Traumatic dental injuries

Prevalence, severity and risk factors along the life course - a study among 16-year-old pupils in Hordaland, Western Norway

Magnus Holmøy Bratteberg

Thesis for the degree of Philosophiae Doctor (PhD)
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Scientific environment

The studies on which this thesis is based were undertaken at The Department of Clinical Dentistry, Faculty of Medicine, University of Bergen, Norway.

The main supervisor was Professor Asgeir Bårdsen.

The co-supervisors were Professor Kristin S. Klock and Dorina Sula Thelen Ph.D.

Collaborators

Oral Health Centre of Expertise

Bergen, Norway

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Abbreviations

BFI	Big Five Inventory
CI	Confidence Interval
COS	Core Outcome Set
DMFT	Decayed Missing and Filled Teeth
EPJ	Electronic Patient Journal
IADT	The International Association of Dental Traumatology
OHRQoL	Oral Health-Related Quality of Life
OR	Odds Ratio
PAI	Periapical Index
PCO	Pulp Canal Obliteration
PDL	Periodontal ligament
PN	Pulpal Necrosis with Infection
REK	Regional Etisk Komité (Regional Committees for Medical and Health Research Ethics)
SES	Socioeconomic Status
SMS	Short Message Service
TDI	Traumatic Dental Injuries
WHO	World Health Organization

Abstract

Purpose/Aim: To assess prevalence, severity and risk factors for traumatic dental injuries (TDI), in a life course perspective, among Norwegian adolescents.

Materials and Methods: A prevalence study, including prospective clinical data, was conducted among 16- year-old high school students in the county of Hordaland, Western Norway. All first-grade students at public high schools, registered in the census as born in 1997, were invited to participate (n = 5 184). Recruitment was by electronically administered invitation (e-mail and SMS), with an attached closed-ended electronic questionnaire (SurveyXact). The questionnaire covered such topics as TDI and life course events, categorized as socioeconomic, biological, psychosocial and behavioural indicators. Consent was given to access the participants' dental records, held by the county Public Dental Service: information about TDI (diagnosis and treatment) and radiographs were interpreted and transferred to the database. Only TDI to anterior teeth was recorded (canine to canine in maxilla and mandible).

Results: A total of 2 055 students agreed to participate (response rate 40 per cent). The prevalence of TDI involving at least one anterior tooth was 16.4 per cent (338 pupils). Boys were more prone to injury than girls ($p < 0.05$). Severity of TDI was categorised as mild, moderate or severe, with the following distribution: mild = 563 (88.4 per cent), moderate = 39 (6.1 per cent) and severe = 35 (5.5 per cent). The peak age for TDI was 8-10 years (50.9 per cent). Hierarchical logistic regression analyses were used to assess risk factors for TDI. Using experience of TDI (Yes/No) as the dependent variable, 12 variables with a significant bivariate effect ($p > 0.05$) on the dependent variable were tested (Stata for Mac ver. 15.0). TDI was more frequent among adolescents reporting a mother with high level of education, among boys, among those reporting a low level of conscientiousness, those answering yes to the question "I like being the way I am", those with no plans for after high school, or who do not see the point in planning for the future, and those reporting a high frequency of sporting activities. Using severity of TDI as the dependent variable, participants reporting religion/beliefs as unimportant in their personal life, those active in wrestling and those who failed to attend four or

more dental appointments are at significantly increased risk of severe TDI. Using multiple versus single episodes of TDI as the dependent variable, multiple episodes were more frequent among participants reporting lack of love and affection from mother/female guardian, those participating in sporting activities and those with moderate/severe TDI. The prevalence of pulpal necrosis with infection was 7.53 per cent. Moderate and severe TDI was associated with a higher frequency of pulpal necrosis with infection. Of teeth with TDI, pulp canal obliteration and root resorption were found in 2.80 and 2.28 per cent respectively. Hard tissue injuries were more prone to development of pulpal necrosis with infection than luxation injuries and combination injuries. The relationship between the stage of root development and development of pulpal necrosis with infection was not statistically significant.

Conclusions: The prevalence of TDI was 16.4 per cent. TDI is more frequent among boys, among adolescents of higher socioeconomic status and among those with adverse scores for psychosocial and behavioural parameters. Moderate and severe TDI is more frequent among adolescents with adverse scores for psychosocial and behavioural parameters and among those who participate in the sport of wrestling. Multiple episodes of TDI are more frequent among adolescents with adverse scores for psychosocial and behavioural parameters and those who participate in sporting activities. Pulpal sequelae in teeth with TDI are infrequent. The risk is greater in moderate and severe TDI. The risk of pulpal necrosis with infection is higher in cases involving hard tissue injuries.

List of Publications

Paper I

Bratteberg M, Thelen DS, Klock KS, Bårdsen A.

Traumatic dental injuries - prevalence and severity among 16-year-old pupils in western Norway. **Dent Traumatol. 2018;34:144-150.**

Paper II

Bratteberg M, Thelen DS, Klock KS, Bårdsen A.

Traumatic dental injuries and experiences along the life course – a study among 16-yr-old pupils in western Norway. **Eur J Oral Sci. 2019;127:445-454.**

Paper III

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Traumatic dental injuries and pulp sequelae in an adolescent population. **Dent Traumatol. 2020.** https://doi.org/10.1111/edt.12635 [E-published ahead of print].

These papers will be referred to as **Paper I, II and III.**

1. General introduction

Traumatic dental injuries (TDI) are acute conditions, with associated pain and discomfort [1-4]. The severity may vary from mild (in soft and hard tissues) to more severe and complex injuries. In severe cases there may be extensive loss of teeth and the supporting tissues, leading to disturbance of normal occlusion, with negative effects on such functions as mastication, speech and smiling. Several studies have shown that changes to facial appearance caused by TDI have negative psychological effects [5,6] and impacts the affected individuals' oral health related quality of life (OHRQoL) [7,8].

