preschool children. An overview with emphasis on recent Norwegian research. Norsk Epidemiologi 2012;22:13-19.

Wigen TI, Espelid I, Skaare AB, Wang NJ. Family characteristics and caries experience in preschool children. A longitudinal study from pregnancy to 5 years of age. Community Dent Oral Epidemiol 2011;39:311-317.

Wigen TI, Skaret E, Wang NJ. Dental avoidance behaviour in parent and child as risk indicators for caries in 5-year-old children. Int J Paediatr Dent 2009;19:431-437.

Wigen TI, Wang NJ. Tooth brushing frequency and use of fuoride lozenges in children from 1.5 to 5 years of age: a longitudinal study. Community Dent Oral Epidemiol 2014;42:395-403.

Woodward GL, Main PA, Leake JL. Clinical determinants of a parent's satisfaction with the appearance of a child's teeth. Community Dent Oral Epidemiol 1996;24:416-418.

World Health Organization. Action plan for the prevention and control of noncommunicable diseases in the WHO European Region. Copenhagen, 2016. Available from: https://apps.who.int/iris/handle/10665/341522. (cited 26 July 2022).

World Health Organization. Guideline: sugars intake for adults and children. Department of Nutrition for Health and Development, Geneva, 2015. Available from: https://www.who.int/publications/i/item/9789241549028. (cited 26 July 2022).

World Health Organization. Oral health: action plan for promotion and integrated disease prevention. Executive Board, 120. 2007. Available form: https://apps.who.int/iris/handle/10665/21909. (cited 26 July 2022).

World Health Organization. Oral health surveys: basic methods, Edn 4, Geneva, World Health Organization, 1997.

World Health Organization. Sugars and dental caries. Geneva, 2017. Available from: https://www.who.int/news-room/fact-sheets/detail/sugars-and-dental-caries. (cited 26 July 2022).

Worthington HV, MacDonald L, Poklepovic PT, Johnson TM, Imai P, Clarkson JE. Home use of interdental cleaning devices, in addition to toothbrushing, for preventing and controlling periodontal diseases and dental caries. Cochrane Database Syst Rev 2019;(4):CD012018.

Wyne AH. Early childhood caries: nomenclature and case definition. Community Dent Oral Epidemiol 1999;27:313-315.

APPENDIX 1

Questionnaire to parents of the 2-year-olds

Registreringsnummer: .....

Klinikk for pedodonti og atferdsfag
Det odontologisk fakultet
Universitetet i Oslo

To år gammel

Spørreskjema til / intervju av foresatte

For å kunne gi best mulig informasjon og behandling ber vi deg svare på spørsmålene.

Vennligst svar på alle spørsmål.

Spør om hjelp til utfyllingen dersom noe er uklart!

Barnets navn: .....

Fødselsdato: .....

1. Kjønn: ☐ **Gutt** ☐ **Jente**

2. Bakgrunn: ☐ **Norsk** ☐ **Annen: Hvilken nasjonalitet? .....**

3a. Har barnet hatt problemer med tennene? ☐ **Nei** ☐ **Ja: Hvilke?**
.....
.....

3b. Har du/dere fått informasjon om barnets tenner og tannstell på helsestasjonen? ☐ **Ja** ☐ **Nei**

3c. Ble barnets munn og tenner inspisert på helsestasjonen? ☐ **Ja** ☐ **Nei**

4. Børstes barnets tenner? ☐ **Nei** ☐ **Ja, fra barnet var ca ..... måneder**

5. Hvor ofte børstes barnets tenner? ☐ **Aldri eller sjelden**
☐ **Av og til**
☐ **En gang per dag**
☐ **To ganger per dag eller oftere**

6. Brukes fluortannkrem? ☐ **Ja** ☐ **Nei**

5. Hvor ofte får barnet fluortabletter? ☐ **Aldri eller sjelden**
☐ **Av og til**
☐ **En gang per dag**
☐ **To ganger per dag eller oftere**

Fortsett på baksiden!

6. Hvor ofte får barnet drikke
på flaske om natten nå?

- ☐ **Aldri eller sjelden**
- ☐ **Av og til**
- ☐ **Hver natt**
- ☐ **To eller flere ganger per natt**

7. Hvis barnet får drikke på flaske om natten, hva?

Sett gjerne flere kryss

- ☐ **Bare vann**
- ☐ **Melk**
- ☐ **Saft eller juice**
- ☐ **Sukkerfri drikke**
- ☐ **Annet: Hva? ……**

8. Har barnet fått drikke på flaske tidligere? ☐ **Nei/bare vann**
(om natten) ☐ **Ja, til barnet var ca …….. måneder**

9. Hvor ofte spiser eller drikker barnet mellom måltidene?
(eks. kjeks, boller, kake, søtsaker, saft, juice)

- ☐ **Aldri eller sjelden**
- ☐ **Av og til**
- ☐ **Hver dag**
- ☐ **To eller flere ganger per dag**

10. Hva synes du om at barnet blir innkalt til tannhelsetjenesten når det er 2 år?

- ☐ **Positivt**
- ☐ **Negativt**
- ☐ **Vet ikke**

Eventuelle kommentarer:

……

……

……

Lever skjema til undersøker!

Takk for hjelpen!

NJW 02.08.11

APPENDIX 2

Questionnaire to the 12-year-olds

12 år – feilfrie tenner? Spørreskjema til deg født i 2002

Personnummer (11 siffer): _____ - _____

---

1. Kjønn:
- ☐ Gutt
- ☐ Jente

2. Er mor eller far født utenfor Norge?
- ☐ Nei
- ☐ Ja, mor; land: _____
- ☐ Ja, far; land: _____

3. Foreldres utdanning:
Høyeste fullførte utdanning

Mor	Far	
☐	☐	Grunnskole
☐	☐	Videregående skole
☐	☐	Høyskole/universitet
☐	☐	Vet ikke

4. Foreldres yrke?
Hva jobber mor og far med?

Mor _____

Far _____

5. Hvem bor du sammen med?
- ☐ Mor og far
- ☐ Delt samvær, halvparten hos mor og halvparten hos far
- ☐ Mest hos mor
- ☐ Mest hos far
- ☐ Annet

6. Hvor ofte børster du tenner?
- ☐ 2 ganger per dag eller mer
- ☐ 1 gang per dag
- ☐ Av og til
- ☐ Aldri

7. Hvor ofte bruker du tanntråd?
- ☐ Sjelden/aldri
- ☐ Omtrent 1 gang i uken
- ☐ Flere ganger i uken
- ☐ Daglig

8. Bruker du fluortabletter/-skylling?

Fluortabletter	Fluorskylling
☐ Nei	☐ Nei
☐ Av og til	☐ Av og til
☐ Ja, daglig	☐ Ja, daglig

9. Er du fornøyd med tennene?
- ☐ Ja
- ☐ Nei
- ☐ Vet ikke

10. Har du noen gang hatt vondt i tennene?
- ☐ Nei
- ☐ Ja

Hvis ja,
hva var årsaken _____

11. Gjorde det vondt sist du var hos tannlege/tannpleier?
- ☐ Nei, ikke i det hele tatt
- ☐ Ja, litt
- ☐ Ja, veldig

12. Gruer du deg til tannlegebesøk?
- ☐ Nei, gleder meg
- ☐ Ja, gruer meg litt
- ☐ Ja, det er det verste jeg vet
- ☐ Hverken gruer eller gleder meg

13. Hvor ofte drikker eller spiser du følgende?

	Sjeldnere enn en gang per uke	*En gang per uke*	*Flere ganger i uken*	*Flere ganger per dag*
a. Sukkerholdig saft/nektar/leskedrikk/brus	☐	☐	☐	☐
b. Sukkerfri saft/leskedrikk/lettbrus	☐	☐	☐	☐
c. Kjeks/boller/vafler	☐	☐	☐	☐
d. Smågodt, seigmann, sjokolade etc	☐	☐	☐	☐

Har du svart på alle spørsmål?

