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Dental anxiety in adolescents and adults

Epidemiological studies based on the Tromsø Study 7 and Fit Futures 1 & 2

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ABBREVIATIONS

BII	Blood-injection-injury
BOP	Bleeding on probing
CBT	Cognitive Behaviour Therapy
DAS	Corah's Dental Anxiety Scale
CI	Confidence Interval
Df	Degrees of freedom
DMF(T or S)	Decayed, Missing, Filled (Teeth or Surfaces)
FF1	Fit Futures 1
FF2	Fit Futures 2
HSCL	Hopkins Symptom Check List
IQR	Interquartile range
MCAR	Missing Completely At Random
MDAS	The Modified Dental Anxiety Scale
MEG	Magnetoencephalography
NOK	Norwegian krone
PTE	Potentially Traumatic Event
PTSD	Post-traumatic Stress Disorder
REC	Regional Committee of Medical and Health Research Ethics
SD	Standard Deviation

SSB	The Norwegian Statistical Central Agency
TOO	Tortur, Overgrep og/eller Odontofobi
UNN	The University Hospital of Northern Norway
Vg1	First-year of upper secondary school (Vidregående trinn 1)
WMA	The World Medical Association

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PREFACE

Historically the dental health services in Norway has not offered a systematic and standardised treatment of dental anxiety. The management of dental anxiety has been limited to the dentists' toolboxes, mainly resorting to sedation. While there existed a local competence in treating dental anxiety at the institute of clinical odontology in Bergen and the following establishment of a nationally organised interest group for odontophobia (NOFOBI), the principal goal for most dentists in regular clinical practice was enabling dental treatment for the current treatment need, not reducing dental anxiety. In 2012, the Norwegian Directorate of Health started to appropriate money to fund treatment, education, and research in adult patients who have been victims of torture and abuse and dental phobia patients. This initiative, called the TOO project (1), was advocated by a notion that people belonging to these clinical groups are unable to make use of the dental health care services. Therefore, the project's overarching goal was to provide equal access to health care for these patient groups. The treatment approach is interdisciplinary, where dental professionals and psychologists work with the patient to reduce the anxiety so that it becomes possible to carry out dental treatment.

The interdisciplinary collaboration broadened the perspective beyond the current dental treatment need. Treatment goals changed from adapting the dental treatment in anxious patients to reducing anxiety, making standard dental treatment possible. While this might seem like mostly different semantics, they are entirely different treatment paradigms.

The TOO project is ongoing to this day, and the project has funded the work behind this thesis at the Public Dental Health Service Competence Centre of Northern Norway and the Department of Clinical Dentistry, Faculty of Health Sciences, UiT Arctic University of Tromsø.

The Norwegian Directorate of Health published a consultation draft 14.02.2020 for the dental health services, recommending that all children in all counties have equal access to interdisciplinary treatment similar to what adults have in the TOO project. The consultation draft is currently under processing, and the final national recommendations are expected this year (2).

LIST OF PAPERS

- I. **Nermo, H.,** Willumsen, T., & Johnsen, J. -A. K. Prevalence of dental anxiety and associations with oral health, psychological distress, avoidance, and anticipated pain in adolescence: a cross-sectional study based on the Tromsø Study, Fit Futures, *Acta Odontol. Scand.* 2018 Oct; 77 (2): 126-134.
- II. **Nermo, H.,** Willumsen, T., & Johnsen, J. -A. K. Changes in dental anxiety among 15- to 21-year-olds. A 2-year longitudinal analysis based on the Tromsø study: Fit futures. *Community Dent Oral Epidemiol.* 2018 Nov; 47(2): 127-133.
- III. **Nermo, H.,** Willumsen, T., Kamilla, R., Thimm, J., Wang, C. E. A, Johnsen, J. -A. K. Dental anxiety and traumatic life events: an epidemiological study based on the Tromsø Study: Tromsø 7. In Review. Preprint available from <https://doi.org/10.21203/rs.3.rs-426613/v1>

ABSTRACT

The consequences of dental anxiety and longstanding anxiety-related avoidance of dental treatment are often detrimental and not limited to poorer oral health; it can jeopardise general health and wellbeing. The present thesis aims to describe dental anxiety among adolescents and adults. Seeking answers to questions about what maintains high dental anxiety among adolescents and explore the potential effect of traumatic life events outside the dental setting on dental anxiety in the adult population.

Paper I (Fit Futures 1 - FF1). High dental anxiety (dental anxiety score ≥ 13) was reported by 11.6% of the adolescents. This study found no significant difference between the dentally anxious and those with lower dental anxiety scores on dental caries, psychological distress, and questions related to self-motivation concerning oral health and knowledge. However, there were significant differences among those with high or low dental anxiety concerning anticipated pain at the dentist, avoidance of dental treatment, social motivation concerning oral health, control belief, and sex.

Paper II (Fit Futures 2 - FF2). Although the mean dental anxiety level decreased over two years (median changed from DAS 7 to DAS 6), the proportion of individuals reporting high dental anxiety (≥ 13) was unchanged and marginally increased for individuals with a dental anxiety score ≥ 15 (from 5.7% in FF1 to 6.4% in FF2). First wave measures (FF1) of dental anxiety, psychological distress, and dental caries significantly predicted high dental anxiety two years later. Nonetheless, the fascinating finding in this study was that more dental caries also significantly predicted reduced dental anxiety. Anticipated pain at the dentist changed in both directions in correspondence with changes in dental anxiety scores, implying that treatment needs offer an opportunity to provide treatment that reduces dental anxiety.

Paper III (The Tromsø Study 7). High dental anxiety was reported by 2.9% of the sample and was most prevalent among women and the youngest age groups. Individuals with high dental anxiety reported more mental health symptoms, and they were more likely to report poorer oral health and irregular dental visits than individuals with no or lower dental anxiety scores. Concerning traumatic life events, the reporting of painful or frightening dental treatment showed the biggest difference between those with high dental anxiety and low dental anxiety scores (a moderate effect). The hierarchical regression model indicated that reporting sexual abuse, traumatic medical treatment in hospital, and childhood neglect

significantly predicted dental anxiety in their entered step. Only sexual abuse remained a significant individual contributor after controlling for current mental health symptoms.

The overall results underline the need for familiarity with trauma-sensitive care among dental health care professionals and that standard dental treatment has the potential for reducing mild and moderate dental anxiety in adolescents. However, while beneficial for most adolescents, existing dental care and prevention is insufficient for reducing dental anxiety in highly anxious individuals.

1 INTRODUCTION

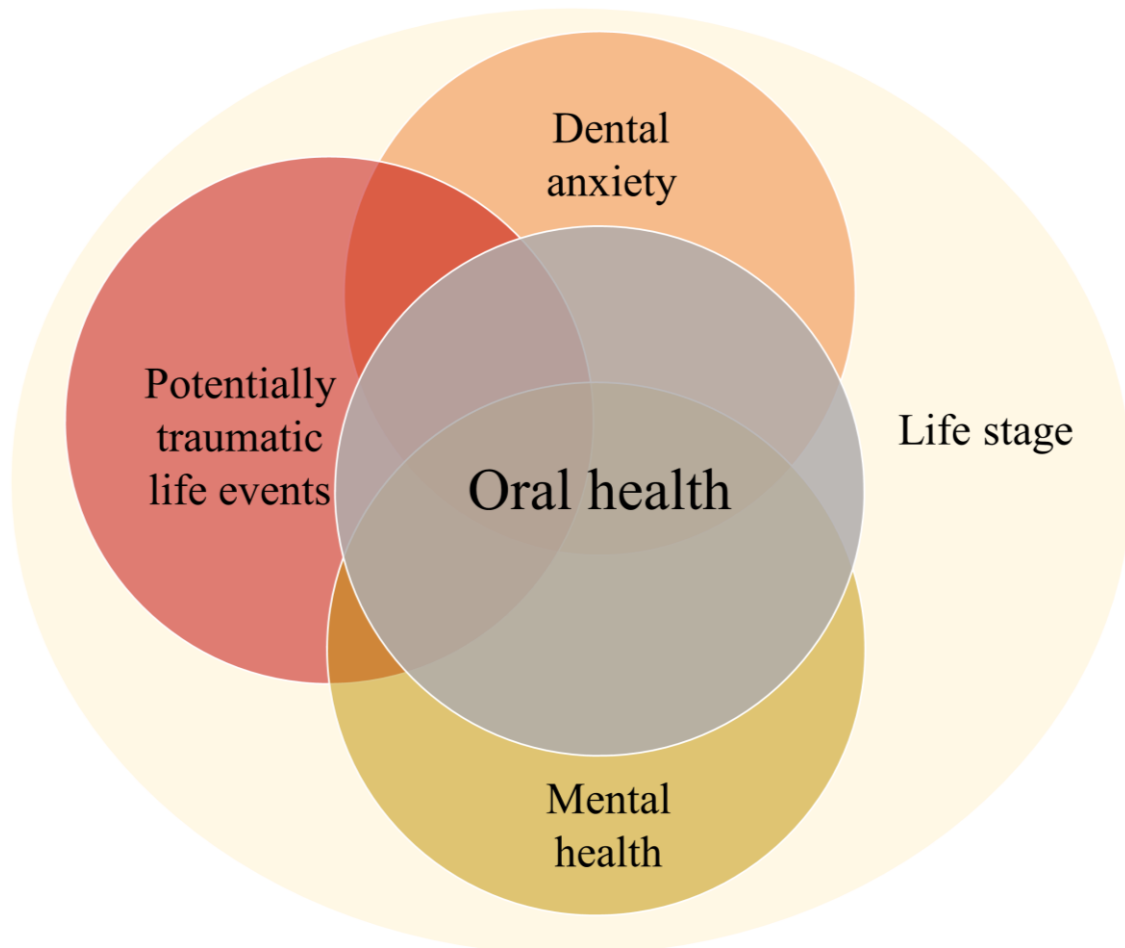
This thesis address topics with a high impact on oral health (Figure 1). Despite the decline in dental caries in high-income countries (3), the burden and cost of oral diseases remain high worldwide (4, 5). If anything, the inequalities of oral diseases are more evident than ever, disproportionally affecting marginalised groups in society (5). In addition, oral diseases share common risk factors with other non-communicable diseases (5, 6). Oral diseases like dental caries are irreversible and follow the individual through the lifespan. Consequently, early preventive interventions and early detection and treatment are essential.

Dental anxiety and the subsequent inability to utilize dental health services can result in poor oral health (7, 8), which may be especially burdensome considering the psychosocial aspects of dental anxiety and accompanying fear of social evaluation (9). Good oral health includes more than the absence of oral diseases and oral pain (10), as it includes the ability to speak, aesthetics (11), and quality of life (12, 13). In other words, oral health affects social and mental wellbeing.

The prevalence of high dental anxiety in the general population has been explored without concurrently considering the impact of traumatic experiences, oral and mental health symptoms. However, high dental anxiety is more prevalent among victims of sexual abuse (14) and torture (15) than in the general population, and interpersonal traumas are directly related to poorer physical health (16). Adverse childhood experiences substantially affect mental and physical health (17-19), including oral health (20-24). Consequently, one could be inclined to theorise that traumas outside the dental setting, in this text referred to as “potentially traumatic events” (PTEs), can be generalised to affect the perception of dental treatment and oral health among trauma survivors. Studies on abused women have shown that traumas of similar invasive character, especially those related to the oral cavity, are important (14, 25). However, there is scarce evidence about the association between sexual abuse and dental anxiety in the general population (26-28). Considering the burden that adverse trauma constitutes to the individual, not addressing the consequences on oral health and potential

difficulties in receiving dental treatment adds to their future risk of disease and social marginalisation (5, 6, 29, 30).

Figure 1. Theoretical interconnected concepts explored in this thesis



Oral health

“The mouth really is a marker of people’s social position and future disease risk” – Richard Watt (31).

Dental caries affects over 80 % of the adult population (4). There has been a decline in caries prevalence due to the use of fluoride in many industrialised countries (3). However, the young adult Norwegian population has high caries activity (4), and caries is still the leading cause of orofacial pain and tooth loss (32). Thus, establishing and maintaining good oral health by preventing caries is an important public health issue (32). The World Dental Federation’s

definition of oral health (10) underlines oral health as an integral part of general health-related physical, psychological, and social wellbeing. Oral health and dental diseases affect more than the ability to chew—it is essential for social abilities, for instance, how to communicate, smile, and express emotions. That is why a deteriorated dentition could have a considerable impact on a person's mental health, quality of life, and wellbeing (6, 33-35). People's health behaviour, and therefore the burden of disease, is a result of the social, cultural, and economic environment. Oral disease affects populations on a social gradient (36), while most adults have caries; severity and extent of oral disease is affected by socio-economical and general health factors (32).

The progression of caries in Norway is highest in the adolescent population; caries incidence usually stabilises in adulthood. The mean number of teeth affected by dentine caries increases from 1 to 4.3 between the ages of 12 and 18 (37). The reasons for the steep rise in caries prevalence in adolescents is not scientifically confirmed but most likely connected to motivation, less parental control, change in sleep patterns, and routines. Many health-related behaviours originate from adolescence. Successful preventive strategies of caries at this age, especially targeting establishing behaviour that is likely to be robust over time, will contribute to a healthy dentition into adulthood and old age.

Avoiding dental care affects oral health depending on the presence of oral disease (7, 8, 38, 39). Oral diseases, like many lifestyle diseases, has extensively progressed when symptoms start to occur. The asymptomatic progression of oral diseases is the rationale behind recommending regular dental visits to detect and treat oral diseases early before tooth substance or tooth attachment has progressed beyond repair. This notion is not lost upon the highly anxious individuals as they often express concerns about their dentition, having catastrophic ideas about their teeth and tooth loss (40, 41). In Norway, not bringing children to regular dental examinations is considered neglect of their oral health. Routine examinations are advantageous on many accounts, not limited to oral health issues. For instance, public dental health services are committed by Norwegian law to prevent, detect and avert violence and sexual abuse (42). In Swedish children, dental caries and avoidance of dental treatment increase the probability of being investigated by social services suspecting childhood abuse or neglect (43).

In addition to oral function, oral health is also central to social interaction and aesthetics. In a society attentive to personal appearance, orofacial aesthetics is paramount, and poor oral

health could lead to social isolation. Dentally anxious individuals are more self-conscious concerning their oral health and considerably less satisfied with their facial and oral appearance compared to samples from the general population (11), which can compromise their wellbeing in social settings. Further, it can impact their mental health (depression and anxiety) and self-image (11). Regardless of potential causal relationships, mental health and oral health status play central roles in how people regard their appearance (11).

Oral health-related quality of life

Clinically measurable oral diseases can have different impacts across different populations and age groups. Several measures try to encapsulate how and to what extent oral health status affects everyday life, which corresponds to the “burden of disease” of oral health status. Dental anxiety impairs oral health-related quality of life (13, 41, 44, 45), and there is evidence to support that it affects health-related quality of life (12, 46) and has a psychosocial impact as well (47). Poor oral health in children and adolescents is linked to school absence, problems with concentration, and school performance (48, 49). While one could think that the impaired oral health status in dentally anxious individuals directs the quality of life measures, studies show that dental anxiety explains changes in quality of life more than oral health measures (50). This finding underlines that oral health status and oral health-related quality of life is more than the sum of decayed, missing, and filled teeth and tooth surfaces.

Oral health behaviour

Oral health, like general health, is dependent on everyday choices and behaviour. It is known that an individual’s health behaviour is guided by more than the individual’s knowledge and ideals concerning our health. The literature provides several theories of health behaviour that attempt to explain why people engage in health-promoting or health-harming behaviours (51). Even though the theories focus on different aspects of health behaviour, there are shared elements between them. Two central elements in theories of health behaviours are the concepts of response efficacy and self-efficacy (51). Response efficacy deals with beliefs an individual has on how well the behaviour prevents a negative outcome, for instance, how well tooth brushing prevents caries. Self-efficacy deals with beliefs about the ability to influence events that affect their lives. Self-efficacy are beliefs developed in part through performance experience, in which experiencing successful attempts at control that is connected to own efforts will strengthen self-efficacy for that behaviour and vice versa. Self-efficacy is also influenced by observations of the behaviour and outcome in others and what others say about

one's abilities and probabilities for success. Concerning oral hygiene, self-efficacy would indicate how likely an individual is to engage in brushing their teeth or use dental floss, depending on different situations, social settings, emotional or physical states (52). In other words, self-efficacy is essential in many aspects of life, such as self-regulation, psychological wellbeing, and physical health (53). Self-efficacy is also central in adopting healthy behaviours, cessation of unhealthy behaviours, and maintaining these changes when situations get difficult (54). In addition, self-efficacy beliefs affect biological processes and thereby physically influencing disease and health. It can alter stress responses in the immune system and increase susceptibility to infection and disease progression (55). Self-efficacy regarding own behaviour in the dental treatment situation is closely related to dental anxiety in children (56).

Dental anxiety

Definition of dental anxiety and clinical characterisation

High dental anxiety is a persistent and excessive fear of dental treatment that prevents or makes dental treatment very difficult. The emotional, physiological and cognitive reactions are similar to those experienced when faced with an immediate threat (57-59). The reactions are caused by the dysregulation of our normal response to threats, disproportioned to the situation's actual threat (60, 61). Dental anxiety is a broad concept that includes people with a wide range of concerns related to dental treatment. Individuals with severe forms of dental anxiety have concerns that extend into everyday life (12, 40, 47), even if dental treatment is not imminent. The individual often acknowledges the disproportionate fear response but cannot self-regulate, and complete avoidance is often the chosen coping mechanism. The general practitioner will rarely encounter individuals with severe dental anxiety due to their avoidance of dental care but rather milder forms of dental anxiety.

Dental phobia (Odontophobia) is classified as a mental health disorder (62). The diagnostic criteria are coinciding with that of specific phobia (62). In correspondence to other mental health disorders, dental phobia is diagnosed using specific criteria, most commonly based on a clinical interview with a licensed mental health professional. However, the classification of dental phobia as a specific phobia can be limiting (63). The anxiety can extend beyond the fear of a particular dental procedure, instrument, or pain. Some have multiple phobias; some are more generally anxious (63), while others distrust dental personnel or feel embarrassed by the situation, which might indicate a closer resemblance to social anxiety disorders (64).

Studies have found that dentally anxious individuals have more coexisting psychopathology (65, 66) and more severe and trauma-related symptoms compared to individuals that suffer from other specific phobias (67). In the literature, the terms dental anxiety and dental phobia are defined differently. In this thesis, the term dental phobia is used to denote diagnosed dental phobia, while dental anxiety or high/severe dental anxiety is used to refer to severe anxiety reactions related to dental treatment.

Prevalence

The prevalence of dental phobia is difficult to establish since diagnostic interviews are too time-consuming and demanding for most epidemiological studies. Therefore, the prevalence of dental phobia in epidemiological studies are usually determined by using self-reporting forms for dental anxiety and then reporting the percentage of respondents that reach the cut-off criterion set for dental phobia. However, there is some inconsistency in which questions and scales are preferred when measuring dental anxiety (68). Some studies separate the anxious from the non-anxious by a single question (69), making it difficult to understand the dimensions or severity of their fear. Still, even when using identical forms, the chosen cut-off may vary (70). Another and perhaps more important reason why the prevalence of severe dental anxiety is difficult to determine is the avoidant nature of the disorder. The issue of the underrepresentation of people with dental anxiety in epidemiological studies has been addressed previously. For instance, in a national epidemiological survey, Armfield, Slade, and Spencer (71) found minimal differences in the proportion of dentally anxious participants in a telephone survey who accepted an oral examination compared to those who declined the examination. However, individuals suffering from dental anxiety might refrain from participating in research on the topic for many interrelated reasons, which might lead to the underrepresentation of individuals with high dental anxiety in research.

Considering these limitations, the prevalence of dental anxiety varies across different age groups, notably higher in younger individuals and women (13). High dental anxiety in adults ranges from 5–24 % depending on measurements, cut-off levels, and study population (45, 67, 72-75). In children and adolescents, the prevalence of dental anxiety varies between 5 and 30 % (76-80).

Aetiology, risk factors, and the onset of dental anxiety

Theories on how dental anxiety develops are mainly based on research on adults but supported by studies on children (78). The aetiology of dental anxiety or dental phobia is not straightforward, and the causes behind each individual's dental anxiety are varied. There has been suggested that the trajectories of dental anxiety vary across different ages of onset (81). Findings indicate that family history of dental anxiety predicts early childhood-onset and trait anxiety characterises the adolescent-onset, while among those with adult-onset, there is more comorbidity with other fears and psychiatric problems (82). Children and adolescents differ from adults in terms of cognitive and social maturation and are probably more vulnerable to invasive and potentially painful dental treatment procedures related to the development of dental anxiety. Several studies have described endogenous or exogenous components of dental anxiety (82-84). Exogenous factors are linked to aversive experiences, or vicarious learning, whereas endogenous factors describe an increased latent vulnerability for developing anxiety disorders, which could be viewed as personality traits (83). Exogenous factors such as negative, painful, or traumatic experiences in the dental setting are central predictors for dental anxiety (82, 85). However, what constitutes a negative experience is subjective. It depends on both individual factors as well as the relational interplay between the patient and the dental personnel. Adding to this complexity, predictors seem to change depending on the age of onset of dental anxiety (82). In line with the latent inhibition theory in classical conditioning, having experienced positive or neutral dental treatments is considered a preventive measure to hinder the development of dental anxiety (86).

Endogenous factors such as personality traits and temperament make individuals more or less vulnerable to develop anxiety based on negative experiences, and endogenous factors also play a role in sustaining high dental anxiety over time (84). For example, the degree of negative emotional response to threats, challenges, and frustrations varies and can be measured as neuroticism (87). Neuroticism describes an individual's inclination to worry, think negatively, and be self-conscious, irritable, hostile, vulnerable, sad, and angry (88). Scoring high on neuroticism is a common denominator associated with other mental health disorders and dental anxiety (87, 89-91). If we rely on the pragmatic definition of a cause, that it is a variable we can produce or prevent, endogenous factors should not be viewed as causes due to our inability to produce or prevent them (92). Still, they explain the variability of dental anxiety across groups that differs in these traits (92).

Studies have shown that among dentally anxious individuals, the proportion that reports adult-onset is as high as 30 to 50 % (90), challenging the view that dental anxiety predominantly originates in childhood and adolescence. Longitudinal studies confirm that although the majority report relatively stable dental anxiety scores over time, new individuals become anxious in all age groups (75, 84, 93-95). The highest incidents rates of dental anxiety occur in the younger age groups and decrease among the elderly (75, 93).

Women report a greater desire for control and to feel less in control in the dental setting compared to men (96). Sex differences are also evident on a neural level, where symptom provocation appears to activate different parts of the brain in the sexes, indicating that men and women suffering from dental anxiety use diverse attention and emotional regulation styles when confronted with fear-provoking stimuli (97). The differences concern prefrontal activity and express a difference in attention focusing and cognitive avoidance (98). These differences in neural activation could explain the sex differences in the loss of control as phobic men have more prefrontal activation than phobic women in an area connected to self-control and self-restraint (97).

Armfield describes cognitive vulnerability concerning the aetiology of phobias as a “pervasive extent of subjective unease and associated feelings of incapacity and inability associated with a stimulus or event” (99). This theory presumes that the combination of how an individual perceives a stimulus as dangerous, disgusting, unpredictable, and uncontrollable reflects their vulnerability to developing a phobia. These perspectives can be traced in qualitative research on how individuals with dental phobia perceive dental treatment (41, 100); patients refer to fear of dying, feeling powerless, loss of autonomy and independence, distrust, fear of unpredicting events, vulnerability, and losing control (41, 100).

Pain

The experience of pain is a result of nociceptive input, attention, cognition, and affect (101). It is different from other somatosensory modalities in that the pain pathway itself may alter to increase or decrease sensitivity to painful stimuli. Thus, the experience of pain and reactions to it can vary independently from the actual sensory stimulus (101). Evidence suggests that cognitive factors directly influence the pain network. For instance, the anticipation of pain can modulate the cortical nociceptive systems without any actual noxious input (102). Pain is probably to a greater extent than any other sensation modulated by top-down mechanisms such as experiences, suggestions, emotions, the activation of other sensory input (101, 102).

In accordance with this understanding, brain mapping and clinical trials have shown that expectations of pain activate areas in the brain that overlap with areas connected to pain intensity and that altering expectations of pain alters the subjective experience of pain (103-106). The sexes differ concerning dental pain, with women reporting to be less acceptant of pain, fear it more, and avoid it more than men do (96). There are also sex differences when it comes to prediction and memory of pain when undergoing periodontal surgery. Men expect more pain preoperatively and report less pain postoperatively, whereas women expect less pain but remember more pain postoperatively (107). Personality traits are also predictive of perceptions of pain; the personality trait “harm avoidance” that is positively associated with neuroticism is linked to higher pain responsiveness (108). Dentally anxious individuals report, recall, and experience more pain in dental settings than non-anxious individuals do (109-111). It is more difficult for them to adapt their expectations of pain in the dental setting when experiencing painless treatment, and they require more painless treatment sessions to adjust their expectance of pain compared to non-anxious individuals (112). Also, Kent proposed that the memory of pain and painful events are coloured over time to match the current level of anxiety (113).

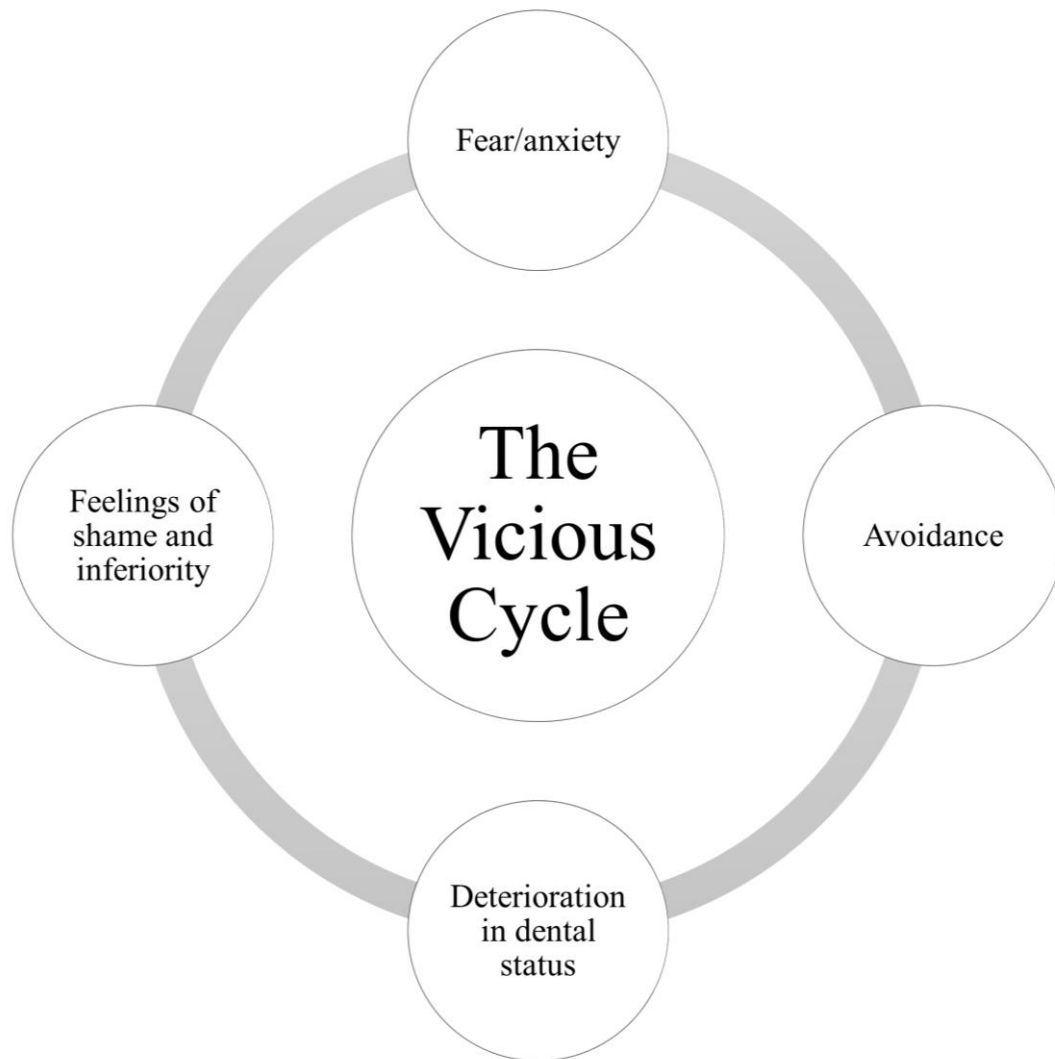
In other words, dental pain is complicated and subjective to an individual and the specific situation. Anxiety, dental anxiety, mood, expectations, prior experiences, personality traits, and anticipation of pain are among the factors that influence the experience of pain related to dental treatment.

Maintenance of dental anxiety

Avoiding necessary dental treatment is a part of the diagnostic criteria for dental phobia (62), and although commonly reported among dentally anxious (114, 115), anxious individuals can report regular attendance at the dentist (116, 117). However, avoidance is the most important predictor for high dental anxiety on a group level (116, 117), and avoiding dental treatment predicts incidents of dental anxiety (80, 95). Avoidance of potentially aversive stimuli is immediately mentally rewarded (118); however, it prevents physiological activation and habituation (119). In dental anxiety, avoidance adds to the burden of anxiety with a potential physical consequence, namely, the worsening of oral health due to untreated oral disease (7, 8, 38). Adults who maintain high dental anxiety over time seem to fail to receive non-invasive dental care and are more likely to report pain concerns, a greater degree of physical arousal, and more embarrassing and frightening dental experiences than individuals who no longer

struggle with dental anxiety (85). Individuals suffering from phobias recognise the irrational nature of the fear without being able to regulate it (62). The irrationality of their fear and failing to get professional treatment for dental disease due to fear and anxiety can affect self-respect and self-confidence (9), which in turn could make seeking help difficult and strengthen the avoidant behaviour. The intrapersonal conflict between avoiding, wanting, or requiring dental treatment could seriously disadvantage and fuel the cycle of anxiety (41). Avoidant behaviour can extend outside the dental clinic, avoiding any reminders of dental treatment all the while constantly worrying about the state of their dentition, feeling foolish about being afraid, and hiding their dental anxiety from others (47). Individuals with dental phobia can refrain from walking down streets with dental offices, having trouble with tooth brushing and flossing, and hiding their teeth when smiling or laughing (47). The illustration of the vicious cycle of dental anxiety from 1984 (see Figure 2) has remained an important conceptual understanding of the maintenance of dental anxiety (120).

Figure 2. *The vicious cycle of dental anxiety, Berggren 1984 (120)*



This is not the only example of a vicious cycle theory at that time (121). However, Berggren's vicious cycle was unique in that it included an emotional dimension (shame and inferiority), in addition to problem-oriented visiting patterns and poor oral health as the drivers behind the avoidance (122). Still, even if embarrassment and negative self-evaluation are consequences of poor oral health following avoidance (9, 123), there are probably other factors that contribute to the increase or continuation of dental anxiety over time. It might be equally relevant to consider cognitive processes connected to a self-perceived, overwhelming dental treatment need and catastrophic thinking (123, 124). Qualitative studies have revealed how high dental anxiety impacts individuals' psychological, cognitive, behavioural, social, and general health (40). Informants confessed a tendency to think less of themselves, fear stigmatisation due to their oral health and fear of being misunderstood and stigmatised on account of their anxiety; in other words, their surroundings perhaps underestimate their

struggles with dental anxiety (40). While Berggren's vicious cycle mentions feelings of inferiority and shame, it fails to address other factors associated with mental health, such as mental disorders and personality factors that have been linked to the chronicity of dental anxiety (90).

Treatment of dental anxiety

Conscious sedation is one way of making dental treatment possible for anxious patients (125), enhancing the patient's acceptance of dental treatment. A pharmacological approach is an effective tool (126) but should be limited to short term use to avoid complications of long-term use (127). Evidence indicates that conscious sedation can reduce dental anxiety and dental attendance (128-131). However, the pharmacological effect is limited to temporary sedation. Hence, other aspects of dental treatment are essential for any long-term effect of reducing dental anxiety (128, 129). Other aspects of the treatment could be sufficient pain control, interpersonal communication, psychoeducation and involving the patient in the treatment plan and succession of treatment (128). General anaesthesia is an option when conscious sedation is insufficient. Even though this requires the competence of anaesthesiologist and medical equipment beyond general dental practice, it should be an available option when the dental treatment is extensive and requires many visits both to children and to adults. Nonetheless, the pharmacological effect of sedation does not eliminate dental anxiety by itself, and other components of the treatment provided could explain the variation of the effectiveness of sedation in reducing dental anxiety (130, 132, 133).