While TDI may occur at any age, primarily children and adolescents are affected [4,9-25]. Most studies are limited to this age group and adults are seldom included in the study population [26-29]. The condition is not limited to social class and may require complex management, including long treatment periods, with an uncertain long-term prognosis. Management of TDI entails direct and indirect costs, which may be a burden on the affected individual, his or her family and society [30-34].

Dental caries and periodontal disease are the main causes of tooth loss at the global level [35,36]. Over the past four decades, the prevalence and severity of dentine carious lesions have declined [37,38]. During the last 30 years, the prevalence of periodontal disease has also decreased [39]. At the same time, data from studies conducted in Scandinavian countries suggest that there has been no significant improvement in TDI rates in children and adolescents [25,40]. After dental caries, TDI is the second most frequent oral condition, ahead of periodontal disease and severe tooth loss [41]. Comparing trends in caries and TDI is of interest: in light of the declining prevalence of severe dentinal caries in children and adolescents and generally lower levels of caries in the population, TDI may in future supersede caries as the most common oral condition [2,33]. The anterior teeth are primarily involved in TDI; hence the aesthetic impact is much higher than that of caries, which affects primarily the posterior teeth [42-45]. Moreover, treatment of TDI is usually more complex and expensive than treatment of caries [1,46].

As TDI occurs frequently in children and adolescents, one would expect this to be reflected in the frequency of scientific paediatric publications in the field. However, Andreasen et al. (2009) disclosed an average rate of scientific publications on dental trauma between 1 and 4 per cent of all articles published between 1980 and 2007 [47]. Moreover, there was no increase in publications in more recent years. This is completely disproportionate to the actual magnitude of the problem. The late Dr. Jens Ove Andreasen has famously called dental traumatology "the orphan of dentistry" [47,48]. Perhaps with good reason.

1.1 Occurrence of TDI

1.1.1 Classification, prevalence and incidence of TDI

A systematic review by Feliciano (2006) [49], disclosed that 54 different classification systems for TDI had been applied in 164 studies. The most widely accepted international classification was developed by Andreasen [2] and based on a system adopted by the World Health Organization (WHO) [50]. This classification is considered the gold standard. However, practical limitations, such as access to facilities like radiography, artificial lighting and different equipment, will determine which classification system is appropriate. An overview of the most commonly used classification systems is presented in Table 1.

Table 1. *Classifications of TDI, based on Petti et al., (2018) [41] updated for 2020.*

Classification	Year	Year updated	# of variables included	Frequency of use, based on [41]	Comments
Andreasen [2]	1972	1994	19	76	Based on WHO classification [50]
Ellis [51]	1945	1970	8	8	Based on WHO classification [50]
Garcia-Godoy [52]	1981	1981	13	5	Based on WHO classification [50]
O'Brien [53]	1994	1994	6	37	-
Sgan-Cohen [54]	2005	2008	6	3	Based on O'Brien classification [53]
Others	-	-	-	25	-

Comparison of study results is complicated by the lack of standardized methods and classifications observed in the literature [41,49]. The use of standardized protocols, data collection and registration would facilitate comparison of studies, both nationally and internationally [2,9,41,55]. One way of improving trauma registration is the use of a core outcome set (COS) when conducting studies. This is a standardized collection of outcomes, required as a minimum in clinical studies. Heterogeneity of outcome measurements and inconsistencies in reported outcomes are common [56]. This also applies to studies on TDI [57]. In 2018, The International Association of Dental Traumatology (IADT) has established a COS, comprising the minimum requirements of registration of factors related to TDI, for application in future studies [55].

Incidence

TDI in a population may be measured by studies of prevalence or incidence. Incidence describes the risk, or probability, of acquiring TDI and includes three basic measures for disease frequency: incidence time, rate and proportion [58]. In the following text, incidence is referred to as incidence proportion, which measures the proportion of people who acquire the disease during a specified period of time [58].

There are few studies of TDI incidence (Table 2). Most have been conducted in the Scandinavian countries [15,20,25,40,59-63], where the Public Dental Health Services provide most dental care for children and adolescents, free of charge. This system ensures long-term consistency in data collection and provides highly accurate results. The incidence of TDI in Scandinavia ranges from 1.3 to 4.0 per cent [15,40,60,62,64]. There is no evidence of increasing incidence globally [2]. Studies suggest that the global incidence is < 5 per cent per year, as reported in a literature review by Lam in 2016 [4].

Table 2. *Incidence (yearly, per cent) and causes of TDI in different countries. (n.a = not available).*

Region	Author (reference)	Country	Year	Age (yrs.)	Sample size (n)	Cause of TDI (%)	Registration method	TDI %
Asia								
	Basha et al. [65]	India	2015	13	785	n.a	Andreasen	3.0
Australasia								
	Stockwell [66]	Australia	1988	6-12	66 500	Falls (22.7)	Not defined	1.7
Europe								
	Andreasen & Ravn [59]	Denmark	1972	0-14	487	n.a	Not defined	4.0
	Hedegård & Stålhane [60]	Sweden	1973	7-15				1.5
	Ravn [15]	Denmark	1974	7-16	214 918	Collisions (35.5)	Not defined	3.0
	Hansen & Lothe [63]	Norway	1982	7-18	53 024	Fighting (46.0)	Not defined	2.5
	Glendor et al. [62]	Sweden	1996	0-19	32 292	n.a	Andreasen	1.3
	Borssén & Holm [61]	Sweden	1997	1-16	3 007	n.a	Not defined	2.8
	Hamilton et al. [67]	UK	1997	11-14	2 022	n.a	Not defined	3.4
	Skaare & Jacobsen [25]	Norway	2003	7-18	n.a	Leisure time injuries (52.0)	Andreasen	1.8
	Oldin et al. [20]	Sweden	2015	0-17	2 363	Falls (42.0)	Not defined	2.8
	Lexomboon et al. [40]	Sweden	2016	8-10	21 721	Falls (30.4)	Not defined	2.2
South America								
	Cecconello & Traebert [68]	Brazil	2007	Adolescents	159	n.a	O'Brien	4.4
	Ramos-Jorge et al. [69]	Brazil	2008	11-13	306	n.a	O'Brien	1.2 – 5.7

Prevalence

Unlike incidence, which measures new events or changes in health status, prevalence is a measure of existing conditions. Thus, the prevalence of a disease is the proportion of the population affected at a specified time [58]. Prevalence gives important information about the extent and impact of TDI in a given population at a specific time. Thus, the prevalence in a population will be higher than the incidence, and higher among older age groups. As shown in Table 3, TDI prevalence ranges from 2.4 to 38.7 per cent (Table 3).