Lever skjema til tannpleier/tannlege!

PAPERS I - III

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ORIGINAL ARTICLE

WILEY Community Dentistry and Oral Epidemiology

Identification of caries risk in 2-year-olds

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Abstract

Objective: The first aim was to describe presence of plaque, caries and oral health behaviours in 2-year-old children. The second aim was to measure increments in caries experience from 2 to 5 years of age and to study whether national background, visible plaque, caries and oral health behaviour at 2 years of age were associated with increments in caries experience.

Methods: The study population consisted of 392 children, of whom 211 were monitored from 2 to 5 years of age. At age 2 years, parents completed a questionnaire about family background and oral health behaviour. The presence of plaque and caries at tooth level was obtained from dental records. Data were tested with chi-square statistics and Mann-Whitney *U* test. Negative binomial regression analysis was conducted to explore the association between caries increment between 2 and 5 years of age and national background, visible plaque, caries and oral health behaviour at 2 years of age.

Results: Caries was found in 4.6% of 2-year-olds, and 4.6% had visible plaque. More than half of these children (57.9%) brushed twice daily, toothbrushing was introduced when the child was 7 months or older in 61.0% of the children, and 15.6% consumed sugary snacks daily. Non-Western children more often had caries, visible plaque and unfavourable oral health behaviour than Western children ($P < .05$). At age 5 years, 28.9% of the children had caries experience. Non-Western background, toothbrushing less than twice daily, not using fluoridated toothpaste, not using fluoride lozenges, consuming sugary drinks at night, consuming sugary snacks daily, presence of plaque and caries at 2 years of age were associated with caries increment between 2 and 5 years of age in bivariable analyses. The results from multivariable analysis showed that children who started toothbrushing late, children who brushed less than twice daily at 2 years of age and children of non-Western background had a higher probability of having caries increment from 2 to 5 years of age than other children.

Conclusions: A small proportion of 2-year-olds had caries, but these children had several decayed teeth. Substantial differences in oral health and oral health behaviour were found between Western and non-Western children. The preventive care delivered to the studied children failed to prevent caries increment from 2 to 5 years of age.

KEYWORDS

caries increment, early childhood caries, immigrants, preschool children, toothbrushing

1 | INTRODUCTION

The majority of children in Norway and in many other countries are not examined by dental personnel before the age of 3 years.[1] As a consequence, oral health data for children younger than 3 years are often not available. Caries prevalence in 2-year-old children has been reported in some studies, showing that up to 10% of the children have developed caries by this age.[2-5] To attain the goal of a cavity-free future for children, early identification of caries risk is essential.[6]

While some data are available on caries prevalence in 2-year-olds, caries prevalence in 5-year-old children is well documented. At 5 years of age, 20%-40% of children in Europe have been reported to have caries experience.[7-10] Caries development in preschool children has been associated with the family's socioeconomic situation and oral health behaviour.[11,12] Children with immigrant background and children of parents with low educational level have been shown to have higher caries prevalence than other children.[11,13,14] Toothbrushing frequency and sugar intake are associated with caries development in young children.[10,15-18] Some studies have reported that the presence of dental plaque and caries in early childhood was associated with caries increment during preschool age.[9,19,20]

Information to parents about caries prevention from birth given by primary care personnel is part of general health promotion in several countries.[1,21,22] In Norway, primary care personnel are required by national guidelines to give information about oral health to parents of infants and toddlers. Caries risk children should be identified early and referred to dental personnel.[23] Knowledge of risk factors for early caries development based on longitudinal studies may allow caries preventive strategies to be targeted towards risk families.

All children in Norway are invited to attend a first oral examination in the dental services at 3 years of age. Children receiving dental care at the student dental clinic at the University of Oslo were invited to their first dental visit at 2 years of age. The background for the study was to explore whether inviting 2-year-olds for a first dental examination with individualized caries preventive advice would help prevent caries between 2 and 5 years of age. The first aim of this study was to describe the presence of dental plaque, caries experience and oral health behaviours in 2-year-olds. The second aim was to measure increments in caries experience between 2 and 5 years of age and to study whether national background, visible plaque accumulation, caries experience and oral health behaviour at 2 years of age were associated with increments in caries experience.

2 | METHODS

This study included children that according to home address had the student dental clinic at the University of Oslo as their regular dental clinic. All children were invited for an oral examination at 2 years of age between 2006 and 2010. The clinic is situated in an area of Oslo where preschool children have higher caries prevalence than average in Norway.[8,24] In total, 495 children were invited and 411 children (83.0%) showed up for the oral examination. Nineteen children were excluded because of lack of data. The study population at 2 years of age consisted of 392 children, 198 boys and 194 girls. A higher proportion of children with Western background (88.3%) showed up for the dental examination than children with non-Western background (66.7%) ($P < .05$). Mean age at the examination at 2 years of age was 26.4 (SD 3.2) months.

Between 2 and 5 years of age, children were recalled at individualized intervals and given preventive care as needed. All children were called at least once a year. Of the children examined at 2 years of age, 211 (102 boys and 109 girls) were still living in the area and available for dental examination at 5 years of age. Mean age at this examination was 60.0 (SD 7.5) months. Among children who had moved from the area and were unavailable for dental examination at 5 years of age, the proportion of Western children was slightly higher (48.9% vs 35.8%, $P = .05$), and proportion of children with caries was lower (1.7% vs 7.1%, $P < .05$) than among children still living in the area.

Oral examinations at 2 and 5 years of age included standard anamnestic information and dental examinations. The examinations were performed in a fully equipped dental clinic using mirror and probe after the teeth had been dried and were carried out by dental students or dental hygienist students. Dentists or dental hygienists verified all registrations. The data were registered in the children's dental records and extracted from the dental records by the examiners. Individualized caries preventive information and oral hygiene instruction were provided for all children and parents as part of the examination, including instructions on sugar consumption, use of fluoridated toothpaste and application of fluoride varnish if considered necessary by dental personnel.

Clinical examination at 2 years of age included registration of visible dental plaque accumulation and caries experience on all emerged teeth. Presence of plaque was recorded as visible and not visible. Clinical examination at 5 years of age included registration of caries. Caries experience was reported as decayed, filled or missing teeth (dmft). All teeth with caries both initial and manifest lesions were categorized as decayed teeth. At 5 years of age, bitewing radiographs were taken when indicated in accordance with standard routines in the dental services (bitewings when visual inspection of approximal surfaces was impossible) and used in 41.2% of the children as an adjunct to the clinical caries registration. Caries increment was calculated as the difference in the number of teeth with caries experience at 2 and 5 years of age, and children were dichotomized as having or not having caries increment between 2 and 5 years of age.

At the examination at 2 years of age, parents completed a questionnaire which included anamnestic information: national background, oral health-related behaviour and dietary habits. National background was recorded as parents' country of birth and in the analyses categorized as both parents with Western background and one or both parents with non-Western background. Non-Western background included parents born in Asia, Africa, south and central America and eastern Europe. In children who did not attend for

dental examination, the child's family name was used to indicate the child's national background.

Toothbrushing frequency was reported as twice daily, once daily, seldom and never and in the analyses categorized as twice daily, once daily and less than daily. Child age when toothbrushing was started was categorized as younger than 7 months and 7 months and older. Use of fluoride lozenges was reported as daily and less than daily. The parents reported whether or not the child had access to sugar-containing drinks during the night, and access to sugar-containing snacks between meals was categorized as seldom/never, sometimes and daily.

