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Changes and relations to psychological well-being

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University of Turku

Faculty of Medicine
Institute of Dentistry
Department of Community Dentistry
Finnish Doctoral Programme in Oral Sciences – FINDOS Turku

Supervised by

Professor Satu Lahti
Department of Community Dentistry
University of Turku, Finland

Docent Mimmi Tolvanen
Department of Community Dentistry
University of Turku, Finland

Reviewed by

Professor Ulla Wide
Department of Behavioral and
Community Dentistry
University of Gothenburg, Sweden

Professor Tiril Willumsen
Institute of Clinical Dentistry
University of Oslo, Norway

Opponent

Professor Magnus Hakeberg
Department of Behavioral and
Community Dentistry
University of Gothenburg, Sweden

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“Anxiety was born in the very same moment as mankind. And since we will never be able to master it, we will have to learn to live with it – just as we have learned to live with storms.” (Paolo Coelho)

To My Angel Mother

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ABSTRACT

This thesis presents results from a longitudinal study of dental anxiety that aimed to evaluate changes in dental anxiety during and after pregnancy in the FinnBrain Birth Cohort. The study also evaluated associations between dental anxiety, general anxiety, depression, trauma outside dental settings and parental bonding.

Data were provided by 201 women and 147 men taking part in the pilot phase of the study, and by 3808 women and 2623 men in the main phase of the study. Participants completed the Modified Dental Anxiety Scale as a valid measure of dental anxiety during the first and third trimesters of pregnancy and 3 months after the childbirth. The MDAS was also completed in the pilot study12 and 24 months after the baby was born. Depression, general anxiety, pregnancy-related anxiety, mental, physical and sexual trauma, positive and negative life events and parental bonding were all measured by valid questionnaires.

Most participants were non-anxious in both cohorts, but approximately every fifth participant experienced changes in their dental anxiety. The prevalence of high dental anxiety at baseline was 8% in the pilot and 8% in the actual cohort among women and 3% in the pilot and 5% in the actual cohort among men. Overall, women were more fearful than men.

Dental anxiety, depression and general anxiety correlated in the main cohort, but the magnitudes of the correlations were modest. In the pilot population, the correlations were statistically significant only among men. In the pilot cohort dental anxiety correlated positively with emotional trauma among men and with the number of life events among women but not with parental bonding.

The findings suggest that dental anxiety is not a stable phenomenon for everyone. It could be influenced by specific life events such as stressors or hormonal changes during pregnancy. Dental clinicians should measure dental anxiety regularly and consider different etiological aspects in the individualized anxiety treatments.

KEYWORDS: dental anxiety, general anxiety, depression, pregnancy, trauma, parental bonding

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TIIVISTELMÄ

Tämä väitöskirja raportoi tuloksia hammashoitopelon seurantatutkimuksesta FinnBrain-kohortissa. Tutkimuksen tavoitteena oli arvioida hammashoitopelon muutoksia raskauden aikana ja sen jälkeen sekä arvioida pelon yhteyttä ahdistuneisuuteen, masennukseen ja erilaisiin elämänkokemuksiin.

Tutkimusaineisto koostui 201 naisesta ja 147 miehestä tutkimuksen pilottikohortista sekä 3808 naisesta ja 2623 miehestä pääkohortista. Osallistujat täyttivät hammashoitopelkokyselyn (Modified Dental Anxiety Scale) raskauden ensimmäisen ja viimeisen kolmanneksen aikana sekä 3 kk synnytyksen jälkeen, pilottiaineistossa myös 12 ja 24 kk kuluttua synnytyksestä. Ahdistuneisuutta, erikseen myös raskauteen liittyvää ahdistuneisuutta, masentuneisuutta, psyykkisiä, fyysisiä ja seksuaalisia traumoja, positiivisia ja negatiivisia elämäntapahtumia sekä kokemuksia omista vanhemmista arvioitiin kyselylomakkein.

Suurin osa osallistujista ei pelännyt hammashoitoa, mutta noin joka viidennellä oli muutoksia hammashoitopelossa tutkimusjakson aikana. Paljon hammashoitopelkoa esiintyi tutkimuksen alussa 8 %:lla naisista sekä pilotti- että pääkohortissa, miehistä 3 %:lla pilotissa ja 5 %:lla varsinaisessa kohortissa. Naiset raportoivat ylipäätään enemmän pelkoa kuin miehet.

Hammashoitopelko, masentuneisuus ja ahdistuneisuus olivat yhteydessä toisiinsa pääkohortissa, mutta yhteys oli lievä. Pilottikohortissa lievä yhteys löytyi ainoastaan miehillä. Pilottikohortissa miehillä löytyi heikko yhteys hammashoitopelon ja henkisten traumojen välillä, naisilla pelon ja elämäntapahtumien määrän välillä. Hammashoitopelko ei yhdistynyt koehenkilöiden muistoihin omien vanhempiensa vanhemmuudesta.

Tulokset viittaavat siihen, että hammashoitopelko ei ole pysyvä ilmiö. Siihen saattavat vaikuttaa erilaiset elämäntapahtumat ja stressitekijät tai jopa raskauden aikaiset hormonaaliset muutokset. Suunterveyden ammattilaisten tulisi mitata hammashoitopelkoa säännöllisesti, ja pelon hoito tulisi suunnitella yksilöllisesti mahdollisten etiologisten tekijöiden mukaan.

AVAINSANAT: hammashoitopelko, ahdistuneisuus, masennus, raskaus, trauma, vanhemmuuskokemus

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Abbreviations

DA	Dental Anxiety
EPDS	Edinburgh Postnatal Distress Scale
gwk	gestational week
LEC	Life Event Checklist
MDAS	Modified Dental Anxiety Scale
PBI	Parental Bonding Instrument
PRAQ	Pregnancy-Related Anxiety Questionnaire
SCL-90	Symptom Checklist -90
STAI	State Trait Anxiety Inventory
TADS	Trauma and Distress Scale

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Tolvanen M, Hagqvist O, Luoto A, Rantavuori K, Karlsson L, Karlsson H, Lahti S. Changes over time in adult dental fear and correlation to depression and anxiety: a cohort study of pregnant mothers and fathers. Eur J Oral Sci 2013; 121: 264-269.

II 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: 96-101.

III Hagqvist O, Tolvanen M, Rantavuori K, Karlsson L, Karlsson H, Lahti S. Short-term longitudinal changes in adult dental fear. Eur J Oral Sci 2018; 126: 300-306.

IV Hagqvist O, Tolvanen M, Rantavuori K, Karlsson L, Karlsson H, Lahti S. Changes in dental fear and its relations to anxiety and depression in the FinnBrain Birth Cohort Study. Eur J Oral Sci 2020; 128: 429-435.

1 Introduction

Dental anxiety is a major challenge and affects the oral health individually and at a population level around the world. The fearful individual avoids seeking treatment, the problems build up, oral health deteriorates and the quality of life sinks. This said, the understanding and treatment of dental anxiety should be one of the priorities of every dentist. Prevention of the development of dental anxiety should be the most important goal for all our actions.

Little is known of the variation of dental anxiety at an individual level longitudinally in short time periods, though some insights in several year intervals have been described. Major life events such as a pregnancy and becoming a parent affects one's life greatly creating all kinds of emotions, also lots of fears. If these kinds of events affect dental fear, it is an interesting question and can help us dentists to understand our patients and their behavior at different stages of life better. The society around us changes quickly and awareness of the physical, mental, and sexual trauma, even torture has risen among medical and dental professionals. These traumas outside the dental setting can affect dental anxiety.

Also the comorbidity of dental anxiety with other psychiatric symptoms helps us to understand and treat some of the fearful patients better. A well-established association between dental and general anxiety exists, and some evidence has been gathered of the association between dental anxiety and depression. The dental anxiety related to previous unpleasant experiences or vicarious learning from others usually responds well to treatment. But we have to be able to recognize the more resistant dental anxiety, which is often related to other psychological problems. These patients might need multi-professional help to overcome their anxiety. In years to come the FinnBrain Birth Cohort could help us also to understand the development of fear in children within a family and perhaps the heritability components of the dental anxiety.

2 Review of the Literature

2.1 Definitions

Most people have experienced fear, which is described as an unpleasant emotion caused by the threat of danger or pain. Fear prepares our body and mind to fight or flight. The reaction includes different components. First of all an unpleasant cognitive state arises, indicating that something bad is about to happen. Physiological symptoms appear as a result of the activation of the sympathetic nervous system including tachycardia, sweating, hyperventilation and muscle tension. The behavioral component pushes us away from the danger and makes us avoid the object or the fearful situation. (Anxiety Disorders: Current Care Guidelines Abstract, 2019)

Anxiety resembles fear as it causes same kind of unpleasant feelings in our body and mind. In contrast to fear, anxiety can be felt though the stimulus is not present and the emotions are more diffuse, i.e. a person being anxious the day before a dental appointment just thinking about the future visit. (Anxiety Disorders: Current Care Guidelines Abstract, 2019)

Phobia is defined according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a marked and persistent fear that is excessive or unreasonable, cued by the presence or anticipation of a specific object or situation. The person recognizes that the fear is excessive. The avoidance, anxious anticipation, or endurance of the feared situations with intense distress interfere significantly with the person's normal routine, occupational functioning, or social activities or relationships. (Diagnostic and Statistical Manual of Mental Disorders, American Psychiatric Association 2013)

In a dental setting, one, two or all of these three (fear, anxiety, phobia) can be present. Some of the procedures dentists perform, could cause pain or a bodily injury and fearful reactions could be seen as a normal reaction. Whether the fear changes into anticipatory anxiety, depends on our cognitive vulnerability, personality and heritability (Beesdo et al. 2009, Czajkowski et al. 2011). If the anxiety leads to a persistant avoidance of dental services, we can talk about phobia. In this thesis the term ”dental anxiety” covers all these forms mentioned above.

2.2 Etiology

A profound question ”Why someone is scared to death when it is time to visit a dentist and someone else could not care less?” has significantly perplexed clinicians, researchers and patients during the past decades. Although there is evidence to suggest that the level of dental anxiety varies over time (Locker and Liddell 1995, Hägglin et al. 1999, Thomson et al. 2000, Maggirias and Locker 2002, Thomson et al. 2009, Liinavuori et al. 2016).), little is known about why someone’s dental anxiety persists while others recover. Dental anxiety has been shown to have multifactorial etiology consisting of exogenous (such as direct experiences or vicarious learning) and endogenous (such as personality traits, psychiatric symptoms and heritability) origins (Weiner and Sheehan 1990, Beaton et al. 2014). Exogenous etiology is often related to experiences in dental treatment, but also other factors such as traumas outside the dental setting could be seen as exogenous components and those could be named environmental. All the etiological aspects of dental anxiety are illustrated in Figure 1.