Table 3. *Prevalence (per cent) and causes of TDI in different countries (n.a = not available).*

Region	Author (reference)	Country	Year	Age (yrs.)	Sample size	Cause of injury (%)	Registration method	TDI %
Africa								
	Kahabuka & Mugonzibwa [70]	Tanzania	2008	8-14	1 119	n.a	Andreasen	24
	Adekoya-Sofowora et al. [71]	Nigeria	2009	12	415	Falls (49.1)	Garcia-Godoy	12.8
	Naidoo [72]	South Africa	2009	11-13	1 665	Falls (43.4)	Ellis	6.4
Asia								
	Nik-Hussein [18]	Malaysia	2001	16	4 085	n.a	Not defined	4.1
	Malikaew et al. [73]	Thailand	2006	11-13	2 725	Falls (24.8)	Cortes	35.0
	Gopinath et al. [74]	Malaysia	2008	12-16	488	n.a	Andreasen	12.3
	Altun et al. [75]	Turkey	2009	6-12	4 956	Falls (40.3)	Andreasen	9.5
	Huang et al. [76]	Taiwan	2009	15-18	6 312	Sports and leisure activities (30.8)	O'Brien	19.9
	Patel & Sujan [77]	India	2012	8-13	3 708	Falls (43.9)	Andreasen	8.8
	Ankola et al. [78]	India	2013	6-11	13 200	Falls (37.0)	WHO	14.7
	Chen et al. [79]	China	2014	8-12	5 165	Daily activities (38.2)	Andreasen	7.1
	Juneja et al. [80]	India	2018	8-15	4 000	Falls (55.6)	Ellis	10.2
Oceania								
	Burton et al. [81]	Australia	1985	12-15	12 287	n.a	Not defined	6.0
Europe								
	Delattre et al. [82]	France	1995	6-15	2 020	Sports and games	Ellis	13.6
	Petti & Tarsitani [83]	Italy	1996	6-11	824	Indoor play (31.9)	Garcia-Godoy	20.3
	Borssén & Holm [61]	Sweden	1997	16	3 007	n.a	Not defined	35.0
	Marcenes & Murray [84]	UK	2001	14	2 242	n.a	O'Brien	23.7
	Thelen et al. [17]	Albania	2010	6-18	2 789	Collisions (27.5)	O'Brien	9.9
	Faus-Damiá [85]	Spain	2011	6-18	1 325	Games (40.0)	Andreasen	6.0
	Norton & O'Connell [86]	Ireland	2012	0-7	839	Falls (66.3)	Andreasen	25.6
	Schatz et al. [87]	Switzerland	2013	6-13	1 900	n.a	NIDR	14.3
	Oldin et al. [20]	Sweden	2015	0-17	2 363	Falls (42.1)	Not defined	37.6
	Bilder et al. [13]	Georgia	2016	12-15	823	n.a	Sgan-Cohen	10.4
Middle East								

	Marcenes et al. [33]	Syria	1999	9-12	1 087	Violence (42.5)	O'Brien	8.0
	Al-Majed et al. [88]	Saudi Arabia	2001	12-14	862	n.a	Not defined	34.0
	Hamdan & Rajab [89]	Jordan	2003	12	1 878	n.a	Ellis	13.8
	Årtun et al. [90]	Kuwait	2005	13-14	1 583	Falls (48.4)	NIDR	14.5
	Sgan-Cohen [54]	Israel	2005	9-13	1 195	Falls	Sgan-Cohen	29.6
	Sgan-Cohen [24]	Israel	2008	10-12	453	Falls (29.1)	Sgan-Cohen	33.8
	Noori & Al-Obaidi [19]	Iraq	2009	6-13	4 015	Falls (60.9)	Garcia-Godoy	6.1
	Livny et al. [91]	Palestine	2010	11-12	804	n.a	O'Brien	17.7
	Navabazam & Farahani [14]	Iran	2010	9-14	1 440	Falls (30.5)	Ellis	27.6
	Al-Bajjali et al. [92]	Jordan	2014	12	1 015	Falls (30.9)	Andreasen	16.3
	Qudeimat et al. [93]	Kuwait	2019	7-18	667	Soccer-related (44.0)	Andreasen	25.0
Central America								
	Garcia-Godoy et al. [94]	Dominican Republic	1986	7-16	1 200	n.a	Garcia-Godoy	18.9
	Sanchez & Garcia-Godoy [23]	Mexico	1990	3-13	1 010	n.a	Garcia-Godoy	28.4
North America								
	Kaste et al. [26]	USA	1996	6-20	3 337	n.a	NIDR	18.4
	Kaste et al. [26]	USA	1996	21-50	4232	n.a	NIDR	28.1
	Alonge et al. [12]	USA	2001	8-9	1 039	n.a	WHO	2.4
	Shulman & Peterson [95]	USA	2004	6-20	6 558	n.a	NIDR	16.0
	Locker [96]	Canada	2005	14	3 010	n.a	O'Brien	18.5
	Fakhruddin [97]	Canada	2008	12-14	2 422	n.a	O'Brien	5.6
South America								
	Cortes et al. [98]	Brazil	2001	9-14	3 702	n.a	O'Brien	12.1
	Nicolau et al. [99]	Brazil	2001	13	652	Falls (24.1)	O'Brien	20.4
	Traebert et al. [100]	Brazil	2003	12	307	Falls (47.9)	O'Brien	18.9
	Soriano et al. [101]	Brazil	2007	12	1 046	Falls (27.3)	Andreasen	10.5
	Bendo et al. [102]	Brazil	2010	11-14	1 612	Falls (43.6)	Andreasen	17.1
	Díaz et al. [103]	Chile	2010	1-15	1 719	Falls (51.8)	Andreasen	37.9
	Jorge et al. [104]	Brazil	2011	15-19	891	Falls (17.7)	Andreasen	24.7
	Damé-Teixeira et al. [105]	Brazil	2012	12	1 528	No memory of incident (53.6)	O'Brien	34.8
	Pulache et al. [106]	Peru	2015	11-14	473	n.a	Andreasen	38.7
	Paiva et al. [22]	Brazil	2015	12	588	n.a	Andreasen	29.9