Data analyses were conducted by use of SPSS for Windows (SPSS version 24, Inc Chicago, IL, USA). Results are presented as frequencies, mean and standard deviation (SD). Data were cross-tabulated and tested using chi-square statistics, and differences between means were tested with Mann-Whitney *U* test. Spearman's rank correlation was used to explore collinearity between the independent variables before multivariable analysis was conducted. In children monitored from 2 to 5 years of age, three variables had missing data in 3, 5 and 46 children, respectively. Missing data were replaced using multiple imputation to reduce loss of data in multivariable analysis. The association between caries increment between 2 and 5 years of age and the presence of plaque, caries, oral health behaviour at 2 years of age and national background were explored using negative binomial regression analysis with caries increment between 2 and 5 years of age as the dependent variable. The goodness of fit was larger than 0.05, and the Omnibus test was $P < .05$ showing that the model fitted the data well. The level of statistical significance was set at 5%.

The study was performed as part of the quality assurance system required by law in the public dental services in Norway. Quality assurance and evaluation that are part of the health service do not require approval from ethical committees. All parents gave informed consent. Data analyses were conducted on anonymized data.

3 | RESULTS

In Table 1, clinical findings and reported oral health behaviours at 2 years of age are presented. Caries experience was registered in 4.6% of the children and 4.6% had visible plaque. Two-year-old children with a non-Western background more often had caries, visible plaque and unfavourable oral health behaviours compared with Western children ($P > .05$).

Table 2 shows mean number of teeth with caries experience at 2 years of age according to national background, presence of plaque, caries experience and oral health behaviour at 2 years of age in the 211 children followed longitudinally. At 2 years of age, 6.6% of the children had caries experience, and no children had filled or lost teeth because of caries. The mean number of teeth with caries experience was 0.3 (SD 1.4) teeth. Children with caries experience at 2 years of age (14 children) had on average 4.4 (SD 3.6) teeth with caries experience. Number of teeth with caries experience at 2 years of age was associated with having visible plaque, toothbrushing frequency, use of fluoride toothpaste, sugar drinks at night, sugar snacking and national background.

TABLE 1 Clinical findings, oral health behaviour and national background at 2 years of age. All children and children by national background (n = 392)

2 years of age	All children (n = 392) % (n)	Western children (n = 311) % (n)	Non-Western children (n = 81) % (n)
Caries experience*			
No	95.4 (375)	99.0 (309)	81.5 (66)
Yes	4.6 (17)	1.0 (2)	18.5 (15)
Visible plaque*			
No	95.4 (374)	98.1 (305)	85.2 (69)
Yes	4.6 (18)	1.9 (6)	14.8 (12)
Age when started tooth brushing[a]*			
<7 months	39.0 (120)	42.7 (108)	21.8 (12)
≥7 months	48.0 (188)	57.3 (145)	78.2 (43)
Toothbrushing frequency*			
Twice daily	57.9 (227)	57.9 (180)	58.0 (47)
Once daily	38.0 (149)	41.2 (128)	25.9 (21)
Less than daily	4.1 (16)	1.0 (3)	16.0 (13)
Fluoride toothpaste*			
Yes	97.4 (382)	98.4 (306)	93.8 (76)
No	2.6 (10)	1.6 (5)	6.2 (5)
Fluoride lozenges*			
Daily	46.2 (181)	50.5 (154)	33.3 (27)
Less than daily	53.8 (211)	49.5 (157)	66.7 (54)
Sugar drinks at night[a]*			
No	81.2 (311)	86.8 (264)	59.5 (47)
Yes	18.8 (72)	13.2 (40)	40.5 (32)
Sugar snacking[a]*			
Seldom/never	23.4 (90)	24.5 (75)	19.2 (15)
Sometimes	60.9 (234)	62.7 (192)	53.8 (42)
Daily	15.6 (60)	12.7 (39)	26.9 (21)
Background			
Western (ref)	79.3 (311)		
Non-Western	20.7 (81)	—	—

[a]Reduced because of internal dropout.
*$P < .05$.

In Table 2, mean number of teeth with caries experience at 5 years of age and mean number of teeth with increment in caries experience between 2 and 5 years of age according to national background, presence of plaque, caries and oral health behaviour at 2 years of age are presented. At 5 years of age, 28.9% of the children had caries experience. Children having caries experience at 2 years of age developed statistically significantly more caries than children without caries experience at 2 years of age (2.4 vs 0.7, $P < .05$). Caries increment was associated with clinical findings at

TABLE 2 Teeth with caries experience (dmft) at the ages 2 and 5 years and change in caries experience (Δ dmft) between 2 and 5 years of age according to clinical findings, oral health behaviour and national background at 2 years of age. Mean and standard deviations (SD). Children monitored from 2 to 5 years of age (n = 211)

2 years of age (n)	2 years dmft mean (SD)	5 years dmft mean (SD)	From 2 to 5 years Δ dmft mean (SD)
All children (211)	0.3 (1.4)	1.0 (2.5)	0.7 (1.9)
Caries experience			
No (197)	0.0 (0.0)	0.6 (1.8)	0.7 (1.8)
Yes (14)	4.4 (3.6)*	6.5 (4.7)*	2.4 (3.7)*
Visible plaque			
No (197)	0.1 (0.7)	0.8 (2.1)	0.6 (1.8)
Yes (14)	2.8 (4.3)*	4.6 (4.7)*	1.9 (3.1)*
Age when starting tooth brushing			
<7 months (81)	0.1 (0.8)	0.3 (1.0)	0.2 (0.5)
≥7 months (130)	0.4 (1.6)	1.4 (2.9)*	1.0 (2.3)*
Toothbrushing frequency			
Twice daily (118) (ref)	0.3 (1.6)	0.7 (2.2)	0.4 (1.6)
Once daily (80)	0.2 (1.2)	1.9 (2.2)	0.7 (1.5)
Less than daily (13)	0.7 (1.4)*	4.5 (4.4)*	3.9 (3.7)*
Fluoride toothpaste			
Yes (205)	0.2 (1.1)	0.9 (2.3)	0.6 (1.7)
No (6)	0.6 (1.4)*	5.8 (4.3)*	4.8 (3.9)*
Fluoride lozenges			
Daily (96)	0.4 (1.9)	1.0 (3.0)	0.5 (2.0)
Less than daily (115)	0.2 (0.9)	1.1 (2.1)*	0.9 (1.8)*
Sugar drinks at night			
No (164)	0.3 (1.5)	0.9 (2.5)	0.6 (1.8)
Yes (47)	0.4 (1.1)*	1.6 (2.8)*	1.2 (2.2)*
Sugar snacking			
Seldom/never (44) (ref)	0.0 (0.0)	0.2 (0.7)	0.2 (0.7)
Sometimes (130)	0.3 (1.5)	1.0 (2.4)*	0.7 (1.9)
Daily (37)	0.8 (1.8)*	2.2 (3.8)*	1.5 (2.7)*
Background			
Western (160)	0.1 (0.6)	0.3 (1.0)	0.3 (0.8)
Non-Western (51)	1.0 (2.6)*	3.2 (4.2)*	2.2 (3.2)*

*$P < .05$.
(ref) reference category.

2 years of age, oral health behaviour and national background. Children, who at 2 years of age did not use fluoridated toothpaste, brushed their teeth less than daily, and children with non-Western background had the highest increase in number of teeth with caries experience between 2 and 5 years of age.