Various forms of cognitive behaviour therapy (CBT) have the most evidence for reducing dental anxiety (133-136). These therapies include gradual exposure combined with techniques to enhance the patient's feelings of control, coping and relaxation during dental treatment (133). The use of cognitive and behavioural techniques can be taught and performed by dental personnel (135, 137, 138). Even though there is evidence to support these techniques, the theoretical evidence needs to be strengthened (139), especially when considering the external validity of this evidence due to the heterogeneity found in the dentally anxious population (140). It is relevant to ask how well the inclusion criteria in these studies describe the variation in the target population. For instance, is the treatment equally successful in dentally anxious individuals displaying symptoms of post-traumatic stress disorder (PTSD) and a history of potentially traumatic life events (PTEs)? To our knowledge, only one publication address this issue, and it provides hopeful evidence that patients displaying symptoms of

PTSD can benefit from both CBT and conscious sedation combined with communication techniques from a general practitioner (138). While trauma-sensitive care is essential in treating survivors of abuse and torture (25, 141, 142), a systematic approach to trauma-sensitive care in dental health services in Norway is lacking.

Mental health

Many studies investigating dental anxiety are cross-sectional studies, which cannot establish the direction of association between dental anxiety, psychological wellbeing, and oral health. However, it is known that patients with high levels of dental anxiety report problems in many aspects of life, including psychological and social disability and reduced quality of life (9, 11, 12, 143-145). There are associations between dental anxiety and signs of depression and anxiety in both adults and adolescents (30, 74, 90, 145-147). Moreover, dental anxiety combined with general fearfulness yields higher psychological distress and more psychosocial consequences (47). Longitudinal studies have indicated that general anxiousness and psychological disorders are risk factors for developing dental anxiety in children and young adults (145, 148).

While Richard Watt pointed to the social gradient of the distribution of oral diseases and connection to other diseases (31), it is relevant to add that the mouth is a marker of people's wellbeing and that mental health and quality of life are important indicators of oral health status (6, 33, 35). Inadequate oral health is common in individuals with serious mental illness; both type and duration of their mental illness are important predictors for their dental and oral health (149-152). Many psychopharmaceutical drugs cause xerostomia, which could extend beyond the bothersome feeling of a dry mouth (153). Disturbances in saliva flow or the constituents of the saliva cripple the protective barrier and functions of the oral cavity and pharynx, which could manifest through an increased risk of caries, oral candidiasis, problems with eating and swallowing, difficulties with speaking, denture wear, sore throat, bad breath, and change in the sense of taste (154). Clinicians often recognise the side effects of prescribed drugs on dry mouth, but there is evidence that mental health symptoms can influence saliva flow regardless of drug use (155). Dry mouth is a common side effect of prescribed drugs affecting the nervous system, but the drug-induced effect on motivation and indifference (156) could be critical for healthy oral health behaviour. Severe mental illness increases the risk of physical illness and premature mortality compared to the general population (157-159), and the behavioural risk factors also pose a threat to oral health (160-163). Mental

health symptoms could also partly explain why being a victim of abuse affects how adolescents rate their oral health (24). Taken together with findings on how oral health affects mental health (152), the bidirectional relationship makes mental health measures relevant in dentistry. Mental health status or psychological functioning is also important to consider with dental anxiety and perception of pain, as psychological functioning can mediate the effect of dental anxiety on pain perception (164). While the direction of association between dental anxiety and mental health symptoms is unclear, treatment of dental anxiety does not only reduce levels of fear, but it significantly reduces general distress (165) and emotional distress symptoms (166).

Potentially traumatic events

This thesis will not provide an extensive understanding or background for psychological trauma. However, it will address some basic concepts and findings within this scientific field that will enable the reader to understand the impact of chronic stress and potentially traumatic life experiences on oral health and coping with dental anxiety.

Stress

Stress is the body's response to any stressor. Stressors are challenges that threaten the body's homeostatic state, and these might include traumatic life events, an accumulation of different minor daily stressors, or physical trauma or disease. Stress occurs when an individual feels unable to adapt to the demands of the environment, and the behavioural and physical adaptation under acute stress is meant to tackle the challenge (167). The physiological systems that activate under stress can protect and restore in the face of stress, but prolonged/chronic and extreme variants of stress can also do damage to the body (167, 168). How well an individual can adjust and balance the potential stressors and the body's response is dependent on many aspects, including genetics, how the stressors are perceived, general health status, timing of the event, and mindset (167, 169). Our body has to react systematically to challenges and stress and to be able to shut off the system and adapt to changes when the challenge or threat is over. Several diseases and disorders are caused by dysregulation in our stress response system (167, 168).

Traumatic events

Traumatic events are stressful events that overpower a person's normal ability and capacity to cope (170). The events are perceived as sudden, negative, with intense fear and horror,

leaving individuals feeling a lack of control (170). When we consider our reactions to danger or threats, most of us think about the catchphrase “fight or flight”, indicating the reactions which mobilise a person to cope with a threat. However, researchers have argued to change this phrase into “freeze, flight, fight and fright” to better indicate the chain of reactions when encountered with an immediate threat (59). The first reaction, freeze, indicate hypervigilance, increased arousal and attention, being on alert. The following reactions are fleeing and fighting, in that order. The last response, fright or tonic immobility, might be our last resort when escaping or fighting is impossible (171, 172). Tonic immobilisation as a peritraumatic response is connected to worsened post-traumatic symptom severity and psychological impairments (171). Tonic immobilisation is highly correlated to peritraumatic dissociation (173), a psychological process involving the fragmentation of awareness. Both can occur during traumatising and have shared beneficial short-term effects and detrimental long-term effects for the individual (173). These fright reactions to trauma are proximal indicators of traumatising, secondary symptoms of trauma and post-traumatic stress syndrome (174, 175).

Post-traumatic stress syndrome (PTSD) is a reaction to traumatic events that lingers and intensifies over time, affecting everyday life (62). The symptoms are excessive fear reactions and helplessness triggered by non-harmful stimuli, intrusive memories of the event, flashbacks, and a nervous system that is constantly “on alert”. The over activation of the sympathetic nervous system and inability to return to a homeostatic state is reflected in symptoms like sleep disturbances, irritability, numbing, reduced concentration, headaches, heart palpitations, and dizziness. Coping mechanisms include avoidant behaviour of any potential triggers and isolation. PTSD does not only affect mental health, but it can also have a wide range of adverse effects on physical health (176, 177), oral health (178, 179), and quality of life (177). Secondary symptoms of trauma or secondary responses are more indirectly associated with the traumatic event and extend further than the classical trauma reactions of re-experiencing and avoidance. Secondary responses can range from depression, aggression, substance abuse, and physical illness to affecting identity and self-esteem, interpersonal relationships and experiences of guilt and shame (170). Traumatic memory is different from normal memory. High arousal and activation of the amygdala seem to intervene with the normal explicit memory formation in the hippocampus, which may explain why the memory of traumatic events are neurologically managed differently than explicit memory or conscious memory (180). When the normal memory storage is disturbed, there is a

failure to integrate explicit memory of events, and the memories are thought to be stored as sensory and emotional memories as implicit memory (181). While this adapting mechanism is beneficial under extreme conditions, it could be the failure to integrate these memories into individuals' narratives that drives the secondary responses and development of PTSD (180).

Several factors are important determinants in how we react and respond to traumatic events. What makes a traumatic event linger and cause secondary responses and PTSD in some individuals, whereas others remain less affected? Firstly, the nature of the event is central. The severity of an event, intensity, and duration are critical for our response. For instance, continued sexual, physical or psychological abuse is highly associated with secondary responses such as PTSD and related psychopathology (182). Next, the timing of the traumatic experience in terms of developmental age is critical. Young children are less capable of handling a threatening situation, rendering them vulnerable to traumatisation (183). In addition, our environment, social context and support systems are imperative in how we respond to a traumatic event and how well we are equipped prior to the event. Poor health or malnutrition increases the risk of traumatisation, while self-confidence and our ability to defend ourselves against threats decrease the risk of traumatisation (184).

Both medical and dental procedures can be potentially traumatic events that may cause traumatisation (185, 186). Age, pain and the patients' sense of control over what is happening are crucial factors to consider in dental treatment in this context. As mentioned, traumatic events and experiencing pain in the dental setting are an important part of the aetiology of dental anxiety (27, 187). Symptoms similar to post-traumatic symptoms have been identified in individuals with severe dental anxiety (187, 188). Further, studies of brain activity using MEG scans (magnetoencephalography; functional neuroimaging technique) have revealed a pattern of activity in dentally anxious individuals that resembles that of individuals who have PTSD (189). These findings could indicate that some individuals initially thought to have severe dental anxiety suffer from undiagnosed PTSD. PTSD has also been linked to poor oral health with more dental decay and tooth loss, temporomandibular disorders, and myofascial pain (178).

Evidence indicates that traumatic events outside the dental setting might have a negative effect on dental anxiety (26). Women who have experienced sexual abuse have a higher prevalence of dental anxiety than the general population (14). Also, survivors of torture are more susceptible to develop dental anxiety, even more so if they display symptoms of PTSD

(15). Dentally anxious individuals often report more traumatic events and, together with horrific dental treatment, violent crimes have been predictive of both dental anxiety and PTSD (187). Conceptually, there are many reasons why trauma seemingly unrelated to dental treatment may affect dental anxiety. Dental treatment can trigger traumatic memories through feelings of lack of control, pain/distress, body position, and other generalised sensations from the traumatic event. In addition, these links between traumatic experiences and dental anxiety should be relevant outside the realm of sexual abuse since the detrimental effects of traumatic experiences arguably could be linked more to the breakdown of coping capability, loss of control and severity/intensity of negative emotions than to specific behaviours or “contents” of trauma (190-192).

A recent qualitative study found evidence of dental anxiety being “trauma-driven” in survivors of sexual abuse, in which the dental treatment situation not only reminded survivors of the abuse, but their reactions resembled the experience of being abused (193). Reliving the trauma in a non-threatening situation corresponds with Levine’s theory about how trauma affects both body and mind, and that in focusing on only how trauma affects the mind, we forget that the body still remembers and carries the trauma (194). The memories that are implicitly stored are challenging to unfold. The coupled sensory experience often remains unprocessed and “speechless”, explaining how unresolved reactions to a traumatic event can be retrieved when experiencing sensory input similar to the trauma, even if the situation is non-threatening. Women tend to generalise fear more than men do. While men are triggered by context strongly associated with the aversive event, women can get triggered in contexts that seem less obviously associated with the aversive event (195). Sex differences in neural circuit activation during anxiety and recall of trauma-associated memories partly explains this variation (195). Nevertheless, it renders women at a higher risk of disorders following traumas, like anxiety and PTSD (195).

Population samples have previously found that sexual abuse affected the prevalence of dental anxiety (26) and that abuse and emotional neglect were associated with dental anxiety in men (28). However, one study of dental patients failed to find evidence of a relationship between traumas outside the dental setting and dental anxiety (27). There are issues with representativeness in these relatively few population studies, making it difficult to conclude on the potential connection between traumas outside the dental setting and dental anxiety in the general population.

Life stage

Adolescence and young adulthood

Adolescence is a period of life with rapid maturing and growth within the age span of 10–24 (196, 197). In addition to the biological changes, there is a marked change in social roles and social expectations. As society changes, what we perceive as adolescence has changed. At one end, puberty sparks earlier in most populations and the onset of adolescence have accelerated to about 10 years of age. While, at the other end, the transition phase continues to lengthen as educations get longer and occupy a more considerable portion of life than before (196). This prolonged transitional stage allows individuals to have more time exploring their identity and becoming their own before the responsible roles and economic freedom of adulthood.

Nevertheless, adolescence is a life period of particular importance regarding health promotion, as individuals are becoming more independent and self-sufficient, also when it comes to oral health and oral health behaviour (198). It is an opportunity to establish a new communication line that is less dependent on parents or caregivers and support them in making healthy choices. Avoidant behaviour is an essential aspect of severe dental anxiety, and dental anxiety is one of the primary reasons for avoiding dental treatment among adolescents (114, 199). This age might be critical in the prevention and treatment of dental anxiety (78).

The historical, scientific perspective on adolescence has evolved from a biologically based view to more dynamic developmental models (200). Since adolescence is a distinctly different developmental stage from childhood and adulthood, it is problematic if findings in selected adult populations are generalised to the adolescent population due to a lack of evidence in this age group. Neurological studies have found that the adolescent brain differs morphologically and functionally from both the child and adult brain (201, 202). The adolescent brain is under rapid neural development and heightened neural plasticity, marked by the proliferation of synaptic connections and eliminations. The increase in functional connectivity in the brain explains changes in adolescents' cognitive control (202, 203). Studies in developmental neuroscience may point to factors linked to the development of psychopathology in this age group, as the heightened activity can pose a vulnerability towards the development of psychiatric illness (202).

The hormonal changes in adolescence induce a change in motivation; hence, there is a change in what drives behaviour at this age (204). These hormonal changes, alongside a heightened activity in the brain area associated with reward, emotional responses, and pleasure, are probably one explanation for why there is a peak of violent, criminal, and adrenaline-seeking behaviour among adolescents (205). They accept more and higher risks for new experiences, especially with their peers (197, 206). While we may focus on increased criminal behaviour, it is necessary to keep in mind that adolescents are often victims of violence and crime since increased risk-taking also increase the risk of exploitation (207). Maturing is particularly difficult when it comes to incompatible expectations from the different roles and relationships, e.g. parents, friends, peers, romantic partners (197). Significant predictors of self-worth at this age are physical appearance, athletic competence, scholastic competence, social acceptance and behavioural conduct (208). Adolescents with high self-worth feel more positive about themselves and their social environment. They feel better equipped to tackle challenges in life and feel more in control over what happens to them (209).

Most adolescents are healthy; however, there is an increase in chronic diseases like asthma and diabetes during adolescence (207). Also, half of the adult mental disorders start in adolescence (210). The prevalence of mental disorders in the adolescent population lies between 10–20 % (206, 207), equivalent to adult populations (211, 212). Anxiety disorders are most common in adolescence, while mood disorders have a higher lifetime prevalence in adult populations (207, 211).

When it comes to health-related behaviours in this life phase, we know that most adult smokers (82%) started smoking in adolescence (207). Moreover, although the reality of obesity and overweight is far more complex than previously thought (213), a poor diet and sedentary lifestyle remain central predictors to the increase in overweight and obesity in this age group and into adulthood worldwide (214). Nutrition is also central in caries and erosion: Dental caries is the predominant oral health problem globally for this age group, and caries experience increases with age, and the progression continues into early adulthood (207). With fluoride and minimally invasive and non-operative treatment of initial caries lesions, fewer teeth are being filled before the age of twelve in the Nordic countries (215). Nevertheless, the incidence of dentine caries, which requires operative treatment, is highest in the age span of 12–18 years old. While 36.5 % of all 12 year-olds in Norway have dentine caries, the prevalence is almost doubled among 18 year-olds, with 70.6 % of this age group having caries experience (216).

The non-operative treatment approach relies on cooperation from both children and parents and a willingness to put in the extra effort to avoid the progression of caries. Children with less family support and complex background may lack the necessary daily support (217), and dialogue between dental professionals and children or adolescents and their caregivers is essential in the successful treatment of caries. Compliance can be lost in motivated parents and children as the child becomes an adolescent due to the changes that follow this life stage. Adolescents are increasingly responsible for their health and lifestyle, and it may prove challenging to be accountable for all newly acquired expectations and responsibilities. An abrupt increase in expectations and responsibilities could prove even more challenging for adolescents that struggle with mental health issues (218). Thus, the failures of non-operative prevention can result in the first invasive dental treatment in adolescence. Although adolescents require a different approach than young children, the need to feel safe and be in control is equally important. Dental health professionals should not lose sight of the circumstances and population characteristics that make specific groups of adolescents more vulnerable to develop oral disease and neglect their oral health. It is necessary to expand health care beyond the technical treatment of disease and injury (207); this is especially relevant in dental services where preventive strategies on a population level are seriously lacking. Increasing focus and knowledge on dental anxiety, conscious sedation and behavioural management techniques are essential tools for practitioners in the public dental service to treat children and adolescents that struggle with receiving dental treatment (219). There is, however, little evidence that preventive measures can affect an already established dental anxiety among adolescents (78).

Early determinants inevitably colour adolescent health and health-related behaviours, but there is an increased awareness of the importance of the biological and social changes specific for this life period (197). Adolescence is a critical age regarding dental and mental health, which is relevant for dental anxiety. Health and health-related behaviours established or reinforced through adolescence can affect both immediate and future health (197). In other words, this period brings about possibilities for changes and an opportunity for interventions (220)—it is a critical time for health promotion.

Rationale

Dental anxiety is common among children and adolescents (79). Studies indicate that different factors come into play at different ages related to the development of dental anxiety (81, 82), but little is known about core processes that drive dental anxiety in adolescents over time (78). While adolescence is considered a central life phase concerning oral health-related behaviour and oral health, there are limited studies of how these factors affect dental anxiety over time.

There is scarce and contradictory evidence concerning the association between traumatic life events and dental anxiety in the general population (27, 221). However, victims of sexual abuse, violence and torture have a significantly higher prevalence of dental anxiety compared to the general population (14, 15, 187), supporting efforts to establish more evidence on the impact of interpersonal traumatic events on dental anxiety in the general population.

Mental health symptoms or psychological distress are associated with dental anxiety as both a risk factor and a burden of disease. Mental health symptoms are correlated with dental anxiety in adolescents, but it is unclear how psychological distress is involved in the continuation of dental anxiety in adolescents and into adulthood. Moreover, mental health symptoms are linked to both life traumas and dental anxiety, yet there is little research on dental anxiety and traumatic events that include mental health symptoms in their analyses. It is not known how mental health symptoms influence the potential association between traumatic events and dental anxiety.

Aims

The overall aim of this thesis was to advance the knowledge base and understanding of dental anxiety in adolescents and adults, with a focus on the relevance of mental health symptoms and traumatic life events.

The specific aims of this thesis were to:

- Describe the prevalence of high dental anxiety in the adolescent and adult population in Tromsø

In the adolescent population:

- Identify important predictors regarding the development and continuation of high dental anxiety
- Detect factors related to changes in dental anxiety over time

In the adult population:

- Determine the potential associations between dental anxiety and traumatic events and analyse how current mental health symptoms affect these potential relationships

2 MATERIALS AND METHODS

This thesis is based on data from three health surveys in Tromsø, Northern Norway; Fit Futures 1, Fit Futures 2, and the Tromsø Study 7.

The Norwegian Dental Health Services

The regulations of the dental health services in Norway affect the methodological consideration and interpretations of results in the studies included in the present thesis.

Dental health care for children and adolescence

The counties are responsible for providing public dental health services to the region. The public dental health services are legally obliged under the Dental Health Services Act, Tannhelsetjenesteloven (42), to provide free outreach dental care for all children under the legal age of 18 and dental care at a reduced cost for dental treatment to 19 and 20-year-olds. If parents or caregivers fail to bring their children to an appointment after repeated notification, the public dental health services notify children's protective services concerning the neglect of oral health. The mandatory recall and routines hinder to some extent avoidance coping until children reach the legal age of 18. However, when the child turns 16, parents and caregivers cannot access their children's medical and dental journals without permission from the child (222). In 2017, there was an addition under the law of dental health services that included a responsibility to prevent, disclose, and avert violence and sexual abuse.

Dental health care for adults

Dental Services for the adult population is heavily dependent on and provided by the private sector. The public regulation of private dental health services is limited, and there is no regulation of geographical placements of clinics or costs of the dental services provided. The lack of regulation is a big challenge in securing equal health care for the adult population. Consequently, regular dental attendance in adults is heavily predicted by convenience, the density of dental clinics in the area, and personal economy (223). This service organisation leads to an abrupt transition from the public dental health care system for young adults. Financially, some treatments are supported through the Norwegian Directorate of Health. The laws and regulations that regulate these benefits are Folketrygdloven § 5-6 and regulations concerning coverage of expenses for oral examinations and treatment at a dentist or dental nurse (224).

Study design and populations

All the papers included in this thesis uses data from population studies in Tromsø municipality, organised through the Tromsø Study. Initiated in 1974, the Tromsø Study was initially a study addressing the high prevalence and mortality of cardiovascular diseases. Over the years, it has expanded to focus on other chronic diseases and conditions, and it has traditions for interdisciplinary collaborations currently collecting data for more than a hundred different research projects (225). Detailed information on questionnaires, invitation letters, consent forms and study data are provided through The Tromsø Study web resource (226).

Fit futures is the most extensive survey on the lifestyle and health of the adolescent population in northern Norway (227). It is an expansion of the Tromsø study, following an adolescent population from the first year of upper secondary school (2010/2011) over time. Information concerning invitation letters, consents and study data can be found through Fit Future web resource (227).

There were 76 992 inhabitants in Tromsø municipality in the second quarter of 2020, most of them live in densely populated areas, and 34.6% have a degree from university or college (228).

Paper I

Fit Futures 1

In the school year 2010/2011, 92.9% of all first-year upper secondary school students in the two neighbouring municipalities of Tromsø and Balsfjord in northern Norway volunteered to participate (N = 1038; 508 females and 530 males) in Fit Future 1. Invitations and information about the study were given at school. The dental examination took place during school hours, and the students that participated were brought by minibuses to the examination site. The students got a 200 NOK (35 \$ US) bonus check as compensation for their participation in the study.

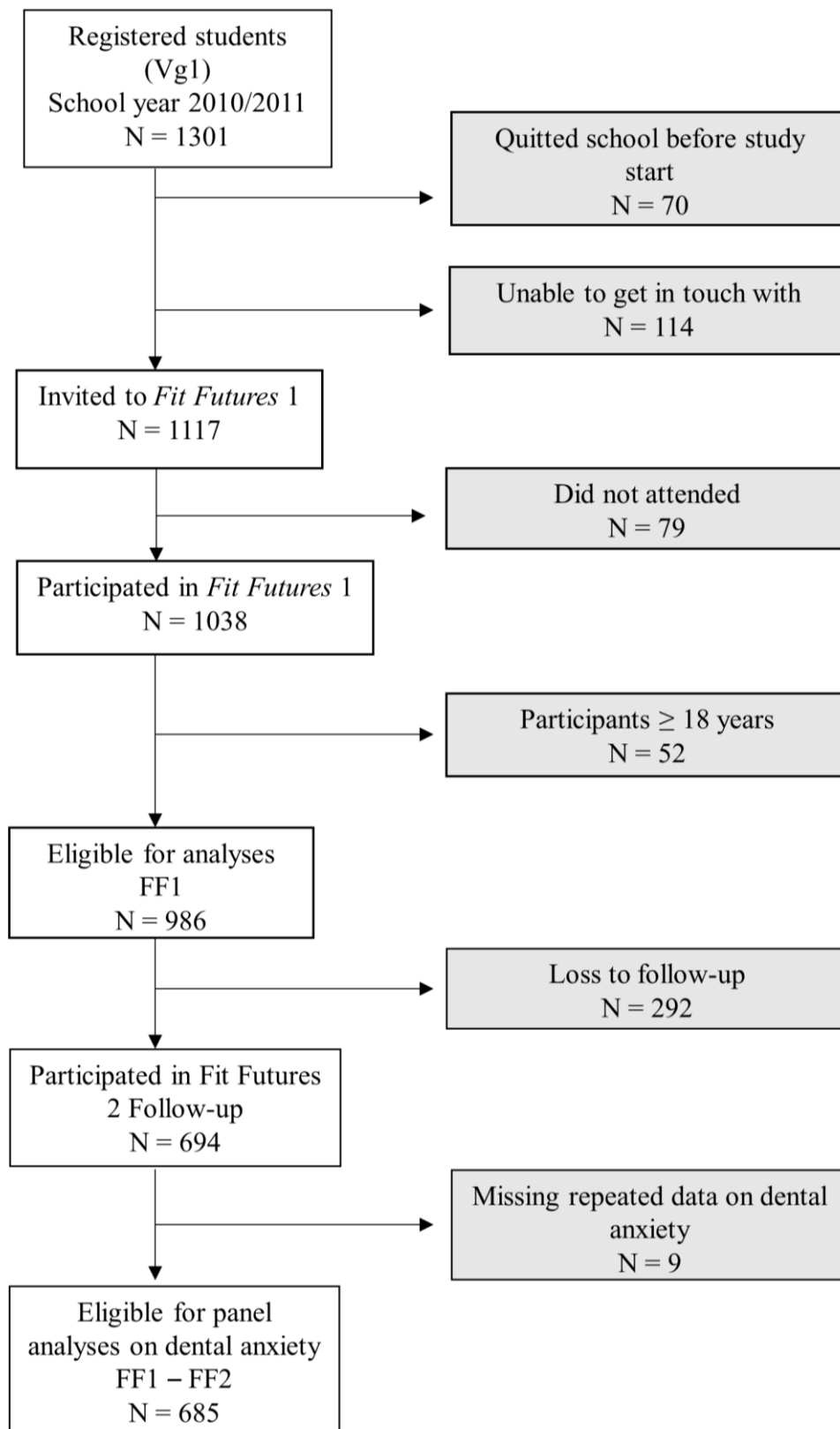
Paper II

Fit Futures 2

Fit Futures 2 (FF2, 2012/2013) invited participants from Fit Futures 1 and newly registered

students in the third-year upper secondary school in the same region for a second study wave. This study utilised longitudinal data from participants who had completed measures of dental anxiety in both waves and who were under the age of 18 during the first wave. This selection left 685 (377 females and 308 males) participants eligible for final analysis: a 69.5% follow-up rate (Figure 2).

Figure 3. Flowchart of the study participants in Fit Futures 1 and 2, The Tromsø Study, 2010/2011 (Paper I & II)



Paper III

Tromsø 7

In the seventh survey of the Tromsø Study (Tromsø 7) in 2015-2016, all adults registered in the Tromsø municipality aged 40 or more were invited to participate (in total 32 591), and 21 083 men and women ended up participating in the study. This provided an attendance rate of 65%. Tromsø 7 took place in 2015 and 2016. The attendants answered two questionnaires and got their general health measures registered. A selection of the participants was invited to a free dental examination. In the present thesis, only questionnaire data were used. The questionnaires could be answered digitally or on paper, at home, or before the physical examinations at the study site.

Clinical examination

Paper I and II used clinical data from the oral examinations in Fit Futures 1. Three experienced and calibrated dentists performed the standard oral examinations with assisting dental nurses at the University Dental Clinic, UiT The Arctic University of Norway, Tromsø. The public dental health services agreed to let the oral examination of participants in FF1 replace their mandatory dental examination that year, and the journal notes were shared in the same database, which provided the public dental health services with access to the intraoral x-rays and the diagnostic evaluations from the oral examinations in the study.

Variables

Table 1. List of variables in Paper I – III

	<i>Paper I</i>	<i>Paper II</i>	<i>Paper III</i>
<i>Outcome variable</i>			
Dental anxiety (DAS or MDAS)	X	X	X
<i>Independent variables</i>			
Age and sex	X	X	X
Education or parents' education	X		X
Ethnicity			X
Parents' birthplace	X		
Household income			X
Caries experience (DMFS)	X	X	
Oral health			X
Mental health symptoms/Psychological distress (HSCL-10)	X	X	X
Dental attendance/ avoidance	X	X	X
Anticipated pain at the dentist	X	X	
Oral health knowledge and behaviour	X	X	
Potentially traumatic events			X

Outcome variable

All the papers used dental anxiety as the outcome of interest. In the Fit Future material, this was measured by Corah's Dental Anxiety Scale, DAS (229), and in Tromsø 7, the Modified Dental Anxiety Scale, MDAS (230), was used. Both scales are validated inventories and have been extensively used in epidemiological research. MDAS is derived from DAS, and they are similar except for an additional question concerning the dental anaesthetic injection. Each item illustrates a situation related to dental treatment, and respondents indicate which

response (of increasing severity) is closest to their likely response to that situation. The scale yields a score of 4 to 20 (DAS) or 5 to 25 (MDAS), with high scores indicating greater anxiety.

Independent variables

Age and education (Paper I–III)

In Paper I and II, adolescents between 15 and 19 years old were included. In Paper III, age was divided into eight categories spanning five years (such as 40-44 and 45-49), where the last age group was 75 years and up. Education was categorised into high (university or college) and low (primary and secondary school).

Ethnicity (Paper III)

Ethnicity was defined by the question: “What [ethnicity] do you consider yourself?” and the following alternatives: Norwegian, Sami, Kven, or other. It was possible to select more than one option.

Socio-economic factors (Paper I–III)

Education was measured with the question: “What is your highest completed degree of education?” and “What was your mother’s/father’s highest completed degree of education?” The options for answering were: 1) primary + middle school 2) High school 3) College/University less than four years, and 4) College/University for more than four years.

Oral health (Paper III)

Self-reported oral health was measured by the statement “How would you rate your dental health?” where participants would perform the rating on a scale from 1–5, 1 being bad and five being excellent.

Oral health knowledge and behaviour (Paper I, II)

Twenty-three items concerning oral health knowledge and behaviour were grouped into three sets of variables based on factor analysis. Sixteen items related to knowledge and attitudes towards tooth brushing constituted the subscale Self-motivation (sum score of 16 items), while six items indicating social motivation concerning oral health and oral health behaviour constituted the subscale Social-motivation (sum score of 6 items). Median scores were used to

dichotomise the self-and social motivation scores into groups of either high (above median) or low scores (below median).

The last item, “Whatever I do, it doesn’t help to prevent caries”, did not fit with any of the subscale components, so it was used as a single item variable called Control Belief.

Anticipated pain (Paper I, II)

Anticipated pain reflects the students’ reports on how painful they judged an average dental session to be. They indicated pain on a scale from 0 (no pain) to 10 (worst conceivable pain).

Avoidance/dental attendance (Paper I–III)

In Paper I and II, avoidance was indicated by participants answering yes to the question: “Have you ever missed a dental appointment due to fear?”

In Paper III, participants answering the item “Do you regularly go to the dentist?” measured avoidance of dental treatment. This variable was dichotomised to indicate avoidance of dental treatment, in which yes / no avoidance (0) included the response alternatives “at least once a year”, “every year”, “every second year”, “longer than 2-year intervals”, and no / avoidance (1) included the response alternatives “only for acute problems” and “never goes”.

Mental health symptoms/Psychological distress (Paper I–III)

Hopkins Symptom Check List (HSCL - 10) is a validated and recognised instrument for epidemiological studies and clinical work in adult and adolescent populations, measuring symptoms of depression and anxiety (231, 232). The instrument struggles to differentiate between anxiety and depression (233), making it insufficient for clinical diagnosis. However, high comorbidity exists between the two constructs, and HSCL-10 is considered reliable for assessing mental health symptoms indicating anxiety or depression (232, 234). It consists of ten items, with 4 response alternatives for each item (no = 1, slightly = 2, much = 3, very much = 4). The threshold level (cut-off) is set to 1.85 (235), which means that those who score 1.85 or higher have symptoms of anxiety/depression (236). Although the measure is similar in all papers, it is referred to as both mental health symptoms (Paper II-III) and psychological distress (Paper I).

Caries experience (Paper I, II)

The DMF (Decayed, Missing, Filled) index has been used for more than 70 years and is well established and standard measure of caries experience in dental epidemiology (237). It estimates how much the dentition has become affected by dental caries up to the day of examination. The sum of the three figures forms the DMF-value. A DMFT (Teeth) value of 28 is maximum, meaning that all teeth are affected. A more detailed index is DMF calculated per tooth surface, DMFS. Molars and premolars have five surfaces, while front teeth have four surfaces, leaving the maximum value for DMFS 128 for 28 teeth (238). The caries experience is referred to as dental health, dental status and oral health in Paper I and II.

Potentially Traumatic Events (Paper III)

A list of eleven Potentially Traumatic Events (PTEs) was included in Tromsø 7 with four response alternatives (no; yes, before age 18; yes, after age 18; yes, in the previous year). In Paper III, events were included that had the potential to affect interpersonal relationships: painful or threatening dental treatment, painful or threatening medical treatment in hospital, experienced childhood neglect, been a victim of violence, been a victim of sexual assault, being bullied, or witnessed someone close to being a victim of violence or sexual assault. The answers were dichotomized into 0 = no and 1 = yes, to avoid deflated effect sizes after assuring that the direction of effects was the same regardless of the timing of the event.