2.2.1 Exogenous etiology

Dental anxiety can develop through direct, unpleasant dental experiences or by learning from others such as parents, friends or from media (Weiner and Sheehan 1990, Locker et al 2001, ten Berge et al. 2002, Oosterink et al. 2008, 2009, Hum-phris and King 2011, Beaton et al. 2014). These are considered to be exogenous origins.

Direct experiences predictive of high dental anxiety include dental procedures such as injections and tooth drilling, but also experiences related to the dentist’s behavior such as extreme helplessness during treatment and lack of understanding from a dentist. Also pain, nausea and embarrassment are associated with high dental anxiety. (Oosterink et al. 2008, 2009, Humphris and King 2011) Dentally anxious patients have also been shown to have inaccurate memories of the experienced pain, which might affect the maintenance of the dental anxiety (Kent et al. 1985). Schneider et al. found that participants reporting high dental anxiety experienced fear-provoking dental imagery focusing on unpleasant sensations, which were associated with the intrusive recollection of negative past experiences and avoidance of dentistry (Schneider et al. 2018).

Vicarious learning happens via family-members (Themessl-Huber et al. 2010) and peer groups (Rantavuori et al. 2004, Steinberg and Monahan 2007, Gao et al. 2013). The role of media in the process of developing dental anxiety is equivocal. Frightening stories told in media have been shown to increase the likelihood of dental anxiety (Humphris and King 2011), but also not to have any impact (Oosterink et al 2009). Family members’ dental anxiety is a predictor of child dental anxiety (Rantavuori et al. 2009, Themessl-Huber et al. 2010). However, according to a Finnish study, this

phenomenon is not straight-forward, and dental anxiety did not change similarly between parents and their children (Luoto et al. 2014, 2017).

2.2.2 Endogenous etiology

Some individuals become dentally anxious though they have never had bad experiences in a dental setting nor heard frightful stories from others or media. It has been described that some people have a vulnerability (such as cognitive) to developing fears and the person might be prone to other mental illnesses (Thomson et al. 2009, Viinikangas et al. 2009, Ray et al. 2010, Pohjola et al. 2011, Halonen et al. 2012, Stenebrand et al. 2013, Randall et al. 2017). Certain personality traits have a propensity to developing into dental anxiety. Neurotic and introverted personalities are more likely to experience dental anxiety (Halonen et al. 2012). Also alexithymic persons are more prone to being anxious (Viinikangas et al. 2009, Pohjola et al. 2011). Interestingly among children of high intelligence, especially verbal intelligence, some protection against dental anxiety has been found to exist (Toledano et al. 1995, Blomqvist et al. 2013). Therefore, cognitive ability may be protective when entering stressful situations like dental visits (Blomqvist et al. 2013).

Also, heritability to anxiety has been raised as an endogenous pathway (Ray et al. 2010, Vassend et al. 2011, Randall et al. 2017). Ray et al. found a genetic com-ponent of dental anxiety among Swedish twins. The heritability was greater among girls (aged 13-17 years) than boys. (Ray et al. 2010) Also Randall et al. have demonstrated a genetic component in the etiology of dental anxiety and shared heritability for dental anxiety and fear of pain (Randall et al. 2016 & 2017).

An example of the multifactorial etiology of dental anxiety in a long follow-up cohort is from New Zealand. The study suggested that the stable anxious group had both exogenous and endogenous origins of fear from adolescence to adulthood. The stable anxious group had the highest caries experience by the age of 5 years suggesting direct conditioning to possibly aversive dental treatments as an exogenous factor, but they also tended to stress easily and have strong negative emotions suggesting endogenous origins. (Thomson et al. 2009) Liddell and Locker have stated in their studies that it is impossible to say whether the dental experiences were very traumatic or whether the subjects were more sensitive to them (Liddell and Locker 2000). These studies highlight that the multifactorial etiology is very complex.

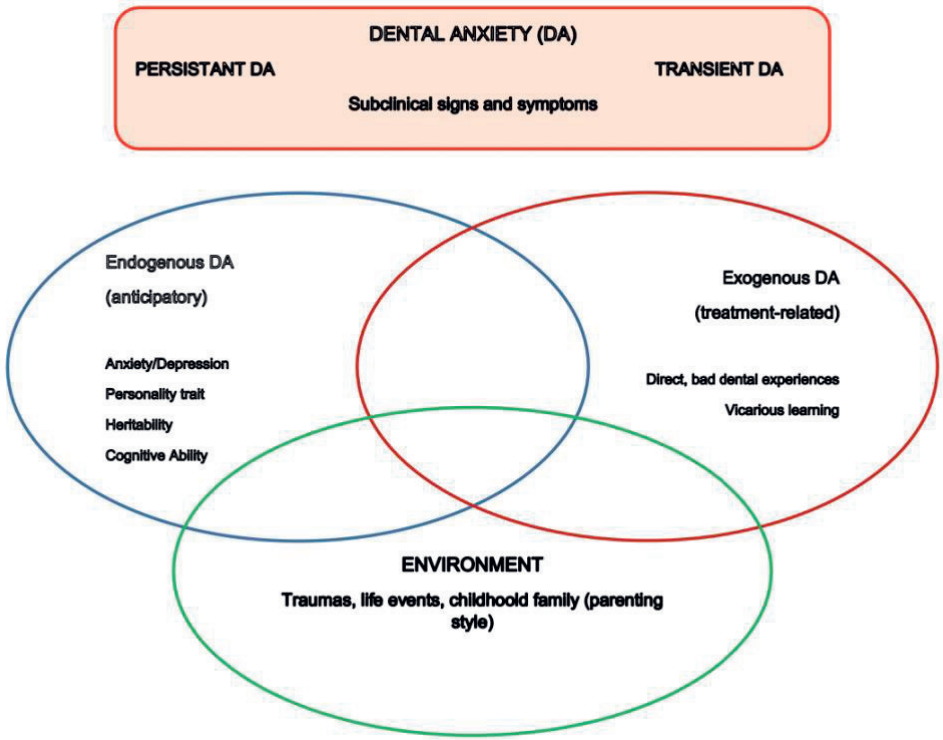


Figure 1. Nature of dental anxiety. Modified from Willumsen et al. 2013.

2.3 Dental anxiety in adulthood

2.3.1 Prevalence

The prevalence of dental anxiety in adulthood varies to some extent between studies. The study populations differ from national samples to smaller dental patient groups. The most comprehensive picture of dental anxiety in Finland recently is described in Liinavuori et al. (2016) in a population-based study gathered in 2011. Among Finns, 6 % were very much afraid of a dentist (women 8 %, men 4%) and 27% somewhat afraid (women 32 %, men 21%). Between 2000 and 2011 dental anxiety decreased among 35- to 75-year-olds, only the age group 30–34 showed a small increase in anxiety (Liinavuori et al. 2016). Dental anxiety during pregnancy has not been studied widely. Studies reporting on dental anxiety during pregnancy are sparse. In a Saudi-Arabian study using convenience sample among patients visiting hospitals, 16% of women reported high dental anxiety during pregnancy (Nazir and Alhareky 2020).

In a large national study in the United Kingdom 12% of the study population reported high levels of anxiety and 36% were slightly anxious (Hill et al. 2013). In a Swedish national sample of adults 13% of women and 5% of men reported moderate to severe dental anxiety. The highest prevalence of dental anxiety (15%) was among 31-35 –year-olds. (Svensson et al. 2016) In a French national population sample, 7% reported severe dental anxiety and 6% moderate, and the prevalence was slightly greater among younger adult age groups. (Nicolas et al. 2007) The numbers are similar also outside Europe, as in an Australian national sample, 9.5 % were very to extremely afraid of a dentist and 12% moderately afraid (Armfield et al. 2009). Comprehensive information on dental anxiety prevalence in other than national sample adult populations was presented in Svensson's thesis in 2020. The variation in the prevalence is due to measurement differences as dental anxiety was measured using either a single question or several different questionnaires.

Overall, there is consistent evidence that women report high dental anxiety more often than men (Armfield et al. 2006, Hill et al. 2013, Liinavuori et al. 2016, Svensson et al. 2016). This trend is evident across different age groups (Armfield et al. 2006, Lahti et al. 2007, Hill et al. 2013, Liinavuori et al. 2016).

2.3.2 Changes in dental anxiety

Several studies have addressed the longitudinal course of adult dental anxiety using follow-up where the measurement points are years apart (Table 1). Dental anxiety seems to increase among younger age groups (Thomson et al. 2000, Maggirias et Locker 2002, Liinavuori et al. 2016), but decreases in older age groups (Hägglin et al. 1999, Liinavuori et al. 2016, Locker and Liddel 1995).

Over a 3.5-year period between 2001-2005, dental anxiety seemed to fluctuate among women and remained stable among men aged on average 40 years in Finland. The high anxiety seemed to be stable throughout the study among those women and men who were very anxious at baseline. (Luoto et al. 2014).

In Norway, among upper secondary school students, dental anxiety decreased significantly over 2 years, but the proportion of youth categorized as highly anxious remained constant (Nermo et al. 2019). In Canada, among 50-year-olds, the dental anxiety slightly decreased in a 3-year-follow-up. Most were not anxious to start with and stayed that way (Locker and Liddel 1995).

Among young adult New Zealanders, during a period of 17 years (containing 4 assessment points at ages 15, 18, 26, 32 years), dental anxiety remained stable among 7%, as 70% were non-anxious throughout the study, and the remaining 23% had changes in their anxiety (Thomson et al. 2009). In Finland, in 10 years 5% of women and 2% of men stayed very fearful in a national sample (Liinavuori et al. 2016).

Dental anxiety can arise also in adulthood. In Finland Luoto et al. reported, that the incidence of high anxiety among women was 8% 2001-2003 and 5% between 2003-2005, and respectively 11% and 4% among men (Luoto et al. 2014). In a Canadian study, a five-year-incidence of dental anxiety in a random general adult population sample was 6%, varying 12% among those aged 18 to 24 years at baseline to 2% among those aged 65 years and over at baseline (Maggirias and Locker 2002).