Negative binomial regression analysis exploring the relationship of caries increment between 2 and 5 years of age with national background, presence of plaque, caries and oral health behaviour and at 2 years of age was performed (Table 3). Age when introducing toothbrushing, toothbrushing frequency at the age of 2 years and national background were associated with increment in caries experience between 2 and 5 years of age. The other included variables (visible plaque, caries experience, use of fluoride toothpaste, use of fluoride lozenges, sugary drinks at night and sugar snacking at 2 years of age) were not statistically significantly associated with increment in caries experience.

4 | DISCUSSION

This longitudinal study aimed to explore oral health in 2-year-old children and to measure increments in caries experience from 2 to 5 years of age. The findings showed that a small proportion of children had caries at 2 years of age. Age when introducing tooth brushing,

TABLE 3 Results from negative binomial regression analysis exploring the association between change in caries experience between 2 and 5 years of age and clinical findings, oral health behaviour and national background at 2 years of age (n = 211)

2 years of age	OR	95% CI
Visible plaque		
No	1	
Yes	0.3	0.1 - 1.1
Caries experience		
No	1	
Yes	1.2	0.5 - 2.9
Age when starting tooth brushing		
<7 months	1	
≥7 months	**2.1**	**1.1 - 4.2**
Toothbrushing frequency		
Twice daily	1	
Once daily	**2.1**	**1.2 - 3.7**
Less than daily	**4.8**	**1.6 - 13.9**
Fluoride toothpaste		
Yes	1	
No	1.5	0.3 - 6.9
Fluoride lozenges		
Daily	1	
Less than daily	1.5	0.9 - 2.7
Sugar drinks at night		
No	1	
Yes	1.2	0.7 - 2.0
Sugar snacking		
Seldom/never	1	
Sometimes	1.8	0.7 - 5.1
Daily	1.9	0.8 - 4.2
Background		
Western	1	
Non-Western	**5.4**	**3.0 - 10.0**

$P < .05$ in bold.

toothbrushing frequency at 2 years of age and national background were related to increment in caries experience from 2 to 5 years of age.

The study was performed in an area which the children in the Norwegian context had high caries prevalence, and a high proportion of children were classified as needing extended and individualized caries preventive care before the age of 3 years. Seventeen per cent of children invited to participate did not attend for the dental examination, and it has been shown that nonattenders have caries experience more often than other children.[25] The proportion of 2-year-old children with caries in the studied area may be higher than registered in this study because of nonattenders. Although some children did not participate, those who did were caries risk children, and the findings can be generalized to other areas with similar caries prevalence in young children.

Among children examined at 2 and 5 years of age, those with non-Western background and children who had caries at 2 years of age were overrepresented compared to children only examined at age 2 years. Thus, a higher proportion of caries risk children was included in the analyses of increment in caries experience. Data were mainly used to study associations, and selection bias has been shown not to influence associations between variables.[26] This study was based partly on questionnaires, and limitations such as nonresponses, misconceptions and errors like answering in a socially desirable way are present in all questionnaire studies.[27] The probability of recall and reporting error in the present study were considered limited as most questions were related to daily routine of oral health habits in young children. Dental students and dental hygienist students performed the clinical dental examinations of children using the established caries diagnostic methods used at the University of Oslo. Experienced dentists or dental hygienists verified all registrations.

The findings showed that only a small proportion of the children had caries at 2 years of age, and most of these had non-Western background. Non-Western children also had a higher probability of developing caries during preschool age than Western children. It is well established that immigrant children have higher caries prevalence than native children.[28] This study also showed that non-Western children acquire carious lesions at a lower age than do Western children, and by the age of 2 years, some children had developed several decayed teeth. Caries preventive care should ideally be provided before the children acquire carious lesions.[22] The reported differences in oral health behaviour between non-Western children and Western children may be due to cultural differences or that the parents did not understand the advice given, and indicate that non-Western parents need targeted oral health information. Oral health information is part of general health information given to all parents at well-baby clinics from the child's first weeks of life.[21] The findings showed that non-Western parents less often follow the advice given than Western parents.

At 2 years of age, 20% of the children were being given sugar-containing drinks each night and 16% of the children received sugary snacks daily. These findings indicate a frequent sugar intake among the children. Sugar is a main cause of dental caries in young children.[29] Children with a high sugar intake at a young age often maintain the high sugar intake during childhood,[15] which in turn is associated with poor dental health and poor general health in later life.[30]

The findings from the longitudinal follow-up study showed substantial increment in caries experience, especially in children who had caries lesions at 2 years of age. The findings were in line with a study from Australia showing a marked increase in caries experience between 18 and 40 months of age.[31] All included children were given an individualized caries preventive programme at 2 years of age. The findings showed that the preventive care delivered failed to prevent increment in caries experience in the studied children. The findings are in line with a newly published study from Ireland showing that biannual application of fluoride varnish did not keep children caries free during preschool age.[32]

Increment in caries experience was associated with age when introducing toothbrushing and toothbrushing frequency at 2 years of age. Tooth brushing with fluoridated toothpaste is widely accepted as a caries preventive method in children,[33] and infrequent brushers have been shown to have higher caries prevalence in the primary dentition.[17] We know that behaviours established at a young age are often maintained during childhood[34]; this includes oral health behaviours.[35]

Important finding from this study was that children who started toothbrushing late, children who did not brush their teeth daily by 2 years of age and children with non-Western background were caries risk children and had a high probability of having increment in caries experience during preschool age. The results from this study confirm that some parents find it difficult to establish toothbrushing twice daily for their child and that non-Western parents do not follow the oral health advice given. Such children should ideally be referred to dental personnel by primary care personnel earlier than at age 2 years for oral health advice so as to initiate favourable oral health behaviour and prevent the substantial increment in caries experience between 2 and 5 years of age. More research is necessary in children younger than 2 years of age to understand better parents' obstacles blocking favourable oral health behaviour in their children.

In conclusion, a minor proportion of 2-year-olds had caries experience, and the children with caries had several decayed teeth. The preventive care delivered to the studied children failed to prevent caries increment from 2 to 5 years of age.

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REFERENCES

1. Kuhnisch J, Ekstrand KR, Pretty I, et al. Best clinical practice guidance for management of early caries lesions in children and young adults: an EAPD policy document. *Eur Arch Paediatr Dent*. 2016;17:3-12.