Data analysis and statistical methods

Table 2. List of statistical methods used in Paper I – III

	<i>Paper I</i>	<i>Paper II</i>	<i>Paper III</i>
<i>Statistical methods</i>	Correlation	Wilcoxon signed-rank Test	Spearman correlation
	Independent-samples t-test	Kruskal-Wallis tests	Mann-Whitney U Test
	Logistic regression analysis	Chi-squared tests	Chi-square tests
		Mann-Whitney U tests	Hierarchical multivariable regression
		Logistic regression analysis	

Paper I

All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 24 (IBM Corp., Armonk, NY, USA). Variables were presented as means and standard deviation (SD). The linear relationship between variables was described through correlation analyses, and the difference in pain scores between anxious and less anxious adolescents was analysed with an independent-samples t-test. Logistic regression analysis was used to predict high dental anxiety and the impact of the different variables (odds ratios and their 95% confidence intervals [CI]) when using Corah's DAS as a dichotomous dependent variable (cut off value for DAS were set at 13) (229).

Paper II

All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 24 (IBM Corp., Armonk, NY, USA). Changes in dental anxiety and mental distress over time were analysed with Wilcoxon Signed Rank Tests. Individuals with DAS scores of 13 or more was classified as dentally anxious. To avoid spurious effects of change in dental anxiety over time, a change in dental anxiety was registered if DAS score differed

by more than 2.0 (the interquartile range) over two years (Y1 [Sum score DAS in FF1] – Y2 [Sum score DAS in FF2]). Kruskal-Wallis Tests were used to compare differences in caries experience, mental health symptoms and pain at the dentist between those with no change in dental anxiety, increased or decreased dental anxiety scores between FF1 and FF2. The predictive value of the variables over time was assessed through logistic regression analysis with the DAS score from FF2 as the dependent variable and included DAS score in FF1 as an independent variable in the analysis. Chi-squared tests and Mann-Whitney U tests were used to evaluate the impact of loss to follow-up. Significance levels were set at 0.05 and 0.001.

Paper III

All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 26 (IBM Corp., Armonk, NY, USA). Simple mediation analyses were performed using the PROCESS macro in SPSS (Hayes, 2017). Pairwise exclusion was used for missing data. Chi-square tests of independence were used to explore the relationship between dichotomized MDAS (cut-off ≥ 19) and independent variables used in the analysis. In order to assess the predictive ability of PTEs, hierarchical multivariable regression was used, test statistics was empirically derived through bootstrapping with 1000 bootstrap samples. The first blocks included variables with a known association to dental anxiety; sex, age, self-assessed oral health, avoidance of dental treatment, and painful or threatening dental treatment. The third block introduced the PTEs, and the last block entered current mental health symptoms. Simple mediation analyses were used to explore if current mental health symptoms could transmit and explain the association between PTEs and dental anxiety.

Missing data and loss to follow-up

In *Paper I* and *Paper II*, missing data occurred at a fairly high rate (0–15.2%). Little's MCAR test was not significant, indicating a high probability for data missing completely at random (MCAR). There was no replacing of missing data, and complete case analyses were performed with the option of excluding cases pairwise, excluding cases only if they are missing the data necessary for the specific analysis. The assumption being that MCAR will not introduce bias but rather increase the standard error of the sample estimates due to the reduced sample size.

Table 3. Baseline characteristics of the adolescents that followed the study and lost to follow-up

	<i>Participated FF2</i>	<i>Drop-outs</i>
	<i>Median</i>	<i>Median</i>
<i>DAS</i>	7.00	7.50
<i>HSCL-10</i>	1.30	1.30
<i>Pain at the dentist</i>	2.00	3.00*
<i>Number of fillings</i>	3.00	4.00*
<i>DMFT</i>	3.00	4.00**
<i>DMFS</i>	4.00	5.00**
<i>Number of BOP (0-6)</i>	4.00	5.00**c
	<i>Percentage</i>	<i>Percentage</i>
<i>Females</i>	55	35.8**c
<i>Males</i>	45	64.2**c
<i>Likely to complete school</i>	97	93*c
<i>Smokes</i>	18.9	31.8**c
<i>Using snuff</i>	33	46.3**c
<i>Avoided dentist due to fear</i>	5.6	13.4**c
<i>The quality of the worst filling is unacceptable</i>	33.9	43.9*c
<i>Number of BOP (0-6)</i>	4.00	5.00

*c Chi-squared test $P < .050$

**c Chi-squared test $P < .001$

* Mann-Whitney U Test $P < .050$

** Mann-Whitney U Test $P < .001$

Chi-square test for independence (with Yates' Continuity Correction when each variable has only two categories) indicated a significant association between loss to follow-up and:

- Gender, $\chi^2(1, n = 986) = 40.8, p < .001, \phi = .21$, (small to medium effect).
- Likely to complete school, $\chi^2(1, n = 973) = 4.84, p = .017, \phi = -.08$, (very small effect).
- Smokers, $\chi^2(1, n = 972) = 13.88, p < .001, \phi = .12$, (small effect).
- Snuff users, $\chi^2(1, n = 972) = 19.82, p < .001, \phi = .15$, (small effect).
- Avoidance coping, $\chi^2(1, n = 958) = 11.43, p = .001, \phi = .11$, (small effect).
- The quality of the worst filling, $\chi^2(1, n = 789) = 4.18, p < .041, \phi = .08$, (very small effect).

In Paper III, 2.4 % of all values were missing, 9.6 % of all subjects had incomplete data, and there were missing values in all but two variables (Sex and Age). The items that made up our variable for measuring mental health symptoms (HSCL-10) had the most missing data (6 %). The number of missing values in the PTEs is difficult to interpret since leaving boxes unchecked were valid answers. Thus, there is probably an underestimation of missing values in these measures. All PTEs had the same number of missing values.

Table 4. Missing values in Paper III

<i>Variable</i>	<i>Number of missing data</i>	<i>Number of complete data</i>
<i>MDAS^a</i>	886	20197
<i>HSCL-10^b</i>	1259	19824
<i>Avoidance^c</i>	479	20604
<i>Oral Health^d</i>	430	20653
<i>PTEs^e</i>	240	20843

^aModified Dental Anxiety Scale

^bHopkins Symptom Check List

^cIrregular attendance or complete avoidance of dental health services

^dSelf-reported oral health, ratings of own dental health on a scale 1–5

^ePotentially Traumatic Events. All of the PTEs had the same number of missing data

To evaluate the impact of missing data for the continuous variables (HSCL-10, MDAS and Oral Health), they were compared by a paired sample t-test with the same variables where missing values were replaced by series mean. However, the standard error of the difference was zero, so there was not possible to perform any of these analyses. There was also a comparison with the original variable when replacing missing data using both regression and expectation-maximization technique. Differences between the variables were minimal and limited to deviation in the second decimal. Finally, the regression analysis was performed by replacing missing values with multiple imputations, which yielded similar results as the original data analysis. The differences were limited to decimal levels in the unstandardized regression coefficients, and there were no differences in β s when rounded up to the first decimal place. Consequently, the analyses were performed on the original data without any imputation with pairwise exclusion of missing data.

Ethics

Participants in all three studies have volunteered and provided informed written consent according to the Regional Committee of Medical and Health Research Ethics (REC) requirements. WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects were followed.

The Regional Committee of Medical and Health Research Ethics (reference number 2014/1093/REC North) approved the studies using data from Fit Future 1 and 2 in September 2014. The study using data from Tromsø 7 was approved in July of 2018 (reference number 2018/1352/REC North).

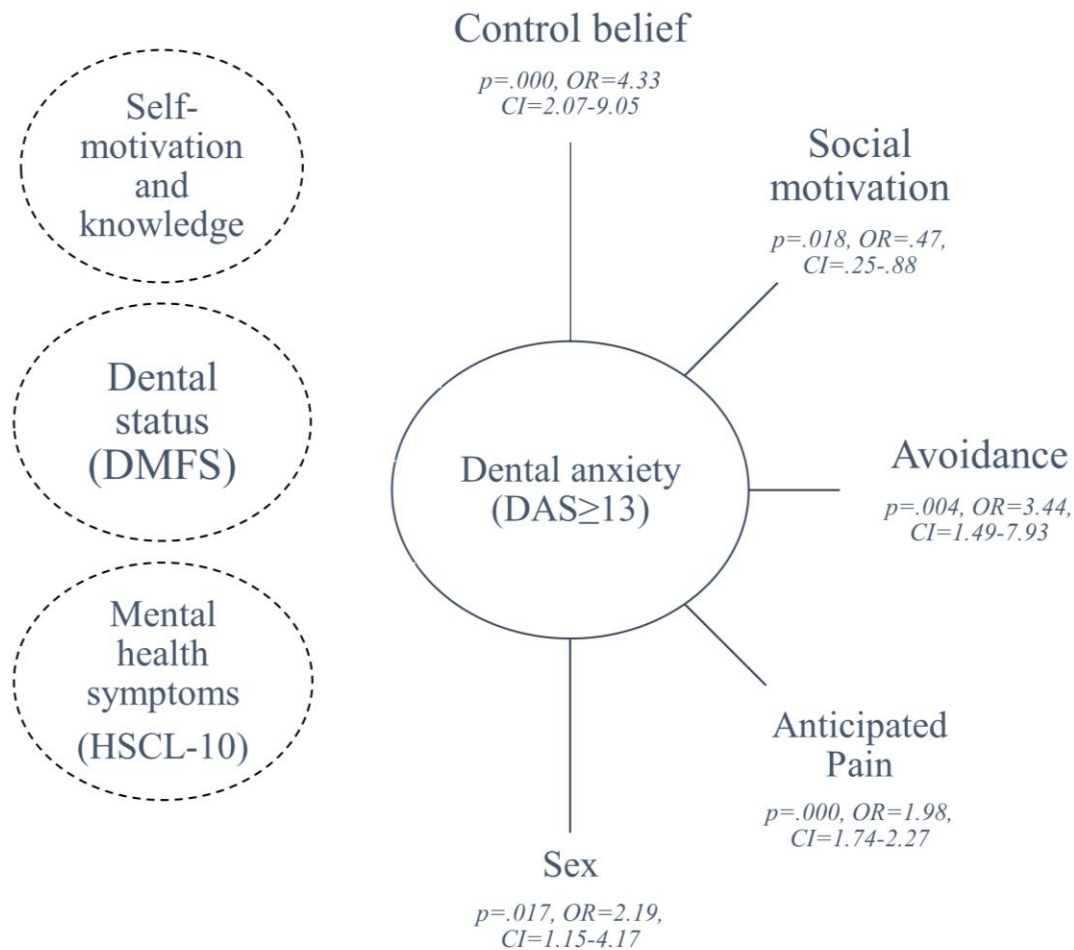
3 SUMMARY OF RESULTS

Paper I

This paper aimed to describe the prevalence of high dental anxiety among adolescents in Tromsø and Balsfjord region and look at different variables ability to predict high dental anxiety in the study participants.

Dental anxiety is an established problem among adolescents. In this study population (aged 15–18), 11.6 % had high anxiety for dental treatment ($DAS \geq 13$), and 5.7 % had severe dental anxiety ($DAS \geq 15$). The mean score of DAS was 8.0, with girls reporting higher dental anxiety compared to boys. Dental anxiety explained 30.9 % of the variance in anticipated pain at the dentist. Logistic regression analyses were performed to model the impact of the different variables of interest, and the full model was statistically able to differentiate between participants with high versus low dental anxiety scores. The strongest predictors for high dental anxiety were anticipated pain at the dentist, avoidance, sex, low social motivation on oral health behaviour and control belief. Psychological distress (HSCL-10), dental status (DMFS), and self-motivation concerning oral health behaviour were not significantly different between anxious adolescents and non-anxious adolescents.

Figure 4. The independent variables in the logistic regression model, lines indicating a significant association with dental anxiety, a variant of Figure 3 from the published Paper I



Paper II

The specific aims of this study were to analyse changes in dental anxiety over two years from the first to the last year of upper secondary school (2010/11–2012/13) and identify variables that predicted high dental anxiety over time. The following hypotheses were tested:

1. Dental caries experience at baseline is higher among youth with increased dental anxiety than youth with stable and decreased dental anxiety.
2. Psychological distress at baseline is higher among youth with increased dental anxiety than youth with stable or decreased dental anxiety.

3. Youth with increased dental anxiety have higher anticipated pain estimates at the dentist than youth with stable or decreased dental anxiety.

Despite the reduction in dental anxiety score over two years (median changed from DAS 7 to DAS 6), the proportion of individuals with high anxiety (DAS \geq 13) was almost unchanged and marginally increased for individuals with a dental anxiety score \geq 15 (from 5.7% in FF1 to 6.4% in FF2). Three central factors that impacted dental anxiety over time were identified: high dental anxiety, high psychological distress, and more caries experience in the first wave were predictive of high dental anxiety in the second wave. Psychological distress was the strongest predictor of dental anxiety over time in this adolescent population. When looking at changes in dental anxiety scores (defining change in the score as \geq the interquartile range [IQR/midsread]), we identified three groups of change: no change, higher dental anxiety and lower dental anxiety. High caries experience predicted change in either direction and was significantly lower in the group with no change in dental anxiety score. Psychological distress was also higher at baseline in both groups with a change in dental anxiety, compared to no change. Anticipated pain at the dentist followed the anxiety score as predicted; more anxious individuals anticipated more pain, whereas those who were less anxious anticipated less pain at the dentist.

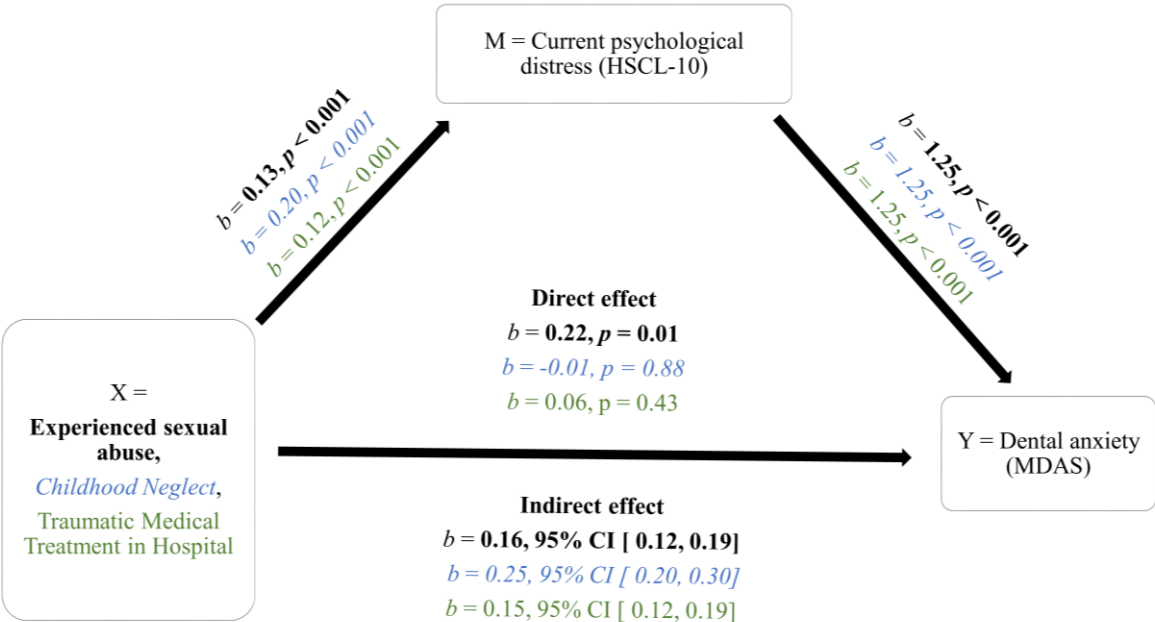
Paper III

This study aimed to describe the prevalence of dental anxiety and the association between dental anxiety and traumatic life events in an adult population.

High dental anxiety was reported by 2.9 % (MDAS \geq 19) of the respondents, and it was more prevalent among women and in the youngest age groups. Reporting high dental anxiety was associated with more current mental health symptoms, poorer oral health and irregular dental visits compared to the less anxious part of the population. Among the potential traumatic life events, traumas linked to the dental setting displayed the largest difference between the anxious and the less anxious. There was a difference between anxious and less anxious adults in all PTEs in the bivariate analyses, but the effect sizes were small. In the hierarchical regression model, the control predictors sex, age, oral health, avoidance, and traumatic or painful dental experiences explained most of the variance in dental anxiety score and remained significant in all steps of the analysis. Concerning PTEs not related to the dental

setting, neglect in childhood, traumatic or painful medical treatment in hospital and sexual abuse was significant predictors in the step they were entered, but only sexual abuse remained significant when current mental health symptoms were entered in the last step. The effect of neglect in childhood and traumatic or painful medical treatment in hospital on dental anxiety was mediated through current mental health symptoms—except for sexual abuse, that had a direct effect on dental anxiety score independent of mental health symptoms.

Figure 5. Mediation analyses of how current psychological distress mediates the effect of three PTEs on dental anxiety score from Paper III



4 GENERAL DISCUSSION

The three papers in this thesis have sought to advance the knowledge base and understanding of dental anxiety in adolescents and adults, focusing on the relevance of mental health symptoms, oral health and potentially traumatic life events. Accordingly, this work describes how dental anxiety is associated with oral health and mental health symptoms at different life stages (adolescence and adulthood). Moreover, it provides an interpretation of the relationship between these variables over time in an adolescent population, indicating that it is a period susceptible to change in dental anxiety (Paper I–II). In addition, it considers the effect of potentially traumatic events and mental health symptoms on dental anxiety in an adult population (Paper III). The discussion will address the concepts explored (Figure 1) across the three papers and answer the corresponding aims (underlined in the text).

Prevalence of dental anxiety

- Describing the prevalence of high dental anxiety in the adolescent and adult population in Tromsø

The prevalence of high dental anxiety in the adolescent population was 11.6 % (FF1), 11.5 % (FF2), and 2.9 % in the adult population. While the prevalence was lower than expected in the adult population, the associations with our control variables behaved as expected. All of the papers in this thesis underline the notion that dental anxiety is more prevalent in women than men and that the prevalence decreases with age. When it comes to the adolescent population, some studies have pointed to an increase in dental anxiety (95, 239), while others notice a decrease in dental anxiety (80), generally agreeing that it is period sensitive to change. One concerning aspect about the change in dental anxiety in Paper I and Paper II is that despite an overall decrease in mean dental anxiety score, the proportion of highly anxious individuals remained stable. This finding implies that the overall decrease in dental anxiety for the adolescents in this study does not reflect a decrease in the proportion of adolescents that struggle with receiving dental treatment. The clinical challenges are not likely to decrease, which is essential when planning and providing dental care for this age group.

Oral health

- Identify important predictors regarding the development and continuation of dental anxiety

No association was found between dental anxiety and caries experience (DMFS) in the adolescent population at the first wave. However, caries experience influenced dental anxiety score at the second wave. Similarly, mental health symptoms were not associated with dental anxiety at the first wave but seemed influential over time. In the adult population, self-reported oral health was associated with dental anxiety, which indicates that this association might be strengthened over time due to avoidance. Catastrophic thinking and expecting the worst, associated with neuroticism, a factor that has previously been linked to dental anxiety (90) and mental disorders (240), could influence the self-reported measure (241). While the oral health status is important, satisfaction with oral health is more than clinical measures (242). There has been a discrepancy between self-reported oral health and clinical oral health measures by dentists (233), where older dentate adults rated their oral health more negatively than the dentists' evaluation (243). Self-reported oral health measure could also be affected by the use of dental health services (244). Nevertheless, dental anxiety affects both oral health measures and oral health-related quality of life (13, 50, 245, 246).

In Paper I, there lacked a well-documented measure of self-efficacy; however, several questions covered themes related to oral health behaviour, knowledge, and beliefs. Dentally anxious reported helplessness in regards to their ability to prevent caries (control belief). While there are uncertainty and weaknesses in using just one item measure, whether or not they feel they can affect their health outcome is an essential part of health-related self-efficacy. It is a concern that dentally anxious adolescents avoid dental treatment and feel that they cannot prevent caries, despite similar caries experience as less anxious adolescents. Furthermore, it poses the question of the origin of this belief. There was no difference between anxious and non-anxious individuals in caries experience and mental health symptoms at this point in the study, so the source of low control beliefs is uncertain. One possibility could be that others have questioned their abilities and probabilities for a healthy dentition. It is possible to speculate that this lack of control can relate to a general low self-efficacy, and if unchanged, will have a continued effect on both physical and mental health (54). Whatever the cause, dental health services should consider their societal role in the prevention of dental disease. Dental caries is a preventable disease highly related to behaviour. Prevention strategies may benefit from supporting adolescents and work actively to increase their own beliefs and abilities in health behaviours that promote their oral health.

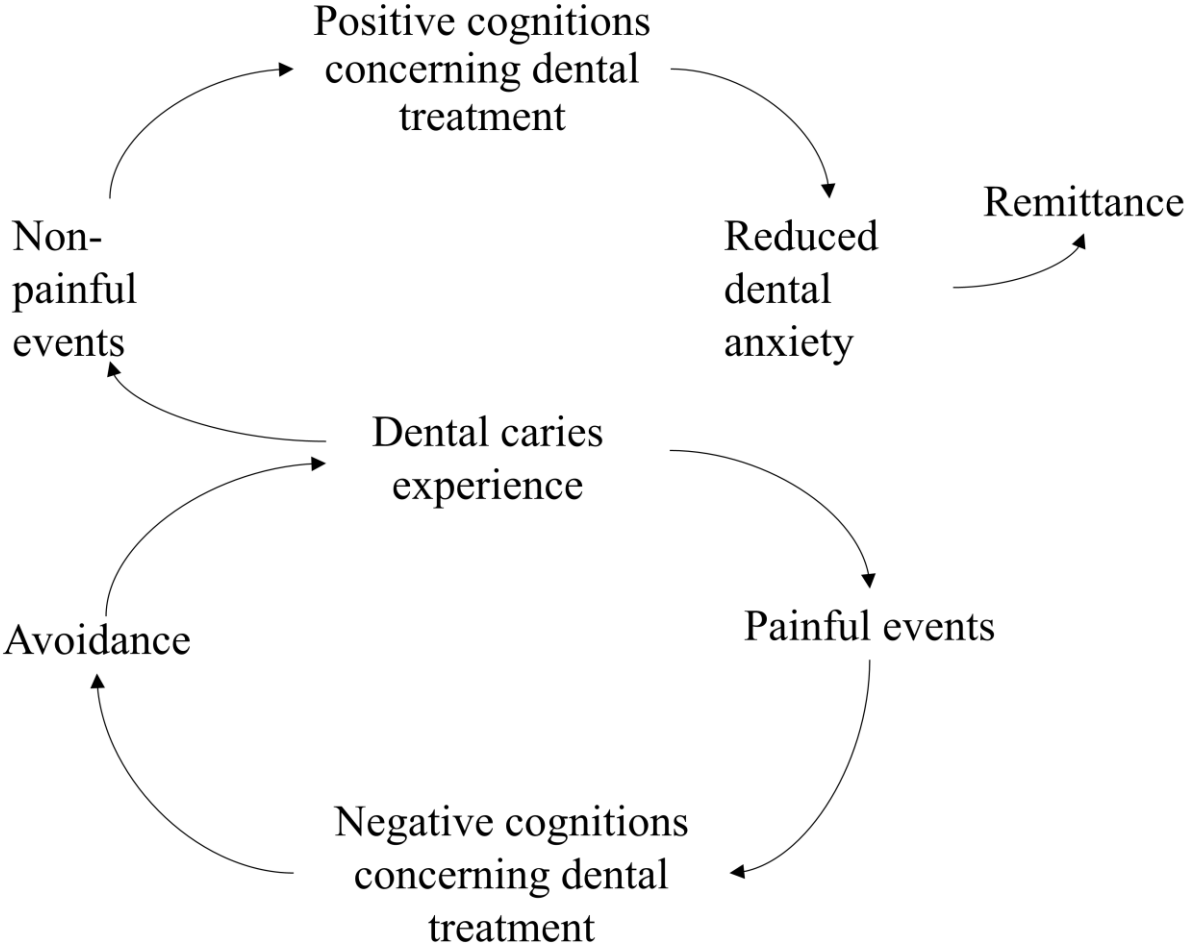
Embarrassment is a central part of Berggren's vicious cycle of dental anxiety (123), which led us to think that anxious adolescents would report more feelings of embarrassment concerning

oral disease and behaviour. This notion did not find support in the adolescent population. Instead, adolescents with high dental anxiety reported significantly lower social motivation concerning oral health and oral health behaviour. They reported less embarrassment and less concern about others' opinions regarding their oral health and behaviour. These findings are difficult to interpret, especially considering earlier evidence on the matter. However, it could be related to a more generalized pattern of social retraction and avoiding judgements by others, mirroring conflicting emotions and feelings concerning oral health and behaviour. Could these questions also be threat-relevant to individuals with high dental anxiety, in that they elicit negative emotions or thoughts concerning oral health (247)? If so, expressions of reduced motivation could be interpreted as a form of avoidance coping, which would extend beyond the clinical situation. This emotional coping strategy involves avoiding unpleasant emotions associated with the threatening situation, and this could also involve cognitive elements such as denial and distancing (247).

Avoiding dental treatment or an irregular attendance pattern is an important associated factor at all ages in all three papers. Avoidance is most often thought of as a consequence of dental anxiety, but based on these results, one might ask whether it could be considered a risk factor? Similarly, Thomson et al. (95) claimed that dental anxiety required in adulthood were unrelated to conditioning events, as complete avoidance predicted incidents of dental anxiety. In children, it is known that preventive care in dental health services before the first invasive dental treatment, to some degree, protects them from developing dental anxiety (148). Avoiding dental health services or only seeking dental treatment when in pain actively prevents non-invasive dental treatment and contributes to sustaining the anxiety (85). The literature often refers to dental treatment as a risk factor for developing dental anxiety since dental treatment in itself increases the chances of negative and painful dental experiences. The result from Paper II is important in establishing that dental treatment is more than a possible conditioning experience for developing dental anxiety. Pain at the dentist in the adolescent population reflected their dental anxiety level, and interestingly pain experience was implicated in both reduction and increase in dental anxiety. This finding indicates that invasive dental treatment can be involved in reducing dental anxiety in standard dental practice. However, little is known about what resources and interpersonal factors comes into play in this process. In other words, what separates between the treatments that contribute to reduce or increase dental anxiety? The key might be related to factors involved in building a trusting relationship and maintaining good communication. Based on the results concerning

changes in dental anxiety over time led to a conceptual model of change in dental anxiety related to dental treatment and experience.

Figure 6. Possible outcomes of dental caries experiences in youth, a conceptual model, Figure 3 in Paper II



- Detect factors related to changes in dental anxiety over time

Changes in the level of dental anxiety, both negatively and positively, were highest among adolescence with more caries experiences. That is, caries experience could be viewed as a window of opportunity to reduce dental anxiety through positive experiences and the absence of pain. It underlines the importance of proper care regarding pain control and the psychological element of dental treatments. Productivity and efficiency are highly regarded and easy to measure in dentistry. While most strive to balance economics with the quality of the specialized treatment—what is considered successful treatment from the patient

perspective? Oral health is more than the number of treated cavities, and good oral health over the life span is dependent on both general health and mental health measures. These perspectives are necessary to improve oral health in the population. This notion supports better integration of dentistry in general health care and in concordance with Lancet's oral health series, a shift in focus toward preventing disease and a more holistic view on dental care (5). It also underscores the potential for change in dental anxiety in the adolescent population. Timing matters; adolescence is an important age concerning many aspects of health, including oral health. However, it is a life phase that has been largely ignored in health and social services (207). The results from the studies on the adolescent population in this thesis provide an optimistic view. Standard dental treatment and care can reduce dental anxiety in adolescents with a moderate dental anxiety level. However, this was not evident for adolescents with severe dental anxiety. Over time they reported higher anxiety levels, extending the gap between non-anxious and anxious individuals.

Mental health

Current mental health symptoms were associated with high dental anxiety in the adult population (Paper III) and predicted dental anxiety over time in the adolescent population (Paper II). Several studies have pointed to the association between dental anxiety and mental illness or symptoms of mental illness in both adolescent and adult populations (66, 90, 145, 146, 248, 249). The social and mental consequences of deteriorating oral health due to dental anxiety and avoidance coping is evident (122, 246, 250). However, mental health disorders and mental health symptoms are linked to more stable traits, like personality, temperament and emotional control (251, 252). Thus, the measure of mental health symptoms could be an expression of a relative stable vulnerability towards developing anxiety concerning dental treatment (74, 90). Based on this notion, the association between mental health symptoms and dental anxiety over time in Paper II, does not indicate a causal relationship between mental health symptoms and dental anxiety. Rather it indicates that the variability of dental anxiety is due to differences in certain personality traits in this population (92). Regardless of the interpretation and direction of the association, mental wellbeing could have implications both from a preventive and treatment perspective of dental anxiety.

Potentially traumatic events

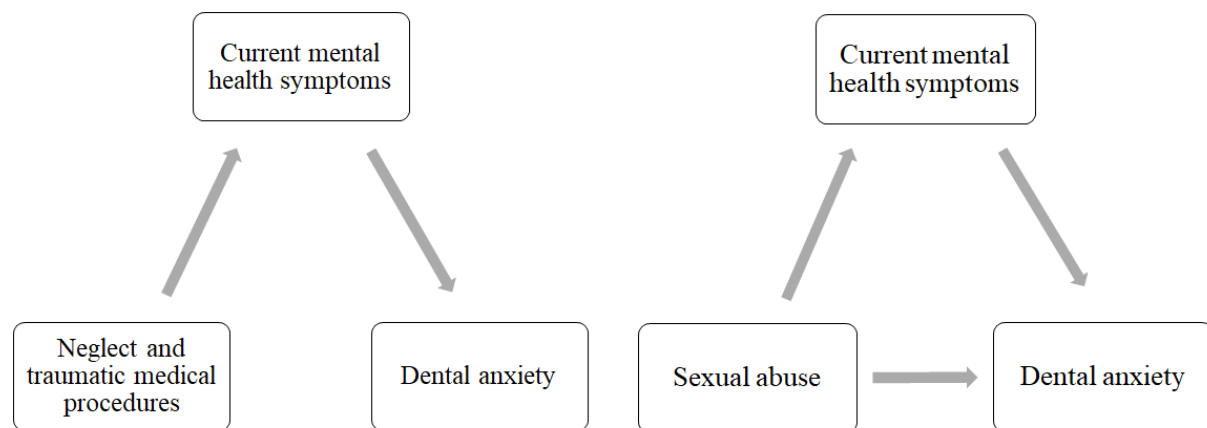
- Determine the potential associations between dental anxiety and potentially traumatic events and how current mental health symptoms affect these prospective relationships

Paper III is the only paper in this thesis that asked about potentially traumatic events (PTEs). Excluding traumatic experiences as an independent variable in the adolescent population under study is unfortunate when we know the potential impact of trauma on health and illness (16, 253-255).

In the preliminary analyses (chi-square tests), all PTEs were significantly associated with high dental anxiety, yet effect sizes were small. Traumatic or painful dental experiences had the highest impact (effect size) on dental anxiety. However, 31% of individuals with high dental anxiety had never experienced a painful or traumatic medical treatment at the dentist. While the question considers both pain and traumatic experiences, it does not necessarily include all negative experiences that have been linked to dental anxiety. Other components, such as feelings of loss of control, embarrassment, and interpersonal issues (64, 256, 257), are essential for dentally anxious individuals in the dental treatment setting but might be unaccounted for when limiting experience to pain and traumatic dental experiences.

When controlling for all relevant covariates, the only PTE outside the dental setting that remained a significant independent predictor of dental anxiety was sexual abuse. Painful or traumatic medical treatment at the hospital and childhood neglect increases the vulnerability of dental anxiety through increased mental health symptoms. Reporting traumatic events combined with a high level of current mental health symptoms could indicate that the respondents still suffer from an earlier trauma. Unresolved trauma could explain why two of the traumatic events in Paper III lost their significant impact on dental anxiety when introducing current mental health symptoms as a covariate.

Figure 7. Sexual abuse maintained a significant direct impact on dental anxiety when accounting for the effect of mediation through mental health symptoms.



Having experienced trauma does not necessarily indicate continued struggles, but there are differences in the processes related to traumatic memory versus “normal” memory (181). High arousal and activation of the amygdala seem to intervene with the normal process of explicit memory formation in the hippocampus, which explains why the memory of traumatic events are neurologically stored differently than explicit memory or conscious memory (180, 194). When the normal memory storage is disturbed, there is a failure to integrate explicit memory of a part of or entire events (180, 194). While this adaptation is beneficial under extreme conditions, the failure to integrate these memories into a personal narrative could affect the ability to recognize safety cues in non-threatening situations (192, 258). Generalization of fear to stimuli that are not directly related to an aversive event is particularly relevant to individuals with PTSD following potentially traumatic events (258), where there is a persisting failure to recognise signs of safety in non-threatening situations (259).