2.3.3 Consequences of dental anxiety

Dental anxiety can lead to an avoidance of dental treatment and problem-oriented attendance (Hägglin et al. 2000, Schuller et al. 2003, Armfield 2013, Hill et al. 2013), which in turn leads to a greater need of treatment. This hypothesis is described as the vicious cycle of dental anxiety (Berggren and Meynert 1984, Hakeberg 1992). In Finnish national study, irregular dental service users were more likely to be very afraid visiting a dentist than regular users with the exception of 30 to 34-year-olds. Irregular dental attendance could be attributed to high dental anxiety in 41% of cases. (Pohjola et al. 2007)

In a longitudinal Finnish national population sample study, dental anxiety predicted nonhabitual dental attendance. The same study also showed that by decreasing dental anxiety, the habitual attendance increases. (Liinavuori et al. 2019) The regular recalls to dental treatment in childhood and subsidized care might be explanations to more regular attendance in younger age groups despite a high dental anxiety (Pohjola et al. 2007, Liinavuori et al. 2019).

Besides irregular attendance, dental anxiety has been shown to be associated with functional impairment and poor oral health (Berggren and Meynert 1984, Hägglin et al. 2000, Schuller et al. 2003). Dental anxiety has been shown to relate to impaired oral health-related quality of life (McGrath and Bedi 2004, Pohjola et al. 2009, Boman

et al. 2012, Carlsson et al. 2015, Svensson et al. 2018), especially with its pain dimensions as well as social and psychological discomfort and disability (Mehrsted et al. 2007, Pohjola et al. 2009). This seems to support the vicious cycle of dental anxiety -hypothesis, where dental anxiety leads to shame, which is then associated with social and psychological impairment.

2.3.4 Treatment of dental anxiety

Encountering dentally anxious patients should always begin with assessing the anxiety. Dental clinicians' ability to evaluate patients' dental anxiety without a screening tool has been shown to be poor (Höglund et al. 2019). An easy and feasible way is to let the patient fill in a self-assessed questionnaire, such as Modified Dental Anxiety Scale, as it has been shown that acknowledging patient's emotions by dental staff already relieves the anxiety (Hally et al. 2017).

The treatment of dental anxiety relies on psychological approaches which could be supplemented with pharmacological interventions such as sedation and general anesthesia in severe cases when acute treatment is needed. The behavioral treatment of dental anxiety consists of good communication and providing information, enhancing control with tell-show-do, rest breaks and signalling, as well as distraction, positive reinforcement, different relaxation breathing techniques and guided imagery (Armfield and Heaton 2013, Appukuttan 2016).

The cognitive behavior therapy has proven to alleviate high dental anxiety (Wide Boman et al. 2013, Kurki et al. 2019). The therapy has elements of cognitive restructuring and systematic desensitization, and the implementation of it needs skillful psychologists (Wide Boman et al. 2013, Kurki et al. 2019). Overall, the treatment of dental anxiety is mainly provided by specialized clinics for dentally fearful patients, and research on dental anxiety treatment in public health settings is sparse (Kankaala et al. 2019, Lahti et al. 2020).

Table 1. The longitudinal studies of adult dental anxiety in a chronological order.

Author and Year	Country	Follow-up time (years)	Participants	Evaluation points	Age	Measurement	Cut-off	Conclusion
Locker & Liddell 1995	Canada	3	272	1989, 1992	≥50	DAS	≥13	DA was mainly stable.
Hägglin et al. 1999	Sweden	28	375 women	1968-69 and 1996	66-82	SQDA	very afraid/terrified	DA declined with age.
Peretz & Mann 2000	Israel	4	30	3rd, 5th, 6th dental school yr	mean 23	DAS	none	DA decreased during dental studies.
Thomson et al. 2000	New Zealand	8	790	age 18, 26	18, 26	DAS	≥13	A marked increase in the prevalence and severity of DA.
Maggirias & Locker 2002	Canada	5	1422	1993-4, 1998-99	≥18	DAS or FS or SQDA	≥12 or ≥8 or very afraid/terrified	DA may arise during adulthood, incidence 6%.
Thomson et al. 2009	New Zealand	17	828	age 15, 18, 26, 32	15-32	DAS	≥13	Six different trajectories of DA identified.
Luoto et al. 2014	Finland	3.5	616	2001, 2003, 2005	mean 40	SQDA	quite/very afraid	The prevalence of high DA fluctuated among women.

Liinavuori et al. 2016	Finland	11	3961	2000, 2011	≥19	SQDA	very much	DA depends on age and DA decreased more often than increased.
Nermo et al. 2019	Norway	2	685	2010-11, 2012-13	15-21	DAS	≥13	DA decreased significantly, but high DA population remained constant.

DA = Dental anxiety
DAS = Dental anxiety scale
FS = Gatchel fear scale
SQDA = Single question of dental anxiety

2.4 Dental anxiety and general anxiety

Of the endogenous aspects related to dental anxiety, the association between dental fear and general anxiety among adults of varying age has been observed in many studies and is rather consistent (Aartman et al. 1997, Locker et al. 1997, De Jongh et al. 1998, Hakeberg et al. 2001, Hägglin et al. 2001, Boman et al. 2010, Pekkan et al. 2011, Pohjola et al. 2011, Bernsson et al. 2013, Halonen et al. 2014, Tellez et al. 2015). The association between dental and general anxiety has been established in general populations (Locker et al. 1997, Hägglin et al. 2001, Halonen et al. 2014, Pohjola et al. 2011, Lahti et al. 2020), in general dental patient populations (De Jongh et al. 1998, Pekkan et al. 2011, Tellez et al. 2015) and in populations with highly dentally anxious patients (Aartman et al. 1997, De Jongh et al. 1998, Hakeberg et al. 2001, Boman et al. 2010, Bernsson et al. 2013). Often women reported higher anxiety scores than men (Aartman et al. 1997, Hakeberg et al. 2001, Pekkan et al. 2011, Halonen et al. 2014), but the association between dental and general anxiety was not reported separately based on gender. In Sweden, there were no gender differences based on the level of dental anxiety, general anxiety or depression (Bernsson et al. 2013).

Besides general anxiety being associated rather consistently with overall dental anxiety it associates differently with the two factors of dental anxiety according to the Modified Dental Anxiety Scale. Among Finnish university students (mean age 25 years) general anxiety was associated with both anticipatory and treatment-related dental anxiety among women, but only with the anticipatory component of dental anxiety among men (Halonen et al. 2014). In a more recent study among pregnant women and their partners, the general anxiety symptoms were associated with anticipatory dental anxiety but not treatment-related. The connection was slightly stronger among men than women. (Lahti et al. 2020)

2.5 Dental anxiety and depression

The association between dental anxiety and depression has not been found to be as clear as with general anxiety. Pohjola et al concluded that in a Finnish national sample the prevalence of depressive disorders was higher among dentally anxious persons. They also found that among highly dentally anxious people the most common anxiety and/or depressive symptom was major depression (7.6 %) (Pohjola et al. 2011). Another Finnish group found an association between dental anxiety and depression among university students. Among women the association was found with both anticipatory and treatment-related dental anxiety, among men only with anticipatory. (Halonen et al. 2014) The association between dental anxiety and depression was also established among Dutch patients in a dental clinic treating fearful patients (Aartman et al. 1997). In Sweden, fearful patients showing irregular dental office attending

patterns also demonstrated an association between dental anxiety and depression (Bernson et al 2013).

However, several studies done on regular, dental patients and fearful dental patient populations have not found the associations between dental anxiety and depression (Hägglin et al. 2001, Pekkan et al. 2011, Wide Boman et al. 2010, Bernson et al. 2013).

2.6 Dental anxiety and environmental aspects

Environmental aspects which could affect dental anxiety could be daily living conditions including parental guiding, mental or physical trauma outside the dental setting or minor and major life events. The dental anxiety and trauma outside dental settings have been shown to be associated to some extent. Sexually abused women have reported higher rates of dental anxiety (Walker et al. 1996, Willumsen 2001, Willumsen et al. 2004). Child sexual abuse survivors' report anxiety reactions in dental setting, primarily triggered by similarities to child sexual abuse experiences (Fredriksen et al. 2020). Humphris and King also reported a significantly high prevalence of dental anxiety among those reporting past sexual assault (Humphris and King 2011) in a UK population. Among healthy Dutch dental patients, physical, mental or sexual trauma outside dental settings were not associated with high rates of dental anxiety (Oosterink et al. 2009). All the above examples could share the theoretic concept of traumatic coupling, where traumatized persons may experience certain sensations, which generate emotional and physical responses coupled to traumatic memories, irrelevant to what is actually going on (Levine 1997).

Tortured refugees were more prone to dental anxiety, especially if they were suffering from post-traumatic stress disorder (PSTD) (Høyvik et al. 2019). Among highly anxious dental patients in the Netherlands, PSTD was diagnosed more often compared to non-anxious controls. In this population dental anxiety was associated with traumas within and outside dental setting. (de Jongh et al. 2006)

Home-related factors, such as a childhood milieu and parenting factors, can modify the development of dental anxiety (Milgrom et al. 1995, ten Berge et al. 2002, Karjalainen et al. 2003, Rantavuori et al. 2004, Klingberg and Broberg 2007). Parenting style is a major part of the childhood environment but has not been shown to be associated with dental anxiety (ten Berge et al. 2003, Krikken and Veerkamp 2008, Krikken et al. 2012). This is contrary to those with general anxiety who recall their parents' rearing style as being overprotective (Gerlsma et al. 1990, Rapee 1997). They also recall less care and warmth from their parents than healthy controls (Gerlsma et al. 1990, Rapee 1997).

2.7 Justification for the present study

Though there is information and evidence of the association between dental anxiety, general anxiety and depression, still little is known whether changes in these psychiatric symptoms affect dental anxiety. The present study aims to study changes in dental anxiety in a shorter timeline as the previous longitudinal studies comprise of follow-up periods of years apart, and to study relationships to changes in general anxiety and depression. Also, this study aims to gather information on the possible environmental aspects associated with dental anxiety.

3 Aims

The general aim of this study is to increase knowledge of changes in adult dental anxiety in the period of life expecting and receiving a child, and evaluate psychological factors associated with it.

The specific aims are:

1. To evaluate the longitudinal course and changes in adult dental anxiety in the FinnBrain cohort (Papers I, III and IV).
2. To evaluate whether dental anxiety and changes in it are associated with depression and general anxiety and changes in them (Papers I, III and IV).
3. To determine whether dental anxiety is associated with trauma, life events and perceived parental bonding (Paper II).