2. Moimaz SA, Borges HC, Saliba O, Garbin CA, Saliba NA. Early childhood caries: epidemiology, severity and sociobehavioural determinants. *Oral Health Prev Dent*. 2016;14:77-83.
3. Wendt LK, Hallonsten AL, Koch G. Dental caries in one- and two-year-old children living in Sweden. Part I-a longitudinal study. *Swed Dent J*. 1991;15:1-6.
4. Anderson M, Dahllof G, Twetman S, Jansson L, Bergenlid AC, Grindefjord M. Effectiveness of early preventive intervention with semiannual fluoride varnish application in toddlers living in high-risk areas: a stratified cluster-randomized controlled trial. *Caries Res*. 2016;50:17-23.
5. Douglass JM, Tinanoff N, Tang JM, Altman DS. Dental caries patterns and oral health behaviors in Arizona infants and toddlers. *Community Dent Oral Epidemiol*. 2001;29:14-22.
6. Shashikiran ND. A step toward cavity-free future. *J Indian Soc Pedod Prev Dent*. 2014;32:195-196.
7. Monaghan N, Davies GM, Jones CM, Neville JS, Pitts NB. The caries experience of 5-year-old children in Scotland, Wales and England in 2011-2012: reports of cross-sectional surveys using BASCD criteria. *Community Dent Health*. 2014;31:105-110.
8. Statistics Norway. Dental status by age 2016. https://www.ssb.no/statistikkbanken/SelectTable/hovedtabellHjem.asp?KortNavnWeb=tannhelse&CMSSubjectArea=helse&StatVariant=&PLanguage=1&checked=true. Accessed December 21, 2017.
9. Leroy R, Bogaerts K, Martens L, Declerck D. Risk factors for caries incidence in a cohort of Flemish preschool children. *Clin Oral Investig*. 2012;16:805-812.
10. Meurman PK, Pienihäkkinen K. Factors associated with caries increment: a longitudinal study from 18 months to 5 years of age. *Caries Res*. 2010;44:519-524.
11. Harris R, Nicoll AD, Adair PM, Pine CM. Risk factors for dental caries in young children: a systematic review of the literature. *Community Dent Health*. 2004;21:71-85.
12. Leong PM, Gussy MG, Barrow SY, de Silva-Sanigorski A, Waters E. A systematic review of risk factors during first year of life for early childhood caries. *Int J Paediatr Dent*. 2013;23:235-250.
13. Grindefjord M, Dahllöf G, Modéer T. Caries development in children from 2.5 to 3.5 years of age: a longitudinal study. *Caries Res*. 1995;29:449-454.
14. Wigen TI, Espelid I, Skaare AB, Wang NJ. Family characteristics and caries experience in preschool children. A longitudinal study from pregnancy to 5 years of age. *Community Dent Oral Epidemiol*. 2011;39:311-317.
15. Ruottinen S, Karjalainen S, Pienihäkkinen K, et al. Sucrose intake since infancy and dental health in 10-year-old children. *Caries Res*. 2004;38:142-148.
16. Wigen TI, Wang NJ. Does early establishment of favorable oral health behavior influence caries prevalence at age 5 years? *Acta Odontol Scand*. 2015;73:182-187.
17. Kumar S, Tadakamadla J, Johnson NW. Effect of toothbrushing frequency on incidence and increment of dental caries: a systematic review and meta-analysis. *J Dent Res*. 2016;95:1230-1236.
18. Winter J, Glaser M, Heinzel-Gutenbrunner M, Pieper K. Association of caries increment in preschool children with nutritional and preventive variables. *Clin Oral Investig*. 2015;19:1913-1919.
19. Wendt LK, Hallonsten AL, Koch G. Oral health in pre-school children living in Sweden. Part III-A longitudinal study. Risk analyses based on caries prevalence at 3 years of age and immigrant status. *Swed Dent J*. 1999;23:17-25.
20. Andre Kramer AC, Skeie MS, Skaare AB, Espelid I, Ostberg AL. Caries increment in primary teeth from 3 to 6 years of age: a longitudinal study in Swedish children. *Eur Arch Paediatr Dent*. 2014;15:167-173.
21. The Norwegian Directorate of Health. Tenner for livet. Helsefremmende og forebyggende arbeid. [Teeth for life. Health promotion and health prevention]. IS-2659. Oslo, 1999.
22. American Academy of Pediatric Dentistry. Guideline on infant oral health care. *Pediatr Dent*. 2012;34:148-152.
23. Wigen TI, Wang NJ. Referral of young children to dental personnel by primary care nurses. *Int J Dent Hyg*. 2017;15:249-255.
24. Skeie MS, Espelid I, Skaare AB, Gimmestad A. Caries patterns in an urban preschool population in Norway. *Eur J Paediatr Dent*. 2005;6:16-22.
25. Wigen TI, Skaret E, Wang NJ. Dental avoidance behaviour in parent and child as risk indicators for caries in 5-year-old children. *Int J Paediatr Dent*. 2009;19:431-437.
26. Nilsen RM, Vollset SE, Gjessing HK, et al. Self-selection and bias in a large prospective pregnancy cohort in Norway. *Paediatr Perinat Epidemiol*. 2009;23:597-608.
27. Sjostrom O, Holst D, Lind SO. Validity of a questionnaire survey: the role of non-response and incorrect answers. *Acta Odontol Scand*. 1999;57:242-246.
28. Congiu G, Campus G, Luglie PF. Early childhood caries (ECC) prevalence and background factors: a review. *Oral Health Prev Dent*. 2014;12:71-76.
29. Sheiham A, James WP. Diet and dental caries: the pivotal role of free sugars reemphasized. *J Dent Res*. 2015;94:1341-1347.
30. Mishra MB, Mishra S. Sugar-sweetened beverages: general and oral health hazards in children and adolescents. *Int J Clin Pediatr Dent*. 2011;4:119-123.
31. Gussy M, Ashbolt R, Carpenter L, et al. Natural history of dental caries in very young Australian children. *Int J Paediatr Dent*. 2016;26:173-183.
32. Tickle M, O'Neill C, Donaldson M, et al. A randomized controlled trial of caries prevention in dental practice. *J Dent Res*. 2017;96:741-746.
33. Dos Santos AP, Nadanovsky P, de Oliveira BH. A systematic review and meta-analysis of the effects of fluoride toothpastes on the prevention of dental caries in the primary dentition of preschool children. *Community Dent Oral Epidemiol*. 2013;41:1-12.
34. Ouellette J, Wood W. Habit and intention in everyday life: the multiple process by which past behavior predicts future behavior. *Psychol Bull*. 1998;124:54-74.
35. Wigen TI, Wang NJ. Tooth brushing frequency and use of fluoride lozenges in children from 1.5 to 5 years of age. A longitudinal study. *Community Dent Oral Epidemiol*. 2014;42:395-403.

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Oral health behaviours in 12-year-olds. Association with caries and characteristics of the children?

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ABSTRACT

Objective: To explore frequency of tooth brushing, dental flossing, fluoride supplements and sugar snacking in 12-year-olds, and to study how these oral health behaviours were associated with background characteristics and caries prevalence.

Material and methods: The study included 4779 children. Data were collected by clinical examination and questionnaires regarding oral health behaviours and child characteristics. Informed consent was obtained from all participants. Data were tested using Chi-square statistics and analyzed by logistic regression. The study was ethically approved.

Results: Of the children, 81% brushed twice daily, 36% flossed once a week or more often, 39% used fluoride supplements daily and 48% consumed sugar between meals once a week or less often. Children who brushed twice daily more often flossed regularly, used fluoride daily and consumed sugar between meals less often than other children ($p < .05$). Girls and children whose parents had long education more often had favourable oral health behaviours than other children; brushed more frequently, more often used floss and fluoride supplements and consumed sugary snacks less often than other children ($p < .05$). In total, 40% of the children were caries-free. Children who brushed less than twice daily had more often caries than other children (OR 1.50, CI 1.29–1.74) when controlling for background characteristics and other oral health behaviours.

Conclusions: The majority of children brushed twice daily and these children had caries less often than other children. The use of dental floss, fluoride supplements or sugar snacking in addition to brushing twice daily, did not reduce the probability of having caries.

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Introduction

Dental caries is a lifestyle disease and may be prevented by removal of dental plaque, exposure to fluoride and avoiding frequent sugary intake [1,2]. Caries prevalence in Western countries has declined in recent decades, but persists as a health problem that affects individuals during their life course [3,4]. Parents have responsibility for children's oral health behaviours up to the age of 10–12 years. After this age, children should be able to maintain their own oral health, but the possibility of doing so is dependent on already established behaviours [5].

Tooth brushing twice daily with fluoridated toothpaste is considered the basic oral self-care behaviour for maintenance of good oral health [6], and is recommended for all individuals to prevent caries [2,7]. About 70% of 10–14-year-olds are reported to brush more than once daily [8,9]. Few studies have focussed on the use of dental floss in teenagers and their frequency of daily flossing is reported to be less than 20% [10,11]. The quality of studies regarding flossing has been considered low and evidence for caries preventive effect inconsistent [12,13].