1.2 Aetiology - risk factors related to TDI

A traumatic dental injury requires a force or impact that generates sufficient kinetic energy to produce an injury [107]. An increase in mass or speed of an object increases its mechanical energy [107] and when sufficient energy is generated, this may result in TDI.

1.2.1 Immediate risk factors

To understand what causes TDI, it is relevant to describe the preceding circumstances and events. Prevention is based on knowledge of risk factors. Most studies on TDI focus on the immediate risk factors, such as oral predisposing factors (overjet with protrusion), sporting activities, accidents and falls. Among the earliest and most significant oral predisposing factors described in the literature are increased overjet, with protrusion of upper incisors and insufficient lip coverage [84,90,95,108-111]. Falls and collisions are reported to be the most common cause of injury [17,20,40,100,103,112], while according to the literature, the most prevalent location is the home [19,72,86,102,113]. The difference in proportions of causes of TDI vary, depending on the population type, culture and region studied [114].

While most TDI are recorded as unintentional injuries (falls, accidents etc.), a significant proportion are reported as “unknown”. In some cases, this will conceal the real cause (e.g., physical abuse and assaults) [114]. It is therefore likely that compared with accidental TDI, such as falls and collisions, the proportion of intentional TDI caused by violence and assaults is underestimated [2,114].

Socioeconomic status (SES) is an important predisposing factor in many diseases. However, with respect to the relationship between SES and TDI, the results are contradictory. Some studies show that groups with lower SES have a higher prevalence of TDI and fewer in this group seek treatment compared with those from higher SES [17,112,115-117]. A Brazilian study has disclosed a relationship between higher SES and higher prevalence of TDI. This is attributed to the fact that a more privileged lifestyle allows participation in TDI risk sports and leisure activities [118].

1.2.2 The "causes of causes"

When studying the causes of TDI, it is also important to consider the "causes of the causes". What leads people to fall, collide, participate in sporting activities or turn to violence? The number of known causes of TDIs presented in the literature has grown during the past few decades, due to increasing interest in the different causes and in epidemiological research [114]. However, this also highlights the complexity of the aetiology: TDI is multifactorial and often occurs when several risk factors combine [114]. For example, overjet and incompetent lip coverage alone do not increase the risk for TDIs. Instead, TDI occurs as a complex and multifaceted interaction between the patient's oral status, and environmental and human factors (Figure 1) [2,114].

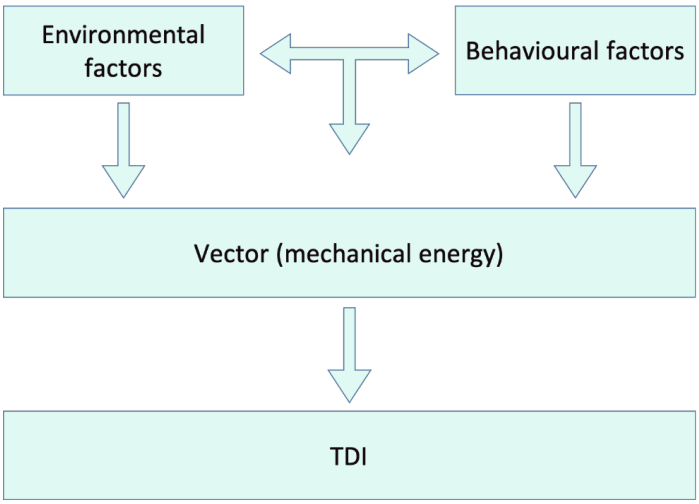

Fig. 1. *Environmental and behavioural causes of TDI, from Glendor et al. (2019) [2].*

1.3 Complications and sequelae of TDI

TDI sequelae can be diagnosed up to 5-10 years after the incident, hence long-term follow-up studies are required to assess risk factors for the development of sequelae. Such studies are often difficult to conduct, largely due to time limitations, data organisation and costs. The literature on dental trauma has been, and still is, dominated

by the research conducted by the University Hospital of Copenhagen and the Copenhagen group [119]. Treatment procedures, recommendations and prognosis estimates are based largely on the results of these studies, and over one-third of the 100 most frequently cited scientific papers on dental trauma originate from this institution. With only limited data available from other institutions for comparison and analysis, there is considerable reporting bias [2]. By conducting such studies elsewhere, global generalization of results is facilitated by greater heterogeneity of study populations and the different factors studied.

1.3.1 Pulpal necrosis with infection

Periodontal and pulp tissue sequelae to TDI are caused primarily by inflammation, in most cases associated with infection [120]. A 2006 literature review by Andreasen et al. [120] presents five possible invasion routes for bacteria in TDI cases: through infractions (e.g. crown infractions), exposed dentinal tubules (e.g. enamel-dentin fractures), direct invasion into soft tissue (injuries where the pulp is exposed, e.g. complicated enamel-dentine fractures), bacterial propagation in a blood clot separating wound surfaces in the periodontal ligament (PDL) (e.g. extrusion, lateral luxation, intrusion, root fracture, replantation) and anachoresis (e.g. severe luxation injuries and root fractures) [120].