Sexual abuse maintained a significant independent influence on dental anxiety irrespective of mental health symptoms in Paper III. Thus, sexual abuse can make dental treatment difficult regardless of how the trauma affects current mental health symptoms. The sensory input that occurs in dental treatment can resemble those experienced during abuse. Recovery from trauma involves coping with everyday life and routine, not preparing survivors to cope with multiple sensory triggers in specialised medical treatment situations. Consequently, traumatic experiences with sexual abuse that are apparently resolved in terms of an individuals’ daily

functioning can still evoke problems in the highly specific dental treatment setting. Problems resurface when sensory input in the dental treatment situation triggers implicit memories of trauma. Triggers might be a range of physical and sensory memories, which might include bodily position, sensations of fingers, liquids and objects in the mouth, physical closeness, smells, reassuring words and sentences, feeling trapped and life-threatening danger, without the individual being consciously aware of the link between these bodily sensations, former trauma, and the dental treatment situation. Survivors of interpersonal related traumas can function well as long as feelings related to traumatic memories are not stirred up, explaining why specific sensory or emotional triggers makes them feel or act as if they are traumatised all over again (180). The direct independent association between sexual abuse and dental anxiety (Paper III) emphasises that dental professionals should recognize and be conscious of how the sensory stimuli in the dental setting could trigger feelings that resemble abuse. Also, such feelings could be reinforced by situational factors, such as the presence of pain, a non-empathic or stressed operator, and poor communication skills. This knowledge is equally relevant in all patient encounters: Few patients feel that their abuse history is relevant to report to their dentist (14), especially traumatic experiences that are not a current problem in their everyday life. In addition, dentistry tends to focus on operative treatment. It is a very practical profession, and it does not always allow the operators to reflect upon other aspects of the treatment. Complex and technical demanding treatment procedures require concentration and focus on ensuring a decent outcome. Patients are often under general anaesthesia or sedation during technically demanding medical treatment and surgery, allowing the operator to focus on the procedure. In contrast, similarly demanding dental procedures are performed with awake and conscious patients, where the dental professional has to maintain communication, collaboration, and focus on the patients' well-being simultaneously. This duality is probably one of the most challenging aspects of the dental profession. Failing to consider both aspects during treatment could potentially lead to a traumatic experience for the patient or re-victimization in individuals with a trauma history (185).

Oral diseases are still common across the general population, but marginalized groups have a higher burden of oral disease (5), which includes survivors of trauma (260). Being a victim of sexual abuse has an independent impact on dental anxiety, but also physical health (16) and oral health (24, 260, 261), leaving the most marginalized and vulnerable groups in society with the most extensive dental treatment need (5, 43, 150, 151). These broader social determinants of oral health need to be addressed in how dental health services are organized

and what focus dental professionals have in providing dental care (25). There is room for a more holistic view of oral health, including aspects of other somatic conditions, psychological illness and more stable vulnerability factors. Collaboration across disciplines will be more critical in future health care and health strategies, including oral health (5).

The link between sexual abuse and dental anxiety in a resourceful adult population with low levels of dental anxiety (Paper III) highlights the complexity of high dental anxiety. Complex aetiology should reflect the treatment available. A treatment approach proven successful to individuals with a specific phobia might be less successful in individuals who struggle with dental treatment due to trauma or generalized anxiety. To reduce dental anxiety across different causal trajectories, we might have to adapt our treatment to address those causal links.

When it comes to dental anxiety and potential risk factors, dental professionals cannot control many aspects. We have no control over the individual differences that our patients reflect, like personality, temperament, emotional regulation, coping mechanisms, mental disorders, or a history of traumatic experiences. However, we control the dental treatment situation.

Methodological considerations

Study design

This thesis includes data from both cross-sectional and longitudinal study designs in the same region. The cross-sectional design is used to study disease and risk factors patterns in the population, and it can generate and test hypotheses based on associations (262). The cross-sectional approach is limiting when trying to understand possible causal effects in health and disease. All measures are at one point in time, which makes causal conclusion impossible.

Paper II uses a longitudinal study design, analysing data from the same population at two points in time (2010/2011–2012/2013). This prospective design permits a study of the disease's natural history, measures incidence, causal links, and assesses the strength of associations (262). The design allows studying causal effects, but there might be issues due to loss to follow-up.

Selection bias and generalizability

Selection bias refers to systematic errors in the recruitment or retention of study participants, potentially resulting in misrepresentation or false distortion of characteristics related to exposure or disease. Volunteers and participants in health studies tend to have different attitudes, behaviour, and health status compared with people that choose not to volunteer (262-265). There is a question of evaluating the studies abilities to recruit the correct share of dentally anxious individuals in the population, which could affect the representativeness of the studies. We have to expect some degree of distortion in the representativeness of dentally anxious individuals in these studies due to the avoidant nature of the disorder (62). Inadequate description of different characteristics in the population under study compared to other populations can cause problems with generalizability (262). Careful consideration of this region's socio-economical and oral health-related characteristics is necessary when comparing it to populations in other geographical areas.

Tromsø and Balsfjord are municipalities in Troms and Finnmark County. Tromsø municipality is the most populous municipality in northern Norway and the ninth-largest municipality in Norway. Tromsø municipality had 76,974 inhabitants (01.01.20); the majority (88.9 %) lives in urban areas, and over 3/4 of the citizens' working force is employed in public and private services or the business sector. The city's largest workplaces are UiT Norway's Arctic University (UiT) and the University Hospital of Northern Norway (UNN). Balsfjord municipality borders Tromsø. It has a population of 5,685 (01.01.17). Agriculture and associated industry are the most important industries in the municipality. No other municipality in Troms has so much cultivated land; however, 28 % of the working population works outside the municipality, and 16 % in Tromsø.

The selected population in Paper I–II are students attending upper secondary school in Tromsø and Balsfjord municipality. This selection excludes adolescents that, for some reason, are not attending school at this age. Based on the Norwegian Statistical Central Agency (SSB) reports, we know that in the age group 16-20 years old, about 9% does not attend a school or have a job (266). Besides, 27% of the adolescents who start their upper secondary education do not complete their studies within five years. Gender, grades from primary school, choice of field of study and parents' educational levels are important determinates for achieving an upper secondary school diploma. Dropping out of school and not getting a job affects social function, expectations and potential marginalization in society (266). These adolescents and young adults show more mental health symptoms (sleep disorders, anxiety and depression) than those attending school or workplace. There is reason to believe that extreme dental

anxiety and avoidance coping might be linked to adverse social effects like isolation and marginalization in society. Nevertheless, all young people in Norway have a statutory right to upper secondary education. Registered students in the first year include students who do not complete their studies and should arguably represent adolescents in this region. The attendance rate at baseline is usually more than acceptable (92.7%), but we could risk an imbalance in the proportion of dentally anxious adolescence among the participants and those that did not participate.

The invitations in Paper III was extended to the entire adult population ≥ 40 years old in Tromsø municipality. Thus, representativeness is primarily dependent on the participation rate (262). The attendance rate in Tromsø 7 was 65%, which is acceptable compared to similar studies (72, 267, 268). However, selection bias might still occur if the non-attendants is not random, that they differ on variables related to predictors or outcome. There is only available comparable data related to age and sex (226). Females had a higher attendance rate in all age groups compared to men, and the lowest attendance rate was (7–58%) among the eldest (80–104 years old) (226). The underrepresentation could affect generalization, especially for the oldest part of the population.

Table 5. Participation in the Tromsø Study 7, 2015-16

<i>Age</i>	<i>Invited males</i>	<i>Invited females</i>	<i>Males in the study</i>	<i>Females in the study</i>	<i>Attendance rate males</i>	<i>Attendance rate females</i>
<i>40–44</i>	2796	2572	1473	1678	52.7	65.2
<i>45–49</i>	2766	2623	1581	1700	57.2	64.8
<i>50–54</i>	2298	2439	1434	1705	62.4	69.9
<i>55–59</i>	2029	2095	1356	1540	66.8	73.5
<i>60–64</i>	1901	1911	1320	1420	69.4	74.3
<i>65–69</i>	1642	1675	1182	1257	72.0	75.0
<i>70–74</i>	1195	1194	852	857	71.3	71.8
<i>75–79</i>	702	807	463	504	66.0	62.5
<i>80–84</i>	426	553	251	268	58.9	48.5
<i>85–89</i>	213	428	74	121	34.7	28.3
<i>90–94</i>	76	185	21	20	27.6	10.8
<i>95–104</i>	8	57	2	4	25.0	7.0
<i>Total</i>	16052	16539	10009	11074	62.4	67.0

The educational level in the population under study was higher compared to both county and national education level (37), which could indicate that individuals with higher education

were more inclined to participate in the study. Since oral health and avoiding dental treatment are connected to socio-economic factors (213, 232), this could lead to underestimating oral disease and overestimating the proportion of individuals who regularly attend the dental health services in this study. Most participants, 89.9 %, reported a regular attendance pattern. This high attendance pattern is more optimistic than the numbers reported in a population study among adults in Troms County in 2014, where 77.7 % of the entire population under study reported similar regular attendance (269). The private sector provides the majority of dental care for the adult population in Norway without any public involvement concerning the geographical distribution of dental clinics or fees for dental services. The lack of regulation could be problematic regarding equal health care, leaving accessibility and the personal economy more predictive of regular dental attendance than other factors (223). Thus, the adult population in Tromsø, a city with a high density of private clinics, would perhaps have better access to dental health care than rural areas. It might also be coloured by the high educational level among the participants. Also, it is possible to speculate that individuals with dental phobia who chose not to participate in this study would be more inclined to use avoidance as a strategy than the phobic participants who participated in this study, influencing the reported attendance pattern. Overall, Tromsø 7 is a population study with an advantage in representativeness compared to studies on a selected part of the population like university students (26), expecting parents (28) and dental patients (27).

Selection bias due to loss to follow-up

The loss to follow-up could pose a serious threat to internal validity. Considering the data from FF1 and FF2, 30% of the participants in FF1 did not participate in the second wave (FF2). The advantage of having a prospective study design in this regard is that it enables us to compare the baseline characteristic of participants that participated in both waves and those lost to follow up. Males were three times more likely to drop out of the study compared to females. Reporting a missed dental appointment due to fear increased the likelihood of dropping out of the study almost twofold compared to non-avoiders. A poor dental status also increased the likelihood of dropping out. These findings indicate that study dropouts differ from those who chose to follow through on relevant variables to our study.

There is a similar pattern of characters that describes the school dropouts and study dropouts. The invitations in the first wave are limited to registered students and conducted during school hours, thereby making school attendance central to participating in both waves. The dental anxiety score did not differ significantly between participants and loss to follow up, but

there was a significant difference in avoidant behaviour (reporting missing a dental appointment due to fear). Earlier studies have revealed that episodic dental visiting patterns are predictive of increased dental anxiety over time (80), indicating that dental anxiety is likely to rise among avoiders. Hence the dental anxiety might be higher among the study dropouts. There was no difference in self-reported mental distress at baseline between the groups. Mental health symptoms increased significantly in the second wave among participants. In theory, if the study dropouts are more likely to be school dropouts, they will report more mental health symptoms than those attending school, according to studies on marginalized youth (266). If the assumptions on dropouts were correct, they would display more caries lesions, more avoidant behaviour, higher levels of mental distress and possibly higher dental anxiety scores. Thus, there is a potential underestimation of the prevalence of both dental anxiety, dental caries and associations between central variables due to dropouts. One might argue that changes in mean dental anxiety scores could be, to a certain degree, explained by the loss to follow up. There is a high probability of losing statistical power concerning avoidance, dental decay and sex. Avoidant behaviour, oral health and dental anxiety is highly associated in the literature, which means that we risk type II error, accepting that there is no correlation between these variables when there is one. We must also consider the potential of introducing a type I error due to the sex difference. However, sex differences in mental disorders, including anxiety disorders and phobias, are supported by the literature.

Selection bias due to the clinical oral examination

Another critical issue that can lead to selection bias is studying dental anxiety paired with a clinical dental examination. Avoidance is one of the diagnostic criteria for dental phobia (62). Thus, participants with a dental phobia that involves avoidant behaviour would struggle to follow through with the examination and probably not volunteer to participate at all. Considering the dental examination as a possible selection bias in the current studies, they had the advantage of having a general health focus; the dental examination was only a minor part of the study. It took place in a different location than the other examinations. The questionnaires on dental anxiety were unrelated to the dental examination, which made it possible for participants to answer the questionnaire and not participate in the dental examination. In Paper I, the oral examination in the study replaced the annual dental examination of the county (270). As mentioned in the method section, the public dental health service in the county provides dental examinations of prioritised groups in society, mainly

children. The dental examinations in children and adolescents are mandatory, and not attending is reported to child protective services. Participating in the oral examination in this study meant that participants did not have to go through with another dental examination that year. Several measures were made to facilitate participation. The examination took place during school hours; the transportation to the examination localization was organized and participants received a small monetary compensation (200 NOK). Most adolescents volunteered for the oral examination, and only 25 individuals (2.5%) did not participate for unknown reasons.

In Paper III, only a selection of the study participants got an oral examination. Online questionnaires enabled data collection independent of any clinical participation. However, all of the participants went through a general clinical examination that included drawing blood. Drawing blood is an obvious problem considering the overlap between dental avoidance and injection phobia (199), affecting avoidance of dental treatment (271). Nevertheless, some of the individuals that have been avoiding dental treatment could look at an invitation to a free dental examination as an opportunity to challenge avoidance coping, especially if the invitation makes participation more accessible. For those that have avoided the dentist by default or because seeking out a dentist has proven to be a big challenge in itself, an invitation could be a welcome possibility. Also, if there is an underrepresentation of dentally anxious in the included studies, the existing literature supports the associations found in all the bivariate analyses. Thus, the effect of including a larger portion of dentally anxious individuals would probably enhance rather than lower the effect sizes of correlations observed but may cause type II error.

Misclassification

Misclassification results from information bias and can lead to a wrongful classification of an individual, a value or an attribute (272). Recall bias, reporting bias, observer bias or imprecise instruments are all information biases.

When asked about events in the past, the frequency of recalled life events diminishes over time (273). Although PTEs are more frequently recalled compared to non-traumatic events, the frequency of recall is associated with the level of distress at recall (273), indicating that

longer recall periods affects the frequency of reporting PTEs with a less severe impact on the individual. There was significant decrease in reported traumatic events with increased age group: $\chi^2 (7, n = 20632) = .18, p = .001, \text{Cramer's } V = .18$. Rather than PTEs being more prevalent in the younger population, it is perhaps more likely that these age-related differences are explained by how time affects the recollection of life events.

Social desirability bias is when participants report false information, avoid mentioning information, or modify it, providing answers adjusted closer to the social norm than reality (274). Attendance patterns in dentistry are affected by social norms and could, to some extent, explain that almost 90 % reported regular dental attendance in Paper III. Social desirability bias could be a potential problem in reports of oral health-related behaviour in Paper I and II and explain the lack of association between oral health behaviour and dental caries experience. Similarly, self-reported oral health in Paper III could be influenced by dental attendance pattern and socio-economic factors rather than clinically relevant dental treatment need. Unfortunately, we lack clinical data on oral health in Paper III, making the potential bias difficult to assess.

When it comes to measuring dental anxiety, the DAS questionnaire used in Paper I and II could potentially fail to include individuals with injection phobia, thereby underestimating the prevalence of adolescents who struggle with dental treatment. The cut-off values in both the DAS and MDAS questionnaire could misclassify individuals in both directions. However, the cut-off levels were based on the available literature, and the effect of misclassification is probably limited since it is equally relevant in both directions.

HSCL-10 was used to measure mental health symptoms or psychological distress. HSCL-10 is a reliable and valid measure of symptoms of depression and anxiety in the population (234). However, it is a measure of current symptoms at the time of administration, and the nature of these symptoms in terms of longevity is unknown (i.e. they could be chronic or time-limited). Using this measure as a predictor over two years poses a potential problem since the current measure could be time-limited. However, there was a significant increase in mental health symptoms over the two years, and the proportion of individuals that maintained a low score (below 1.85) was over 80 %. Only 11.3 % reported a reduction in mental health symptoms (\geq the IQR of 0.5) over the two years. In addition, prospective studies have concluded that mental health symptoms often persist in adolescents over time.

Caries experience in Paper I and II relied on data from the clinical examination. Classification errors in the clinical estimation of caries are more sensitive to what degree the caries lesion has evolved and, to a lesser extent, on caries' presence in the dentition. The papers only used data on the DMF index, which only included caries lesions that require a restorative treatment, introducing a potential underestimation of caries experience and activity.

Ethical considerations

To protect the rights and safety of participants in health research, all research involving humans require informed consents. While there could be questions related to information, comprehension and understanding, the risks of participation in an observational study concerning potential harm from the oral examination with radiographs are considered minor. For the adolescent population under study in Paper I and II, this examination and exposure to x-rays are a part of standard preventive care. However, there is a question concerning the ability to understand and evaluate what information they share in different research projects. The participants in Paper I and II received gift cards (value 200NOK) as a small compensation for participating. The examination took place during school hours, which could have led to a feeling that participation was mandatory. However, participants can choose to withdraw their data from the study. The retrieval of data from The Tromsø Study assures de-identification. In addition to a central ethical approval for the Tromsø Study, every research project must obtain independent ethical approval from REK (Medical Committee for Medical and Health Research Ethics). The unwarranted influence on participation based on health risk and compensation is considered low.

Asking about traumatic experiences

It is expected that issues relating to physical and sexual abuse will cause the participants some degree of distress, especially for individuals who have experienced this themselves or have second-hand experiences of abuse. However, the literature has found that environmental triggers, rather than being asked about the trauma, triggers traumatic memory (180, 275), as discussed in Paper III. Thus, the oral examination has more potential for provoking traumatic memory than a question in a questionnaire. Also, there is convincing evidence to claim that not asking about trauma is also an ethical dilemma (275). The benefits of asking about abuse, both to the individual participant and society, are underestimated (275).

Gender issues

Both genders were included in the studies, and the research topics are equally important to women and men. There are indications that men and women might have different symptomatology (96, 276) and neurological responses (97) regarding dental phobia and sexual abuse.

5 CONCLUSIONS

Based on population studies in Tromsø municipality, this thesis provides information on the prevalence of dental anxiety and associated variables in adolescents and adults. It considers a new perspective, analysing clinical data on caries experience, mental health symptoms, potential traumatic life experiences and dental anxiety over time.

The specific conclusions:

- High dental anxiety scores were most prevalent in adolescents (11.6%) and the younger age groups in the adult population under study.
- While the prevalence of high dental anxiety in the adult population in Paper III was lower than previously reported in similar populations (2.9 %), the associated factors indicate a high burden of disease. Dentally anxious individuals report more current mental health symptoms, poor oral health and symptom-driven or complete avoidance of dental treatment.
- Dentally anxious adolescents, regardless of caries experience, avoid dental treatment and feel that they are unable to prevent caries.
- Caries experience and mental health symptoms did not correlate in the adolescent population's first study wave (Paper I). Nevertheless, they were significant predictors of dental anxiety over time (Paper II), indicating that they are risk factors rather than a consequence of dental anxiety at this point in life.
- Changes in dental anxiety in youth are most likely due to an interplay between individual vulnerability and subjective experiences. The individual vulnerability factors (here: caries and mental health symptoms) are predictive of a change in both directions. Thus, subjective experiences (here: estimations of pain at the dentist) are the only variable measured that differentiate between those who reported an increase and those who reported decreased dental anxiety scores during upper secondary school.

- While most of the adolescent population under study reported decreased dental anxiety levels, highly anxious adolescents felt more anxious; this may create an even greater gap between the anxious and the non-anxious.
- The influence of childhood neglect and traumatic or painful medical treatment at the hospital on dental anxiety was mediated through current mental health symptoms (Paper III).
- Survivors of sexual abuse can experience challenges in receiving dental treatment regardless of whether their history of sexual abuse affects their current mental health status.

Clinical Implications

- Adolescence is a period sensitive to change in dental anxiety. Dental treatment need could be viewed as a window of opportunity to reduce dental anxiety through positive experiences and the absence of pain in adolescents with moderate dental anxiety levels.
- Severe dental anxiety is an established problem in the adolescent population. This thesis provides evidence suggesting that existing dental care and prevention, while beneficial for most adolescents, is insufficient for reducing dental anxiety in highly anxious individuals. Severely anxious adolescents would probably benefit from being offered treatment, similar to what is provided to adults, for their dental anxiety.
- The direct effect sexual abuse had on dental anxiety emphasizes the importance of educated and empathic dental personnel who can recognize and be conscious of how the sensory stimuli in the dental setting could trigger feelings that resemble abuse.
- It might not be apparent for the patient that their experiences with sexual abuse can be directly related to their anxiety and difficulties in getting dental treatment.

6 FUTURE PERSPECTIVES

This thesis presents findings on dental anxiety and its development over time in an adolescent population that invite future studies to focus on what factors in standard dental care contribute to lowering dental anxiety. The cost of severe dental anxiety to the individual and society in adulthood urges us to focus on preventing and treating this condition at a younger age.

Reducing dental anxiety in the general population and preventing avoidance coping is critical to secure equal opportunities to maintain good oral health throughout the life span.

The longitudinal data showed that a reduction in mental health symptoms corresponded with a reduction in dental anxiety in the adolescent population. Taken together with the finding of how mental health symptoms predicts high dental anxiety scores over time, reducing mental health symptoms could affect dental anxiety and anticipation of pain at the dentist or vice versa; that a reduction in dental anxiety could affect the general well-being of adolescents through a reduction in mental health symptoms. Regardless of what factor leads to the other, it is evident that they appear together and change together, indicating interdisciplinary benefits.

Traumatic experiences, directly or mediated through mental health symptoms, influenced dental anxiety—Traumatic history matters in the dental chair and should be considered in resolving and reducing dental anxiety. Treatment of dental anxiety when there is a history of trauma might require a different approach. Maybe a close collaboration with rehabilitation clinics for survivors of abuse is warranted, and greater trauma awareness and trauma-sensitive care among dental practitioners. One should question whether it is possible to expect the same outcome for an individual with a dental phobia that is specific, limited to, for instance, the syringe, and an individual with a dental phobia due to traumatisation. Without sufficient evidence on the effect of treatment across different causal trajectories, we should be cautious about narrowing our treatment options and guidelines, creating standards that could fail to address the individuals that struggle the most.

This thesis presents evidence that could imply that we are currently failing anxious adolescents in supporting their abilities to control their health outcome and manage dental treatment. However, we need to know more about what factors, resources, or skills are essential in securing adolescents positive treatment experience in the dental setting.

REFERENCES

1. Health TND. Tilrettelagt tannhelsetilbud - TOO 2012 [Available from: <https://www.helsedirektoratet.no/tema/tannhelse/tilrettelagt-tannhelsetilbud--too#hva-er-tilrettelagt-tannhelsetilbud-too>].
2. Health TND. Nasjonal faglig retningslinje for tannhelsetjenester til barn og unge 0–20 år. In: Services MoHaC, editor. 2020.
3. Marthaler T. Changes in dental caries 1953–2003. *Caries Research*. 2004;38(3):173-81.
4. Oscarson N, Espelid I, Jönsson B. Is caries equally distributed in adults? A population-based cross-sectional study in Norway – the TOHNN-study. *Acta Odontol Scand*. 2017;75(8):557-63.
5. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. *The Lancet*. 2019;394(10194):249-60.
6. Kandelman D, Petersen PE, Ueda H. Oral health, general health, and quality of life in older people. *Special Care in Dentistry*. 2008;28(6):224-36.
7. Hägglin C, Berggren U, Hakeberg M, Ahlqwist M. Dental anxiety among middle-aged and elderly women in Sweden. A study of oral state, utilisation of dental services and concomitant factors. *Gerodontology*. 1996;13(1):25-34.
8. Agdal LM, Raadal M, Skaret E, Kvale G. Oral health and oral treatment needs in patients fulfilling the DSM-IV criteria for dental phobia: Possible influence on the outcome of cognitive behavioral therapy. *Acta Odontologica Scandinavica*. 2008;66(1):1-6.
9. Moore R, Brødsgaard I, Rosenberg N. The contribution of embarrassment to phobic dental anxiety: a qualitative research study. *BMC Psychiatry*. 2004;4:10-1.
10. Glick M, Williams DM, Kleinman DV, Vujicic M, Watt RG, Weyant RJ. A new definition for oral health developed by the FDI World Dental Federation opens the door to a universal definition of oral health. *J Public Health Dent*. 2017;77(1):3-5.
11. Carlsson V, Hakeberg M, Blomkvist K, Wide Boman U. Orofacial esthetics and dental anxiety: associations with oral and psychological health. *Acta Odontol Scand*. 2014;72(8):707-13.
12. Vermaire JH, Houtem CMHH, Ross JN, Schuller AA. The burden of disease of dental anxiety: generic and disease-specific quality of life in patients with and without extreme levels of dental anxiety. *Eur J Oral Sci*. 2016;124(5):454-8.
13. Carlsson V, Hakeberg M, Wide Boman U. Associations between dental anxiety, sense of coherence, oral health-related quality of life and health behaviour – a national Swedish cross-sectional survey. *BMC Oral Health*. 2015;15:100.
14. Willumsen T. Dental fear in sexually abused women. *Eur J Oral Sci*. 2001;109(5):291-6.
15. Høyvik AC, Lie B, Willumsen T. Dental anxiety in relation to torture experiences and symptoms of post-traumatic stress disorder. *European Journal of Oral Sciences*. 2019;127(1):65-71.
16. López-Martínez AE, Serrano-Ibáñez ER, Ruiz-Párraga GT, Gómez-Pérez L, Ramírez-Maestre C, Esteve R. Physical Health Consequences of Interpersonal Trauma: A Systematic Review of the Role of Psychological Variables. *Trauma, Violence, & Abuse*. 2018;19(3):305-22.
17. Dube SR, Felitti VJ, Dong M, Giles WH, Anda RF. The impact of adverse childhood experiences on health problems: evidence from four birth cohorts dating back to 1900. *Prev Med*. 2003;37(3):268-77.
18. Hughes K, Bellis MA, Hardcastle KA, Sethi D, Butchart A, Mikton C, et al. The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. *Lancet Public Health*. 2017;2(8):e356-e66.
19. Schilling EA, Aseltine RH, Gore S. Adverse childhood experiences and mental health in young adults: a longitudinal survey. *BMC Public Health*. 2007;7(1):30.
20. Akinkugbe AA, Hood KB, Brickhouse TH. Exposure to Adverse Childhood Experiences and Oral Health Measures in Adulthood: Findings from the 2010 Behavioral Risk Factor Surveillance System. *JDR Clinical & Translational Research*. 2019;4(2):116-25.

21. Bright MA, Alford SM, Hinojosa MS, Knapp C, Fernandez-Baca DE. Adverse childhood experiences and dental health in children and adolescents. *Community Dent Oral Epidemiol.* 2015;43(3):193-9.
22. Matsuyama Y, Fujiwara T, Aida J, Watt RG, Kondo N, Yamamoto T, et al. Experience of childhood abuse and later number of remaining teeth in older Japanese: a life - course study from Japan Gerontological Evaluation Study project. *Community Dent Oral Epidemiol.* 2016;44(6):531-9.
23. Kirkengen AL, Lygre H. Exploring the relationship between childhood adversity and oral health: An anecdotal approach and integrative view. *Medical Hypotheses.* 85(2):134-40.
24. Kvist T, Annerback EM, Sahlqvist L, Flodmark O, Dahllöf G. Association between adolescents' self-perceived oral health and self-reported experiences of abuse. *Eur J Oral Sci.* 2013;121(6):594-9.
25. Wolf E, McCarthy E, Priebe G. Dental care – an emotional and physical challenge for the sexually abused. *Eur J Oral Sci.* 2020;128(4):317-24.
26. Humphris G, King K. The prevalence of dental anxiety across previous distressing experiences. *J Anxiety Disord.* 2011;25(2):232-6.
27. Oosterink FMD, de Jongh A, Aartman IHA. Negative events and their potential risk of precipitating pathological forms of dental anxiety. *J Anxiety Disord.* 2009;23(4):451-7.
28. Hagqvist O, Tolvanen M, Rantavuori K, Karlsson L, Karlsson H, Lahti S. Dental fear and previous childhood traumatic experiences, life events, and parental bonding. *Eur J Oral Sci.* 2015;123(2):96-101.
29. Goma N, Tenenbaum H, Glogauer M, Quiñonez C. The Biology of Social Adversity Applied to Oral Health. *J Dent Res.* 2019;98(13):1442-9.
30. Halonen H, Nissinen J, Lehtiniemi H, Salo T, Riipinen P, Miettunen J. The Association Between Dental Anxiety And Psychiatric Disorders And Symptoms: A Systematic Review. *Clin Pract Epidemiol Ment Health.* 2018;14:207-22.
31. Davies R. Richard Watt: time to tackle oral diseases. *The Lancet.* 2019;394(10194):209.
32. Petersen PE. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century – the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol.* 2003;31(s1):3-24.
33. Coles E, Chan K, Collins J, Humphris GM, Richards D, Williams B, et al. Decayed and missing teeth and oral-health-related factors: Predicting depression in homeless people. *J Psychosom Res.* 2011;71(2):108-12.
34. Rosenoer LM, Sheiham A. Dental impacts on daily life and satisfaction with teeth in relation to dental status in adults. *J Oral Rehabil.* 1995;22(7):469-80.
35. Kisely S. No Mental Health without Oral Health. *The Canadian Journal of Psychiatry.* 2016;61(5):277-82.
36. Petersen PE, Kwan S. Equity, social determinants and public health programmes – the case of oral health. *Community Dent Oral Epidemiol.* 2011;39(6):481-7.
37. Statistics Norway S. Statistikkbanken Norway2020 [cited 2020 30.01.]. Available from: <https://www.ssb.no/statbank/list/utniv>.
38. Armfield JM, Slade GD, Spencer AJ. Dental fear and adult oral health in Australia. *Community Dent Oral Epidemiol.* 2009;37(3):220-30.
39. Schuller AA, Willumsen T, Holst D. Are there differences in oral health and oral health behavior between individuals with high and low dental fear? *Community Dent Oral Epidemiol.* 2003;31(2):116-21.
40. Cohen SM, Fiske J, Newton JT. Behavioural dentistry: The impact of dental anxiety on daily living. *Br Dent J.* 2000;189(7):385-90.
41. Abrahamsson KH, Berggren U, Hallberg LRM, Carlsson SG. Ambivalence in Coping with Dental Fear and Avoidance: A Qualitative Study. *J Health Psychol.* 2002;7(6):653-64.
42. Lov om tannhelsetjenesten/The Dental Health Act, (1984).
43. Kvist T, Annerbäck EM, Dahllöf G. Oral health in children investigated by Social services on suspicion of child abuse and neglect. *Child Abuse & Neglect.* 2018;76:515-23.