The use of fluoride supplements such as rinse and lozenges among children varies worldwide. In most countries in Europe and in the US, fluoride supplements are recommended for children considered to be at elevated risk of developing caries and for children who do not use fluoride toothpaste [2,7,14,15]. In Norway, fluoride supplements were recommended for all children until 1996 when risk-based use of fluoride supplements was introduced [16]. There is no water fluoridation in Norway and the fluoride content naturally occurring in water is low.

Frequent intake of sugary food has been considered a major risk factor for caries development [1,17,18]. More research is needed to explore association between sugar snacking and other oral health behaviours and caries in children and adolescents.

Children's caries status has been shown to be associated with background characteristics [19]. Children whose parents had short education, non-Western background, were not living with both parents, have been reported to have more caries than other children [20–22]. The reason for this difference

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is not fully understood, but differences in oral health behaviours may be one explanation.

At the age of 12 years, permanent teeth erupt, approximal contacts are established and responsibility for oral health behaviours is gradually transferred from parents to children. There may be lifelong consequences for oral and general health if favourable oral health behaviours are not established and caries has developed at this age [1,23].

The aim of this study was to explore frequency of tooth brushing, dental flossing, use of fluoride supplements and sugar snacking in 12-year-olds, and to study how these oral health behaviours were associated with background characteristics and caries prevalence.

Material and methods

Study population and sampling procedure

In Norway, all children and adolescents under 19 years of age are entitled to free dental care in the dental services [24], and 97% of the children were enrolled in the services [25].

All 12-year-old children (7595 children) born in 2002 in one Norwegian county (Akershus) which comprised 11% of the Norwegian population [26] were in 2014 invited to participate in the study at the time of their regular dental examination. In total, 4779 children were included. The socio-economic information obtained from the parents was compaired with the national database, and socio-economic factors in the studied children was similar to national average [27,28]. The proportion of 12-year-old children without dentine caries in the studied county was similar to national average (63% versus 60%) [29].

Methods

Data were collected by clinical examination and questionnaire. The children assisted by parents completed a questionnaire regarding oral health behaviours and background characteristics of the children.

Tooth brushing frequency was reported as twice daily, once daily, sometimes and never and dichotomized as twice daily (favourable) and once daily or less often (unfavourable).

The use of dental floss was reported as daily, several times a week, once a week and less often, and dichotomized as once a week or more often (favourable) and less often than once a week (unfavourable).

The use of fluoride lozenges and fluoride mouthrinses were reported as daily, sometimes and never. Lozenges and rinses were combined into one variable; fluoride supplements and dichotomized as using lozenges and/or rinses daily (favourable) and less often than daily (unfavourable).

Consumption of sugar-containing drinks and sugary snacks was reported as less often than once a week, once a week, several times a week or several times a day. Drinks and foods were combined into one variable, sugar snacking and dichotomized as consuming sugary drinks and/or foods once a week or less often (favourable) and several times a week (unfavourable).

Characteristics of the children included gender, parents' origin, parents' education and family status. Origin of the parents was recorded as mother and father's country of birth. In the analyses, mother and father's origin was combined into one variable and dichotomized as both parents having Western origin and one or both having non-Western origin. Non-Western origin included parents born in Asia, Africa, South America, Central America and Eastern Europe.

Mother and father's education was measured as number of years at school. More than 12 years at school was defined as long education and 12 years or less was defined as short education. Mother and father's education was combined into one variable and dichotomized as both parents having long education and one or both parents having short education.

Family status was dichotomized as children living in nuclear families and children living in single-parent families comprising mostly living with mother, mostly with father and in shared custody.

The clinical examinations including bitewing radiographs were performed by dental hygienists or dentists in dental clinics using mirror and probe after teeth had been dried with air. Caries was reported at tooth level. Teeth were registered and given codes using the DMFT index. Caries lesions extending to dentine were recorded and children dichotomized as caries-free and having caries.

Intra- and inter-examiner agreement

Written and oral information about the clinical caries criteria was given to and discussed with the examiners before data collection started. Agreement was examined using eight bitewing radiographs of permanent molars including 12 approximal surfaces in each radiograph. A 'gold standard' was developed based on the second and third authors' registrations and compared with the examiners' registrations. Intra- and inter-examiner agreements were calculated using Cohen's kappa [30]. Mean intra-examiner and inter-examiner values were 0.69 (SD 0.16) and 0.69 (SD 0.17). Cohen's kappa values were categorized as substantial to almost perfect [30].

Ethical considerations

Written, informed consent was obtained from all parents. The investigation was approved by the Regional Committee for Medical Research Ethics in South-Eastern Norway (2013/1881).

Data analyses

The statistical analyses were performed using the Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, NY)). Data were cross-tabulated and tested with Chi-square statistics. Bivariable and multivariable logistic regression analyses were conducted with children's oral health behaviours and dentine caries prevalence as the dependent variables. Results were reported using odds ratio (OR) and 95% confidence interval (CI). Spearman's correlation was used to explore associations between the

Table 1. Characteristics of the 12-year-old children ($n = 4779$).

	%	(*n*)
Gender		
Girl	49	(2319)
Boy	51	(2460)
Parents' origin		
Both Western	81	(3879)
One or both non-Western	19	(900)
Parents' education[a]		
Both long	54	(2562)
One or both short	46	(2200)
Family status[a]		
Nuclear family	76	(3644)
Single-parent family	24	(1129)

[a]Reduced number because of internal drop-out.

Table 2. Proportion and number of children according to frequency of oral health behaviours ($n = 4779$).

	%	(*n*)
Brushing		
Twice daily	81	(3867)
Once daily or less	19	(912)
Flossing[a]		
Once a week or more often	36	(1726)
Less than once a week	64	(3016)
Fluoride supplements[a]		
Daily	39	(1842)
Less than daily	61	(2905)
Snacking[a]		
Once a week or less	48	(2292)
Several times a week	52	(2458)

[a]Reduced number because of internal drop-out.

independent variables before the multivariable analyses were conducted. The level of statistical significance was set at 5%.

Results

In Table 1, characteristics of the 12-year-old children are presented. The majority lived in nuclear families and had parents of Western origin. Half of the children had parents with long education.

Table 2 describes the oral health behaviours in children. The majority (81%) brushed twice daily, while one-third used dental floss at least once a week and fluoride supplements daily. Half of the children reported unfavourable sugar snacking behaviours.

Figure 1 shows the number of favourable oral health behaviours reported by the children. One third reported having more than two favourable oral health behaviours, and only 6% reported no favourable behaviours.

Table 3 shows associations between brushing frequency and other oral health behaviours. A higher proportion of children brushing twice daily reported more often other favourable oral health behaviours than children who brushed less than twice daily.

Table 4 shows results from the four multivariable analyses exploring associations between oral health behaviours and characteristics of the children. Brushing, flossing and use of fluoride supplements were associated with all child characteristics. Sugar snacking was associated with gender and parental education.

Table 5 shows results of bivariable and multivariable logistic regression analyses exploring associations between caries

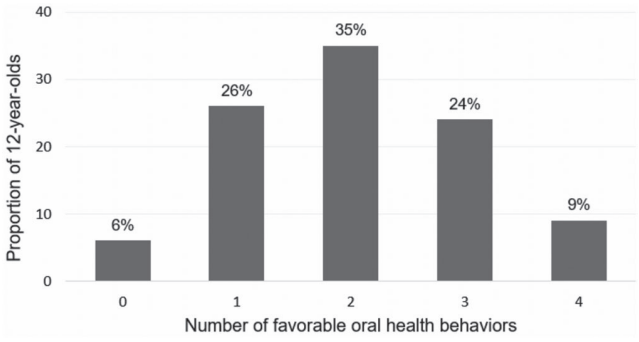

Figure 1. Proportion of 12-year-olds according to number of favourable oral health behaviours.