Loss of the neurovascular supply to the pulp results in a pulp tissue infarct and necrosis, leading in turn to infection-related necrosis, sterile necrosis, or revascularisation of the pulp [121,122]. The outcome is dependent on the competition between cellular ingrowth and bacterial invasion [121,122].

According to a paper by Andreasen et al. (2006) [123], the main predictors of development of pulpal necrosis with infection (PN) are the size of the apical foramen, length of pulp, pulp exposure, dentin exposure, external contaminants subsequent to avulsion and accuracy in repositioning teeth with root fractures.

The reported range of frequency of PN in teeth sustaining luxation injuries is 15 to 59 per cent [124]. Factors strongly linked to the development of PN are the type of luxation injury, the stage of root development and concomitant crown fracture.

1.3.2 Pulp canal obliteration

Pulp canal obliteration (PCO) is regarded as a response to severe injury to the neurovascular supply to the pulp which, after healing, leads to accelerated dentine deposition [124,125]. This is a frequent sequela to luxation, the literature showing a prevalence range from 3 to 35 per cent [126-129]. PCO usually appears between 3 to 12 months after the TDI incident [129]. Type, severity of injury and the stage of root development are implicated [129]. A typical clinical manifestation of PCO is yellow discoloration of the crown, reduced thermal sensibility and response to electrical stimulation [130]. Although PCO is considered a mild sequela, some studies have noted increased risk for development of PN in such cases [130,131]. An important finding is that PCO rarely develops in cases of dental hard tissue injuries alone [128].

1.3.3 Root resorption related to dental trauma

Root resorption is a complication of luxation injuries to the permanent dentition [124,132]. Root resorption can be classified according to the stimulation factors involved: repair-related root resorption, replacement resorption, infection-related resorption (pulpal infection resorption, periodontal infection resorption) and pressure-related resorption (orthodontic pressure resorption or impacted tooth or tumour pressure resorption) [133]. Root resorption is most frequently associated with luxation injuries and the outcome is dependent on the healing response (favourable or unfavourable) [132,133]. The major determinants are the severity of the injury, the stage of root development and the degree of bacterial contamination in the pulp canal [124,132,134,135].

1.4 Impact of TDI and cost of treatment

1.4.1 Aesthetics and TDI

In modern society, aesthetics has become increasingly important: it has a major role in defining a person's character [136]. Historically, restorative dentistry was primarily concerned with the maintenance of a functional dentition [136]. However, in today's technology-driven society, social media, internet and television have led to greater emphasis on physical attractiveness [137]. Thus, aesthetics has become an increasingly

important aspect of dentistry [137]. A simple dental anomaly, such as a missing or fractured tooth, can be viewed as a deviation from the 'norm', and thus alter facial appearance [138]. The face has profound social significance and facial aesthetics are important in self-identification, self-image, self-presentation and interpersonal confidence [1,137,139]. Studies also show a strong correlation between physical attractiveness and SES [140] and higher employment rates [140,141]. Thus, compared with other oral conditions, such as caries, TDI has a much greater potential impact on facial aesthetics [1].

TDI will to varying degrees impair a person's ability to chew, speak and smile, which has been shown to have a negative psychological effect [5,6] and impact on oral health related quality of life [7,8]. The psychological impact of TDI on the individual will depend on several factors: the type and severity of the injury, the type of event associated with the injury, the level of pain and fear, and the quality of treatment provided [1].

1.4.2 Economic aspects of TDI

The economic implications of managing TDI are important, not only for the affected individuals, but also for society. Only limited information is available about treatment time and treatment costs for TDI. Studies on the economic impact of TDI are difficult to compare, because of differences in national structures, different financing methods (public vs private), treatment procedures and local costs. A Swedish study conducted by Glendor et al. in 2001 disclosed that the average total costs related to TDI were 4 569 SEK (6 015 SEK = 677 USD, inflation adjusted for 2020) [46]. The total costs related to TDI should include both direct costs (emergency treatment, health care services and cost of patient transportation) and indirect costs (loss of time and income of patients and carers [46].

Severity of TDI is the most important factor influencing present and future costs of treatment and treatment time [30,31,46,142,143]. Glendor et al. reported that compared with uncomplicated TDI, the cost of managing complicated TDI was on average three

times higher [46]. The reason for this is the greater treatment time and the greater number of appointments required for complicated TDI [30].

1.5 Conceptual framework – a life course approach

Due to the fact that most studies analysing risk factors related to TDI focus on current or immediate risk factors, little information is available about the experiences of affected individuals along their life course. According to Ben-Shlomo & Kuh (2002) [144], a definition of a life course approach to chronic disease epidemiology is

> *"The study of long-term effects on chronic disease risk of physical and social exposures during gestation, childhood, adolescence, young adulthood and later adult life. It includes studies of the biological, behavioural and psychosocial pathways that operate across an individual's life course, as well as across generations, to influence the development of chronic diseases."*

The aim of this theoretical framework is to explain biological, behavioural, and psychosocial processes along the life course, influencing the development of disease risk [145]. Although life course epidemiology has gained popularity in recent decades [144,146], the data in relation to TDI are limited.

Life course epidemiology examines the accumulation of advantages and disadvantages that may generate differences in health later in life. Intrinsic factors (individual resources) and extrinsic factors (environmental factors) are evaluated collectively [145,147,148]. This approach focuses on a wider range of experiences of the affected individuals at different stages in life, where potential poor early environment may lead to illness, negative behaviour and adverse environmental conditions, which in turn may increase the risk of disease.