4 Materials and Methods

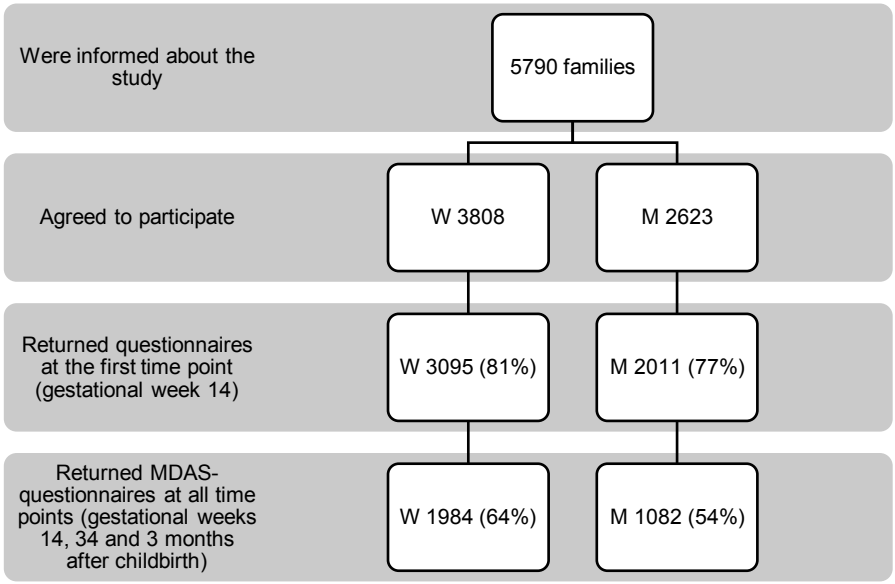
4.1 Study design and population

This thesis consists of two different study populations both of which are part of the FinnBrain Birth Cohort Study (www.finnbrain.fi). This cohort study is prospective and was established to study the effects of prenatal and early life stress exposure on child brain development and health outcomes (Karlsson et al. 2018). The research is multidisciplinary and the follow-up of the children will continue for decades. The actual cohort was preceded with a pilot cohort to test the protocols first with a smaller population. The data for this thesis consists of the parents of the children from the pilot (Studies I–III) and the actual FinnBrain Birth Cohorts (Study IV).

The pilot study recruitment started in 2010. Personal recruitments were done in ultrasonography appointments in public maternity clinics in Turku, Finland. These appointments are offered free of charge to all mothers. Of 254 families expecting a baby, 203 (80 %) agreed to participate (201 women and 147 men). The recruitment for the actual FinnBrain Cohort was done between 2011 and 2015. Three public maternity welfare clinics of a geographically defined area, which performed pregnancy ultrasound scans for the women referred to give birth at Turku University Hospital in the Southwest Finland Hospital District and the Åland Islands, were used. Out of 8895 newly pregnant women visiting the recruitment sites, 5790 were contacted and informed about the FinnBrain study. Of those informed about the study, a total of 3808 women and 2623 men decided to participate. Participants in the different phases of the study are described in Figure 2.

The data collection was performed using questionnaires sent via post or via the Internet. The data was collected during pregnancy and 3,12 and 24 months after the delivery. The pilot data was collected in gestational weeks 18-20 and 32-34 and in the main cohort in weeks 14 and 34. The participants reported their age at baseline. In the pilot cohort the mean age was 29.0 (SD ± 4.6) years for women and 30.6 (SD ± 5.1) years for men. The corresponding numbers in the main cohort were 30.4 (SD ± 4.6) years and 32.1 (SD ± 5.4) years.

MAIN COHORT



PILOT COHORT

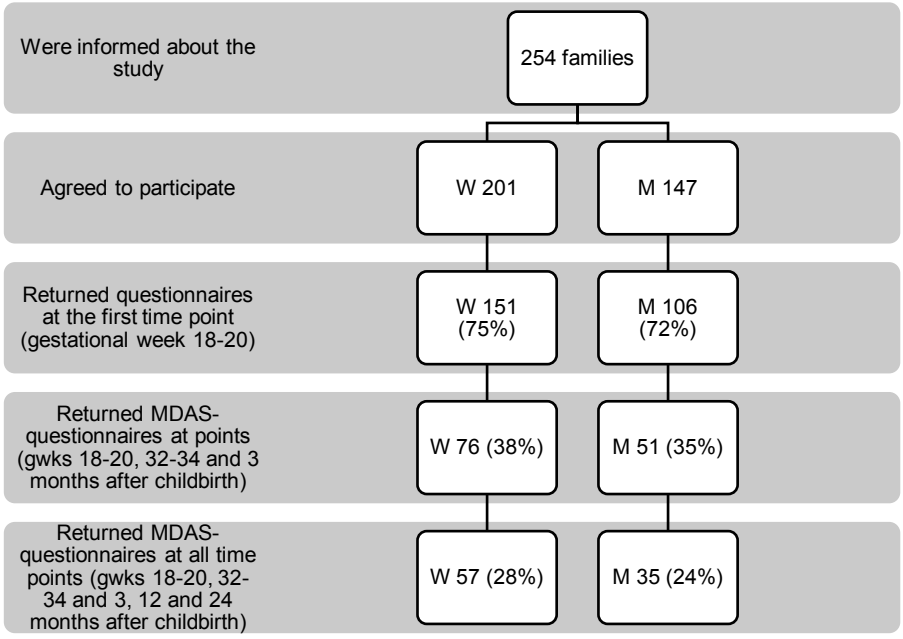


Figure 2. The participants in the different phases of the study (gwk = gestational week, W = women, M = men).

4.2 Questionnaires

4.2.1 Dental anxiety

The MDAS is a valid and reliable five-item instrument translated to Finnish for self-rating dental anxiety (Humphris et al. 1995 & 2000) showing high internal consistency (Cronbach's alpha = 0.93) and reliability over time (intraclass correlation coefficient = 0.93) (Newton and Edwards 2005). The questions in the MDAS are as follows: (item 1) if you went to your dentist for treatment tomorrow, how would you feel; (item 2) if you were sitting in the waiting room (waiting for treatment), how would you feel; (item 3) if you were about to have a tooth drilled, how would you feel; (item 4) if you were about to have your teeth scaled and polished, how would you feel; and (item 5) if you were about to have a local anaesthetic injection in your gum, above an upper back tooth, how would you feel? Each item has five response alternatives with scores ranging from 1 (not anxious) to 5 (extremely anxious); the range for total sum score being 5–25. The MDAS has also shown to contain two separate factors: anticipatory dental anxiety (items 1 and 2, range 2–10) and treatment-related dental anxiety (items 3, 4 and 5, range 3–15) (Yuan et al. 2008, Lahti et al. 2020).

4.2.2 Depression

Depressive symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPDS) (Cox et al. 1987). The EPDS is a widely used and studied questionnaire, valid to screen both pre- and postnatal depression, also among men (Cox et al. 1987 & 1996, Eberhard-Gran et al. 2001, Matijasevich et al. 2014, Loscalzo et al. 2015). The scale consists of 10 questions scored on a 4-point Likert-scale (from 0 to 3). The higher the score the more depressive symptoms the respondent has.

4.2.3 General and pregnancy-related anxiety

The general anxiety was measured with different questionnaires in the pilot and the main cohort. The assessment was done with the state anxiety scale of the State Trait Anxiety Inventory (STAI) (Spielberger et al. 1983) in the pilot study and with the anxiety subscale of the Symptom Checklist -90 (SCL) (Degoratis et al. 1973) in the main study. The participants in the pilot reported also the pregnancy-related anxiety with the Pregnancy Related Anxiety Questionnaire (PRAQ) (Huizink et al. 2004).

The 20-item state anxiety scale of the STAI was used (Spielberg et al. 1983, Spielberg 1989) which ask the respondent to describe how she/he feels at a particular moment. The scale consists of a 4-point Likert scale (from 1 to 4, 1 being not at all and 4 very much) and the total sum is calculated (20-80). The higher the score the

more anxiety symptoms the respondent has. The STAI is reliable with an average Cronbach's alpha of 0.91 (Barnes et al. 2002).

The SCL-90 anxiety subscale has good validity and reliability. The subscale consists of 10 items scored on a 5-point Likert scale (from 0 to 4) and the range of the total sum score is 0−40. Higher values indicate more anxiety symptoms. (Degoratis et al. 1973, Holi et al. 1998, Prinz et al. 2013)

The PRAQ consists of 10 items with response scores ranging from 1 (absolutely disagree) to 5 (absolutely agree) (Huizink et al. 2004). The scale can be used as a total sum score (10-50) or as three factors based on the items: fear of giving birth (three items; score range 3-15), fear of bearing a physically or mentally handicapped child (four items; score range 4-20) and concern about one's appearance (three items; score range 3-15).

4.2.4 Trauma, life events and parental bonding

Trauma experience was evaluated with the Trauma and Distress Scale (TADS) (Patterson et al. 2002). It is a 43-item list of trauma and distress experiences (0 = never, 1 = rarely, 2 = sometimes, 3 = often, 4 = nearly always) in childhood before finishing school. The TADS includes five domains: emotional abuse, emotional neglect, physical abuse, physical neglect and sexual abuse. (Patterson et al. 2002, Luutonen et al. 2013)

Life events were assessed using a modified version of the Life Event Checklist (LEC) (Johnson et al. 1980), which is a 37-item questionnaire relating to events experienced during the 10 years preceding the survey. The respondent rates whether or not each event occurred, and whether its impact was positive or negative. The scale has been shown to have good validity and reliability (Johnson & Sarason 1979). Impact ratings are obtained on a 5-point Likert scale (1 = very negative, 2 = negative, 3 = both negative and positive, 4 = positive, 5 = very positive).

Parental bonding was assessed using the Parental Bonding Instrument (PBI) (Parker et al. 1979). It measures perceived parental bonding from the child's perspective, as perceived during the first 16 years of life. The PBI measures parental behavior and attitudes using two variables: parental care (12 items) and control/overprotection (13 items). The scale is completed separately for the mother and the father, and so maternal and paternal bonding may be examined separately or collectively. Based on the care and control items, the parental bonding style is classified into one of four quadrants: affectionate constraint (high care, high overprotection), affectionless control (low care, high overprotection), optimal parenting (high care, low overprotection) or neglectful parenting (low care, low overprotection). (Parker et al.1979)

Table 2. The data collection points of different questionnaires during the pregnancy time and 3, 12 and 24 months after the child delivery.

Questionnaire	PP 1	PP 2	3 mos	12 mos	24 mos
MDAS *					
pilot	x	x	x	x	x
main	x	x	x		
EPDS *					
pilot	x	x	x		
main	x	x	x		
STAI (state anxiety scale)	x	x	x		
SCL-90 (anx. subscale) *	x	x	x		
PRAQ		x			
TADS		x			
LEC		x			
PBI		x			

PP 1 = pregnancy point 1, gestational weeks 18-20 in the pilot cohort, week 14 in the main cohort
PP 2 = pregnancy point 2, gestational weeks 32-34 in the pilot cohort, week 34 in the main cohort
* measured in the main cohort

4.3 Methods

4.3.1 Categorization of variables

Total sum scores were calculated for MDAS (range 5–20), EPDS (range 0–30), STAI (range 20–80), SCL-90 (range 0–40), PRAQ (10–50), TADS (range 0–100) and LEC (range 0–37). If there were ≤ 30% missing items for MDAS, EPDS or SCL -90, they were replaced with mean values in the main cohort. In the pilot cohort the missing values were substituted with mean values of other items, if there was only one missing value for MDAS and no more than three missing values for EPDS at each time point.