Table 3. Proportion of children using dental floss, fluoride supplements and sugar snacking according to tooth brushing frequency ($n = 4779$).

		Tooth brushing		
	All children % (*n*)	Twice daily %	Once daily or less %	*p*
Flossing[a]				
Once a week or more often	36 (1726)	85	15	
Less than once a week	64 (3016)	79	21	<.05
Fluoride supplements[a]				
Daily	39 (1842)	86	15	
Less than daily	61 (2905)	78	22	<.05
Snacking[a]				
Once a week or less	48 (2292)	83	17	
Several times a week	52 (2458)	79	21	<.05

[a]Reduced number because of internal drop-out.

prevalence, oral health behaviours and characteristics of the children. Of the studied children, 35% had caries extending into dentine. In the bivariable analyses, tooth brushing frequency, use of fluoride supplements, frequency of sugar snacking, parents' origin, parents' education and family status were associated with having caries. The results of the multivariable analysis showed that children who brushed seldom had a higher probability of having dentine caries than other children (OR 1.50, CI 1.29–1.74). None of the other oral health behaviours was associated with caries prevalence. Parental origin and parental education were associated with caries prevalence. Children having one or both parents with non-Western origin (OR 1.76, CI 1.51–2.04) or short education (OR 1.40, CI 1.23–1.58) had a higher probability of having caries than other children.

Discussion

The purpose of this study was to explore oral health behaviours in 12-year-old children and to study associations between brushing, flossing, use of fluoride supplements, sugar snacking, characteristics of the children and caries prevalence. The main findings were that a majority brushed twice daily and that these children more seldom had caries than other children. In addition, nearly half of the children reported one or more other favourable oral health behaviours, but these behaviours were not associated with caries prevalence.

This study was based on data from the dental services and included a large group of 12-year-olds. One-third of the

Table 4. Tooth brushing frequency, use of dental floss, use of fluoride supplements and sugar snacking related to characteristics of the children.

	Brushing less than daily ($n = 4757$)	Flossing[a] less than once a week ($n = 4720$)	Fluoride supplements[a] less than daily ($n = 4725$)	Snacking[a] less than once a week ($n = 4729$)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gender				
Girl (ref)				
Boy	**1.37 (1.18–1.58)**	**1.31 (1.16–1.47)**	**0.86 (0.76–0.96)**	**1.19 (1.06–1.34)**
Parents' origin				
Both Western (ref)				
One or both non-Western	**1.24 (1.04–1.49)**	**0.79 (0.68–0.92)**	**1.18 (1.01–1.38)**	0.90 (0.78–1.05)
Parents' education[†]				
Both long (ref)				
One or both short	**1.44 (1.24–1.67)**	**1.32 (1.17–1.49)**	**1.35 (1.20–1.53)**	**1.37 (1.22–1.55)**
Family status[a]				
Nuclear family (ref)				
Single-parent family	**1.68 (1.43–1.97)**	**1.35 (1.17–1.56)**	**1.24 (1.08–1.44)**	1.08 (0.94–1.24)

ref: reference category. Statistically significant results ($p<.05$) marked in bold. Multivariable logistic regression analyses.
[a]Reduced number because of internal drop-out.

Table 5. Children with caries related to oral health behaviours and characteristics of the children.

	Children with caries	
	Bivariable ($n = 4779$)	Multivariable ($n = 4681$[a])
	OR (95% CI)	OR (95% CI)
Brushing		
Twice daily (ref)		
Once daily or less	**1.59 (1.38–1.84)**	**1.50 (1.29–1.74)**
Flossing[a]		
Once a week or more often (ref)		
Less than once a week	1.00 (0.88–1.12)	0.93 (0.82–1.06)
Fluoride supplements[a]		
Daily (ref)		
Less than daily	**1.18 (1.05–1.34)**	1.09 (0.96–1.24)
Snacking[a]		
Once a week or less (ref)		
Several times a week	**1.17 (1.04–1.31)**	1.12 (0.99–1.27)
Gender		
Girl (ref)		
Boy	0.94 (0.83–1.05)	0.91 (0.81–1.03)
Parents' origin		
Both Western (ref)		
One or both non-Western	**1.94 (1.68–2.25)**	**1.76 (1.51–2.04)**
Parents' education[a]		
Both long (ref)		
One or both short	**1.58 (1.40–1.78)**	**1.40 (1.23–1.58)**
Family status[a]		
Nuclear family (ref)		
Single-parent family	**1.25 (1.09–1.43)**	1.14 (0.99–1.32)

ref: reference category. Statistically significant ($p<.05$) results marked in bold. Bivariable and multivariable logistic regression analyses.
[a]Reduced number because of internal drop-out.

invited children did not participate, non-attenders were children who refused to participate, did not show up for the scheduled examination and children who the dental clinicians forgot to invite. Non-participation may cause selection bias. Selection bias may influence the level of the variables, but has been shown to a lesser extent to influence associations between the variables [31]. In the studied children, parents' origin, educational level and caries prevalence did not differ from the national average [27–29]. It was reasonable to assume that the results from the study were representative for the country in general. The present study was partly based on questionnaires. Limitations such as nonresponse, misconceptions and errors like giving answers that are socially acceptable are present in all questionnaire studies. The probability of reporting errors in the present study was considered limited as most questions were related to daily routine of oral health behaviours in children and self-reporting of oral health behaviours has been shown to be a valid measurement [32]. Experienced dentists or dental hygienists performed the clinical examinations of the children. Calibration of clinicians showed substantial intra- and interexaminer agreement [30].

The results showed that the majority of children brushed twice daily. The proportion who reported brushing was slightly higher than previously reported [10]. Several studies have shown that tooth brushing frequency has increased among schoolchildren in many countries [8,33]. The present study showed that one of the five children did not perform the recommended brushing twice daily, and brushing frequency was associated with caries prevalence. It has been well documented that tooth brushing with fluoridated toothpaste is an effective caries-preventive method [2]. Children who reported brushing twice daily more often reported other favourable behaviours indicating that brushing behaviours is important for chance of establishing other favourable oral health behaviours. Brushing frequency was associated with child characteristics, showing that some children may need tailored oral health advice to be able to establish favourable brushing behaviour.

One-third of the children in the present study reported flossing more than once a week. Few studies have reported the use of dental floss in teenagers and the frequency of use varies [10,11,13]. The results showed no association between flossing and having caries at 12-year of age when controlled for the other oral health behaviours and characteristics of the children. It has been shown that the use of dental floss or interdental brushes in addition to tooth brushing may reduce interproximal gingivitis or plaque more than tooth brushing alone, but the evidence for use of dental floss to prevent caries development is limited [12].

In this study, nearly half of the 12-year-old children used fluoride supplements daily. The results from the present study found no association between this behaviour and caries prevalence. The scientific evidence for fluoride supplements in caries prevention is poor, and there is no support in recent research that the use of fluoride supplements

prevents additional caries in children who use fluoridated toothpaste [14].

More than half of the 12-year-olds reported sugar snacking several times a week. Frequent sugar consumption has been associated with caries development [1], though studies including children and adolescents have shown contradictory results [34]. These findings have been explained by methodological differences in study design and recording of sugar intake. In this study, sugar snacking was not associated with caries prevalence in the multivariable analysis, suggesting that tooth brushing frequency should be emphasized when informing children about caries prevention.