44. Kumar S, Bhargav P, Patel A, Bhati M, Balasubramanyam G, Duraiswamy P, et al. Does dental anxiety influence oral health-related quality of life? Observations from a cross-sectional study among adults in Udaipur district, India. *Journal of Oral Science*. 2009;51(2):245-54.
45. Gisler V, Bassetti R, Mericske-Stern R, Bayer S, Enkling N. A cross-sectional analysis of the prevalence of dental anxiety and its relation to the oral health-related quality of life in patients with dental treatment needs at a university clinic in Switzerland. *Gerodontology*. 2012;29(2):e290-6.
46. Crofts-Barnes NP, Brough E, Wilson KE, Beddis AJ, Girdler NM. Anxiety and quality of life in phobic dental patients. *J Dent Res*. 2010;89(3):302-6.
47. Locker D. Psychosocial consequences of dental fear and anxiety. *Community Dent Oral Epidemiol*. 2003;31(2):144-51.
48. Jackson SL, Vann Jr WF, Kotch JB, Pahel BT, Lee JY. Impact of poor oral health on children's school attendance and performance. *Am J Public Health*. 2011;101(10):1900-6.
49. Seirawan H, Faust S, Mulligan R. The impact of oral health on the academic performance of disadvantaged children. *Am J Public Health*. 2012;102(9):1729-34.
50. Vermaire JH, De Jongh A, Aartman IHA. Dental anxiety and quality of life: the effect of dental treatment. *Community Dent Oral Epidemiol*. 2008;36(5):409-16.
51. Noar SM. *A Health Educator's Guide to Theories of Health Behavior*. International Quarterly of Community Health Education. 2004;24(1):75-92.
52. Syrjälä A-MH, Knecht MC, Knuutila MLE. Dental self-efficacy as a determinant to oral health behaviour, oral hygiene and HbA1c level among diabetic patients. *Journal of Clinical Periodontology*. 1999;26(9):616-21.
53. O'Leary A. Self-efficacy and health: Behavioral and stress-physiological mediation. *Cognitive therapy and research*. 1992;16(2):229-45.
54. O'Leary A. Self-efficacy and health. *Behav Res Ther*. 1985;23(4):437-51.
55. Wiedenfeld SA, O'Leary A, Bandura A, Brown S, Levine S, Raska K. Impact of perceived self-efficacy in coping with stressors on components of the immune system. *J Pers Soc Psychol*. 1990;59(5):1082.
56. Liddell A, Murray P. Age and sex differences in children's reports of dental anxiety and self-efficacy relating to dental visits. *Canadian Journal of Behavioural Science / Revue canadienne des sciences du comportement*. 1989;21(3):270-9.
57. Tsigos C, Kyrou I, Kassi E, Chrousos GP. *Stress, endocrine physiology and pathophysiology*. 2015.
58. Nesse RM. Fear and fitness: An evolutionary analysis of anxiety disorders. *Ethology and sociobiology*. 1994;15(5-6):247-61.
59. Bracha S, Williams AE, Bracha AS. Does "fight or flight" need updating? *Psychosomatics*. 2004;45(5):448-9.
60. Bourne EJ. *The anxiety and phobia workbook*: New Harbinger Publications; 2011.
61. Emmelkamp PM, Van Oppen P. *Anxiety disorders*. *Advanced abnormal psychology*: Springer; 2001. p. 285-306.
62. American psychiatric association. *Diagnostic and statistical manual of mental disorders: DSM-5*. 5th ed. Washington, DC2013.
63. Moore R, Brodsgaard I. Differential diagnosis of odontophobic patients using the DSM-IV. *Eur J Oral Sci*. 2002;103.
64. Moore R, Brødsgaard I, Rosenberg N. The contribution of embarrassment to phobic dental anxiety: a qualitative research study. *BMC Psychiatry*. 2004;4(1):10.
65. Aartman IHA, de Jongh A, van der Meulen MJ. Psychological characteristics of patients applying for treatment in a dental fear clinic. *Eur J Oral Sci*. 1997;105(5P1):384-8.
66. Roy-Byrne PP, Milgrom P, Khoon-Mei T, Weinstein P, Katon W. Psychopathology and psychiatric diagnosis in subjects with dental phobia. *J Anxiety Disord*. 1994;8(1):19-31.
67. Oosterink FMD, De Jongh A, Hoogstraten J. Prevalence of dental fear and phobia relative to other fear and phobia subtypes. *Eur J Oral Sci*. 2009;117(2):135-43.
68. Newton JT, Buck DJ. Anxiety and pain measures in dentistry: a guide to their quality and application. *J Am Dent Assoc*. 2000;131(10):1449-57.
69. Neverlien PO. Assessment of a single-item dental anxiety question. *Acta Odontol Scand*. 1990;48(6):365-9.

70. Freeman R, Clarke H, Humphris G. Conversion tables for the corah and modified dental anxiety scales. *Community dental health*. 2007;24(1):49.
71. Armfield JM, Slade GD, Spencer AJ. Are people with dental fear under-represented in oral epidemiological surveys? *Soc Psychiatry Psychiatr Epidemiol*. 2008;44(6):495-500.
72. Hakeberg M, Berggren U, Carlsson SG. Prevalence of dental anxiety in an adult population in a major urban area in Sweden. *Community Dent Oral Epidemiol*. 1992;20(2):97-101.
73. Moore R, Birn H, Kirkegaard E, Brodsgaard I, Scheutz F. Prevalence and characteristics of dental anxiety in Danish adults. *Community Dent Oral Epidemiol*. 1993;21.
74. Pohjola V, Mattila AK, Joukamaa M, Lahti S. Anxiety and depressive disorders and dental fear among adults in Finland. *Eur J Oral Sci*. 2011;119(1):55-60.
75. Liinavuori A, Tolvanen M, Pohjola V, Lahti S. Changes in dental fear among Finnish adults: a national survey. *Community Dent Oral Epidemiol*. 2016;44(2):128-34.
76. Cianetti S, Lombardo G, Lupatelli E, Pagano S, Abraha I, Montedori A, et al. Dental fear/anxiety among children and adolescents. A systematic review. *Eur J Paediatr Dent*. 2017;18(2):121-30.
77. 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(6):391-406.
78. Seligman LD, Hovey JD, Chacon K, Ollendick TH. Dental anxiety: An understudied problem in youth. *Clinical Psychology Review*. 2017;55:25-40.
79. Grisolia BM, dos Santos APP, Dhyppolito IM, Buchanan H, Hill K, Oliveira BH. Prevalence of dental anxiety in children and adolescents globally: A systematic review with meta-analyses. *Int J Paediatr Dent*. n/a(n/a).
80. Thomson WM, Poulton RG, Kruger E, Davies S, Brown RH, Silva PA. Changes in self-reported dental anxiety in new zealand adolescents from ages 15 to 18 years. *J Dent Res*. 1997;76 (6).
81. Poulton R, Waldie KE, Thomson WM, Locker D. Determinants of early- vs late-onset dental fear in a longitudinal-epidemiological study. *Behav Res Ther*. 2001;39(7):777-85.
82. Locker D, Liddell A, Dempster L, Shapiro D. Age of onset of dental anxiety. *J Dent Res*. 1999;78(3):790-6.
83. Weiner AA, Sheehan DV. Etiology of dental anxiety: psychological trauma or CNS chemical imbalance? *Gen Dent*. 1990;38(1):39-43.
84. Thomson WM, Broadbent JM, Locker D, Poulton R. Trajectories of dental anxiety in a birth cohort. *Community Dent Oral Epidemiol*. 2009;37(3):209-19.
85. Liddell A, Locker D. Changes in Levels of Dental Anxiety as a Function of Dental Experience. *Behav Modif*. 2000;24(1):57-68.
86. Davey GCL. Dental phobias and anxieties: Evidence for conditioning processes in the acquisition and modulation of a learned fear. *Behav Res Ther*. 1989;27(1):51-8.
87. Lahey BB. Public health significance of neuroticism. *Am Psychol*. 2009;64(4):241-56.
88. Widiger TA. *Neuroticism*. 2009.
89. Halonen H, Salo T, Hakko H, Rasanen P. Association of dental anxiety to personality traits in a general population sample of Finnish University students. *Acta Odontol Scand*. 2012;70(2):96-100.
90. Hägglin C, Hakeberg M, Hällström T, Berggren U, Larsson L, Waern M, et al. Dental anxiety in relation to mental health and personality factors. *European Journal of Oral Sciences*. 2001;109(1):27-33.
91. Vassend O, Roysamb E, Nielsen CS. Dental anxiety in relation to neuroticism and pain sensitivity. A twin study. *J Anxiety Disord*. 2011;25(2):302-8.
92. Wide S., Boman U. W. *Explanation and causal reasoning: A contribution to the interpretation of competing explanatory claims. Theory & Psychology*. 2013.
93. Locker D, Liddell A. Stability of Dental Anxiety Scale scores: a longitudinal study of older adults. *Community Dent Oral Epidemiol*. 1995;23(5):259-61.
94. Hägglin C, Berggren U, Hakeberg M, Hallstrom T, Bengtsson C. Variations in dental anxiety among middle-aged and elderly women in Sweden: a longitudinal study between 1968 and 1996. *J Dent Res*. 1999;78(10):1655-61.
95. Thomson WM, Locker D, Poulton R. Incidence of dental anxiety in young adults in relation to dental treatment experience. *Community Dent Oral Epidemiol*. 2000;28(4):289-94.

96. Liddell A, Locker D. Gender and age differences in attitudes to dental pain and dental control. *Community Dent Oral Epidemiol*. 1997;25(4):314-8.
97. Schienle A, Scharmüller W, Leutgeb V, Schäfer A, Stark R. Sex differences in the functional and structural neuroanatomy of dental phobia. *Brain Structure and Function*. 2013;218(3):779-87.
98. Schienle A, Köchel A, Leutgeb V. Frontal late positivity in dental phobia: A study on gender differences. *Biological Psychology*. 2011;88(2):263-9.
99. Armfield JM. Cognitive vulnerability: A model of the etiology of fear. *Clin Psychol Rev*. 2006;26(6):746-68.
100. Abrahamsson KH, Berggren U, Hallberg L, Carlsson SG. Dental phobic patients' view of dental anxiety and experiences in dental care: a qualitative study. *Scand J Caring Sci*. 2002;16(2):188-96.
101. Wiech K. Deconstructing the sensation of pain: The influence of cognitive processes on pain perception. *Science*. 2016;354(6312):584-7.
102. Porro CA, Baraldi P, Pagnoni G, Serafini M, Facchin P, Maieron M, et al. Does Anticipation of Pain Affect Cortical Nociceptive Systems? *The Journal of Neuroscience*. 2002;22(8):3206-14.
103. Koyama T, McHaffie JG, Laurienti PJ, Coghill RC. The subjective experience of pain: Where expectations become reality. *Proceedings of the National Academy of Sciences of the United States of America*. 2005;102(36):12950-5.
104. Seifert F, Schubert N, De Col R, Peltz E, Nickel FT, Maihöfner C. Brain activity during sympathetic response in anticipation and experience of pain. *Human Brain Mapping*. 2013;34(8):1768-82.
105. Ogden RS, Moore D, Redfern L, McGlone F. The effect of pain and the anticipation of pain on temporal perception: A role for attention and arousal. *Cognition and Emotion*. 2015;29(5):910-22.
106. Palermo S, Benedetti F, Costa T, Amanzio M. Pain anticipation: An activation likelihood estimation meta-analysis of brain imaging studies. *Human Brain Mapping*. 2015;36(5):1648-61.
107. Eli I, Baht R, Kozlovsky A, Simon H. Effect of gender on acute pain prediction and memory in periodontal surgery. *Eur J Oral Sci*. 2000;108(2):99-103.
108. Pud D, Eisenberg E, Sprecher E, Rogowski Z, Yarnitsky D. The tridimensional personality theory and pain: harm avoidance and reward dependence traits correlate with pain perception in healthy volunteers. *European Journal of Pain*. 2004;8(1):31-8.
109. Klages U, Kianifard S, Ulusoy Ö, Wehrbein H. Anxiety sensitivity as predictor of pain in patients undergoing restorative dental procedures. *Community Dent Oral Epidemiol*. 2006;34(2):139-45.
110. Lin CS, Wu SY, Yi CA. Association between Anxiety and Pain in Dental Treatment: A Systematic Review and Meta-analysis. *J Dent Res*. 2016;96(2):153-62.
111. Maggiri J, Locker D. Psychological factors and perceptions of pain associated with dental treatment. *Community Dent Oral Epidemiol*. 2002;30(2):151-9.
112. Arntz A, van Eck M, Heijmans M. Predictions of dental pain: The fear of any expected evil, is worse than the evil itself. *Behav Res Ther*. 1990;28(1):29-41.
113. Kent G. Memory of dental pain. *Pain*. 1985;21(2):187-94.
114. Skaret E, Raadal M, Berg E, Kvale G. Dental anxiety and dental avoidance among 12 to 18 year olds in Norway. *Eur J Oral Sci*. 1999;107(6):422-8.
115. Armfield JM. Predicting dental avoidance among dentally fearful Australian adults. *Eur J Oral Sci*. 2013;121(3pt2):240-6.
116. Haugejorden O, Solveig Klock K. Avoidance of dental visits: the predictive validity of three dental anxiety scales. *Acta Odontol Scand*. 2000;58(6):255-9.
117. Mellor AC. Dental anxiety and attendance in the North-west of England. *Journal of Dentistry*. 1992;20(4):207-10.
118. Kim H, Shimojo S, O'Doherty JP. Is avoiding an aversive outcome rewarding? Neural substrates of avoidance learning in the human brain. *PLoS Biol*. 2006;4(8):e233.
119. Foa EB, Kozak MJ. Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin*. 1986;99(1):20-35.
120. Berggren U, Meynert G. Dental fear and avoidance -causes, symptoms and consequences. *J Am Dent Assoc*. 1984;109.

121. Klepac RK, Dowling J, Hauge G. Characteristics of clients seeking therapy for the reduction of dental avoidance: reactions to pain. *J Behav Ther Exp Psychiatry*. 1982;13(4):293-300.
122. Armfield JM. What goes around comes around: revisiting the hypothesized vicious cycle of dental fear and avoidance. *Community Dent Oral Epidemiol*. 2013;41(3):279-87.
123. De Jongh A, Schutjes M, Aartman IH. A test of Berggren's model of dental fear and anxiety. *Eur J Oral Sci*. 2011;119(5):361-5.
124. De Jongh A, Muris P, Horst GT, Duyx MPMA. Acquisition and maintenance of dental anxiety: the role of conditioning experiences and cognitive factors. *Behav Res Ther*. 1995;33(2):205-10.
125. Southerland JH, Brown LR. Conscious intravenous sedation in dentistry: a review of current therapy. *Dental Clinics*. 2016;60(2):309-46.
126. Pereira-Santos D, Brêda-Júnior MA, Ferraz EP, Crippa GE, de Oliveira FS, da Rocha-Barros VM. Study Comparing Midazolam and Nitrous Oxide in Dental Anxiety Control. *Journal of Craniofacial Surgery*. 2013;24(5):1636-9.
127. Folayan MO, Faponle A, Lamikanra A. A review of the pharmacological approach to the management of dental anxiety in children. *Int J Paediatr Dent*. 2002;12(5):347-54.
128. Willumsen T, Vassend O, Hoffart A. A comparison of cognitive therapy, applied relaxation, and nitrous oxide sedation in the treatment of dental fear. *Acta Odontol Scand*. 2001;59(5):290-6.
129. Willumsen T, Vassend O. Effects of cognitive therapy, applied relaxation and nitrous oxide sedation. A five-year follow-up study of patients treated for dental fear. *Acta Odontol Scand*. 2003;61(2):93-9.
130. Thom A, Sartory G, Jöhren P. Comparison between one-session psychological treatment and benzodiazepine in dental phobia. *Journal of Consulting and Clinical Psychology*. 2000;68(3):378.
131. Hakeberg M, Berggren U, Carlsson SG, Gröndahl HG. Long-term effects on dental care behavior and dental health after treatments for dental fear. *Anesth Prog*. 1993;40(3):72-7.
132. Savanheimo N, Vehkalahti MM. Five-year follow-up of children receiving comprehensive dental care under general anesthesia. *BMC Oral Health*. 2014;14(1):154.
133. Gordon D, Heimberg RG, Tellez M, Ismail AI. A critical review of approaches to the treatment of dental anxiety in adults. *J Anxiety Disord*. 2013;27(4):365-78.
134. Kvale G, Berggren U, Milgrom P. Dental fear in adults: a meta-analysis of behavioral interventions. *Community Dent Oral Epidemiol*. 2004;32(4):250-64.
135. Rodd H, Kirby J, Duffy E, Porritt J, Morgan A, Prasad S, et al. Children's experiences following a CBT intervention to reduce dental anxiety: one year on. *Br Dent J*. 2018;225(3):247-51.
136. Rothbaum BO, Meadows EA, Resick P, Foy DW. *Cognitive-behavioral therapy. Effective treatments for PTSD: Practice guidelines from the International Society for Traumatic Stress Studies*. New York, NY, US: Guilford Press; 2000. p. 320-5.
137. Abrahamsson KH, Berggren U, Hakeberg M, Carlsson SG. The importance of dental beliefs for the outcome of dental-fear treatment. *Eur J Oral Sci*. 2003;111(2):99-105.
138. Hauge MS, Stora B, Vassend O, Hoffart A, Willumsen T. Dentist - administered cognitive behavioural therapy versus four habits/midazolam: An RCT study of dental anxiety treatment in primary dental care. *Eur J Oral Sci*. 2021:e12794.
139. Wide Boman U, Carlsson V, Westin M, Hakeberg M. Psychological treatment of dental anxiety among adults: a systematic review. *Eur J Oral Sci*. 2013;121(3 Pt 2):225-34.
140. Stuart EA, Bradshaw CP, Leaf PJ. Assessing the generalizability of randomized trial results to target populations. *Prevention Science*. 2015;16(3):475-85.
141. Raja S, Hoersch M, Rajagopalan CF, Chang P. Treating patients with traumatic life experiences: Providing trauma-informed care. *J Am Dent Assoc*. 2014;145(3):238-45.
142. Kranstad V, Sjøftestad S, Fredriksen TV, Willumsen T. Being considerate every step of the way: a qualitative study analysing trauma-sensitive dental treatment for childhood sexual abuse survivors. *Eur J Oral Sci*. n/a(n/a).
143. Henning Abrahamsson K, Berggren U, Carlsson SG. Psychosocial aspects of dental and general fears in dental phobic patients. *Acta Odontol Scand*. 2009;58(1):37-43.
144. Boman UW, Lundgren J, Berggren U, Carlsson SG. Psychosocial and dental factors in the maintenance of severe dental fear. *Swed Dent J*. 2010;34(3):121-7.

145. Locker D, Poulton R, Thomson WM. Psychological disorders and dental anxiety in a young adult population. *Community Dent Oral Epidemiol.* 2001;29(6):456-63.
146. Stenebrand A, Boman UW, Hakeberg M. Dental anxiety and symptoms of general anxiety and depression in 15-year-olds. *J Dent Hyg.* 2013;11(2):99-104.
147. Halonen H, Salo T, Hakko H, Räsänen P. The Association between Dental Anxiety, General Clinical Anxiety and Depression among Finnish University Students. *Oral Health Prev Dent.* 2014;13(2):320-5.
148. Murray P, Liddell A, Donohue J. A longitudinal study of the contribution of dental experience to dental anxiety in children between 9 and 12 years of age. *J Behav Med.* 1989;12(3):309-20.
149. Matevosyan NR. Oral Health of Adults with Serious Mental Illnesses: A Review. *Community Mental Health Journal.* 2010;46(6):553-62.
150. Kisely S, Baghaie H, Lalloo R, Siskind D, Johnson NW. A Systematic Review and Meta-Analysis of the Association Between Poor Oral Health and Severe Mental Illness. *Psychosomatic Medicine.* 2015;77(1):83-92.
151. Kisely S, Sawyer E, Siskind D, Lalloo R. The oral health of people with anxiety and depressive disorders – a systematic review and meta-analysis. *J Affect Disord.* 2016;200:119-32.
152. Okoro CA, Strine TW, Eke PI, Dhingra SS, Balluz LS. The association between depression and anxiety and use of oral health services and tooth loss. *Community Dentistry and Oral Epidemiology.* 2012;40(2):134-44.
153. Visvanathan V, Nix P. Managing the patient presenting with xerostomia: a review. *International Journal of Clinical Practice.* 2010;64(3):404-7.
154. Epstein JB, Scully C. The role of saliva in oral health and the causes and effects of xerostomia. *Journal (Canadian Dental Association).* 1992;58(3):217-21.
155. Gholami N, Hosseini Sabzvari B, Razzaghi A, Salah S. Effect of stress, anxiety and depression on unstimulated salivary flow rate and xerostomia. *J Dent Res Dent Clin Dent Prospects.* 2017;11(4):247-52.
156. Sansone RA, Sansone LA. SSRI-Induced Indifference. *Psychiatry (Edgmont).* 2010;7(10):14-8.
157. Firth J, Siddiqi N, Koyanagi A, Siskind D, Rosenbaum S, Galletly C, et al. The Lancet Psychiatry Commission: a blueprint for protecting physical health in people with mental illness. *The Lancet Psychiatry.* 2019;6(8):675-712.
158. Hayes J, Miles J, Walters K, King M, Osborn D. A systematic review and meta - analysis of premature mortality in bipolar affective disorder. *Acta Psychiatrica Scandinavica.* 2015;131(6):417-25.
159. Chesney E, Goodwin GM, Fazel S. Risks of all-cause and suicide mortality in mental disorders: a meta-review. *World Psychiatry.* 2014;13(2):153-60.
160. Danson R, Jones, Ph.D. , Cathaleene Macias, Ph.D. , Paul J. Barreira, M.D. , William H. Fisher, Ph.D. , William A. Hargreaves, Ph.D. , and, Courtenay M. Harding, Ph.D. Prevalence, Severity, and Co-occurrence of Chronic Physical Health Problems of Persons With Serious Mental Illness. *Psychiatric Services.* 2004;55(11):1250-7.
161. Aschbrenner K, Carpenter-Song E, Mueser K, Kinney A, Pratt S, Bartels S. A Qualitative Study of Social Facilitators and Barriers to Health Behavior Change Among Persons with Serious Mental Illness. *Community Mental Health Journal.* 2013;49(2):207-12.
162. Thornicroft G. Physical health disparities and mental illness: the scandal of premature mortality. *British Journal of Psychiatry.* 2011;199(6):441-2.
163. Scott D, Happell B. The High Prevalence of Poor Physical Health and Unhealthy Lifestyle Behaviours in Individuals with Severe Mental Illness. *Issues in Mental Health Nursing.* 2011;32(9):589-97.
164. Marsac ML, Funk JB. Relationships Among Psychological Functioning, Dental Anxiety, Pain Perception, and Coping in Children and Adolescents. *Journal of Dentistry for Children.* 2008;75(3):243-51.
165. Willumsen T, Vassend O, Hoffart A. One-year follow-up of patients treated for dental fear: effects of cognitive therapy, applied relaxation, and nitrous oxide sedation. *Acta Odontol Scand.* 2001;59(6):335-40.

166. Vassend O, Willumsen T, Hoffart A. Effects of dental fear treatment on general distress. The role of personality variables and treatment method. *Behav Modif.* 2000;24(4):580-99.
167. Charmandari E, Tsigos C, Chrousos G. ENDOCRINOLOGY OF THE STRESS RESPONSE. *Annual Review of Physiology.* 2005;67(1):259-84.
168. Cohen S, Janicki-Deverts D, Miller GE. Psychological stress and disease. *JAMA.* 2007;298(14):1685-7.
169. Crum AJ, Salovey P, Achor S. Rethinking stress: The role of mindsets in determining the stress response. *J Pers Soc Psychol.* 2013;104(4):716-33.
170. Carlson EB, Dalenbergh CJ. A Conceptual Framework for the Impact of Traumatic Experiences. *Trauma, Violence, & Abuse.* 2000;1(1):4-28.
171. Abrams MP, Nicholas Carleton R, Taylor S, Asmundson GJG. Human tonic immobility: measurement and correlates. *Depression and Anxiety.* 2009;26(6):550-6.
172. Bracha HS. Freeze, flight, fight, fright, faint: Adaptationist perspectives on the acute stress response spectrum. *CNS spectrums.* 2004;9(9):679-85.
173. Hoagland H. Peritraumatic dissociation and tonic immobility: clinical findings. *Neurobiology and Treatment of Traumatic Dissociation: Towards an Embodied Self.* 2014:51.
174. Hagenars MA, Stins JF, Roelofs K. Aversive life events enhance human freezing responses. *Journal of Experimental Psychology: General.* 2012;141(1):98-105.
175. Waller G, Hamilton K, Elliott P, Lewendon J, Stopa L, Waters A, et al. Somatoform Dissociation, Psychological Dissociation, and Specific Forms of Trauma. *Journal of Trauma & Dissociation.* 2001;1(4):81-98.
176. Lauterbach D, Vora R, Rakow M. The Relationship Between Posttraumatic Stress Disorder and Self-Reported Health Problems. *Psychosomatic Medicine.* 2005;67(6):939-47.
177. Pacella ML, Hruska B, Delahanty DL. The physical health consequences of PTSD and PTSD symptoms: A meta-analytic review. *J Anxiety Disord.* 2013;27(1):33-46.
178. Muhvić-urek M, Uhač I, Vukšić-mihaljević Ž, Leović D, Blečić N, Kovač Z. Oral health status in war veterans with post-traumatic stress disorder. *J Oral Rehabil.* 2007;34(1):1-8.
179. Alhaffar MBA, Mustafa K, Sabbagh S, Yabrode K, Shebib G, Kouchaji C. Seven years of war in Syria: The relation between oral health and PTSD among children. *Indian Journal of Oral Health and Research.* 2018;4(1):10.
180. Van der Kolk BA, McFarlane AC. *Traumatic stress: The effects of overwhelming experience on mind, body, and society:* Guilford Press; 1996.
181. Brewin CR. Autobiographical memory for trauma: Update on four controversies. *Memory.* 2007;15(3):227-48.
182. Van der Kolk BA. *Psychological trauma:* American Psychiatric Pub; 2003.
183. Bureau J-F, Martin J, Lyons-Ruth K, van der Kolk BA, d'Andrea W, Ford JD, et al. *The Impact of Early Life Trauma on Health and Disease: The Hidden Epidemic United States of America,* New York: Cambridge University Press; 2010.
184. Van der Kolk BA, McFarlane AC, Weisaeth L. *Traumatic stress.* New York: Guilford. 1996.
185. Lerwick JL. Minimizing pediatric healthcare-induced anxiety and trauma. *World J Clin Pediatr.* 2016;5(2):143-50.
186. de Jongh A, Olf M, van Hoolwerff H, Aartman IHA, Broekman B, Lindauer R, et al. Anxiety and post-traumatic stress symptoms following wisdom tooth removal. *Behav Res Ther.* 2008;46(12):1305-10.
187. De Jongh A, Fransen J, Oosterink-Wubbe F, Aartman I. Psychological trauma exposure and trauma symptoms among individuals with high and low levels of dental anxiety. *Eur J Oral Sci.* 2006;114:286-92.
188. De Jongh A, Aartman IHA, Brand N. Trauma-related phenomena in anxious dental patients. *Community Dent Oral Epidemiol.* 2003;31(1):52-8.
189. Alexopoulos J, Steinberg C, Liebergesell-Kilian NE, Hoeffkes B, Doering S, Junghöfer M. Biased emotional attention in patients with dental phobia. *European Journal of Neuroscience.* 2019;49(2):290-302.
190. van der Kolk BA, Roth S, Pelcovitz D, Sunday S, Spinazzola J. Disorders of extreme stress: The empirical foundation of a complex adaptation to trauma. *Journal of Traumatic Stress.* 2005;18(5):389-99.

191. Morey RA, Dunsmoor JE, Haswell CC, Brown VM, Vora A, Weiner J, et al. Fear learning circuitry is biased toward generalization of fear associations in posttraumatic stress disorder. *Transl Psychiatry*. 2015;5(12):e700-e.
192. Weiss SJ. Neurobiological Alterations Associated With Traumatic Stress. *Perspectives in Psychiatric Care*. 2007;43(3):114-22.
193. Fredriksen TV, Sjøftestad S, Kranstad V, Willumsen T. Preparing for attack and recovering from battle: Understanding child sexual abuse survivors' experiences of dental treatment. *Community Dent Oral Epidemiol*. 2020;48(4):317-27.
194. Levine PA, Frederick A. *Waking the tiger: Healing trauma: The innate capacity to transform overwhelming experiences*: North Atlantic Books; 1997.
195. Keiser AA, Turnbull LM, Darian MA, Feldman DE, Song I, Tronson NC. Sex Differences in Context Fear Generalization and Recruitment of Hippocampus and Amygdala during Retrieval. *Neuropsychopharmacology*. 2017;42(2):397-407.
196. Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. *The Lancet Child & Adolescent Health*. 2018;2(3):223-8.
197. Sawyer SM, Afifi RA, Bearinger LH, Blakemore S-J, Dick B, Ezech AC, et al. Adolescence: a foundation for future health. *The Lancet*. 2012;379(9826):1630-40.
198. BRUKIENĖ V, ALEKSEJŪNIENĖ J. An overview of oral health promotion in adolescents. *Int J Paediatr Dent*. 2009;19(3):163-71.
199. Vika M, Skaret E, Raadal M, Öst L-G, Kvale G. Fear of blood, injury, and injections, and its relationship to dental anxiety and probability of avoiding dental treatment among 18-year-olds in Norway. *Int J Paediatr Dent*. 2008;18(3):163-9.
200. Lerner RM, Steinberg L. The scientific study of adolescent development. *Handbook of adolescent psychology*. 2004;2:1-12.
201. Steinberg L. A behavioral scientist looks at the science of adolescent brain development. *Brain and cognition*. 2010;72(1):160-4.
202. Blakemore S-J. Imaging brain development: The adolescent brain. *NeuroImage*. 2012;61(2):397-406.
203. Luna B, Padmanabhan A, O'Hearn K. What has fMRI told us about the Development of Cognitive Control through Adolescence? *Brain and Cognition*. 2010;72(1):101-13.
204. Dahl RE. Adolescent brain development: a period of vulnerabilities and opportunities. Keynote address. *Annals of the New York Academy of Sciences*. 2004;1021(1):1-22.
205. Galvan A, Hare TA, Parra CE, Penn J, Voss H, Glover G, et al. Earlier development of the accumbens relative to orbitofrontal cortex might underlie risk-taking behavior in adolescents. *Journal of Neuroscience*. 2006;26(25):6885-92.
206. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: a Lancet commission on adolescent health and wellbeing. *Lancet (London, England)*. 2016;387(10036):2423-78.
207. National Research Council (US) and Institute of Medicine (US) Committee on Adolescent Health Care Services and Models of Care for Treatment P, and Healthy Development. *Adolescent health services: missing opportunities*. Robert S L, J Appelton G, Leslie J S, editors. Washington (DC): National Academies Press (US); 2009.
208. Harter S, Leahy RL. *The construction of the self: A developmental perspective*. Springer; 2001.
209. Davey M, Eaker DG, Walters LH. Resilience Processes in Adolescents: Personality Profiles, Self-Worth, and Coping. *Journal of Adolescent Research*. 2003;18(4):347-62.
210. Gore FM, Bloem PJ, Patton GC, Ferguson J, Joseph V, Coffey C, et al. Global burden of disease in young people aged 10-24 years: a systematic analysis. *Lancet*. 2011;377(9783):2093-102.
211. de Graaf R, Ten Have M, van Gool C, van Dorsselaer S. Prevalence of mental disorders and trends from 1996 to 2009. Results from the Netherlands Mental Health Survey and Incidence Study-2. *Soc Psychiatry Psychiatr Epidemiol*. 2012;47(2):203-13.
212. Bourdon KH, Rae DS, Locke BZ, Narrow WE, Regier DA. Estimating the prevalence of mental disorders in U.S. adults from the Epidemiologic Catchment Area Survey. *Public Health Rep*. 1992;107(6):663-8.