Several categorized variables were calculated. The MDAS was handled in many ways to insure a multifaceted approach to dental anxiety (Table 3). Firstly, the participants were divided into high, low and no anxiety –groups based on the cut-off points of total sum score: 19 + highly anxious, 10-18 moderately anxious and 5-9 non-anxious (Humphris 1995, King and Humphris 2010, Humphris et al. 2013). Also the division into factors was made as described earlier.

To analyze changes in dental anxiety, the study populations were divided into different groups based on MDAS scores and changes in them. The data distribution affected these divisions. The pilot cohort was divided into four different change-of-

dental-anxiety-status groups: always anxious, never anxious, one change in anxiety status and two to four changes in anxiety status. For this, the cut-off point was chosen to be 10 or more in MDAS to be anxious based on the distribution of the data. The changes were measured longitudinally between different data collection points (Study III).

Also, to facilitate the evaluation of longitudinal changes in anxiety in the pilot cohort, the proportion of the study population who had at least a five-point difference in MDAS total scores at two consecutive data points were considered to have a major change. To the best of our knowledge clinically relevant changes in MDAS score has not been described in the literature and this change was chosen as it corresponds to an average difference of one point in each question (Study III).

In the main cohort (Study IV), also anxiety-change groups were formed. According to the distribution of the data, the study population was divided into three different groups based on changes in their MDAS-scores at two time-intervals: between gestational weeks 14-34 and between gestational week 34 and three months after childbirth. These groups were: "fear increased at least two points", "fear changed ± 1 point" and "fear decreased at least two points".

The different TADS domains were calculated by totalling the corresponding items. Besides total sums, the proportions of negative and positive life events out of all events were calculated for both genders.

Table 3. Categorization of MDAS.

MDAS			
Level of fear (cut-off points)	Publication	Change of fear (points)	Publication
Low fear 10-18	I, IV	±5	III
High fear 19+	I, IV	±2	IV
Fear 10+	III	±1	IV

4.3.2 Statistical analyses

All statistical analyses were conducted using IBM SPSS Statistics v. 22.0-25.0 (SPSS Inc, Chicago, IL, USA). Sum scores for dental anxiety, depression, general anxiety, pregnancy-related anxiety, trauma and life events were calculated. Factor sums, as described in previous sections, for dental anxiety and pregnancy-related anxiety were also calculated. TADS and PBI domains were formed. Life events were also divided into positive and negative by participants' impact ratings. Proportions of negative and positive events of all events were calculated.

Statistical significance of the changes in dental anxiety, depression and general anxiety scores were analyzed using repeated-measures ANOVA. For the main cohort, a longitudinal linear mixed model for MDAS was also estimated. The MDAS was the dependent variable, and fixed effects were gender (female/male), time (gestational weeks 14 and 34, 3 months after birth), and SCL and EPDS as continuous variables. Also, interaction terms between gender and each of the three other variables (time, EPDS, and SCL) were added. For the final model, only those interaction terms that were statistically significant and did not compromise the model fit were included.

Statistical significance of differences in means of dental anxiety, depression and general anxiety at consecutive data collection points in main cohort were analyzed using the Friedman test. Stage transitions for trichotomized dental anxiety groups were determined by cross tabulations.

Cross-sectional correlations between dental anxiety, depression, general anxiety, trauma and life events were analyzed with Spearman correlation co-efficients as the data was not normally distributed. The correlations between change-variables were analyzed with Pearson correlation coefficients due to the normal distribution of these variables. As in the pilot cohort data, we had only one PRAQ measurement and no change, the association with PRAQ and changes in dental anxiety were studied with repeated-measures ANOVA using PRAQ as a covariate. Within-subject variables were three anxiety measures, separate model for total sum and both factors. The association between dental anxiety and parenting style quadrants was evaluated using the Kruskal-Wallis test.

Gender differences in dental anxiety, trauma, life events and parental bonding in the pilot data at gestational weeks 30-32 were analyzed using the Mann-Whitney U-test.

Attrition analyses were conducted using the Mann-Whitney U-test.

4.3.3 Ethical aspects

The Ethics Committee of the Hospital District of Southwest Finland approved the study protocol. Each participant had read and understood the study protocols and gave their written consent. The parents gave the consent on behalf of their child. All participants had the choice to withdraw from the study at any point without giving an explanation. All the answers were handled anonymously.

5 Results

5.1 The longitudinal course and changes in adult dental anxiety in the Finnbrain Birth Cohort Study

In the beginning of the study period the prevalence of high dental anxiety was 8.4% in the pilot and 8.5% in the main cohort among women and 2.5% in the pilot and 4.5% in the main cohort among men. In both data sets women were more dentally anxious than men. Participants in the main cohort were slightly more anxious than in the pilot. (Table 4)

Table 4. The prevalence and incidence of high dental anxiety (MDAS ≥ 19) during the pregnancy and after the childbirth in both FinnBrain cohorts among those who had answered MDAS-questionnaires at all data collection points

	Prevalence			Incidence	
	PP1	PP2	3 mos	PP1-PP2	PP2-3 mos
Women					
Cohort (n=1984)	7%	7%	9%	2%	3%
Pilot (n=76)	5%	3%	5%	0%	3%
Men					
Cohort (n=1082)	4%	3%	4%	0%	2%
Pilot (n=51)	2%	2%	4%	1%	2%

PP1 = pregnancy point 1, in pilot data gestational weeks 18-20 and in cohort gestational week 14.
PP2 = pregnancy point 2, in pilot data gestational weeks 32-34 and in cohort gestational week 34.
3 months = three months after the childbirth.

Among women dental anxiety tended to decrease during pregnancy and increased again after the delivery in both study populations. In the pilot study the anxiety increased in a 2-year follow up after the childbirth. The changes were attributed more by the treatment-related dental anxiety in both data sets. (Table 5)

Among men dental anxiety slightly increased during the early pregnancy and decreased after 12 months after the childbirth in the pilot data. In the actual cohort,

dental anxiety stayed fairly stable during the pregnancy and slightly increased three months after childbirth. During the pregnancy in the pilot data the change was mainly contributed by the anticipatory fear factor and after the childbirth by both factors. In the main cohort the change was mainly contributed by the treatment-related factor. (Table 5)

According to the trichotomized dental anxiety groups, anxiety was mostly stable. In the pilot study, women's dental anxiety decreased more often than increased during pregnancy, men's fear followed an opposite course. After childbirth, the changes in both directions were similar among both genders. (Table 6) In the main cohort, dental anxiety increased as often as decreased during pregnancy among women and men, but after the childbirth the anxiety more often increased. (Table 6 and Figures 3 & 4)

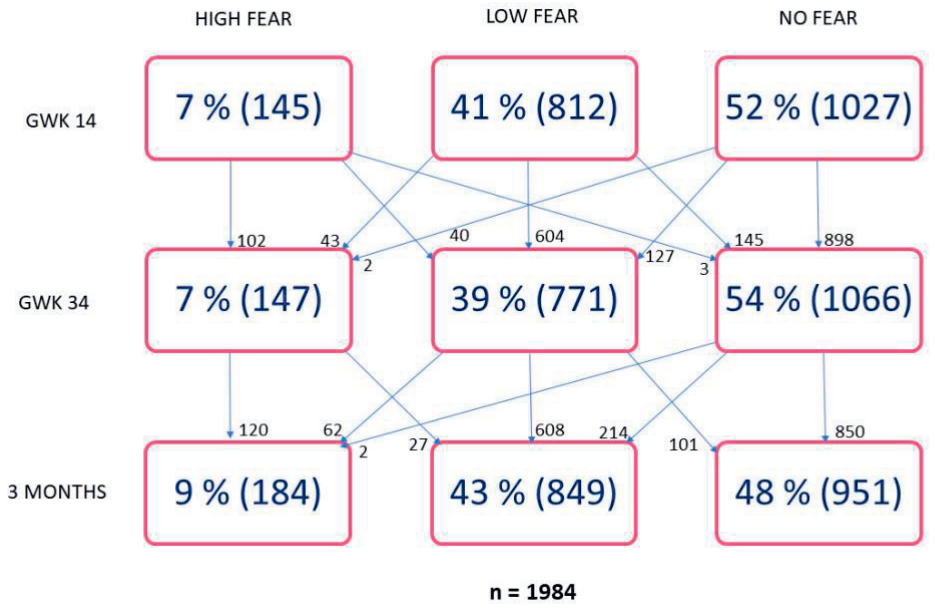


Figure 3. Stage transitions between trichotomized dental anxiety score subgroups at the three data collection points – gestational weeks 14 & 34 and 3 months after childbirth among women in the main cohort.

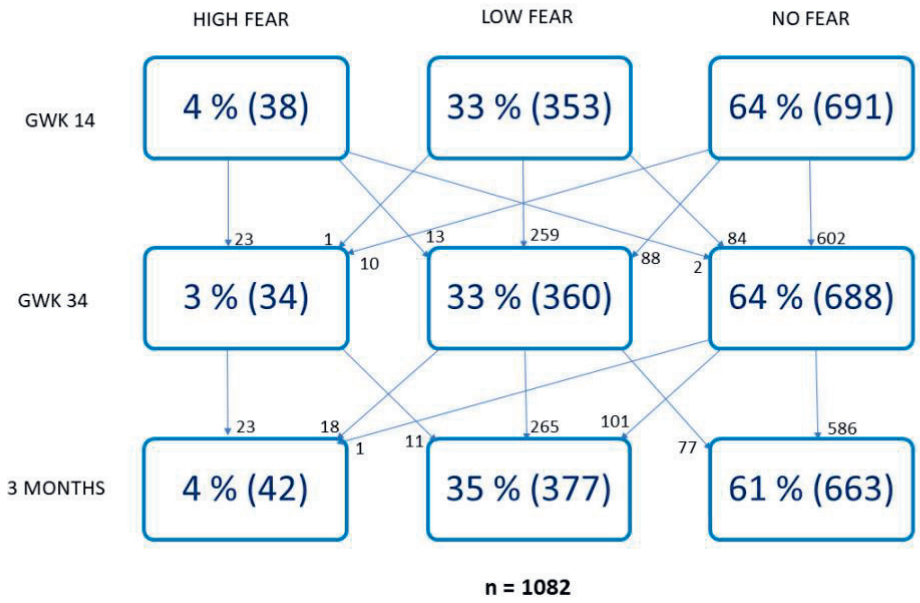


Figure 4. Stage transitions between trichotomized dental anxiety score subgroups at the data collection points – gestational weeks 14 & 34 and 3 months after childbirth among men in the main cohort.