The results show that characteristics of the children were associated with oral health behaviours and caries prevalence. Socioeconomic factors have been shown to influence children's oral health [9,19]. Children of parents with short education or non-Western origin are reported to have higher caries prevalence than other children [21,22]. The present results confirmed these findings and show that though 12-years-old are starting to behave independently, family background still influences children's oral health behaviours and caries prevalence.

This study shows that although all children in Norway are recalled regularly for individualized oral health care, socioeconomic inequalities in oral health behaviours and caries prevalence still exist. Establishing favourable brushing routines before the eruption of permanent teeth seems to be the most effective preventive oral health behaviour as brushing was associated with caries prevalence controlled for other oral health behaviours. Regularly performed tooth brushing before age 12 years often will become a lifelong routine as previous behaviours predict future behaviours [35].

In conclusion, favourable tooth brushing behaviours were established in the majority of 12-year-olds. Children with unfavourable brushing behaviours, having parents with non-Western background or short education were caries risk children. The use of dental floss, fluoride supplements or sugar snacking was not associated with caries prevalence.

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References

[1] Moynihan P. Sugars and dental caries: evidence for setting a recommended threshold for intake. Adv Nutr. 2016;7(1):149–156.
[2] Walsh T, Worthington HV, Glenny AM, et al. Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst Rev. 2019;(3):CD007868.
[3] Sheiham A. Oral health, general health and quality of life. Bull World Health Organ. 2005;83(9):644.
[4] Kassebaum NJ, Smith AGC, Bernabé E, GBD 2015 Oral Health Collaborators, et al. Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990–2015: a systematic analysis for the global burden of diseases, injuries, and risk factors. J Dent Res. 2017;96(4):380–387.
[5] Christensen P. The health-promoting family: a conceptual framework for future research. Soc Sci Med. 2004;59(2):377–387.
[6] Kumar S, Tadakamadla J, Johnson NW. Effect of toothbrushing frequency on incidence and increment of dental caries: a systematic review and meta-analysis. J Dent Res. 2016;95(11):1230–1236.
[7] Toumba KJ, Twetman S, Splieth C, et al. Guidelines on the use of fluoride for caries prevention in children: an updated EAPD policy document. Eur Arch Paediatr Dent. 2019;20(6):507–516.
[8] Honkala S, Vereecken C, Niclasen B, et al. Trends in toothbrushing in 20 countries/regions from 1994 to 2010. Eur J Public Health. 2015;25(Suppl 2):20–23.
[9] Inchley J, Currie D, Young T. WHO. Growing up unequal: gender and socioeconomic differences in young people's health and well-being. HBSC study (2013/2014 survey). [cited 2020]. Available from: https://www.euro.who.int/en/publications/abstracts/growing-up-unequal.-hbsc-2016-study-20132014-survey.
[10] Kuusela S, Honkala E, Kannas L, et al. Oral hygiene habits of 11-year-old schoolchildren in 22 European countries and Canada in 1993/1994. J Dent Res. 1997;76(9):1602–1609.
[11] Wigen TI, Wang NJ. Characteristics of teenagers who use dental floss. Community Dent Health. 2020;37:1–5.
[12] Worthington HV, MacDonald L, Poklepovic PT, et al. Home use of interdental cleaning devices, in addition to toothbrushing, for preventing and controlling periodontal diseases and dental caries. Cochrane Database Syst Rev. 2019;4:CD012018.
[13] Hujoel PP, Cunha-Cruz J, Banting DW, et al. Dental flossing and interproximal caries: a systematic review. J Dent Res. 2006;85(4):298–305.
[14] Tubert-Jeannin S, Auclair C, Amsallem E, et al. Fluoride supplements (tablets, drops, lozenges or chewing gums) for preventing dental caries in children. Cochrane Database Syst Rev. 2011;12:CD007592.
[15] The Norwegian Directorate of Health. Dental health services for children and adolescents 0-20 years; [cited 2020]. Available from: https://www.helsedirektoratet.no/retningslinjer/tannhelsetjenester-til-barn-og-unge-020-ar.
[16] The Norwegian Directorate of Health. Teeth for life-Health promotion and health prevention; [cited 2020]. Available from: https://www.uio.no/studier/emner/odont/tannlege/OD3200/v15/pensumliste/tenner-for-livet-helsefremmende-og-forebyggende-arbeid-is-2659.pdf.
[17] Sohn W, Burt BA, Sowers MR. Carbonated soft drinks and dental caries in the primary dentition. J Dent Res. 2006;85(3):262–266.
[18] Sheiham A, James WP. Diet and dental caries: the pivotal role of free sugars reemphasized. J Dent Res. 2015;94(10):1341–1347.
[19] Petersen PE, Bourgeois D, Ogawa H, et al. The global burden of oral diseases and risks to oral health. Bull World Health Organ. 2005;83(9):661–669.
[20] Wigen TI, Espelid I, Skaare AB, et al. Family characteristics and caries experience in preschool children. A longitudinal study from pregnancy to 5 years of age. Community Dent Oral Epidemiol. 2011;39(4):311–317.
[21] Rouxel P, Chandola T. Socioeconomic and ethnic inequalities in oral health among children and adolescents living in England, Wales and Northern Ireland. Community Dent Oral Epidemiol. 2018;46(5):426–434.
[22] Christensen LB, Twetman S, Sundby A. Oral health in children and adolescents with different socio-cultural and socio-economic backgrounds. Acta Odontol Scand. 2010;68(1):34–42.

[23] Gift HC, Atchison KA. Oral health, health, and health-related quality of life. Med Care. 1995;33(11):57–77.
[24] Norwegian legislation. The dental health services act. Lovdata 1984. [cited 2020]. Available from: https://lovdata.no/dokument/NL/lov/1983-06-03-54?q=LOV-1983-06-03-54.
[25] Statistics Norway. Dental health care. Patient treatment in public dental health care, by patient group. Statistisk sentralbyrå. [cited 2020]. Available from: https://www.ssb.no/statbank/table/11961/tableViewLayout1/.
[26] Statistics Norway. Population 2014. Statistisk sentralbyrå. [cited 2020]. Available from: https://www.ssb.no/en/statbank/table/06913/tableViewLayout1/.
[27] Statistics Norway. Distribution of the immigrant population. Statistisk sentralbyrå. [cited 2020]. Available from: https://www.ssb.no/befolkning.
[28] Statistics Norway. Educational attainment of the population. Statistisk sentralbyrå. [cited 2021]. Available from: https://www.ssb.no/en/statbank/table/09429/.
[29] Statistics Norway. Dental health service. Key figures by region, statistical variable and year. Statistisk sentralbyrå. [cited 2020]. Available from: https://www.ssb.no/en/statbank/table/04920/tableViewLayout1/.
[30] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159–174.
[31] Nilsen RM, Vollset SE, Gjessing HK, et al. Self-selection and bias in a large prospective pregnancy cohort in Norway. Paediatr Perinat Epidemiol. 2009;23(6):597–608.
[32] Sjöström O, Holst D. Validity of a questionnaire survey: response patterns in different subgroups and the effect of social desirability. Acta Odontol Scand. 2002;60(3):136–140.
[33] Maes L, Vereecken C, Vanobbergen J, et al. Tooth brushing and social characteristics of families in 32 countries. Int Dent J. 2006;56(3):159–167.
[34] Swedish Agency for Health Technology Assessment and Assessment of Social Services. Preventing dental caries. a systematic review; 2002. Available from: https://www.sbu.se/en/publications/sbu-assesses/preventing-dental-caries/.
[35] Ouellette JA, Wood W. Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. Psychol Bull. 1998;124(1):54–74.

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