213. Jess T. Microbiota, Antibiotics, and Obesity. *New England Journal of Medicine*. 2014;371(26):2526-8.
214. Lobstein T, Jackson-Leach R, Moodie ML, Hall KD, Gortmaker SL, Swinburn BA, et al. Child and adolescent obesity: part of a bigger picture. *The Lancet*. 2015;385(9986):2510-20.
215. Birkeland JM, Haugejorden O, Fehr FRvd. Analyses of the caries decline and incidence among Norwegian adolescents 1985-2000. *Acta Odontol Scand*. 2002;60(5):281-9.
216. Dental health care [Internet]. 2020 [cited 20.10.2020]. Available from: <https://www.ssb.no/en/helse/statistikker/tannhelse>.
217. Duijster D, van Loveren C, Dusseldorp E, Verrips GHW. Modelling community, family, and individual determinants of childhood dental caries. *Eur J Oral Sci*. 2014;122(2):125-33.
218. Wille N, Bettge S, Wittchen H-U, Ravens-Sieberer U, The Bsg. How impaired are children and adolescents by mental health problems? Results of the BELLA study. *European Child & Adolescent Psychiatry*. 2008;17(1):42-51.
219. Strøm K, Rønneberg A, Skaare AB, Espelid I, Willumsen T. Dentists' use of behavioural management techniques and their attitudes towards treating paediatric patients with dental anxiety. *European Archives of Paediatric Dentistry*. 2015;16(4):349-55.
220. Westen D, Chang C. Personality pathology in adolescence: A review. *Adolescent psychiatry: Developmental and clinical studies*, Vol 25. *The Annals of the American Society for Adolescent Psychiatry*. Mahwah, NJ, US: Analytic Press; 2000. p. 61-100.
221. Humphris G, King K. The prevalence of dental anxiety across previous distressing experiences. *J Anxiety Disord*. 2011;25(2):232-6.
222. Lov om pasient- og brukerrettigheter (pasient- og brukerrettighetsloven), (LOV-1999-07-02-63).
223. Abelsen B. What a difference a place makes: Dental attendance and self-rated oral health among adults in three counties in Norway. *Health Place*. 2008;14(4):829-40.
224. Forskrift om stønad til dekning av utgifter til undersøkelse og behandling hos tannlege og tannpleier for sykdom (Regulations on benefits to cover the cost of dental treatment), (2014).
225. Jacobsen BK, Eggen AE, Mathiesen EB, Wilsgaard T, Njølstad I. Cohort profile: The Tromsø Study. *Int J Epidemiol*. 2011;41(4):961-7.
226. Norway UTAUo. Tromsøundersøkelsen Tromsø: UiT; 2021 [Available from: <https://uit.no/research/tromsundersokelsen>].
227. (UiT) UoTTAUoN. Fit Future Tromsø: University of Tromsø – The Arctic University of Norway (UiT); 2020 [Available from: https://uit.no/research/fitfutures?p_document_id=668286].
228. Tromsø municipality [Internet]. 2020. Available from: <https://www.ssb.no/kommunefakta/tromso>.
229. Corah NL, Gale EN, Illig SJ. Assessment of a dental anxiety scale. *J Am Dent Assoc*. 1978;97.
230. Humphris GM, Freeman R, Campbell J, Tuutti H, D'Souza V. Further evidence for the reliability and validity of the Modified Dental Anxiety Scale. *International Dental Journal*. 2000;50(6):367-70.
231. Haavet O, R.; Sirpal, M., K.; Haugen, W.; Christensen, K., S. Diagnosis of depressed young people in primary health care- a validation of HSCL-10. *Family Practice*. 2010.
232. Schmalbach B, Zenger M, Tibubos AN, Kliem S, Petrowski K, Brähler E. Psychometric Properties of Two Brief Versions of the Hopkins Symptom Checklist: HSCL-5 and HSCL-10. *Assessment*.0(0):1073191119860910.
233. Glaesmer H, Braehler E, Grande G, Hinz A, Petermann F, Romppel M. The German Version of the Hopkins Symptoms Checklist-25 (HSCL-25) — Factorial structure, psychometric properties, and population-based norms. *Comprehensive Psychiatry*. 2014;55(2):396-403.
234. Haavet OR, Sirpal MK, Haugen W, Christensen KS. Diagnosis of depressed young people in primary health care-a validation of HSCL-10. *Family Practice*. 2011;28(2):233-7.
235. Strand BH, Dalgard OS, Tambs K, Rognerud M. Measuring the mental health status of the Norwegian population: A comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). *Nord J Psychiatry*. 2003;57(2):113.
236. Søggaard AJ, Bjelland I, Tell GS, Røysamb E. A comparison of the CONOR Mental Health Index to the HSCL-10 and HADS. *Norsk epidemiologi*. 2003;13(2):279-84.

237. Larmas M. Has dental caries prevalence some connection with caries index values in adults? *Caries Res.* 2010;44(1):81-4.
238. Broadbent JM, Thomson WM. For debate: problems with the DMF index pertinent to dental caries data analysis. *Community Dent Oral Epidemiol.* 2005;33(6):400-9.
239. Locker D, Thomson WM, Poulton R. Onset of and patterns of change in dental anxiety in adolescence and early adulthood: a birth cohort study. *Community dental health.* 2001;18(2):99-104.
240. Kotov R, Gamez W, Schmidt F, Watson D. Linking “big” personality traits to anxiety, depressive, and substance use disorders: a meta-analysis. *Psychological bulletin.* 2010;136(5):768.
241. Williams PG, O'Brien CD, Colder CR. The effects of neuroticism and extraversion on self-assessed health and health-relevant cognition. *Pers Individ Differ.* 2004;37(1):83-94.
242. Ekbäck G, Åström AN, Klock K, Ordell S, Unell L. Variation in subjective oral health indicators of 65-year-olds in Norway and Sweden. *Acta Odontol Scand.* 2009;67(4):222-32.
243. Atchison KA, Matthias RE, Dolan TA, Lubben JE, De Jong F, Schweitzer SO, et al. Comparison of Oral Health Ratings by Dentists and Dentate Elders. *J Public Health Dent.* 1993;53(4):223-30.
244. Brennan DS, Spencer AJ, Roberts-Thomson KF. Change in self-reported oral health in relation to use of dental services over 2 yr. *Eur J Oral Sci.* 2012;120(5):422-8.
245. Ng SKS, Leung WK. A community study on the relationship of dental anxiety with oral health status and oral health - related quality of life. *Community Dent Oral Epidemiol.* 2008;36(4):347-56.
246. Armfield JM, Stewart JF, Spencer AJ. The vicious cycle of dental fear: exploring the interplay between oral health, service utilization and dental fear. *BMC Oral Health.* 2007;7:1.
247. Hayes-Skelton SA, Eustis EH. *Experiential avoidance.* 2020.
248. Hakeberg M, Hägglin C, Berggren U, Carlsson SG. Structural relationships of dental anxiety, mood, and general anxiety. *Acta Odontol Scand.* 2001;59(2):99-103.
249. Majstorović M, Škrinjarić T, Szivoczka L, Glavina D, SJ Veerkamp J. Dental anxiety in relation to emotional and behavioral problems in Croatian adolescents. *Collegium antropologicum.* 2007;31(2):573-8.
250. Crego A, Carrillo-Díaz M, Armfield JM, Romero M. From Public Mental Health to Community Oral Health: The Impact of Dental Anxiety and Fear on Dental Status. *Front Public Health.* 2014;2:16.
251. Loevaas MES, Sund AM, Patras J, Martinsen K, Hjemdal O, Neumer SP, et al. Emotion regulation and its relation to symptoms of anxiety and depression in children aged 8–12 years: does parental gender play a differentiating role? *BMC Psychology.* 2018;6(1):42.
252. Compas BE, Jaser SS, Bettis AH, Watson KH, Gruhn MA, Dunbar JP, et al. Coping, emotion regulation, and psychopathology in childhood and adolescence: A meta-analysis and narrative review. *Psychological bulletin.* 2017;143(9):939.
253. Kessler RC, Davis CG, Kendler KS. Childhood adversity and adult psychiatric disorder in the US National Comorbidity Survey. *Psychol Med.* 1997;27(5):1101-19.
254. Haavet O, Straand J, Saugstad O, Grünfeld B. Illness and exposure to negative life experiences in adolescence: two sides of the same coin? A study of 15-year-olds in Oslo, Norway. *Acta Paediatrica.* 2004;93(3):405-11.
255. Maschi T, Baer J, Morrissey MB, Moreno C. The Aftermath of Childhood Trauma on Late Life Mental and Physical Health: A Review of the Literature. *Traumatology.* 2013;19(1):49-64.
256. Maggiri J, Locker D. Five-year incidence of dental anxiety in an adult population. *Community Dent Health.* 2002;19(3):173-9.
257. de Jongh A, ter Horst G. What do anxious patients think? An exploratory investigation of anxious dental patients' thoughts. *Community Dent Oral Epidemiol.* 1993;21(4):221-3.
258. Lis S, Thome J, Kleindienst N, Mueller-Engelmann M, Steil R, Priebe K, et al. Generalization of fear in post-traumatic stress disorder. *Psychophysiology.* 2020;57(1):e13422.
259. Wicking M, Steiger F, Nees F, Diener SJ, Grimm O, Ruttorf M, et al. Deficient fear extinction memory in posttraumatic stress disorder. *Neurobiology of learning and memory.* 2016;136:116-26.
260. Bosch J, Weaver TL, Arnold LD. Impact of Adverse Childhood Experiences on Oral Health Among Women in the United States: Findings From the Behavioral Risk Factor Surveillance System. *Journal of Interpersonal Violence.* 0(0):0886260519883872.

261. da Silva Júnior IF, Goettems ML, Azevedo MS. Oral health status of children and adolescents victims of abuse: a literature review. *RSBO Revista Sul-Brasileira de Odontologia*. 2016;13(2):104-8.
262. Bhopal RS. *Concepts of epidemiology: integrating the ideas, theories, principles, and methods of epidemiology*: Oxford University Press; 2016.
263. Lundberg I, Thakker KD, Hällström T, Forsell Y. Determinants of non-participation, and the effects of non-participation on potential cause-effect relationships, in the PART study on mental disorders. *Soc Psychiatry Psychiatr Epidemiol*. 2005;40(6):475-83.
264. Harald K, Salomaa V, Jousilahti P, Koskinen S, Vartiainen E. Non-participation and mortality in different socioeconomic groups: the FINRISK population surveys in 1972–92. *Journal of Epidemiology and Community Health*. 2007;61(5):449-54.
265. Jousilahti P, Salomaa V, Kuulasmaa K, Niemelä M, Vartiainen E. Total and cause specific mortality among participants and non-participants of population based health surveys: a comprehensive follow up of 54 372 Finnish men and women. *Journal of Epidemiology and Community Health*. 2005;59(4):310-5.
266. Lunde ES. Unge uten jobb og skoleplass sliter med helsen Samfunnsspeilet 2013(3).
267. Svensson L, Hakeberg M, Boman UW. Dental anxiety, concomitant factors and change in prevalence over 50 years. *Community Dent Health*. 2016;33(2):121-6.
268. Nicolas E, Collado V, Faulks D, Bullier B, Hennequin M. A national cross-sectional survey of dental anxiety in the French adult population. *BMC Oral Health*. 2007;7(1):1-7.
269. Jönsson B, Holde GE, Baker SR. The role of psychosocial factors and treatment need in dental service use and oral health among adults in Norway. *Community Dent Oral Epidemiol*. 2020;48(3):215-24.
270. Jacobsen ID, Eriksen HM, Espelid I, Schmalfuss A, Ullbro C, Crossner CG. Prevalence of dental caries among 16-year-olds in Troms County, Northern Norway. *Swed Dent J*. 2016;40(2):191-201.
271. Vika M, Raadal M, Skaret E, Kvale G. Dental and medical injections: prevalence of self-reported problems among 18-yr-old subjects in Norway. *Eur J Oral Sci*. 2006;114(2):122-7.
272. Szklo M, Nieto FJ. *Epidemiology: beyond the basics*: Jones & Bartlett Publishers; 2014.
273. Lalande KM, Bonanno GA. Retrospective memory bias for the frequency of potentially traumatic events: A prospective study. *Psychological Trauma: Theory, Research, Practice, and Policy*. 2011;3(2):165-70.
274. 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):136-40.
275. Becker-Blease KA, Freyd JJ. Research participants telling the truth about their lives: The ethics of asking and not asking about abuse. *American Psychologist*. 2006;61(3):218-26.
276. Fillingim RB. Complex associations among sex, anxiety and pain. *Pain*. 2013;154(3):332-3.

Paper I

Paper II

Changes in dental anxiety among 15- to 21-year-olds. A 2-year longitudinal analysis based on the Tromsø study: Fit futures

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Abstract

Objective: Identify predictive variables related to the development and continuation of high dental anxiety among young people over 2 years and assess differences between youth experiencing increased, decreased or unchanged dental anxiety scores over time.

Methods: An observational panel study of 15- to 21-year-old people in Tromsø and Balsfjord region followed students from their first to their last year of upper secondary school (2010/11-2012/13). Logistic regression was used to estimate odds ratios and their 95% confidence intervals (CI) of possible predictive variables assessed at baseline when using dental anxiety score from the second wave as a dichotomous dependent variable. Variables measured at baseline: Sex, Dental Caries Experiences (DMFS index), Dental Anxiety (Corah's Dental Anxiety Scale/DAS), Psychological Distress (Hopkins Symptom Checklist/HSCL-10), Avoidance of dental treatment, Pain Estimation at the dentist and motivational questions related to tooth brushing and caries (Self and Social Motivation). Wilcoxon signed-rank tests and Kruskal-Wallis tests were used to test whether changes in DAS score between waves were associated with changes in Pain Estimation between waves and HSCL-10 scores at baseline.

Results: Hopkins Symptom Checklist, DMFS and DAS scores at baseline predicted high dental anxiety scores after 2 years. Sex, motivation related to oral hygiene and avoidance due to fear at baseline did not contribute significantly to our model. DMFS and HSCL-10 were higher among young people who reported a substantial change in DAS score (2.0 > Interquartile range/IQR), irrespective of the direction of change. Pain Estimation changed consistently with a change in DAS score.

Conclusion: Mental health symptoms, pre-existing dental anxiety and dental health status are important contributors to the development of dental anxiety in youth. Estimations of pain at the dentist are central when it comes to changes in dental anxiety over time in this study.

1 | INTRODUCTION

Dental fear and anxiety in youth are estimated between 5% and 20%¹ and can have serious detrimental effects on oral health both in the short and long term.²⁻⁵ In order to explain development of dental anxiety in young people, studies point to the impact of negative or traumatic events (conditional events) relating to dental treatment,¹ and in particular pain.⁶

The terms “young people” or “youth” are used here to describe the study population of individuals aged 15-21 years, in accordance with the UN's definition of youth as “people aged between 15 years and 24 years.”⁷ This life phase is of particular interest, as health-related behaviours and health outcomes during this period have a continued effect in adulthood.⁸ Several studies have pointed to youth being more vulnerable to the onset of dental anxiety,^{9,10} and dental anxiety in this age span is more unstable than in other ages.¹¹ Hence, this age group presents an opportunity for dental healthcare providers to promote positive health behaviours and attitudes that build a foundation for future oral health. A better understanding of what contributes to the development and changes in dental anxiety in youth is needed to improve age-relevant prevention and treatment approaches.

While many studies have addressed the onset of dental anxiety in young age, relatively few in comparison have investigated what contributes to changes or continuation in dental anxiety among youth. Seligman et al¹ proposed an extension of the vicious cycle model of dental anxiety/fear^{4,12} for youth. In this model, repeated painful experiences lead to avoidance behaviour, which over time leads to deterioration of oral health. This in turn leads to negative thinking about dental treatment, which increases avoidance behaviours. What others think or express concerning dental treatment (familial and cultural beliefs) also contributes to this process. Thus, avoidance behaviour is an important factor in maintenance of dental anxiety.^{13,14} Avoidance effectively prevents experiencing nonpainful dental treatment, which could serve as exposure to feared situations in line with cognitive-behavioural treatment models of dental phobia.^{15,16} Correspondingly, research has pointed to the protective factor of positive dental treatment experiences and maintaining regular use of dental health services to prevent or alleviate dental anxiety.^{11,17}

In addition to the impact of negative, conditional events on dental anxiety, an individual's psychological characteristics might influence also impact dental anxiety. Psychological disorders have been associated with the stability of high dental anxiety,¹⁸ and Locker et al¹⁹ found that both co-existing psychological problems and conditional events such as invasive treatment were important in the development of dental anxiety in young adulthood. For instance, depression and anxiety disorders appears to show comorbidity with dental fear,²⁰ perhaps because the cognitive processes associated with depression influence how an individual perceives life events (ie, that events are perceived more negatively).²¹ In accordance with this, constructs such as “psychological functioning”, which is related to regulation of emotion and behaviour,²² have been shown to act as a mediator between

dental anxiety and pain perception.²³ This indicates that increased sensitivity to pain among anxious patients is not only due to higher anxiety, but that the ability to tolerate or regulate pain experiences by cognitive processes (ie, psychological functioning) might be equally important. Also, expectations of pain have important behavioural consequences, as we tend to avoid situations where we anticipate pain or unpleasantness. Patients with high dental anxiety expect dental treatment to be more painful than nonanxious patients,²⁴ and research indicates that management of pain expectations might lower pain perception.²⁵ Thus, how patients think about and estimate pain could be related to changes in dental anxiety.

The main objective was to identify predictive variables in the development and continuation of high dental anxiety from the first to the last year of upper secondary school in the Tromsø and Balsfjord region of Norway. Differences between youth experiencing increased, decreased or stable dental anxiety scores over time are also assessed.

We wanted to test the following hypotheses about change in dental anxiety over time:

1. Dental caries experience at baseline is higher among youth with increased dental anxiety than youth with stable and decreased dental anxiety.
2. Psychological distress at baseline is higher among youth with increased dental anxiety than youth with stable or decreased dental anxiety.
3. Youth with increased dental anxiety have greater estimates of pain at the dentist than youth with stable or decreased dental anxiety.

2 | METHOD

Fit Futures is an expansion of the Tromsø study.²⁶ The Tromsø Study has a general health focus, and the collected data are based on extensive self-reporting questionnaires and a wide range of clinical examinations, including a dental examination and collection of biological samples. In Fit Futures 1 (FF1, 2010/2011) 92.9% of all first-year upper secondary school students in the two neighbouring municipalities of Tromsø and Balsfjord in northern Norway volunteered to participate (N = 1038; 508 females and 530 males). Two years later, Fit Futures 2 (FF2, 2012/2013) invited previous participants and new registered students in third-year upper secondary school for a second study. Participants were included who had completed measures of dental anxiety in both waves and who were under the age of 18 during the first wave. This left 685 (377 females and 308 males) participants eligible for final analysis: a 69.5% follow-up rate (Figure 1). All participants gave written consent. The Regional Committee of Medical and Health Research Ethics (reference number 2014/1093/REK nord) approved the study in September 2014.

Corah's Dental Anxiety Scale (DAS) was used to measure dental anxiety.²⁷ The scale yields a score of 4-20, with high scores

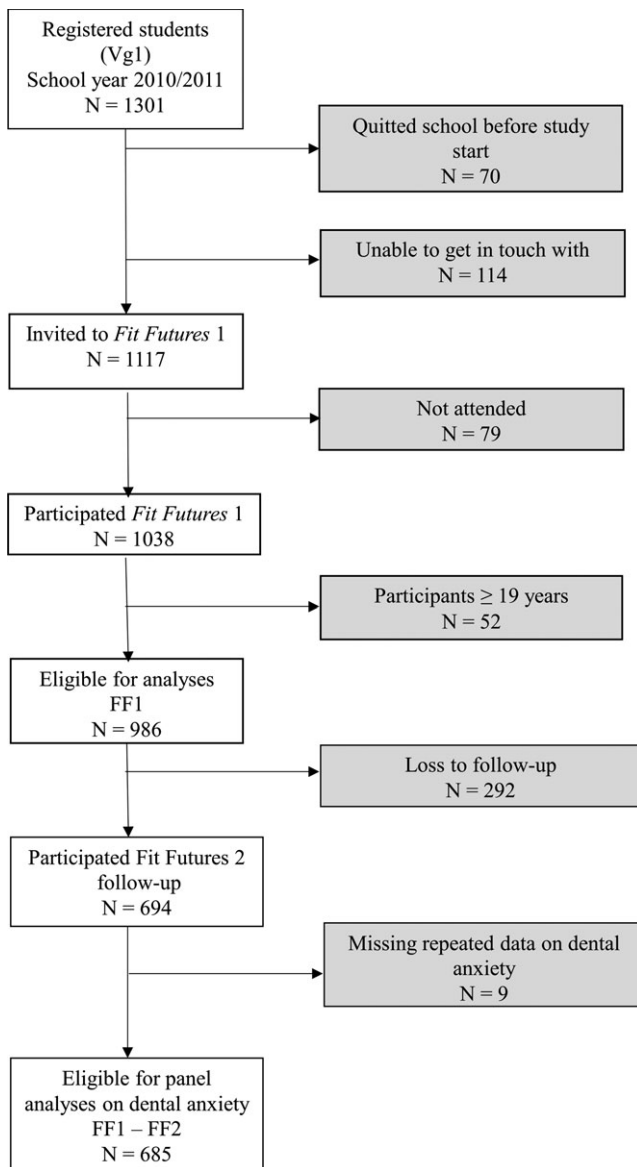


FIGURE 1 Flowchart, participation in Fit Future 1 & 2 in selected adolescents with repeated measures of dental anxiety score

indicating greater anxiety. We classified individuals with DAS scores of 13 or more as dentally anxious.^{5,11,18} A change in dental anxiety was registered if DAS score differed by more than 2.0 (the interquartile range) over 2 years (Y_1 [Sum score DAS in FF1] – Y_2 [Sum score DAS in FF2]). This approach was chosen to safeguard against spurious effects and to focus on more substantial changes. Three groups indicating change in dental anxiety was identified: increased dental anxiety, decreased dental anxiety and no change.

In an effort to describe oral health as more than the presence or absence of caries,²⁸ we decided to include questionnaire items concerning oral health attitudes and motivation. Dental Caries Experiences was registered by the Decayed, Missing, Filled, Surfaces (DMFS) index.²⁹ Description of the clinical oral examination can be found in a previous article on this dataset describing the caries

prevalence.³⁰ An exploratory factor analysis was performed for 23 questionnaire items concerning oral health knowledge and behaviour. Details on these questionnaire items and the analysis can be viewed in an Data S1 and in a previous paper describing dental anxiety at baseline.³¹ The resulting scales are called Self-Motivation concerning knowledge and attitudes about tooth-brushing behaviour and Social Motivation related to feelings of embarrassment and recognition concerning dental health and tooth brushing. The Cronbach's alpha coefficient of these scales was 0.89 and 0.85, respectively.

Avoidance due to fear was measured with participants responding, "yes" to the question: "Have you ever missed a dental appointment due to fear?" We refer to this variable as Avoidance in the Results and Discussion sections.

The study participants were also asked to estimate pain during dental treatment using the question, "How painful, on average, do you think it is to go to the dentist?" and to indicate pain from 0 (no pain) to 10 (worst conceivable pain). We refer to this variable as Pain Estimation (PE) in the Results and Discussion sections.

Psychological Distress was measured using the Hopkins Symptom Checklist (HSCL-10). HSCL-10 is validated and recognized for use in epidemiological studies and in clinical work among youth measuring symptoms of depression and anxiety.³² An average HSCL-10 score over 1.85 was set as an indicator for symptoms of anxiety and/or depression as recommended by former research.³³

The study utilized a prospective design. DAS scores was assessed twice, over the course of 2 years. HSCL-10, DMFS, Self-Motivation, Social Motivation, Avoidance and demographic characteristics assessed at baseline were treated as predictors of high dental anxiety scores in the second wave in a logistic regression model.

All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 24 (IBM Corp., Armonk, NY, USA). We performed a logistic regression analysis with DAS score from the second wave as a dichotomous dependent variable (cut-off DAS > 13) and included DAS sum score in the first wave as one of the independent variables. We used the Wilcoxon signed-rank test for repeated measurements (FF1 and FF2) of dental anxiety and psychological distress. Kruskal-Wallis tests were used to compare groups with changes in DAS score between waves (DAS FF1 and DAS FF2), on PE between waves (PE FF1-PE FF2), and HSCL-10 scores at baseline. Chi-squared tests and Mann-Whitney *U* tests were used to evaluate the impact of loss to follow-up. Pairwise exclusion was used for missing data; hence, the number of observations varies in the analyses.

3 | RESULTS

There were significant changes over the 2 years in DAS scores and HSCL-10. DAS scores significantly decreased from first (Md = 7.0) to senior year (Md = 6.0) in high school, $z = -2.81$, $P = 0.005$. The HSCL-10 sum scores, however, significantly increased from first (Md = 1.3) to senior year (Md = 1.4), $z = -3.14$, $P = 0.002$ (Table 1).

TABLE 1 Changes in dental anxiety score and mental health symptoms over 2 y

	Total	N	Female	N	Male	N
Dental anxiety scale score ^b	Median (IQR ^a)		Median (IQR ^a)		Median (IQR ^a)	
FF1 ^c	7.0 (5.0)	951	8.0 (6.0)	464	6.0 (4.0)	487
FF2 ^d	6.0 (4.0)*	685	7.0 (6.0)**	377	5.0 (3.0)**	308
Average score Hopkins symptom checklist ^e						
FF1 ^c	1.3 (0.6)	952	1.4 (0.7)	465	1.2 (0.5)	487
FF2 ^d	1.4 (0.8)*	684	1.5 (0.9)*	378	1.2 (0.6)	306

^aThe interquartile range.

^bCorah's Dental Anxiety Scale range from 4 to 20, high scores indicating greater anxiety.

^cThe Tromsø Study: Fit Futures 1 (2010/2011).

^dThe Tromsø Study: Fit Futures 2 (2012/2013).

^eHopkins symptom checklist has an average sum score range from 1 to 4, higher scores indicating higher psychological distress.

*Wilcoxon signed-rank test $P < 0.001$.

**Wilcoxon signed-rank test $P < 0.05$.

To assess the predictive value of our measures on high dental anxiety, we performed a logistic regression with DAS in FF2 (DAS FF2) as a dichotomous dependent variable. The model contained seven variables from the first wave: Sex, DAS scores, DMFS, HSCL-10, Avoidance, Self-Motivation and Social Motivation. We chose not to include the PE in the first wave due to the substantial correlation (>0.7) with DAS score in the same wave, avoiding problems due to multicollinearity. The full model was statistically significant, χ^2 (7, $N = 609$) = 187.35, $P < 0.0001$, indicating that the model was able to distinguish between respondents who reported high and low dental anxiety scores. The model explained 52% (Nagelkerke R squared) of the variance in dental anxiety, and correctly classified 90.6% of cases. The goodness of fit was satisfactory according to a Hosmer and Lemeshow test ($P > 0.17$). Three of the independent variables made a significant contribution to the model: DAS score in the first wave, DMFS and HSCL-10. The strongest predictor is HSCL-10 with an odds ratio of 2.03 (Table 2).

The calculation of change scores in DAS between the first and second wave (Y_1 [Sum score DAS in FF1] – Y_2 [Sum score DAS in FF2]) showed that 476 participants reported no change, 108 reported less dental anxiety and 78 reported more dental anxiety. In order to test Hypothesis 1, a Kruskal-Wallis test revealed a statistically significant difference in DMFS between these groups, χ^2 (2, $n = 652$) = 21.47, $P < 0.001$. The median DMFS score was lowest in the group with no change in dental anxiety (Md = 3), while both groups with changes in DAS scores recorded higher DMFS scores (Md = 5). Concerning Hypothesis 2, a Kruskal-Wallis test showed a statistically significant difference in average HSCL-10 scores in the first wave between the groups, χ^2 (2, $n = 648$) = 6.25, $P = 0.044$. The median was lower among the participants experiencing no change in DAS score (Md = 1.30) and higher in the groups where changes were reported (both Md = 1.40). Hypothesis 3 was

TABLE 2 Logistic regression with dental anxiety scale score in fit future 2 (Sum DAS ≥ 13) as the dependent variable

Variables ^a	B	SE	Odds ratio (95% CI)
Sex	-0.69	0.41	0.50 (0.22, 1.13)
Dental caries experience	0.058*	0.02	1.06 (1.02, 1.11)
DAS score FF1	0.44*	0.05	1.55 (1.4, 1.72)
HSCL-10 ^b	0.71*	0.28	2.03 (1.18, 3.49)
Avoidance	0.93	0.56	2.53 (0.84, 7.60)
Self-motivation	0.242	0.35	1.27 (0.65, 2.51)
Social motivation	0.044	0.049	1.05 (0.95, 1.15)
Constant	-8.66	1.24	0.00
χ^2	187.35		
df	7		

^aReference group for dichotomous variables was set to first (Sex: 0 = female; 1 = male. Avoidance: 0 = no, have not avoided going to the dentist due to fear; 1 = yes, have avoided going to the dentist due to fear. Self-motivation: 0 = low self-motivation concerning oral hygiene; 1 = high self-motivation. Social motivation: 0 = less feelings of embarrassment concerning caries and less need for recognition concerning oral hygiene; 1 = higher concern about social opinions concerning caries and oral hygiene). No one of the dichotomous variables had a significant impact on this model.

^bHopkins symptom checklist.

* $P < 0.05$.

supported as changes in PE followed dental anxiety scores: Participants who got more anxious had increased PE (PE levels increased by Md = 2.00). Also, those feeling less anxious had decreased PE (Md = -2.00), χ^2 (2, $n = 660$) = 65.24, $P < 0.001$ (Figure 2).

In our study, we lost 30.5% of the participants to follow-up. To evaluate the possible bias on this account, we compared the baseline information between those who participated in both waves and dropouts with chi-squared and Mann-Whitney U tests on several variables. Concerning variables related to this current study, there was a statistically significant difference on Avoidance, PE, DMFS, Sex, but not in DAS or HSCL-10 score. Details are presented in a separate Data S1.

4 | DISCUSSION

Dental Anxiety decreased significantly over 2 years, but the proportion of youth categorized with high dental anxiety remained constant. This implies that, from a clinical viewpoint in this population, there was no reduction in the number of individuals assumed to require adaptation of treatment and more professional resources due to dental anxiety, in spite of an overall reduction of dental anxiety scores. Experiencing high psychological distress, more caries experience and high dental anxiety scores in the first wave are important predictors of high dental anxiety scores at the second wave, implying that these particular factors are instrumental in sustaining dental anxiety over time among youth. Interestingly, Psychological Distress emerges as the strongest predictor, indicating that experiencing

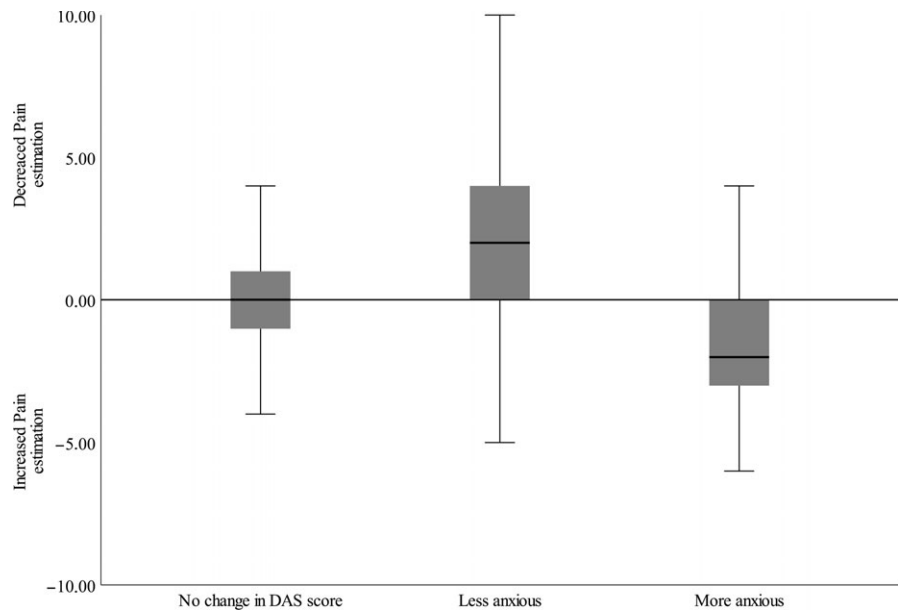


FIGURE 2 Distribution of changes in reported pain level at the dentist across different changes in dental anxiety

mental health symptoms might serve as a vulnerability factor among young individuals relating to the development and continuation of dental anxiety. Earlier findings relating to stressful life events and mental health problems in adolescents have indicated that stressful life events are linked to psychiatric morbidity through disruption of the adaptive processing of emotion.³⁴ This period of life is especially relevant, considering the increase in psychopathology and exposure for stressors,³⁴ and the current findings support this notion with regard to dental anxiety.

Also, Dental Caries Experiences was significantly higher in youth experiencing changes in Dental Anxiety Scores irrespective of the direction of change. The odds of having proximal caries lesions have been found to be more than three times higher for subjects with earlier caries experience in this population.³⁵ Thus, the probability of having a dental treatment need is higher among youth with previous dental caries experiences. The Norwegian public dental health services has a legal obligation to provide outreach dental care, with full public coverage, for children under the age of 18.³⁶ Accordingly, one can assume that they have received dental treatment in the study period.

The association between painful dental experiences and dental anxiety is well documented,⁶ but this study also implies that reduced estimates of pain at the dentist may decrease dental anxiety. Estimates of pain may be reduced by a number of mechanisms in the period covered by this study, for instance by actual experience with dental treatment or by indirect mechanisms such as social learning processes³⁷ (eg, peers, significant others) or biological and/or cognitive change or maturity.³⁸ Of these, however, only the experiences with dental treatment can be easily and reliably influenced by dental health professionals in a systematic manner. Dental treatment received in a trustful relation to the dental staff, and proper pain control in association with dental treatment, should be of central importance in dental practice. The current findings can serve to redefine dental treatment situations in young

individuals as not mere potential negative conditioning events,¹² but as a “window of opportunity” where dental health professionals have the opportunity to ensure a positive experience for young patient (see Figure 3).

A high attendance rate at baseline probably provides a fair representation of the young population, but the representativeness of the participants at the second wave is compromised due to participants lost to follow-up. However, there was no significant difference in Dental Anxiety Scores or Psychological Distress between these groups at baseline.

Changes in dental anxiety in youth are most likely due to interplay between individual vulnerability and subjective experiences. In this period of life, there is a potential for both reducing and increasing dental anxiety, and estimations of pain at the dentist are central to such changes.