Besides the evaluation of means and trichotomized stage transitions, the number of changes in dental anxiety status during the 1.5 years of follow-up in the pilot cohort (the cut-off point for anxiety was ≥10 in MDAS sum score) was determined. Of the participants 62% did not experience changes in dental anxiety (22 % always anxious, 40 % never anxious), and 15 % changed their status once and 23 % 2-4 times.

In the pilot cohort, 22/201 = 10 % (14 women and 8 men) had a ≥5 points change in MDAS between two time points (gestational weeks 18-20 – 32-34, gestational weeks 32-34 – 3 months after childbirth) during the follow up. Five persons had two of these changes. These considerable changes were mostly in reduction of dental anxiety. Among women they were mainly attributable to the anticipatory factor and among men to the treatment-related factor.

Table 5. Mean total, anticipatory and treatment-related dental anxiety scored according to the Modified Dental Anxiety Scale (MDAS) at three data-collection points in both data sets (FinnBrain pilot cohort data and main cohort data). Participants who had filled in the MDAS at all points were included (n = 76 women in the pilot and 1984 in the cohort, n = 51 men in the pilot and 1082 in the cohort).

	Study phases							
	PP1		PP2		3 MONTHS		P-VALUE	
PARENT	PILOT	MAIN	PILOT	MAIN	PILOT	MAIN	PILOT	MAIN
WOMEN								
MDAS total	11.1	10.5	10.2	10.3	10.6	10.9	0.005	<0.001
Anticipatory	3.5	3.6	3.3	3.5	3.5	3.7	0.136	<0.001
Treatment-related	7.6	7.0	6.9	6.9	7.1	7.2	0.002	<0.001
MEN								
MDAS total	8.8	9.0	9.0	9.0	9.2	9.3	0.330	<0.001
Anticipatory	3.0	3.1	3.2	3.1	3.3	3.2	0.067	0.002
Treatment-related	5.8	5.8	5.8	5.9	5.9	6.1	0.780	<0.001

Values are presented as means.

PP1: pregnancy point 1, in pilot data gwks 18-20 and in main cohort data gwk 14
PP2: pregnancy point 2, in pilot data gwks 32-34 and in the main cohort data gwk 34
3 months: three months after the childbirth
P, significance of the change (determined using repeated-measures ANOVA)

Table 6. The changes in dental anxiety (in percentages of total n) according to trichotomized dental anxiety -classes at two time-intervals during the study period: during pregnancy and after the childbirth. Total n of women 76 in the pilot and 1984 in the main cohort, n of men 51 in the pilot, 1082 in the cohort.

	PILOT		MAIN	
	PP1 – PP 2	PP2 – 3 mos	PP1 – PP2	PP2 – 3 mos
Women				
DA increased	7	12	9	14
DA decreased	16	11	9	7
DA stable	78	78	81	80
Men				
DA increased	14	6	9	11
DA decreased	2	6	9	8
DA stable	84	88	82	81

DA = dental anxiety
PP1 (pregnancy point 1): gestational weeks 18-20 in the pilot, 14 in the cohort
PP2 (pregnancy point 2): gestational weeks 32-34 in the pilot, 34 in the cohort
3 mos: three months after the childbirth

5.2 The associations between dental anxiety, depression and general anxiety

In the main cohort according to the multivariable longitudinal linear model, when gender, time, anxiety and depression were taken into account simultaneously, they all were statistically significant predictors of dental anxiety (Table 7).

Table 7. Results of the longitudinal linear mixed modelling of the MDAS score as a function of gender, time of measurement, and SCL and EPDS scores in the main cohort.

Variable and reference group		Beta	Std. error	95% CI
Gender (ref. male)	Female	*** 1.40	0.17	1.07 – 1.73
Time (ref. 3 months after birth)	Gwk 14	-0.36	0.18	-0.72 – 0.00
	Gwk 34	-0.21	0.19	-0.57 – 0.16
Time * gender interaction	Gwk 14 * gender	-0.21	0.23	-0.66 – 0.25
(ref. 3 months after birth, male)	Gwk 34 * gender	* -0.49	0.23	-0.95 − -0.04
SCL		*** 0.10	0.02	0.07 – 0.14
EPDS		*** 0.17	0.02	0.14 – 0.20

* , p <0.05; ***, p<0.001

In the pilot cohort, there were no significant correlations between dental anxiety, depression and anxiety among women. Among men, dental anxiety correlated positively with both depression and general anxiety, especially the treatment-related factor of anxiety. In the main cohort, dental anxiety correlated positively at all points with depression and general anxiety among women and men. The correlations were weaker than in the pilot, and stronger among men. (Table 8)

In the pilot cohort, there were very modest correlations between changes in dental anxiety and changes in depression or general anxiety. Within the pregnancy-related anxiety, fear of giving birth was associated with changes in total, anticipatory and treatment-related dental anxiety.

In the main cohort, among women the changes in dental anxiety correlated with changes in depression and general anxiety during pregnancy and with changes only in general anxiety after childbirth. Among men the changes in dental anxiety correlated with changes in depression and general anxiety through the entire study period. These correlations were stronger than among women. Overall, the magnitude of the correlations was moderate.

Table 8. Correlations between dental anxiety, depression, general anxiety and pregnancy-related anxiety in the Finnbrain Birth Cohort Study (women main cohort n= 1984, pilot n=76; men main cohort n=1082, pilot n=51).

	Dental anxiety measures					
Data collection point	MDAS total		Anticipatory anxiety		Treatment-related anxiety	
	Main	Pilot	Main	Pilot	Main	Pilot
WOMEN						
PP1						
Depression	0.231	0.079	0.195	0.028	0.234	0.104
General anxiety	0.184	0.045	0.143	0.043	0.194	0.041
PP2						
Depression	0.195	-0.026	0.152	0.027	0.198	-0.018
General anxiety	0.158	0.057	0.121	0.057	0.163	0.037
Pregnancy-related anxiety	0.312	0.109	0.261	0.104	0.308	0.082
3 mos						
Depression	0.154	-0.058	0.112	-0.202	0.164	0.046
General anxiety	0.130	-0.085	0.091	-0.112	0.143	-0.053
MEN						
PP1						
Depression	0.229	0.369**	0.186	0.227	0.221	0.367**
General anxiety	0.179	0.238	0.159	0.122	0.169	0.210
PP2						
Depression	0.223	0.389**	0.181	0.283*	0.213	0.392**
General anxiety	0.196	0.377**	0.153	0.311*	0.193	0.341*
3 mos						
Depression	0.209	0.372**	0.140	0.250	0.221	0.429**
General anxiety	0.260	0.252	0.189	0.211	0.268	0.265

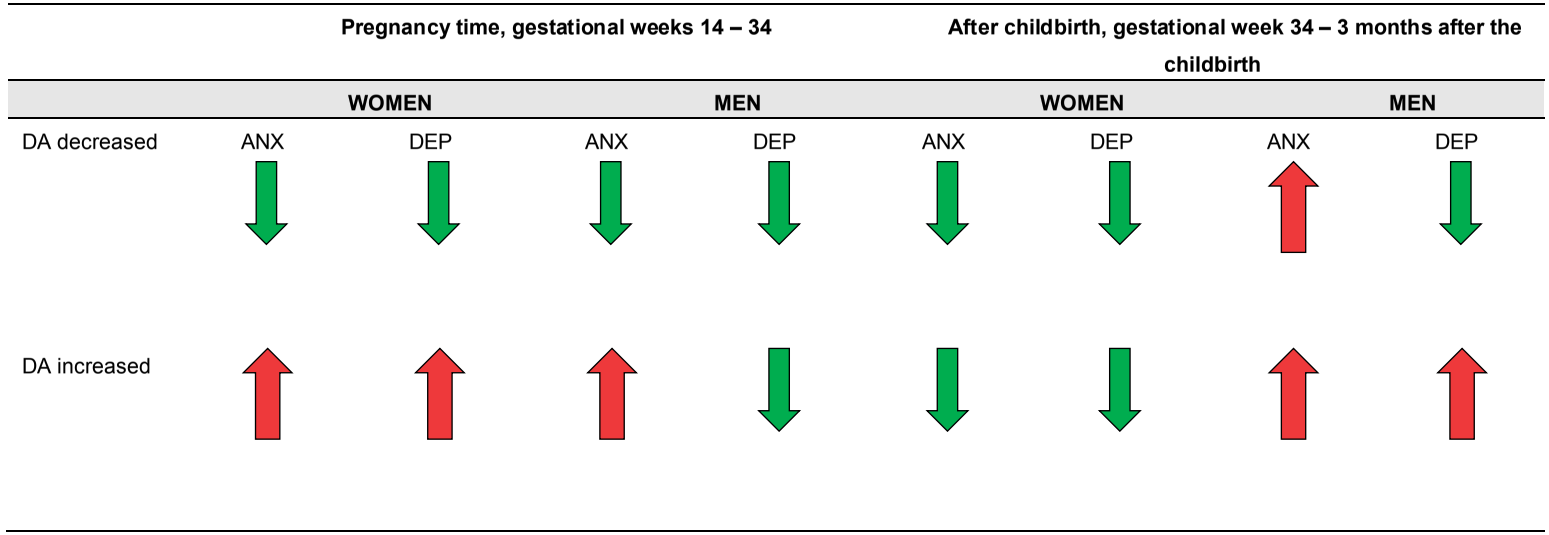
* P < 0.05, ** P < 0.01

In the main cohort all correlations were statistically significant at the level P < 0.01.
PP1 (pregnancy point 1): gestational weeks 18-20 in the pilot, 14 in the cohort
PP2 (pregnancy point 2): gestational weeks 32-34 in the pilot, 34 in the cohort
3 mos: three months after the childbirth

In the main cohort, the changes in depression and general anxiety (mean changes of EPDS and SCL) were also determined according to change in dental anxiety which was determined by a two-point change in MDAS between the data collection points (Figure 5). During pregnancy when dental anxiety decreased, depression and general

anxiety also decreased among women and men. When dental anxiety increased, depression increased among women and decreased among men. When dental anxiety increased, general anxiety increased slightly among women and men.

After childbirth, when dental anxiety increased, there existed a decrease in depression and general anxiety among women. Among men both increased. When dental anxiety decreased during this period, depression also decreased among women and men. General anxiety decreased among women but increased among men.