Over recent decades, several different life course models have been developed. These include "the critical period"-model; "the critical period model with later life effect modifiers"; "the accumulation of risk"-model; and "the chains of risk"-model. [145,149].

"The critical period"-model is applicable when exposure at a specific point in time has long-lasting or permanent effects on a person's health [145]. For example, poor growth *in utero* leads to different chronic diseases later in life, such as cardiovascular disease and hypertension [145]. The second model extends the first by incorporating later life effect modifiers, such as the effect of later life obesity on people with low birthweight [145].

The "accumulation of risk"-model assumes that cumulative insults or exposures during the life course increase the health risk later in life, irrespective of their timing [144,145,149]. As the number of exposures increases, there is cumulative damage to biological systems. Exposures may cause long-term damage and gradual damage to health, with risk exposure being either independent or clustered. The accumulation of environmental, economic, and behavioural risk exposures may cause long-term progressive damage to health in independent or correlated ways (Figure 2, Model 1). It is more common for exposures to cluster in socially patterned ways [144], and "the accumulation model with risk clustering" takes this into account. [144,145,149]. Risk factors which cluster are of interest to epidemiologists, because they are often related to the SES of the individual or family [145].

The "chains of risk"-model refers to a sequence of linked exposures which raise disease risk [145]. Different "mediating factors" and often "modifying factors", such as biological, social and psychological factors are involved in different chains of risk. There are two different models of chains of risk [145]. The first proposes that each individual factor not only increases the risk of the subsequent factor, but also has an independent effect on the disease risk, regardless of the subsequent factor (Figure 2, model 2). Thus, it results in an "additive effect" when each unfavourable experience increases the risk of disease in a cumulative fashion. Alternatively, without the inclusion of the final link in the chain, the earlier exposures have no direct effect on the disease risk.

A 2007 review by Nicolau et al. concluded that a life-course approach is a valid methodology in dental epidemiology [146] and several studies on dental caries [150-

152] and periodontal disease [153] have incorporated a life course methodology. To date, only one previous study has tested a life course model linking the chains of causation related to TDI [148]. The study population comprised Brazilian adolescents and it was concluded that adverse psychosocial environments were a statistically significant risk factor for TDI. These adverse environments comprised living in non-nuclear families and experiencing high levels of paternal abuse. This study confirms that the life course approach is relevant to investigation of the causes of TDI, providing a potentially broader and longer-term perspective of risk factors.

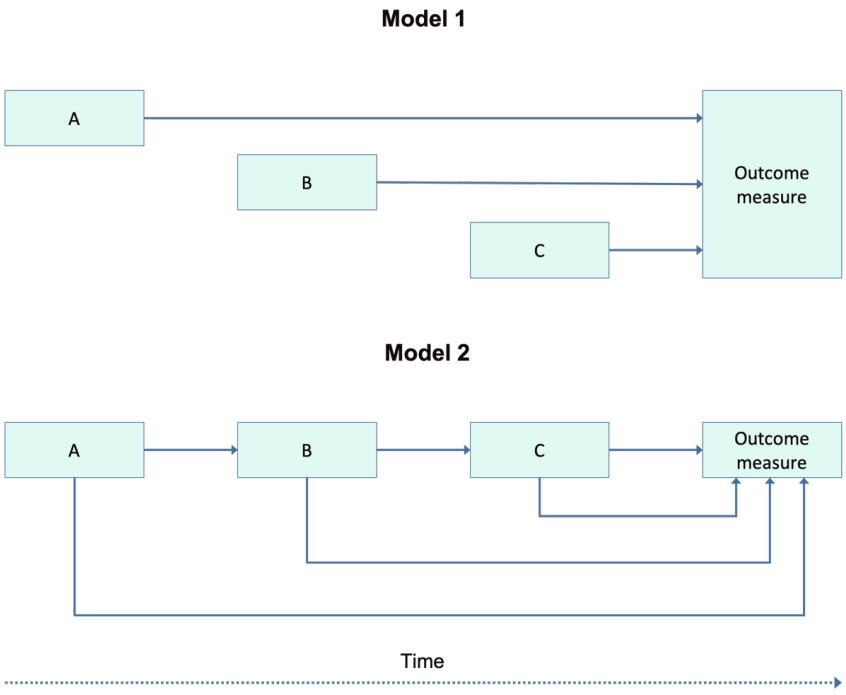

Fig. 2. *Hypothetical causal life course models with exposures operating at different points along the life course, modified from Kuh et al. (2003) [145].*

1.6 Justification of the study

Although the oral region comprises approximately 1 per cent of the human body, oral injuries account for around 5 per cent of all bodily injuries [41,113]. TDI prevalence (Table 3) and incidence (Table 2) are generally high worldwide but reports in the literature show considerable geographic variation. There may be several reasons. Apart from cultural, socioeconomic and behavioural differences in the study populations, there is also a lack of standardization of registration, classification and treatment of TDI [2,9,41,49]. This lack of standardization may be one of the reasons that dental trauma is not included in the list of over 300 main chronic diseases and injuries worldwide, presented in the Global Burden of Disease 2015 study [154,155]. According to the systematic review by Petti et al. in 2018, TDI is the second most frequent oral condition worldwide, after dental caries, with a greater frequency than periodontal disease and severe tooth loss [41]. Moreover, with respect to all diseases and injuries, TDI would rank fifth, after caries, headache, anaemia, hearing loss, and ahead of migraine [41]. It is therefore important to estimate the prevalence of TDI and the different associated risk factors, in order to be able to assess the societal and individual burden in the population. In Norway, information about the occurrence of TDI is limited: to date, no comprehensive prevalence study has been conducted. Assessing the oral health impact of TDI in the population will provide the authorities with information necessary for planning public health strategies and allocation of resources to address this issue.

2. Aims

The overall aim of the thesis was to provide new information about the occurrence of traumatic dental injuries, associated risk factors and outcomes, in a life course perspective, among adolescents in Western Norway.