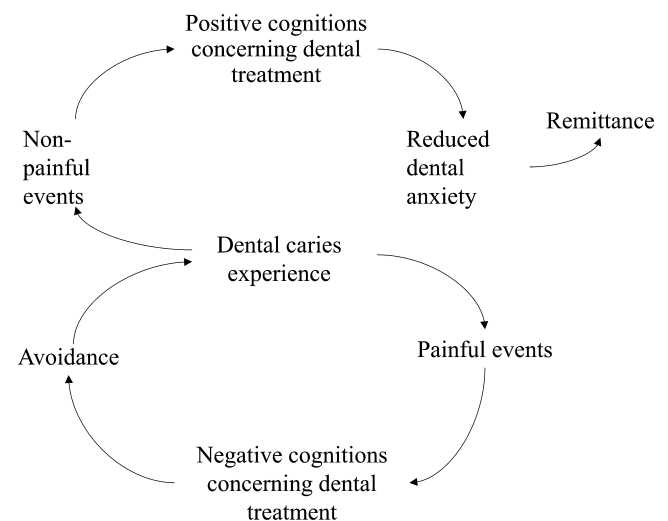


FIGURE 3 Possible outcomes of dental caries experiences in youth, a conceptual model

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REFERENCES

- Seligman LD, Hovey JD, Chacon K, Ollendick TH. Dental anxiety: an understudied problem in youth. *Clin Psychol Rev*. 2017;55:25-40.
- Agdal LM, Raadal M, Skaret E, Kvale G. Oral health and oral treatment needs in patients fulfilling the DSM-IV criteria for dental phobia: possible influence on the outcome of cognitive behavioral therapy. *Acta Odontol Scand*. 2008;66:1-6.
- Schuller AA, Willumsen T, Holst D. Are there differences in oral health and oral health behavior between individuals with high and low dental fear? *Community Dent Oral Epidemiol*. 2003;31:116-121.
- Armfield JM, Stewart JF, Spencer AJ. The vicious cycle of dental fear: exploring the interplay between oral health, service utilization and dental fear. *BMC Oral Health*. 2007;7:1.
- Kruger E, Thomson WM, Poulton R, Davies S, Brown RH, Silva PA. Dental caries and changes in dental anxiety in late adolescence. *Community Dent Oral Epidemiol*. 1998;26:355-359.
- Lin C-S, Wu S-Y, Yi C-A. Association between anxiety and pain in dental treatment: a systematic review and meta-analysis. *J Dent Res*. 2017;96:153-162.
- United Nations. Definition of Youth. United Nation Fact Sheets. <http://www.un.org/esa/socdev/documents/youth/fact-sheets/youth-definition.pdf>. Published 2008. Accessed July 6, 2018.
- Sawyer SM, Afifi RA, Bearinger LH, et al. Adolescence: a foundation for future health. *Lancet*. 2012;379:1630-1640.
- Thomson WM, Locker D, Poulton R. Incidence of dental anxiety in young adults in relation to dental treatment experience. *Community Dent Oral Epidemiol*. 2000;28:289-294.
- Locker D, Thomson WM, Poulton R. Onset of and patterns of change in dental anxiety in adolescence and early adulthood: a birth cohort study. *Community Dent Health*. 2001;18:99-104.
- Thomson WM, Poulton RG, Kruger E, Davies S, Brown RH, Silva PA. Changes in self-reported dental anxiety in New Zealand adolescents from ages 15 to 18 years. *J Dent Res*. 1997;76(6):1287-1291.
- Berggren U, Meynert G. Dental fear and avoidance -causes, symptoms and consequences. *J Am Dent Assoc*. 1984;109(2):247-251.
- Skaret E, Raadal M, Berg E, Kvale G. Dental anxiety and dental avoidance among 12 to 18 year olds in Norway. *Eur J Oral Sci*. 1999;107:422-428.
- Armfield JM. What goes around comes around: revisiting the hypothesized vicious cycle of dental fear and avoidance. *Community Dent Oral Epidemiol*. 2013;41:279-287.
- Wide Boman U, Carlsson V, Westin M, Hakeberg M. Psychological treatment of dental anxiety among adults: a systematic review. *Eur J Oral Sci*. 2013;121:225-234.
- Gordon D, Heimberg RG, Tellez M, Ismail AI. A critical review of approaches to the treatment of dental anxiety in adults. *J Anxiety Disord*. 2013;27:365-378.
- Poulton R, Waldie KE, Thomson WM, Locker D. Determinants of early- vs late-onset dental fear in a longitudinal-epidemiological study. *Behav Res Ther*. 2001;39:777-785.
- Locker D, Poulton R, Thomson WM. Psychological disorders and dental anxiety in a young adult population. *Community Dent Oral Epidemiol*. 2001;29:456-463.
- Locker D, Thomson WM, Poulton R. Psychological disorder, conditioning experiences, and the onset of dental anxiety in early adulthood. *J Dent Res*. 2001;80:1588-1592.
- Pohjola V, Mattila AK, Joukamaa M, Lahti S. Anxiety and depressive disorders and dental fear among adults in Finland. *Eur J Oral Sci*. 2011;119:55-60.
- Gotlib IH. Perception and recall of interpersonal feedback: negative bias in depression. *Cognit Ther Res*. 1983;7:399-412.
- Versloot J, Veerkamp JSJ, Hoogstraten J. Dental anxiety and psychological functioning in children: its relationship with behaviour during treatment. *Eur Arch Paediatr Dent*. 2008;9:36-40.
- Marsac ML, Funk JB. Relationships among psychological functioning, dental anxiety, pain perception, and coping in children and adolescents. *J Dent Child*. 2008;75:243-251.
- Lin C-S, Lee S-Y. Dental anxiety and expectation of pain: cognitive modulation of the pain experience of dental patients. *J Dent Sci*. 2007;2:129-135.
- Koyama T, McHaffie JG, Laurienti PJ, Coghill RC. The subjective experience of pain: where expectations become reality. *Proc Natl Acad Sci USA*. 2005;102:12950-12955.
- UiT The Arctic University of Norway. The Tromsø Study. https://en.uit.no/forskning/forskningsgrupper/gruppe?p_document_id=453582. Published 2017. Accessed July 6, 2018.
- Corah NL. Development of a dental anxiety scale. *J Dent Res*. 1969;48(4):596.
- Glick M, Williams DM, Kleinman DV, Vujicic M, Watt RG, Weyant RJ. A new definition for oral health developed by the FDI World Dental Federation opens the door to a universal definition of oral health. *J Public Health Dent*. 2017;77:3-5.
- Broadbent JM, Thomson WM. For debate: problems with the DMF index pertinent to dental caries data analysis. *Community Dent Oral Epidemiol*. 2005;33:400-409.
- Jacobsen ID, Eriksen HM, Espelid I, Schmalfluss A, Ullbro C, Crossner CG. Prevalence of dental caries among 16-year-olds in Troms County, Northern Norway. *Swed Dent J*. 2016;40:191-201.
- Nermo H, Willumsen T, Johnsen J-AK. Prevalence of dental anxiety and associations with oral health, psychological distress, avoidance and anticipated pain in adolescence: A cross-sectional study based on the Tromsø study, Fit Futures. *Acta Odontol Scand*. 2018;76. <https://doi.org/10.1080/00016357.2018.1513558>
- Haavet OR, Sirpal MK, Haugen W, Christensen KS. Diagnosis of depressed young people in primary health care-a validation of HSCL-10. *Fam Pract*. 2011;28:233-237.
- Strand BH, Dalgard OS, Tambs K, Rognerud M. Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). *Nord J Psychiatry*. 2003;57:113.
- McLaughlin KA, Hatzenbuehler ML. Mechanisms linking stressful life events and mental health problems in a prospective, community-based sample of adolescents. *J Adolesc Health*. 2009;44:153-160.
- Jacobsen ID. *Dental Health and Need for Non-operative Treatment Among 16-year-olds in Northern Norway*. Tromsø, Norway: Faculty of Health Sciences Department of Clinical Dentistry, UiT The Arctic University of Norway; 2018.
- Services MoHaC. Lov om tannhelsetjenesten/The Dental Health Act. In: Ministry of Health and Care Services, ed. LOV-1983-06-03-54. LOV-2017-06-16-55 fra 01.01.2018 ed. Lovdata.no1984.
- Colloca L, Benedetti F. Placebo analgesia induced by social observational learning. *Pain* 2009;144:28-34.

38. Esteve R, Marquina-Aponte V. Children's pain perspectives. *Child Care Health Dev* 2012;38:441-452.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Paper III

“Dental anxiety and potentially traumatic events” “A cross-sectional study based on the Tromsø Study: Tromsø 7”

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Abstract

Background The objectives of the study were to describe the prevalence of high dental anxiety and the possible associations between dental anxiety and potentially traumatic life events in an adult population.

Method The study is based on cross-sectional questionnaire data from the 7th wave of the Tromsø Study, a study of the adult general population in the municipality of Tromsø carried out in 2015–2016. The Modified Dental Anxiety Scale was used to measure dental anxiety across potentially traumatic events, oral health, dental attendance (avoidance) and current mental health symptoms (Hopkins Symptom Checklist). Individuals with high and low dental anxiety scores were compared to investigate differences in the distribution of potentially traumatic events, current mental health symptoms, avoidance, sex and oral health, and hierarchical multivariable regression was used to study the influence of traumatic events on dental anxiety.

Results High dental anxiety was reported by 2.9% of the sample and was most prevalent among women and in the youngest age groups. Individuals with high dental anxiety reported more current mental health symptoms, and they were more likely to report poorer oral health and more irregular dental visits compared to individuals with no or lower dental anxiety scores. Concerning traumatic life events, the reporting of painful or frightening dental treatment showed the biggest difference between those with high dental anxiety and low dental anxiety scores (a moderate effect). The hierarchical regression model indicated that reporting sexual abuse, traumatic medical treatment in hospital and childhood neglect significantly predicted dental anxiety in the step they were entered in, but only sexual abuse remained a significant individual contributor after controlling for current mental health symptoms.

Conclusions The prevalence of high dental anxiety was lower than expected (2.9%), but dentally anxious individuals expressed a high burden of mental health symptoms, poor oral health and the avoidance of dental care. The regression analysis indicated that experiences with sexual abuse can also affect dental anxiety levels in the absence of generalised symptoms of anxiety and depression.

Background

Dental anxiety: prevalence, severity, aetiology

Individuals with high dental anxiety are often unable to utilise standard dental health services adequately [1, 2]. As a consequence, dental professionals in general practice rarely encounter these patients, and without specialised care, dentally anxious individuals will have more missing teeth and fewer filled and sound surfaces due to a lack of adequate dental treatment [3, 4]. High dental anxiety extends beyond the aversive emotional response that interferes with dental treatment; it may include flashbacks, nightmares, intrusive images, difficulties sleeping, irritability and impaired concentration, even if dental treatment is not imminent [5, 6]. Consequently, high dental anxiety often leads to reduced oral health-related quality of life [7–10] and has demonstrated comorbidity with generalised anxiety and depression disorders [11, 12]. The prevalence of high dental anxiety among adults is reported to be between 3.9% and 15.5% [9, 11, 13–

20], depending on the measurements used and cut-off levels. Dental anxiety levels are reported to be higher among women and in younger age groups [13].

The aetiology of dental anxiety is likely multifactorial. Conditioning theories, focusing on the development of a generalised fear response in the dental setting from previous painful and/or traumatic dental treatments [21, 22], are generally accepted as central to the acquisition of high dental anxiety, but are an inadequate explanation in many respects [23, 24]. The experience and processing of a potentially traumatic or aversive event in a dental setting depend on many factors, including life history [25]. Nonetheless, pain is an important factor in conditioning experiences for developing and maintaining dental anxiety [26-28]. Besides, dental anxiety is an important predictor for reporting and expecting pain during dental treatment [29-32], implying that it might be more difficult to achieve dental treatment without pain in anxious individuals. A dentally anxious individual will both expect and report more pain during dental experiences compared to a non-anxious individual [33].

Potentially traumatic events

Potentially traumatic events (PTEs) are highly stressful and threatening events, such as exposure to violence, sexual abuse or neglect in childhood. Several studies have pointed to the negative impact of adverse childhood experiences on multiple health outcomes [34, 35], and similar associations with the development of oral disease may also be expected [36]. The brain reacts differently to traumatic events depending on sex, age, the possession of particular genotypes, personality characteristics, coping strategies, the nature of the trauma and the relationship to the perpetrator [22, 37]. In other words, the emotional load from aversive life events and the nature and timing of them are important in terms of how individuals respond and move forward after such events. Individuals with high dental anxiety have shown trauma-related symptoms similar to those of people suffering from posttraumatic stress disorder (PTSD) [5, 38]. Traumatic life events inflicted by others, like sexual or physical assault, are reported by 10% to 30% of the general population [39, 40]. These traumatic events, in particular, impact interpersonal relationships and can have severe consequences for the mental health and interpersonal functioning of the individuals that are affected [41].

PTEs and dental anxiety

There are limited population studies concerning dental anxiety and PTEs outside the dental setting, and the evidence regarding whether or not there is an association in the general population is contradictory [5, 22, 42, 43]. However, studies on selected subgroups of the population indicate that victims of torture and violence and sexually abused women have a higher prevalence of dental anxiety compared to the general population [5, 44, 45]. Mental health symptoms are a measure of clinical importance with regard to the long-term effects of PTEs and dental anxiety but have, to our knowledge, not been taken into consideration when examining the association between traumatic events and dental anxiety. There are several hypotheses as to how traumas outside the dental clinic can influence dental anxiety. Situations, feelings and other cues from a traumatic experience in the past might be generalised to the dental treatment situation, following a broader conditioning pattern through traumatic coupling [46]. Also, a

dental treatment situation is intimate and can leave patients with a sense of a lack of control and helplessness, which could potentially evoke reactions related to the past traumatic experience [5, 45]. A history of abuse and neglect is associated with difficulties in interpersonal relationships, the increased likelihood of depression and anxiety disorders and substance abuse [47, 48]. This burden might increase such patients' vulnerability to developing dental anxiety. It is possible to hypothesise that general anxiety disorders might be extended to include anxiety towards dental treatment, or that potentially negative or painful dental experiences have a larger impact when mental health is compromised [49]. In other words, it could be the mental health symptoms that follow traumatic experiences that are central when it comes to the development of dental anxiety. It is a reliable finding that psychiatric disorders are associated with dental anxiety and that symptoms of depression and anxiety are predictive of dental anxiety over time [50]. Hence, symptoms of depression and anxiety could intermediate the association between traumatic events and dental anxiety. Since a dental treatment situation is arguably a highly relational, intimate and interpersonal circumstance [46], it comes as no surprise that dental experiences are inevitably coloured by the interpersonal relationship between the dental caregiver and the recipient [51-54]. Regarding sexual abuse, there is evidence indicating a more direct conditioning pattern. For instance, sexually abused women that had experienced oral penetration as part of the abuse reported higher dental fear than sexually abused women without experiences of oral penetration [45]. A recent qualitative study indicated that dental anxiety in survivors of sexual abuse was trauma-driven, in which their anxiety reactions were triggered by their traumatic abuse and not their negative dental experiences (traumatic coupling) [46]. Studies have indicated that the response to triggers is overwhelming to the point of blurring previous memories of abuse and the current experiences in the dental chair [55]. Nonetheless, there is limited research on how traumatic events involving interpersonal relationships influence dental anxiety in the general population. Moreover, current mental health symptoms have not yet, to our knowledge, been considered in research on dental anxiety and traumatic events.

The objectives of the present study are to investigate the associations between dental anxiety, oral health and mental health symptoms, as well as the potential influence of different PTEs on dental anxiety in the general population. The specific aims are as follows:

1. To describe the prevalence of high dental anxiety within a large population-based study of individuals aged 40 and above in Northern Norway (the Tromsø 7 study).
2. To analyse the influence of PTEs on dental anxiety when controlling for sex, age, oral health, dental attendance (avoidance) and current mental health symptoms.
3. To analyse the mediating effect of current mental health symptoms on the relationship between potentially traumatic events and dental anxiety.

Method

Study population and design: The Tromsø Study

The Tromsø Study [56] is a repeated population health survey. This study used data collected from the 7th survey of the Tromsø Study, in which all adults registered in Tromsø municipality aged 40 or above were invited to participate (32,591 in total). The registration and examination of participants took place from 2015 to 2016. In total, 21,083 residents (10,009 men and 11,074 women) took part in the study, which resulted in a participation rate of 65%. The participants answered questionnaires about several different health topics and received a physical health examination. In the present study, only the questionnaire data were used. Detailed information on the questionnaires and study data are provided through the Tromsø Study web resource [<https://uit.no/research/tromsostudy>] [57]. Every project in the Tromsø Study is obliged to follow the EU's General Data Protection Regulation and the Personal Data Act (Norwegian law). All participants gave informed consent. This present study only retrieved anonymised data. The Regional Committee of Medical and Health Research Ethics (reference number 2018/1352/REK nord) approved the present study in July 2018. It is confirmed that all methods in the present study were carried out in accordance with the stated guidelines and regulations.

Measures

Age and education

Age was divided into 8 categories each spanning 5 years (40–44, 45–49, etc.), where the last age group was 75 years old and above. Education was categorised into high (university or college) and low (primary and secondary school).

Dental anxiety

Dental anxiety was measured using the Modified Dental Anxiety Scale (MDAS) [14]. The MDAS is a five-item scale, with response options ranging from “not anxious” to “extremely anxious”, yielding a score from 5–25. This variable was dichotomised in the chi-square analysis with a recommended cut-off value of 19 [15](55). The MDAS had a Cronbach's alpha of 0.932 (N = 20,197) and a mean inter-item correlation of 0.743.

Current mental health symptoms

The current mental health symptoms of the study participants were measured using the 10-item Hopkins Symptom Checklist (HSCL-10), validated for use in epidemiological studies as an indicator of symptoms of depression and anxiety during the last two weeks [58]. Each question is answered based on 4 responses, ranging from “not bothered” to “very bothered”, providing a score between 10 and 40. An average score of 1.85 or higher on the HSCL-10 indicates symptoms of mental illness [58]. The Cronbach's alpha of the HSCL-10 was 0.866 (N = 19,824), and it had a mean inter-item correlation of 0.413.

Oral health

Oral health was assessed with a single question: "How do you consider your oral health to be?" The participants selected one out of five response options to this question: "excellent", "good", "neither good nor bad", "bad" or "very bad". The scores were dichotomised in the bivariate analyses. Good (0) included the responses "excellent" and "very good", while bad (1) comprised "neither good nor bad", "bad" and "very bad". In the hierarchical multivariable regression, the Likert format response was used as a continuous variable, assuming that the distances between the answers were reasonably equal and meaningful. Both visual inspection and the low values of skewness and kurtosis indicated that these items could be treated as numerical. Also, the regression was run with the dichotomised variable, which yielded the same result.

Avoidance

Dental attendance patterns were measured by the item, "Do you go to the dentist regularly?", where participants could indicate their attendance patterns by choosing one of six alternatives: "at least once a year", "every year", "every second year", "less than once every two years", "only for acute problems" and "never". This variable was dichotomised to indicate the avoidance of dental treatment, in which yes (0) included the response alternatives "at least once a year", "every year", "every second year" and "less than once every two years", and no (1) included the response alternatives "only for acute problems" and "never".

Potentially traumatic events (PTEs)

A list of eleven potentially traumatic life events was included in the Tromsø 7 Study with four response options (no; yes, before the age of 18; yes, after the age of 18; yes, in the last year). In this study, events were included that had the potential to affect interpersonal relationships: painful or threatening dental treatment, painful or threatening medical treatment in hospital, childhood neglect, violence, sexual assault, bullying or witnessing someone close being a victim of violence or sexual assault. The answers were dichotomised into 0 = no and 1 = yes to avoid deflated effect sizes after assuring that the direction of the effects was the same regardless of the timing of the event.

Analyses

All the analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 26 (IBM Corp., Armonk, NY, USA). Chi-square tests for independence were used to explore the relationship between the dichotomised MDAS and the independent variables used in the analysis. Hierarchical multivariable regression was used to assess the ability of selected traumatic life events (sexual abuse, violence, bullying, witness, childhood neglect, painful or threatening medical treatment at the hospital) to predict levels of dental anxiety when controlling for sex, age, self-assessed oral health, the avoidance of dental treatment and painful or threatening dental treatment. The demographic control variables, sex and age, were entered in the first step, followed by the known predictors of dental anxiety from the dental setting in the second step and all the traumatic life events listed above in the third step. To assess how HSCL-10 influenced the model and the effect of the predictors on dental anxiety, it was

entered in the final step. Preliminary analyses on the assumptions for linear regression indicated issues with the normal distribution. When inspecting the outliers, all of them reported a higher dental anxiety level than predicted by the model; however, they are a natural part of the population and were therefore not removed or transformed for the current analysis. Hence, the distribution of the test statistics was empirically derived through bootstrapping with 1,000 bootstrap samples. Simple mediation analyses were performed using the PROCESS macro in SPSS [59]. Analysing the dataset with regard to missing values disclosed that 2.4% of all the values were missing, 9.6% of all the subjects had incomplete data and there were missing values in all but two variables (sex and age). The items that made up our variable for measuring mental health symptoms (HSCL-10) had the most missing data (6%), followed by the MDAS (4.2%), avoidance (2.3%) and oral health (2.0%). All the PTEs had the same number of missing values (1.1%). The Little's MCAR (Missing Completely At Random) test was significant, which indicated that data were not missing completely at random. To evaluate the impact of the missing data on the continuous variables (HSCL-10, MDAS and oral health), the variables were compared with a version of themselves where the missing values were replaced by the series mean using a paired sample t-test. However, since the standard error of the difference was zero, it was not possible to perform any of these analyses. A comparison with the original dataset and the dataset with imputation of missing data was also performed, using both regression and expectation-maximisation techniques. The differences between the variables in the two datasets were minimal and limited to deviations in the second decimal. Finally, a regression analysis was performed by replacing the missing values with multiple imputations, which yielded similar results as the analysis of the original data. The differences were limited to decimal levels in the unstandardised regression coefficient, and there were no differences in β when rounded up to the first decimal place. Based on these findings, the analyses were performed on the original data without any imputation with the pairwise exclusion of missing data.

Results

Almost half of the participants in this study reported higher education levels, and 30% had more than 4 years of university education. Over 94% of the participants specified their nationality as Norwegian, 2.8% as Sami and 1.9% as Kven, and 4.2% felt they belonged to another ethnicity. Most of the participants fell in the second age group (45–49), which constituted 15.6% of the population under study. The age groups with the least participants were the oldest (70–74 and 75+), representing 8.1% and 8.2% of the population, respectively.

The mean sum score of the MDAS was 7.7, with a median of 6. The prevalence of highly anxious (MDAS ≥ 19) participants in this study was 2.9%. The mean value of the MDAS among the highly anxious was 21.7, and the median was 21. Current psychological symptoms were indicated by 8.7% of the participants (10.7% of the women compared to 6.5% of the men). The majority reported good oral health (54.9%), and women scored their oral health a little higher than men, with 58.9% having good or excellent oral health compared to 50.6% of the men. The avoidance of dental health services was reported by 10.2%, with fewer avoiders being observed among women (7.8%) than among men (12.8%). Nearly a quarter of the

population under study (23.8%) had experienced one or more traumatic and/or painful dental experiences, with little difference between the sexes (females: 23.7%, males: 23.8%).

Associations of dental anxiety with age, education, income and oral health

Spearman's correlation showed that dental anxiety scores significantly declined with age; r_s ($n = 20,195$) = -0.25 , $p < 0.001$, and comparing the youngest (MDAS; median = 7) and the oldest (MDAS; median = 5) groups with a Mann-Whitney U test revealed a medium to large effect; $U = 3476217$, $z = 226.92$, $p < 0.001$, $r = 0.4$. The proportions of highly anxious individuals were also significantly higher in the younger age groups (Fig. 1).

There was a minimal difference in dental anxiety scores across education levels, with differences in the MDAS means being less than 0.4 (participants with a primary and/or an upper secondary education reported a mean MDAS score of 7.6, and participants with a college or a university education reported a mean MDAS score of 7.7). Dental anxiety levels varied somewhat but inconsistently across the different groups of household income, but when dichotomising above and below the national median of household income that year [60], the difference in dental anxiety means was insignificant (participants both above and below the national median of household income had a mean MDAS of 7.68).

As shown in Table 1, chi-square tests for independence (with Yates' continuity correction) indicated a significant difference in individuals with high and low dental anxiety scores and oral health. Dentally anxious individuals were more inclined to report very bad oral health (71.7%) compared to individuals with lower dental anxiety scores (11.9%). Furthermore, among the dentally anxious, 39.9% never went to the dentist or only went for acute problems versus 9% among those with lower dental anxiety levels (Table 1). There were also significant associations between high or low dental anxiety scores between the sexes and current mental health symptoms (Table 1). No significant differences were found for dental anxiety between different ethnicities. When repeating this analysis separately for the sexes, anxious men reported significantly poorer oral health (90.2% reported very bad oral health) compared to anxious women (61.1% reported very bad oral health). More anxious (MDAS ≥ 19) women (69.6%) than anxious men (41.2%) reported going to the dentist regularly.

Chi-square tests of independence were used to test the proportion of traumatic experiences in the high and low dental anxiety groups and the strength of the associations between the two (Table 2). There were significant differences in dental anxiety for all the traumatic events, and the effect sizes were small and highest for traumatic and/or painful dental experiences ($\phi = 0.18$).

Predicting dental anxiety from PTEs

The results of this analysis are given in Tables 3a and 3b. The control variables entered in steps 1 and 2 in Table 3b explained most of the variance in dental anxiety (23.1%). In the final model, the only traumatic life event entered in step 3 that remained a significant contributor to the model was sexual abuse; $B = 0.220$, $SE = 0.086$, $\beta = 0.017$, $p = 0.011$. All the control measures entered in the two first stages remained statistically significant ($p < 0.001$).

As it is well known that experiencing traumatic events may increase the risk of mental health symptoms [61, 62], and there is a relationship between mental health symptoms and dental anxiety [11, 63], the mediating effect of mental health symptoms was investigated in three separate simple mediation models. The predictor variables of sexual abuse, childhood neglect and traumatic medical treatment in the hospital were tested with the HSCL-10 as the mediator and the MDAS as the outcome (Fig. 1). All the other covariates from the regression model were included in these analyses. Mental health symptoms mediated the effect of the three traumatic events investigated, but sexual abuse had a larger direct effect on dental anxiety than an indirect one, hence the continued significant effect in our hierarchical regression model. The effects of childhood neglect and traumatic medical treatment were fully mediated through current mental health symptoms (HSCL-10) (Fig. 2).

Discussion

To our knowledge, this is the first study to investigate the association between dental anxiety and PTEs while considering mental health symptoms and self-reported oral health.

The present study investigated dental anxiety in the adult population (> 40 years old) in Tromsø and in accordance with the stated objectives, this population expressed a lower prevalence of dental anxiety than expected [9, 11, 13, 16, 64]; however, this study confirmed previously reported associations between dental anxiety and sex, age, dental attendance, previously traumatic or painful dental treatments and oral health [13, 16, 20, 65].

This study also found that the following potentially traumatic events outside the dental setting had a significant impact on our hierarchical regression model at the stage they were entered: sexual abuse, painful or scary medical treatment at the hospital and childhood neglect. Of these, only sexual abuse remained a significant predictor after controlling for current mental health symptoms. Furthermore, the mediation analysis provided evidence that current mental health symptoms seem to mediate the effect of traumatic or painful medical treatment in hospital, sexual abuse and neglect in childhood on dental anxiety. However, sexual abuse was only partially mediated.

The results of this study indicate that reporting sexual abuse has a direct significant influence on dental anxiety in the general population. In other words, the experience of sexual abuse appears to impact dental anxiety in individuals irrespective of whether the same individuals are experiencing generalised mental health problems (e.g. depression, anxiety). This could point to sexual abuse experiences being somehow directly conditional on dental anxiety [46], but also clarifies the lack of conscious awareness of the link between sexual abuse and dental anxiety, which might be evident in some survivors of sexual abuse [45]. Evidence shows that many aspects of dental treatment can trigger memories and flashbacks from sexual abuse within the concept of trauma coupling [46, 54, 66]. Crossing lines of intimacy in the dental setting can be difficult in itself, but the oral cavity may have been violated directly, which could make the dental setting even more challenging [45, 67]. Dental treatment requires touching the face and head of the patient, inserting fingers in the oral cavity, using water spray and rubber gloves and relying on the

patient's ability to keep their mouth open during certain procedures. Furthermore, being in a reclined position with dental health professionals leaning over and intruding into one's personal space can trigger feelings associated with losing control and being trapped [67]. Remaining motionless, not having the ability to speak and not seeing what the dentist is doing also may echo feelings of being violated all over again [55, 66]. The dental personnel's reassurances can also trigger memories since perpetrators often do this as well as a means of justifying their actions or controlling the situation. This might include telling victims to keep calm, that it will not hurt and that it will be over soon [68]. Survivors of sexual abuse have reported persistent problems with dental treatment despite the processing and mental resolving of the abuse in other aspects of their lives [55], which could indicate that exposure to the dental setting, with all its triggers, is especially important for these individuals.

The regression analysis underlines the importance of traumatic dental treatment, oral health and the avoidance of dental treatment as predictors of dental anxiety. However, it is worth noting that most of the variance in dental anxiety is unaccounted for in this model, which points to the fact that there is more to explaining variance in dental anxiety than the factors included in the current model. One aspect that was not controlled for was personality factors, such as neuroticism, which are considered an important predictor of health in general [69], and dental anxiety specifically [12, 63]. Another factor that was not considered was oral health-related quality of life, which evidence shows is often impaired in dentally anxious individuals [70]. Oral health affected by dental anxiety and subsequent avoidance behaviour may affect the oral health-related quality of life and lead to social isolation and the presentation of symptoms related to depression and general anxiety [71, 72]. Dental anxiety has a multifactorial aetiology; hence, effect sizes for the single variables are not expected to be high. Identifying these variables is important, but they must be considered as a part of a set of variables to be able to understand the clinical variations in the population.

The avoidance of dental treatment is much more prevalent among anxious individuals compared to the rest of the population. Still, 60% of the dentally anxious participants reported going regularly to the dentist, and 89.8% of all the participants in this study reported a regular attendance pattern. This is higher than the numbers reported in a population study including adults from the whole of Troms County, where 77.7% of the entire population under study reported similar regular attendance [73]. The private sector provides the majority of dental care for the adult population in Norway without any public involvement concerning the geographical distribution of dental clinics or fees for dental services. That could be problematic with regard to the provision of equal health care, making accessibility and personal economy more predictive of regular dental attendance than other factors [74]. Thus, the adult population in Tromsø, a city with a high density of private clinics, will perhaps have better access to dental health care compared to more rural areas. Also, individuals with a dental phobia who chose not to participate in this study would probably be more inclined to use avoidance as a strategy than the phobic participants that participated in this study, which would influence the reported attendance pattern. Note that the reporting of regular dental treatment includes the option "less than once every two years", an alternative that could be considered to be more irregular.

There is some controversy in terms of performing mediation analyses on cross-sectional data since the order of occurrence of reported measures is unknown in an individual's life. The HSCL-10 measures current symptoms (the last two weeks), and it is reasonable to assume that traumatic life events most likely happened sometime previous to the last two weeks in these types of studies. Similarly, the MDAS is also a current measure, which makes it impossible to pinpoint the onset of dental anxiety in the past. Even though the order of events can be stipulated or hypothesised, causal effects cannot be ascertained, and the direction of correlation in the mediation analyses is probably, to some extent, bidirectional. Current mental health symptoms might affect reported traumatic events [75], and high dental anxiety could influence current mental health symptoms. Nevertheless, there is a well-documented link between traumatic life events and mental health. Having experienced trauma increases the likelihood of developing mental health disorders, like PTSD, depression and anxiety [76–79]. There is also convincing evidence concerning the higher prevalence of psychological disorders among highly dentally anxious individuals [23] and the role of psychological disorders in the maintenance of dental anxiety. It could be argued that some traumatic life events might affect dental anxiety as a result of causing increased vulnerability in an individual. That is, the psychological consequences of traumatic experiences might increase susceptibility to dental anxiety and poorer oral health.

There was a low prevalence of highly anxious participants in this study compared to previous investigations, as only 2.9% of the participants scored over the cut-off value of 19 for high dental anxiety. This could be interpreted as a result of a continuous decline in dental anxiety in the adult population [13] or reflect differences in the measures used to classify high dental anxiety. Still, the possibility of issues with the representativeness of individuals with high dental anxiety in the study population cannot be ruled out, especially considering that some of the participants were to undergo a thorough clinical dental examination. This could, to some extent, hinder recruitment among highly dentally anxious individuals due to the avoidance behaviour that characterises the phobic disorder [80]. This is the obvious pitfall of all population studies in the field. However, the questionnaire data used were collected independently of the dental examination, so the dentally anxious could participate in the study while declining the oral examination. Also, if considering the possible bias of representativeness, it can be inferred that the associations in all the bivariate analyses are supported by the existing literature, and including a larger portion of dentally anxious individuals would probably enhance rather than lower the effect sizes of the correlations observed.