DA = dental anxiety, ANX = general anxiety, DEP = depression

Figure 5. The direction of changes of general anxiety and depression according to changes in dental anxiety during pregnancy and after childbirth in the main FinnBrain Birth Cohort.

5.3 The associations between dental anxiety and trauma, life events and perceived parental bonding

Among women in the pilot cohort there were no statistically significant correlations between dental anxiety and different forms of trauma. Among men, there were moderate positive correlations with dental anxiety and emotional neglect and abuse. These correlations were mainly attributed to the anticipatory dental anxiety factor.

Among women the total sum of life events, especially the sum of positive life events, correlated moderately with dental anxiety. The more of these events a person had, the higher the anxiety was. Among men there were very weak correlations.

Mostly women and men recalled the parenting style of their own parents optimal. Nevertheless, 35% of women thought that their mothers and fathers were neglectful, 11% of men thought the same about their mothers and 30% about their fathers. There were very weak correlations between dental anxiety and parenting style either among women or men. The respondent's mean MDAS-scores according to parenting style of their mothers and fathers are represented in figures 6 and 7.

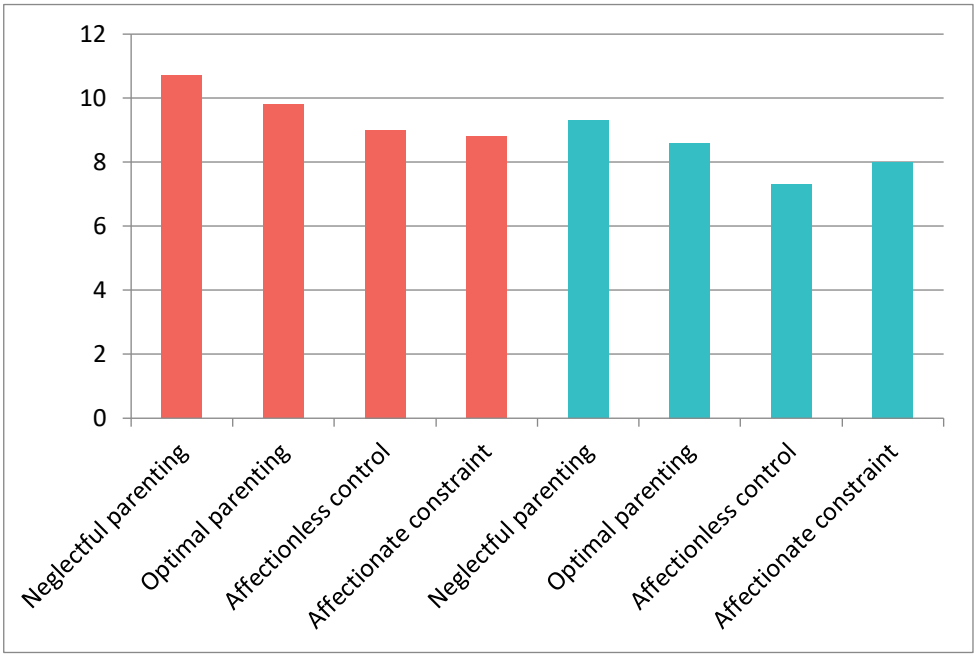


Figure 6. MDAS scores according to respondent's mothers' parenting style (red columns indicate that the respondent was a woman, blue columns that the respondent was a man).

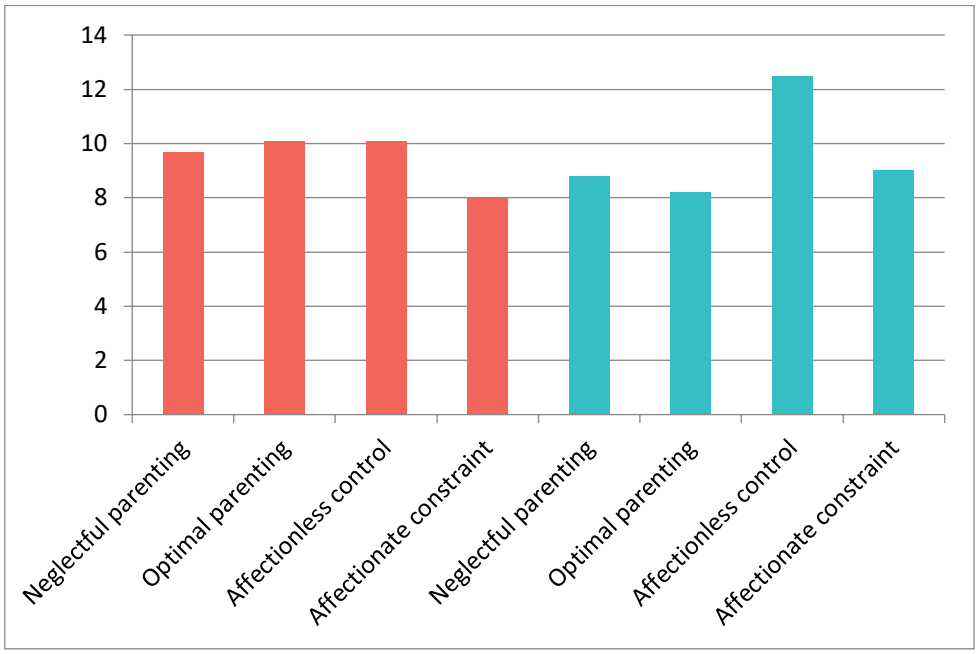


Figure 7. MDAS scores according to respondent's fathers' parenting style (red columns indicate that the respondent was a woman, blue columns that the respondent was a man)

6 Discussion

6.1 Main results

Dental anxiety remained stable and low to moderate for most participants in both cohorts. The longitudinal course of dental anxiety was similar in the pilot and the main cohort during the pregnancy. Women's dental anxiety slightly decreased towards the delivery of a child, men's anxiety increased. After childbirth, men's dental anxiety remained fairly stable or slightly decreased, women's increased to the baseline level. Some individuals experienced major fluctuations in their dental anxiety during the study period. The level of the dental anxiety was higher in the main cohort, and women were more anxious in both.

In the main cohort, gender, time, general anxiety and depression were significant predictors of dental anxiety. The dental anxiety correlated positively with general anxiety and depression among women and men in the main cohort, but only among men in the pilot cohort. The correlations were stronger in the pilot cohort. In the pilot cohort among those who reported high or fluctuating dental anxiety, reported more depressive symptoms during pregnancy. In the main cohort dental anxiety, general anxiety and depression did not change systematically in the same direction.

In the pilot cohort dental anxiety correlated with emotional abuse and neglect among men, and the correlation was observed with the anticipatory dental anxiety. In the same cohort, the number of life events, especially positive, correlated with dental anxiety among women. Dental anxiety was not associated with parental bonding in the pilot cohort.

6.2 Methodological considerations

The study population was relatively small in the pilot cohort, but remarkably larger in the main cohort. Manuscript IV was conducted to repeat the analyses of the first publication in a bigger population and to observe the similarities and differences in the results. The sample is a representative population group with limited age and pregnancy as a special condition. Also including both parents in the same family could cause some dependency between the respondents. Thus, the findings should be treated cautiously when generalizing to other populations.

The study has some limitations. The attrition analysis was conducted and included dental anxiety, depression and anxiety measures and age. The analysis of the main cohort revealed that women who dropped out were slightly younger and reported higher depression and anxiety levels than those who were included in the study. The men who dropped out reported slightly higher depression scores than those who were included. In the pilot cohort, the dropped-out participants did not differ of those who remained when dental anxiety, depression, general anxiety measures and age were considered.

Replacing the missing values with mean values may reduce variance, but in our data there were so few missing values that it would not have affected the findings. To maintain the participants' motivation is a challenge in a long follow-up study. The participants face a large number of questionnaires to fill in, in the beginning of the study the timeline was a few months apart, later less frequently. Nevertheless, this might result in fatigue and careless answers, which could affect the results. To overcome this issue, regular presentations of the results and information of the beneficial findings concerning the attending families, is one of the best preventive actions. Especially fathers should be in the spotlight as they have dropped out more often than the mothers.

The MDAS was chosen as the dental anxiety measurement, because it has shown to be valid and reliable and it provides us with more information than a single question with the two different factors. On the other hand, the MDAS is short enough to be filled in as a part of a larger questionnaire entity. In the analyses, using cut-off points can cause misclassification bias. Yet the cut-offs have a lot of research in their background and have proven to be a useful way to analyse one aspect of dental anxiety. To overcome these issues, we have used continuous variables besides the categorized ones. The other questionnaires, which were chosen, have also been proven to be valid and reliable in several studies. Unfortunately, we did not have information about the participants' oral health.

Statistical methods were chosen based on the specific research aim and the statistical distribution of the variables. Though correlation does not prove cause and effect, it can become distorted in a small sample or the correlation can be explained by a third factor. Longitudinal linear modelling was chosen to study the associations between dental anxiety, gender, general anxiety and depression in more detail.

The strengths of this study lie in the longitudinal nature of the data, with a rather large sample in the main cohort consisting of population from all socio-economic classes including women and men from the same family. The length of the study is shorter than most of the previous studies reporting longitudinal changes of dental anxiety. This could be considered as a strength as we need information of the changes and fluctuations of dental anxiety at different time intervals.

The questionnaires were self-reported and filled in at home in a non-dental setting, which can result in more accurate answers concerning dental anxiety. This study

provides a base for further research of the children of these parents and can provide us with more detailed etiological pathways of developing dental anxiety and certain risk factors could be identified.

6.3 Results in relation to earlier studies

6.3.1 The longitudinal course and changes in adult dental anxiety in the Finnbrain Birth Cohort Study

The prevalence of high dental anxiety in both cohorts at baseline is very similar to a Finnish national sample of rather similar age (Liinavuori et al. 2016). In the FinnBrain main cohort, low dental anxiety was more prevalent than in a national sample in 2011 (W 41-43% vs. 32%, M 33-35% vs. 21%) (Liinavuori et al. 2016). In the UK National Health Survey in 2009, 12% of participants were very fearful, 32% slightly fearful (Hill et al. 2009). Also, in Norway among 18-year-olds 8% reported high dental anxiety (Strøm et al. 2020). Women have re-ported more dental anxiety as in many studies earlier (Lahti et al. 2007, Hill et al. 2009, Thomson et al. 2009, Luoto et al. 2014, Liinavuori et al. 2016, Strøm et al. 2020). Our results are in line with that.