The specific objectives were:

- To assess the prevalence, distribution and severity of TDI among 16-year-old high school students in the county of Hordaland, Western Norway *(Paper I)*.

- To study risk factors associated with TDI in 16-year-old high school students, with special reference to the relationship with experiences along the life course *(Paper II)*.
    - Hypothesis: Occurrence of TDI in 16-year-old students in the county of Hordaland is affected by events along the life course.

- To assess prevalence and risk factors in relation to different pulpal responses and complications following TDI among Norwegian adolescents *(Paper III)*.
    - Hypothesis: Frequency of pulpal complications is associated with severity of TDI.

3. Materials and Methods

This thesis is based on a prevalence study of TDI, including prospective clinical data, in 16-year-old high school students in the county of Hordaland, Western Norway. The study was conducted between 2014 and 2016.

3.1 Study area

The study population comprised adolescents born in 1997 and attending public high school in the former county of Hordaland. Hordaland is in the south-west of Norway and at the end of 2019 the population was 524 495, in 33 different municipalities [156]. The study was conducted between 2014 and 2016. At the time, Norway comprised 19 different counties [157]. Today, there are 11 counties and 356 municipalities [157] with a total population of 5 372 355 (per 25.05.2020) [156]. Vestland county, established in 2020, includes the former counties of Hordaland and Sogn og Fjordane, with Bergen as the major city.

3.2 Selection procedure and study profile

A prevalence study, including prospective clinical data, was conducted between 2014 and 2016 among 16-year-old high school students in the county of Hordaland, Western Norway. All socioeconomic levels are represented and the population can be characterised as culturally diverse: 15.1 per cent are immigrants [158]. In Norway, the county governments are responsible for secondary education in their respective counties and the county Public Dental Health Services are responsible for the dental health of all residents up to the age of 18 years. The study was conducted in close collaboration with both departments in the county government of Hordaland.

3.2.1 Identifying study population

The school system in Norway includes both private and public high schools. Most students attend public schools (86.12 per cent for the school year 2013/2014 [159]). A total of 6 878 adolescents were enrolled in first grade at public high schools in

Hordaland in the school year 2013/2014 [159]. At the time there were 58 high schools in the county, according to information provided by the School Administration, based on information from "Skoleporten" in 2013 (no longer available). Enrolment at the largest school accounted for 6.75 per cent of the students. Of the students born in 1997, a total of 5 202 pupils were in first grade, including "general studies" and "vocational studies" (Figure 3). Older students in the same grade were excluded from participating. The students invited to participate in the study were selected from the register of students in the School Administration in the County of Hordaland. A census approach was used.

3.2.2 Collection of data from questionnaire

In order to increase awareness of the study, information graphics with information on the purpose of the study were sent beforehand to the principals of all 58 high schools. A recruitment letter with information about the aim of the study and a link to a closed-ended electronic questionnaire (SurveyXact) was sent by e-mail to all 5 184 pupils (see detailed information under 3.3). An invitation to participate was also sent via SMS (phone numbers obtained through the School Administration). If the questionnaire was not opened or only partially completed, a reminder was sent out after two weeks, through the same channels. To encourage participation, those who responded had the chance of winning one of three tablet computers in a raffle.

3.2.3 Collection of clinical data

By returning the electronic questionnaire, the respondents also consented to retrieval of information from their electronic patient journals (EPJ) in the Public Dental Health Service. All participating students had regular dental check-ups and treatment, which was registered in their EPJ. Data were collected from a total of 54 different public dental clinics. When all data had been collected, the data set was anonymised. No clinical examination or intervention was conducted. Information on TDI (diagnosis, follow up, treatment and outcome) were acquired from the EPJ and available dental radiographs were analysed.