Self-reported measures without any clinical markers are problematic and can give rise to bias. Recall bias is often an issue in epidemiological research, and the reporting of traumatic life events can be over- or underreported due to such bias. This can affect the association between reported traumatic events and health-related outcomes, here dental anxiety and current mental health symptoms. Studies have shown that the effect of adverse childhood experiences is present in adult health, despite people not recalling or failing to report such events [75, 81]. Adverse or traumatic life events can be useful and important to individuals when they are trying to make sense of their health problems [81, 82]. Hence, traumatic events could be more relevant to individuals that struggle with mental health problems, and traumatic dental treatment experiences could be more accessible to individuals with dental anxiety. People that are in

good health without current problems tend to “forgive and forget” adverse events in their past [83], adding to the risk of underestimating the associations of interest.

Conclusion

The findings of this study show that survivors of sexual abuse can experience challenges in terms of receiving dental treatment regardless of whether their history of sexual abuse affects their current mental health status. Dental personnel should integrate this knowledge into their daily practices, recognise signs of sexual abuse, avoid re-traumatisation and refer patients to specialists in the field.

Abbreviations

PTE Potentially traumatic events

MDAS Modified dental anxiety scale

PTSD Posttraumatic stress disorder

HSCL-10 Hopkins symptom checklist

SPSS IBM Statistical package for the social sciences

MCAR Missing completely at random

Declarations

Ethics approval and consent to participate

All participants in Tromsø 7 gave informed consent. Every project in the Tromsø Study is obliged to follow the EU's General Data Protection Regulation and the Personal Data Act (Norwegian law). The responsible research institution must assess the need to implement the Data Protection Impact Assessment and research processing personal data has to notify the Norwegian Centre for Research Data. This current study only retrieved anonymised data. The Regional Committee of Medical and Health Research Ethics (reference number 2018/1352/REK nord) approved the present study in July 2018. It is confirmed that all methods were carried out in accordance with the stated guidelines and regulations.

Consent for publication

Not applicable

Availability of data and materials

Researchers affiliated with approved research institutions can apply for access to research of the Tromsø Study's material, available from The Tromsø Study [<https://uit.no/research/tromsostudy>]. All projects

applying for data in the Tromsø study must have their own approval from the Regional ethics committee (REK).

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

All authors have read and approved the final manuscript.

HN as first author, contributed in planning the study, performed all statistical analyses, drafted and wrote the manuscript.

J-AKJ planned the study, contributed in statistical analyses, interpretations of data, contributed in writing and substantively revised the manuscript.

TW contributed in planning the study, contributed in writing and substantively revised the manuscript.

KR contributed with the statistical analyses, interpretation of data and revised the manuscript.

CEAW contributed in the conception of the study and revised the manuscript.

JT contributed in the conception of the study and revised the manuscript.

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Authors' information

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References

1. Hill KB, Chadwick B, Freeman R, O'Sullivan I, Murray JJ: **Adult Dental Health Survey 2009: relationships between dental attendance patterns, oral health behaviour and the current barriers to dental care.** *Br Dent J* 2013, **214**:25.
2. Schuller AA, Willumsen T, Holst D: **Are there differences in oral health and oral health behavior between individuals with high and low dental fear?** *Community Dent Oral Epidemiol* 2003, **31**(2):116-

121.

3. Armfield JM: **Predicting dental avoidance among dentally fearful Australian adults.** *Eur J Oral Sci* 2013, **121**(3pt2):240-246.
4. Abrahamsson KH, Berggren U, Hakeberg M, Carlsson SG: **Phobic avoidance and regular dental care in fearful dental patients: a comparative study.** *Acta Odontol Scand* 2001, **59**(5):273-279.
5. De Jongh A, Fransen J, Oosterink-Wubbe F, Aartman I: **Psychological trauma exposure and trauma symptoms among individuals with high and low levels of dental anxiety.** *Eur J Oral Sci* 2006, **114**:286-292.
6. De Jongh A, Aartman IHA, Brand N: **Trauma-related phenomena in anxious dental patients.** *Community Dent Oral Epidemiol* 2003, **31**(1):52-58.
7. Hakeberg M, Wide U: **General and oral health problems among adults with focus on dentally anxious individuals.** *Int Dent J* 2018, **68**(6):405-410.
8. Vermaire JH, De Jongh A, Aartman IHA: **Dental anxiety and quality of life: the effect of dental treatment.** *Community Dent Oral Epidemiol* 2008, **36**(5):409-416.
9. Gisler V, Bassetti R, Mericske-Stern R, Bayer S, Enkling N: **A cross-sectional analysis of the prevalence of dental anxiety and its relation to the oral health-related quality of life in patients with dental treatment needs at a university clinic in Switzerland.** *Gerodontology* 2012, **29**(2):e290-296.
10. Svensson L, Hakeberg M, Wide U: **Dental pain and oral health-related quality of life in individuals with severe dental anxiety.** *Acta Odontol Scand* 2018, **76**(6):401-406.
11. Pohjola V, Mattila AK, Joukamaa M, Lahti S: **Anxiety and depressive disorders and dental fear among adults in Finland.** *Eur J Oral Sci* 2011, **119**(1):55-60.
12. Halonen H, Salo T, Hakko H, Rasanen P: **Association of dental anxiety to personality traits in a general population sample of Finnish University students.** *Acta Odontol Scand* 2012, **70**(2):96-100.
13. Svensson L, Hakeberg M, Boman UW: **Dental anxiety, concomitant factors and change in prevalence over 50 years.** *Community Dent Health* 2016, **33**(2):121-126.
14. Humphris GM, Freeman R, Campbell J, Tuutti H, D'Souza V: **Further evidence for the reliability and validity of the Modified Dental Anxiety Scale.** *Int Dent J* 2000, **50**(6):367-370.
15. Humphris GM, Dyer TA, Robinson PG: **The modified dental anxiety scale: UK general public population norms in 2008 with further psychometrics and effects of age.** *BMC Oral Health* 2009, **9**(1):20.
16. Carlsson V, Hakeberg M, Wide Boman U: **Associations between dental anxiety, sense of coherence, oral health-related quality of life and health behaviour – a national Swedish cross-sectional survey.** *BMC Oral Health* 2015, **15**:100.
17. Halonen H, Salo T, Hakko H, Räsänen P: **The Association between Dental Anxiety, General Clinical Anxiety and Depression among Finnish University Students.** *Oral Health Prev Dent* 2014, **13**(2):320-325.

18. Bell RA, Arcury TA, Anderson AM, Chen HY, Savoca MR, Gilbert GH, Quandt SA: **Dental anxiety and oral health outcomes among rural older adults.** *J Public Health Dent* 2012, **72**(1):53-59.
19. Nicolas E, Collado V, Faulks D, Bullier B, Hennequin M: **A national cross-sectional survey of dental anxiety in the French adult population.** *BMC Oral Health* 2007, **7**(1):1-7.
20. Hägglin C, Berggren U, Hakeberg M, Ahlqwist M: **Dental anxiety among middle-aged and elderly women in Sweden. A study of oral state, utilisation of dental services and concomitant factors.** *Gerodontology* 1996, **13**(1):25-34.
21. De Jongh A, Muris P, Horst GT, Duyx MPMA: **Acquisition and maintenance of dental anxiety: the role of conditioning experiences and cognitive factors.** *Behav Res Ther* 1995, **33**(2):205-210.
22. Oosterink FMD, de Jongh A, Aartman IHA: **Negative events and their potential risk of precipitating pathological forms of dental anxiety.** *J Anxiety Disord* 2009, **23**(4):451-457.
23. Locker D, Poulton R, Thomson WM: **Psychological disorders and dental anxiety in a young adult population.** *Community Dent Oral Epidemiol* 2001, **29**(6):456-463.
24. Rachman S: **The conditioning theory of fearacquisition: A critical examination.** *Behav Res Ther* 1977, **15**(5):375-387.
25. **Resilience in later adulthood and old age: Resources and potentials for successful aging.** New Jersey: John Wiley & Sons Inc; 2006.
26. Carter AE, Carter G, Boschen M, AlShwaimi E, George R: **Pathways of fear and anxiety in dentistry: A review.** *World J Clin Cases* 2014, **2**(11):642-653.
27. Locker D, Shapiro D, Liddell A: **Negative dental experiences and their relationship to dental anxiety.** *Community Dent Health* 1996, **13**(2):86-92.
28. Maggiras J, Locker D: **Five-year incidence of dental anxiety in an adult population.** *Community Dent Health* 2002, **19**(3):173-179.
29. Lin C-S, Wu S-Y, Yi C-A: **Association between Anxiety and Pain in Dental Treatment: A Systematic Review and Meta-analysis.** *J Dent Res* 2017, **96**(2):153-162.
30. Tickle M, Milsom K, Crawford FI, Aggarwal VR: **Predictors of pain associated with routine procedures performed in general dental practice.** *Community Dent Oral Epidemiol* 2012, **40**(4):343-350.
31. Lin C-S, Lee S-Y: **Dental Anxiety and Expectation of Pain: Cognitive Modulation of the Pain Experience of Dental Patients.** *J Dent Sci* 2007, **2**(3):129-135.
32. Maggiras J, Locker D: **Psychological factors and perceptions of pain associated with dental treatment.** *Community Dent Oral Epidemiol* 2002, **30**(2):151-159.
33. Lin CS, Wu SY, Yi CA: **Association between Anxiety and Pain in Dental Treatment: A Systematic Review and Meta-analysis.** *J Dent Res* 2016, **96**(2):153-162.
34. Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, Koss MP, Marks JS: **Relationship of Childhood Abuse and Household Dysfunction to Many of the Leading Causes of Death in Adults: The Adverse Childhood Experiences (ACE) Study.** *Am J Prev Med* 1998, **14**(4):245-258.

35. Hughes K, Bellis MA, Hardcastle KA, Sethi D, Butchart A, Mikton C, Jones L, Dunne MP: **The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis.** *Lancet Public Health* 2017, **2**(8):e356-e366.
36. Kirkengen AL, Lygre H: **Exploring the relationship between childhood adversity and oral health: An anecdotal approach and integrative view.** *Medical Hypotheses* 2015, **85**(2):134-140.
37. Beasley M, Thompson T, Davidson J: **Resilience in response to life stress: the effects of coping style and cognitive hardiness.** *Pers Individ Differ* 2003, **34**(1):77-95.
38. Jongh A, Aartman IHA, Brand N: **Trauma-related phenomena in anxious dental patients.** *Community Dent Oral Epidemiol* 2003, **31**(1):52-58.
39. Benjet C, Bromet E, Karam EG, Kessler RC, McLaughlin KA, Ruscio AM, Shahly V, Stein DJ, Petukhova M, Hill E *et al*: **The epidemiology of traumatic event exposure worldwide: results from the World Mental Health Survey Consortium.** *Psychol Med* 2016, **46**(2):327-343.
40. Heir T, Bonsaksen T, Grimholt T, Ekeberg Ø, Skogstad L, Lerdal A, Schou-Bredal I: **Serious life events and post-traumatic stress disorder in the Norwegian population.** *BJPsych Open* 2019, **5**(5):e82.
41. Mauritz MW, Goossens PJJ, Draijer N, van Achterberg T: **Prevalence of interpersonal trauma exposure and trauma-related disorders in severe mental illness.** *Eur J Psychotraumatol* 2013, **4**:10.3402/ejpt.v3404i3400.19985.
42. Humphris G, King K: **The prevalence of dental anxiety across previous distressing experiences.** *J Anxiety Disord* 2011, **25**(2):232-236.
43. Hagqvist O, Tolvanen M, Rantavuori K, Karlsson L, Karlsson H, Lahti S: **Dental fear and previous childhood traumatic experiences, life events, and parental bonding.** *Eur J Oral Sci* 2015, **123**(2):96-101.
44. Høyvik AC, Lie B, Willumsen T: **Dental anxiety in relation to torture experiences and symptoms of post-traumatic stress disorder.** *Eur J Oral Sci* 2019, **127**(1):65-71.
45. Willumsen T: **Dental fear in sexually abused women.** *Eur J Oral Sci* 2001, **109**(5):291-296.
46. Fredriksen TV, Søftestad S, Kranstad V, Willumsen T: **Preparing for attack and recovering from battle: Understanding child sexual abuse survivors' experiences of dental treatment.** *Community Dent Oral Epidemiol* 2020, **48**(4):317-327.
47. MacMillan HL, Fleming JE, Streiner DL, Lin E, Boyle MH, Jamieson E, Duku EK, Walsh CA, Wong MY-Y, Beardslee WR: **Childhood Abuse and Lifetime Psychopathology in a Community Sample.** *Am J Psychiatry* 2001, **158**(11):1878-1883.
48. Mullen PE, Martin JL, Anderson JC, Romans SE, Herbison GP: **Childhood sexual abuse and mental health in adult life.** *Br J Psychiatry* 1993, **163**:721-721.
49. van der Stouwe ECD, Groenewold NA, Bos EH, de Jonge P, Wichers M, Booij SH: **How to assess negative affective reactivity to daily life stress in depressed and nondepressed individuals?** *Psychiatry Res* 2019, **279**:259-266.

50. Nermo H, Willumsen T, Johnsen J-AK: **Changes in dental anxiety among 15- to 21-year-olds. A 2-year longitudinal analysis based on the Tromsø study: Fit futures.** *Community Dent Oral Epidemiol* 2019, **47**(2):127-133.
51. Carey JA, Madill A, Manogue M: **Communications skills in dental education: a systematic research review.** *Eur J Dent Educ* 2010, **14**(2):69-78.
52. Rouse RA, Hamilton MA: **Dentists' technical competence, communication, and personality as predictors of dental patient anxiety.** *J Behav Med* 1990, **13**(3):307-319.
53. Auerbach SM, Martelli MF, Mercuri LG: **Anxiety, information, interpersonal impacts, and adjustment to a stressful health care situation.** *J Pers Soc Psychol* 1983, **44**(6):1284-1296.
54. Kranstad V, Søftestad S, Fredriksen TV, Willumsen T: **Being considerate every step of the way: a qualitative study analysing trauma-sensitive dental treatment for childhood sexual abuse survivors.** *Eur J Oral Sci*, n/a(n/a).
55. Wolf E, McCarthy E, Priebe G: **Dental care – an emotional and physical challenge for the sexually abused.** *Eur J Oral Sci* 2020, **128**(4):317-324.
56. Jacobsen BK, Eggen AE, Mathiesen EB, Wilsgaard T, Njølstad I: **Cohort profile: The Tromsø Study.** *Int J Epidemiol* 2011, **41**(4):961-967.
57. **The Tromsø Study 7** [<https://uit.no/research/tromsostudy>]
58. Strand BH, Dalgard OS, Tambs K, Rognerud M: **Measuring the mental health status of the Norwegian population: A comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36).** *Nord J Psychiatry* 2003, **57**(2):113.
59. Hayes AF: **Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.** Guilford publications; 2017.
60. (SSB) SN: **Income and wealth statistics for households.** In.: Statbank; 2016.
61. Perkonig A, Kessler RC, Storz S, Wittchen H-U: **Traumatic events and post-traumatic stress disorder in the community: prevalence, risk factors and comorbidity.** *Acta Psychiatr Scand* 2000, **101**(1):46-59.
62. Perkonig A, Pfister H, Stein MB, Höfler M, Lieb R, Maercker A, Wittchen H-C: **Longitudinal Course of Posttraumatic Stress Disorder and Posttraumatic Stress Disorder Symptoms in a Community Sample of Adolescents and Young Adults.** *Am J Psychiatry* 2005, **162**(7):1320-1327.
63. Hägglin C, Hakeberg M, Hällström T, Berggren U, Larsson L, Waern M, Pálsson S, Skoog I: **Dental anxiety in relation to mental health and personality factors.** *Eur J Oral Sci* 2001, **109**(1):27-33.
64. King K, Humphris G: **Evidence to confirm the cut-off for screening dental phobia using the Modified Dental Anxiety Scale.** *Soc sci dent* 2010, **1**(1):21-28.
65. Agdal LM, Raadal M, Skaret E, Kvale G: **Oral health and oral treatment needs in patients fulfilling the DSM-IV criteria for dental phobia: Possible influence on the outcome of cognitive behavioral therapy.** *Acta Odontol Scand* 2008, **66**(1):1-6.
66. Leeners B, Stiller R, Block E, Gorres G, Imthurn B, Rath W: **Consequences of childhood sexual abuse experiences on dental care.** *J Psychosom Res* 2007, **62**(5):581-588.

67. Larijani HH, Guggisberg M: **Improving Clinical Practice: What Dentists Need to Know about the Association between Dental Fear and a History of Sexual Violence Victimization.** *Int J Dent* 2015, **2015**:452814.
68. Berliner L, Conte JR: **The process of victimization: The victims' perspective.** *Child Abuse Negl* 1990, **14**(1):29-40.
69. Lahey BB: **Public health significance of neuroticism.** *Am Psychol* 2009, **64**(4):241-256.
70. Mehrstedt M, John MT, Tönnies S, Micheelis W: **Oral health-related quality of life in patients with dental anxiety.** *Community Dent Oral Epidemiol* 2007, **35**(5):357-363.
71. Crofts-Barnes NP, Brough E, Wilson KE, Beddis AJ, Girdler NM: **Anxiety and quality of life in phobic dental patients.** *J Dent Res* 2010, **89**(3):302-306.
72. Henning Abrahamsson K, Berggren U, Carlsson SG: **Psychosocial aspects of dental and general fears in dental phobic patients.** *Acta Odontol Scand* 2009, **58**(1):37-43.
73. Jönsson B, Holde GE, Baker SR: **The role of psychosocial factors and treatment need in dental service use and oral health among adults in Norway.** *Community Dent Oral Epidemiol* 2020, **48**(3):215-224.
74. Abelsen B: **What a difference a place makes: Dental attendance and self-rated oral health among adults in three counties in Norway.** *Health Place* 2008, **14**(4):829-840.
75. Sheikh MA: **Coloring of the past via respondent's current psychological state, mediation, and the association between childhood disadvantage and morbidity in adulthood.** *J Psychiatr Res* 2018, **103**:173-181.
76. Hovens JGFM, Giltay EJ, Wiersma JE, Spinhoven P, Penninx BWJH, Zitman FG: **Impact of childhood life events and trauma on the course of depressive and anxiety disorders.** *Acta Psychiatr Scand* 2012, **126**(3):198-207.
77. Kessler RC, Davis CG, Kendler KS: **Childhood adversity and adult psychiatric disorder in the US National Comorbidity Survey.** *Psychol Med* 1997, **27**(5):1101-1119.
78. Kessler RC: **Posttraumatic stress disorder: The burden to the individual and to society.** *J Clin Psychiatry* 2000, **61**(Suppl 5):4-14.
79. McLaughlin KA, Koenen KC, Hill ED, Petukhova M, Sampson NA, Zaslavsky AM, Kessler RC: **Trauma Exposure and Posttraumatic Stress Disorder in a National Sample of Adolescents.** *J Am Acad Child Adolesc Psychiatry* 2013, **52**(8):815-830.e814.
80. American psychiatric association: **Diagnostic and statistical manual of mental disorders: DSM-5.** In., 5th edn. Washington, DC; 2013.
81. Reuben A, Moffitt TE, Caspi A, Belsky DW, Harrington H, Schroeder F, Hogan S, Ramrakha S, Poulton R, Danese A: **Lest we forget: comparing retrospective and prospective assessments of adverse childhood experiences in the prediction of adult health.** *J Child Psychol Psychiatry* 2016, **57**(10):1103-1112.

82. Brewin CR, Andrews B, Gotlib IH: **Psychopathology and early experience: A reappraisal of retrospective reports.** *Psychol Bull* 1993, **113**(1):82-98.

83. Colman I, Kingsbury M, Garad Y, Zeng Y, Naicker K, Patten S, Jones PB, Wild TC, Thompson AH: **Consistency in adult reporting of adverse childhood experiences.** *Psychol Med* 2016, **46**(3):543-549.

Tables

Table 1 The distribution of low and high dental anxiety in key variables

Variable	n	% low dental anxiety	% high dental anxiety	χ^2 ^a	<i>phi</i> ^b
<i>Sex</i>	20197				
<i>Female (0)</i>	10583	52	66.6	47.63*	-0.05
<i>Male (1)</i>	9614	48	33.4		
<i>Total count</i>		19614	583		
<i>current mental health symptoms</i>	19415				
<i>HSCL < 1.84</i>	17729	91.8	75.7	170.74*	0.09
<i>HSCL ≥ 1.85</i>	1686	8.2	24.3		
<i>Total count</i>		19197	562		
<i>Avoidance^c</i>	20144				
<i>Never, only for acute problems (0)</i>	3249	9.0	39.9	602.69*	0.17
<i>Goes regularly (1)</i>	16895	91	60.1		
<i>Total count</i>		19565	579		
<i>ORAL HEALTH^d</i>					
<i>Excellent (0)</i>		88.1	28.3	323.69*	0.31
<i>Very bad (1)</i>		11.9	71.7		
<i>Total count</i>	3506	3393	113		

Legend: Frequency of high (≥ 19) and low (< 19) dental anxiety scores (MDAS) according to sex, mental health symptoms, dental attendance (avoidance) and oral health

^aYates' correction for continuity; Chi-square test of independence

^bPhi coefficient (effect size: 0.10 for small effect, 0.30 for medium effect, 0.50 for large effect [Cohen's criteria 1988])

^cDo you go to the dentist/experience dental care regularly? 0 = no, never or only for acute problems 1 = yes, often, yearly, every other year or less than once every two years

^dComparing high and low evaluations of one's own oral health

* $p < 0.001$

Table 2 The proportion of reported PTEs in the high and low dental anxiety groups

<i>Trauma</i>	<i>MDAS ≥ 19</i>	<i>MDAS < 19</i>	χ^2^a	phi ^b	OR	95% CI
Any trauma	82.3	51.4	212.23*	0.10	4.4	3.54 - 5.44
Dental trauma ^c	69.0	22.7	660.49*	0.18	7.6	6.32 - 9.04
Sexual abuse ^d	20.8	9.2	85.21*	0.07	2.6	2.09 - 3.16
Violence ^e	26.4	15.2	53.60*	0.05	2.0	1.66 - 2.42
Bullying ^f	32.1	21.1	39.77*	0.05	1.8	1.48 - 2.11
Witness ^g	16.6	9.1	37.39*	0.04	2.0	1.60 - 2.50
Medical trauma ^h	20.6	10.6	57.38*	0.05	2.2	1.78 - 2.69
Failure of care ⁱ	13.0	6.7	34.58*	0.04	2.1	1.64 - 2.69

Legend: The proportion of reported PTEs in the high and low dental anxiety groups and the strength of the associations (odds ratios) between traumatic events and anxiety level

* $p < 0.001$

^aYates' correction for continuity; Chi-square tests of independence

^bPhi coefficient (effect size: 0.10 for small effect, 0.30 for medium effect, 0.50 for large effect (Cohen's criteria 1988))

^cReceived painful or terrifying medical treatment at the dentist

^dBeen exposed to sexual abuse, i.e. sexual actions against your will

^eBeen exposed to violence (for example, hit, kicked, beaten, robbed or threatened with a firearm)

^fBeen called negative things, marginalised, threatened or bullied by schoolmates, fellow students or coworkers over a long period of time

^gWitnessed someone close to you being exposed to violence or sexual abuse

^hReceived painful medical treatment when hospitalised due to sickness or serious injury

ⁱFailure of care in childhood, i.e. not having received the necessities of food, clothing, protection and care/love from parents/caregivers

Table 3a Model summary of the hierarchical regression analysis with the MDAS as the dependent variable

	$\Delta F(df1, df2)$	ΔR^2
<i>Model 1</i>	646.68* (2,19012)	0.064
<i>Model 2</i>	1374.83* (3,19009)	0.167
<i>Model 3</i>	8.63* (6,19003)	0.002
<i>Model 4</i>	341.72* (1,19002)	0.014

Legend: *p < 0.001

Table 3b Hierarchical regression with the MDAS as the dependent variable

		<i>B</i>	<i>SE Bⁱ</i>	β	<i>Sig.ⁱ</i>	<i>CI 95%ⁱ</i>		Legend:
						<i>Lower</i>	<i>Upper</i>	
<i>Step 1</i>	<i>Constant</i>	<i>9.58</i>	<i>0.07</i>		<i>0.001</i>	<i>9.45</i>	<i>9.72</i>	
	Sex	-1.08	0.05	-0.14	0.001	-1.18	-0.97	
	Age	-0.36	0.01	0.20	0.001	-0.38	-0.34	
<i>Step 2</i>	<i>Constant</i>	<i>11.38</i>	<i>0.14</i>		<i>0.001</i>	<i>11.10</i>	<i>11.67</i>	
	^a Oral health	-0.67	0.03	-0.16	0.001	-0.73	-0.61	
	^b Avoidance	1.91	0.12	0.15	0.001	1.67	2.15	
	^c Pain dentist	2.55	0.07	0.30	0.001	2.4	2.67	
<i>Step 3</i>	<i>Constant</i>	<i>11.20</i>	<i>0.15</i>		<i>0.001</i>	<i>10.91</i>	<i>11.49</i>	
	^d Neglect	0.23	0.11	0.02	0.042 ⁱⁱⁱ	0.01	0.45	
	^e Violence	0.01	0.08	0.00	0.881	-0.15	0.17	
	^f Sexual abuse	0.38	0.10	0.03	0.001	0.19	0.58	
	^g Bullying	0.09	0.07	0.01	0.215	-0.05	0.22	
	^h Witness	0.09	0.10	0.01	0.391	-0.12	0.28	
	ⁱ Hospital pain	0.21	0.09	0.02	0.025 ⁱⁱⁱ	0.04	0.41	
<i>Step 4</i>	<i>Constant</i>	<i>9.36</i>	<i>0.18</i>		<i>0.001</i>	<i>8.98</i>	<i>9.73</i>	
	^j HSCCL-10	1.25	0.09	0.13	0.001	1.09	1.42	

ⁱConfidence intervals (CI) and standard errors (SE) are based on 1000 bias-corrected and accelerated bootstrap samples

ⁱⁱStandardised coefficients

ⁱⁱⁱLost their significant contribution in the last model (see figure on mediation)

^aSelf-reported oral health (Likert format)

^bAvoidance: 0 = goes regularly to the dentist, 1 = never goes or only for acute dental pain

^cReceived painful or terrifying medical treatment at the dentist

^dFailure of care in childhood, i.e. not having received the necessities of food, clothing, protection and care/love from parents/caregivers

^eBeen exposed to violence (for example, hit, kicked, beaten, robbed or threatened with a firearm)

^fBeen exposed to sexual abuse, i.e. sexual actions against your will

^gBeen called negative things, marginalised, threatened or bullied by schoolmates, fellow students or coworkers over a long period of time

^hWitnessed someone close to you being exposed to violence or sexual abuse

ⁱReceived painful medical treatment when hospitalised due to sickness or serious injury

^jHopkins Symptom Checklist: current mental health symptoms

Figures

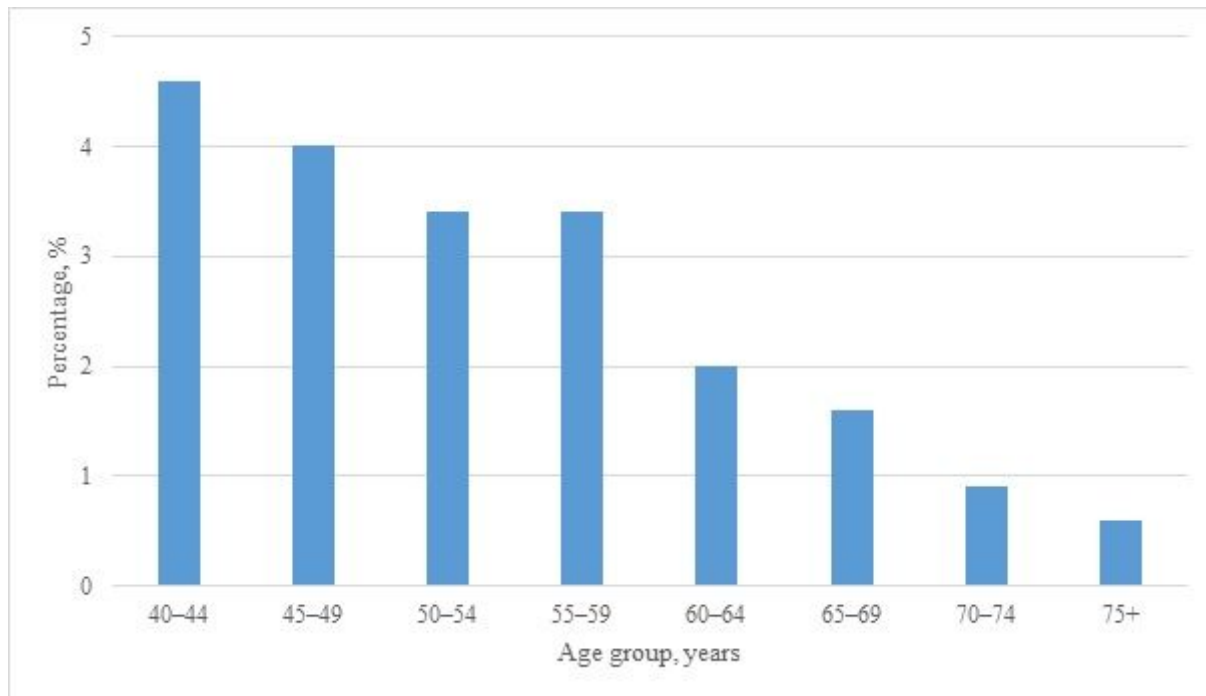


Figure 1

Prevalence of high dental anxiety (MDAS ≥ 19) by age group

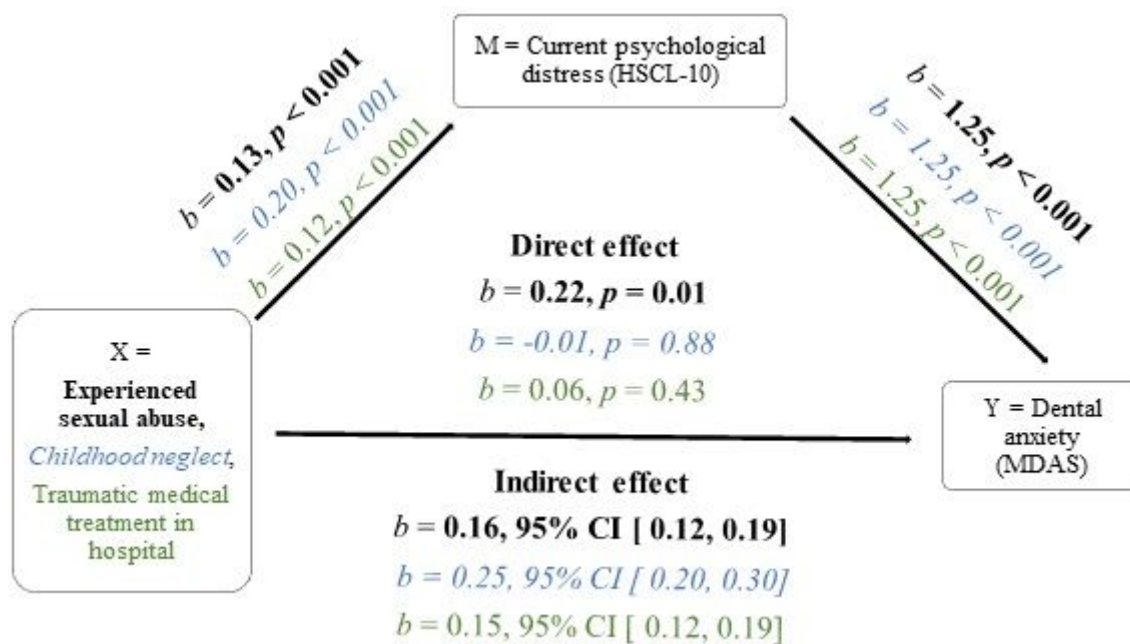


Figure 2

Mediation analyses. Analyses of how the HSCL-10 mediates the effect of three potential traumatic life events on dental anxiety scores using the PROCESS macro in SPSS. The figure contains three analyses that are distinguished through both colour coding and the use of bold and italic text formatting. All events are mediated through the HSCL-10, but only sexual abuse continues to have a significant direct effect on dental anxiety when accounting for the effect of mediation through the HSCL-10.