The overall trend in longitudinal studies evaluating long-term changes in dental anxiety is that the anxiety has remained stable for the majority of people. If there have been changes, the anxiety has more often decreased than increased among different age-groups. (Hägglin et al. 1999, Åstrøm et al. 2011, Liinavuori et al. 2016, Strøm et al. 2020) Nevertheless in a large national sample comprising different ages, younger age groups have reported increased dental anxiety (Thomson et al. 2000, Liinavuori et al. 2016).

Luoto et al. found in a Finnish longitudinal setting that among 26-57-year-old women and men, the prevalence of high dental fear did not seem to increase but rather fluctuated. Among the girls, the prevalence of high dental fear increased between the ages of 11-16. (Luoto et al. 2014) This study had three assessment points and the time-interval between them was approximately two years. Their findings of fluctuating dental anxiety are closer to our findings according to short-term changes. Also, Maggirias and Liddell reported a higher incidence of dental anxiety among young adults compared to over 65-year-olds in a five-year follow-up in Canada (Maggirias and Liddell 2002).

The prevalence and incidence of high dental anxiety were lower in this study compared to Luoto et al. (Luoto et al. 2014). The differences in prevalence among women were 11-13 percentage points and among men 3-14 percentage points. The incidence in our study was also much lower.

Differences in the prevalence and changes in dental anxiety in this study compared to previous findings could be due to different anxiety scales, lengths of the assessment

intervals and age groups. However, the FinnBrain study population is also special as all the adults involved are becoming parents. Having a child is a major life event, which can involve different emotions. Pregnant women go through also several physiological changes in their bodies, such as hormonal changes. This could result in different findings also in dental anxiety between the genders.

Orofacial pain has been shown to diminish during pregnancy and increase 1 year postpartum among women. It was concluded that the change was probably associated with increased levels of estrogen and progesterone. (Le Resche et al. 2005) It could be possible that hormones modify the course of dental anxiety also during pregnancy, as also in our cohorts, women's dental anxiety returns postpartum to the same level as it was in an early gestation.

It has also been suggested that pregnancy reduces the perception of anxiety by a progressive vanishing of the processing of anxiety chemosignals without any cognitive control towards the end of the pregnancy (Lübke et al. 2017). In a relatively recent, cross-sectional Saudi-Arabian study with pregnant women, the prevalence of high dental anxiety was greater in the first trimester (Nazir and Alhareky 2020). These findings are similar to ours, and suggest, that changes in dental anxiety among pregnant women could be affected by hormones or chemosignaling. This needs future research.

6.3.2 The associations between dental anxiety, depression and general anxiety

According to the results of this study, dental anxiety was positively associated with general anxiety with the exception of women in the pilot cohort. This is in line with other studies conducted on general populations (Locker et al. 1997, Hägglin et al. 2001, Pohjola et. al 2011, Halonen et al. 2014). The changes in dental anxiety correlated with changes in general anxiety in the main cohort among both genders throughout the study period. To our best knowledge, studies comparing the changes between dental anxiety, general anxiety and depression have not been reported. Dental anxiety was moderately associated with the pregnancy-related anxiety with its fear of giving birth –factor. The well-established association between dental and general anxiety support the endogenous etiology of dental anxiety.

According to the results of this study, dental anxiety was positively associated with depression among both genders in the main cohort and among men in the pilot cohort. Previous findings on this matter have been controversial, but in two Finnish populations the results are in line with our research (Pohjola et al. 2011, Halonen et al. 2014). In this study, the changes in dental anxiety correlated with changes in depression during pregnancy among women and throughout the study among men.

The dental anxiety measured with MDAS has been shown to consist of two factors, anticipatory and treatment-related anxiety (Yuan et al. 2008, Lahti et al.

2020). Lahti et al. found that the anticipatory factor is more strongly associated with depression and general anxiety (Lahti et al. 2020). In this study, correlations between depressive and anxiety symptoms and dental anxiety were stronger with the treatment-related factor.

Pregnancy and childbirth can trigger depressive and anxiety symptoms in some individuals, and the prenatal depressive symptoms affect 10-20% of women and 2-13% of men, anxiety symptoms 9.5-29% of women and 8-14% of men (Heron et al. 2004, Escribe-Aguir et al. 2008, Skouteris et al. 2009, Teixeira et al. 2009, Paulson et al. 2010, Figueiredo et al. 2011, Parfitt et al. 2014, Verreault et al. 2014, Ngai and Ngu 2015, Navaratne et al. 2016). In the FinnBrain cohort, approximately 85-90 % of the parents in the main cohort reported low levels of depressive or anxiety symptoms. Between anxiety and depressive symptoms comorbidity existed. However, they are also partially distinct conditions. (Korja et al. 2018) Pregnancy can affect also the associations between dental anxiety, general anxiety and depression. To explain gender differences in our results, pregnancy-related factors (i.e. hormones) could be possible. Also, other mechanisms, such as increased stress as the parents face a new phase in a life or decreased sleep, could lead to vulnerability to anxiety and/or depressive symptoms.

6.3.3 The associations between dental anxiety and trauma, life events and perceived parental bonding

According to the results of this study, in the pilot cohort there was a positive association between dental anxiety and emotional trauma and neglect among men. Other studies have found associations with sexual trauma (Walker et al. 1996, Willumsen et al. 2001 and 2004, Humphris and King 2011). In a recent study in Norway refugees with torture experiences were six times more likely to be highly dentally anxious than other refugees (Høyvik et al. 2019) Understanding of the association between trauma outside dental setting and dental anxiety becomes more important as we face growing populations of refugees in our clinics. The population in this study had probably not faced major trauma to same extent as refugees. Nevertheless, a weak positive association between emotional trauma and dental anxiety was found among men. It could be a reflection of the endogenous etiology of dental anxiety involving psychological aspects. Regardless, in the etiology of dental anxiety, trauma inside the dental setting (negative experiences of pain, being trapped) seems to have a greater effect on the development of the anxiety (Oosterink et al. 2009, Humphris and King 2011). These dental traumas were not measured in this thesis.

This study did not find associations between dental anxiety and parental rearing styles. The finding is similar as in previous studies (ten Berge et al. 2003, Krikken and Veerkamp 2008, Krikken et al. 2012). Parenting style could be seen as part of the

environment, which could promote or inhibit the development of anxiety through other mechanisms.

6.4 Clinical significance and implications for further studies

According to the results of this study, dental anxiety status is fairly stable for the majority of people. Still, we have a minor population with a difficult dental anxiety problem perhaps related to other psychological challenges, and we also have a population, whose anxiety fluctuates strongly. To be able to help all these patients adequately, the most important part of the treatment is to evaluate their dental anxiety at the start of a new treatment episode with a valid questionnaire (Humphris et al. 1995 & 2000, Hally et al. 2017). Good evidence for this is supplied by a recent study from Sweden with large number of participants. According to their findings, clinicians are unsuccessful in identifying a dentally anxious patient without the concurrent use of patient self-assessment (Höglund et al. 2019). Dental clinicians rated dental anxiety lower than their patients did and there was also an inverse correlation between the clinicians' confidence and their ability to rate a patient's dental anxiety (Höglund et al. 2019).

After assessing anxiety correctly, we should consider the different etiological backgrounds and possibly customize our anxiety treatment according to that. If the patient does not respond to our chair-side dental anxiety treatment including providing information, tell-show-do-technique, rest breaks, signalling and psychological approaches such as distraction, positive reinforcement and relaxation breathing (Milgrom et al. 1995, Kim et al. 2011, Armfield & Heaton 2013, Lahti et al. 2020), we should consider in addition to exogenous etiology the endogenous pathways. The patient should be referred forward to assess the possible underlying psychological disorders and to receive proper treatment to those and to dental anxiety (Wide Boman et al. 2013). Interestingly, it also could be, that the stimulus value of a dental treatment-related stimuli changes relative to other anxiety-provoking stimuli (like childbirth) or that life stress affects manifestation of dental anxiety. This could be comforting information for a patient as the treatment could be faced easier as the stressful stimulus is bypassed.

It would be greatly interesting to determine the possible trajectories of dental anxiety in this study population and study the congruence of these trajectories (i.e. constantly anxious, pregnancy onset anxious) within a family or with trajectories of general anxiety and depression. Also, to understand better the changes, a qualitative study (i.e., interviews and/or focus groups) could help elucidate why dental fear may change during these life events, whether expectant parents feel this is a clinically significant change, and what dentists may be able to do to help alleviate temporary increases in dental fear. We also know from the literature, that maternal prenatal

psychological distress is associated with offspring development and health outcomes (Odonnell & Meaney 2017, van den Bergh et al. 2020). As dental professionals, we do not want to add up this stress.

One major topic for future research is also, whether the fluctuations of dental anxiety seen in these cohorts have clinical significance: are they associated with attendance patterns and oral health-related quality of life. These questions need linking the changes in dental anxiety to clinical data on oral health and visiting patterns in oral health care services, which were not available during this thesis. Overall, a better understanding of dental anxiety may prevent treatment avoidance, change visiting patterns to more regular, lower the costs of dental treatment at individual and national level, and most importantly enhance the oral-health-related quality of life. The better understanding will help dental staff to treat patients better and in difficult endogenous situations refer the patient to another expert, i.e. to a psychologist or a psychiatrist for further treatment of the dental anxiety with therapy.

7 Summary/Conclusions

During pregnancy and after childbirth, dental anxiety seemed to fluctuate slightly among Finnish families. The course of the fluctuation of dental anxiety seemed to differ by gender, and the magnitude of the fluctuation was very moderate. While dental anxiety remained stable for most participants in both cohorts, for those whose dental anxiety changed, it was more likely to increase than decrease.

On average, dental anxiety, depression and general anxiety were positively correlated throughout the study period in the main cohort, but the magnitudes of the correlations were mainly modest. In the pilot, the correlations existed only among men. In the main cohort general anxiety and depression were significant predictors of dental anxiety.

All associations found between dental anxiety and trauma measures or life events were gender specific in the pilot cohort. Dental anxiety correlated with emotional trauma among men and with the number of life events among women. Dental anxiety was not associated with parental bonding among women or men.

Based on the findings of this thesis, there potentially are “critical periods” in people’s lives during which they are more vulnerable to developing and/or being affected by dental anxiety. These are times, when intervention could be most efficacious and more sensitive approaches by dental professionals are needed. The results provide additional evidence, that dental anxiety exists on a continuum with anxiety levels being dynamic across time and influenced by life stress. Dental professionals should measure dental anxiety at the start of a new treatment period. If the treatment tackling the exogenous origins of dental anxiety does not provide desired outcomes, clinicians should also consider and discuss possible endogenous sources affecting the patient’s dental anxiety, and possibly refer the patient onwards to another specialist.

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