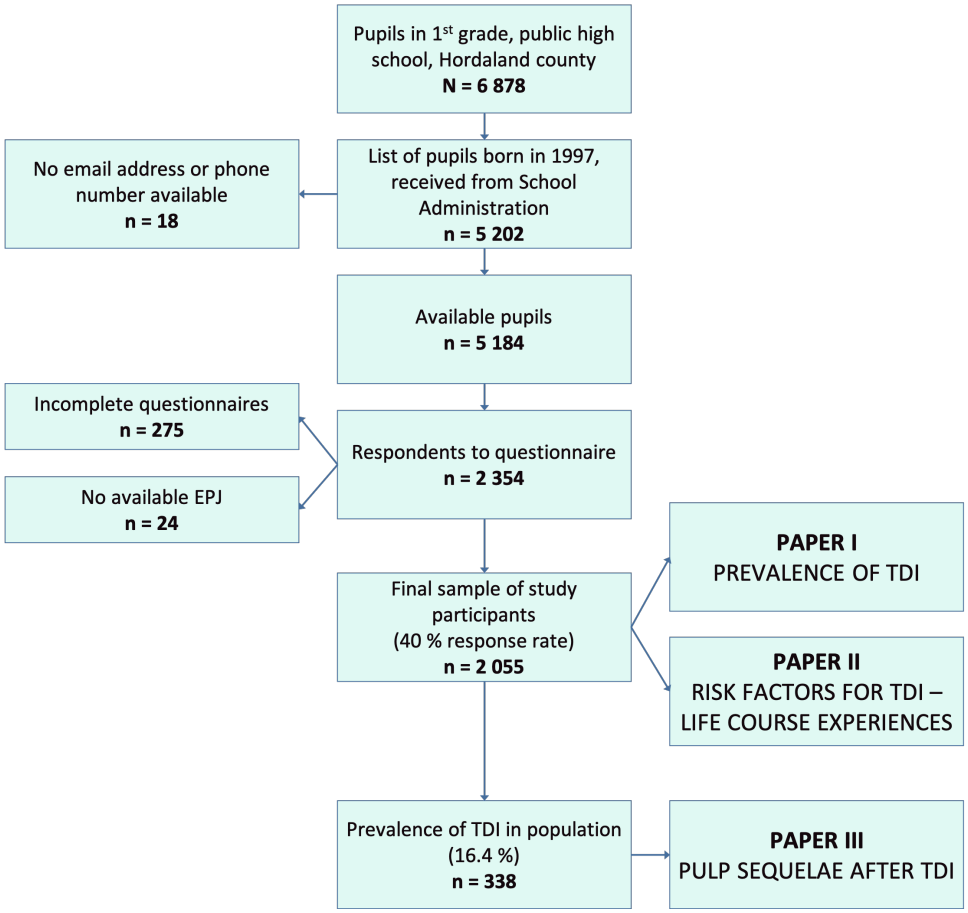

Fig. 3. *Sampling and number of participants in Papers I-III.*

3.2.4 Paper I

This paper focused on epidemiological aspects of TDI. All participants (n = 2 055) were included in the study, to identify the occurrence of TDI in the population. The Public Dental Health Service has used an EPJ (Opus Dental) since 1998 (Opus Systemer AS ©). The classification of TDI used in the EPJ trauma registration form is based on the WHO classification system, modified by Glendor et al. [2]. The operator can register data related to the injury, such as diagnosis, time and place of injury, emergency treatment, general condition of the patient, radiographic findings,

orthodontic treatment and any relevant malocclusion, the prognosis and a treatment plan. Follow-up of TDI is registered by measuring variables such as tooth mobility, tenderness to percussion, colour change and sensibility. All these data points ensure not only reliable patient data but also high external validity.

In 2001, a trauma registration form was included in the EPJ. As a result, TDI on the permanent teeth of all students born in 1997 should have been registered in the EPJ. The 95 per cent confidence limits for an expected TDI prevalence of 10 per cent [17], based on a sample size of 2 000, would be approximately 8.7 - 11.3 per cent. This confidence limit was considered sufficiently narrow to give a precise estimate of the prevalence of TDI in this population.

The injury diagnosis was retrieved from the participant's EPJ and classified according to the WHO system, modified by Glendor et al. [2]. This classification has also been used in previous Norwegian incidence studies by Skaare et al. [25,160]. TDI were then stratified according to severity as mild, moderate and or severe [160].

3.2.5 Paper II

In order to explore the effect of experiences along the life course and their influence on TDI in the study population (n = 2 055), data from the questionnaire (Appendix 1) were used. The topics from the questionnaire were grouped into different risk indicators. The questionnaire covered socioeconomic, biological, psychosocial and behavioural-related indicators, as well as experience and cause of TDI. A hierarchical approach was used: the variables were sorted into socio-economic, biological, psychosocial, and behavioural variables) representing risk indicators for traumatic dental injuries (Figure 4). Each variable from the questionnaire was tested against the dependent variables using the chi-square test. Variables showing an association with the dependent variables ($p < 0.05$) were then tested in three separate hierarchical logistic regression analyses: presence, severity and multiple episodes of TDI (Figure 4).

3.2.6 Paper III

In order to assess the prevalence of and risk factors for different pulpal sequelae to TDI in the study population, data retrieved from the EPJ of participants with TDI (n = 338) were analysed. Radiographic images were analysed and scored according to the PAI index [161]. Intra- and inter-observer agreement for PAI scores was measured using Cohen's Kappa coefficient (Table 4) [162], where benchmarks according to Landis & Koch were used [163]. Outcome variables, such as PN, PCO, root resorption and onset of the different sequelae, were analysed. The values for intra- and inter-observer agreement for PN (PAI), PCO, stage of root development and root resorption ranged from 0.66 to 0.91.

Table 4. *Cohen's Kappa coefficient (95 per cent CI) for intra- and inter-observer agreement in the interpretation of PAI-scores (calibration) at the first (R1) and the second (R2) readings.*

			Observer 1		**Observer 2**	
		Silver PAI	**R 1**	**R 2**	**R 1**	**R 2**
	Silver PAI	-	0.78	0.79	0.84	0.81
Observer 1	**R 1**	0.78	-	0.77	0.69	0.70
	R 2	0.79	0.77	-	0.71	0.75
Observer 2	**R 1**	0.84	0.69	0.71	-	0.85
	R 2	0.81	0.70	0.75	0.85	-

3.3 Questionnaire and variables

The questionnaire (Appendix 1) comprised a total of 135 questions on 51 different topics. Data from early childhood to the present day were collected, and then sorted into four different groups of risk indicators, related to socioeconomic-, biological-, psychosocial and behavioural factors. The socioeconomic indicators assessed the parents' level of education, the number of family-owned vehicles and frequency of

family vacations. The biological indicators comprised gender and anthropometric data. The psychosocial indicators assessed the adolescents' relationship with their parents, family structure and personality characteristics. The behavioural and attitudinal related indicators covered school grades, attendance at dental appointments, frequency of exercise, participation in sporting activities, experience of violence, sleeping habits, television viewing habits, experience of tobacco and alcohol, oral hygiene routines, use of fluoride, experience of orthodontic treatment, as well as experience and cause of TDI.

The adolescent–parent relationship was measured using validated questions derived from the study of Nicolau et al. (2003) [148]. The individual items from the questionnaire used in this study were translated from English to Norwegian and cross-culturally validated. A back translation of the questionnaire was undertaken by colleagues who had not previously been involved in the project and who had no prior knowledge of the study objectives. Further, a pilot study was conducted among upper secondary school students in the county, in order to test the face validity and reliability of the questionnaire (n = 6) [164,165]. Validity reflects how accurately items measure what they are intended to measure within a domain [166]. The average time spent on completing the questionnaire in this phase was less than 15 min. Moreover, a select group of colleagues with competence in epidemiological research undertook a review of the questions and items in the questionnaire (construct validity testing) [165,167] As a result, two questions, related to screen habits and plans after high school graduation, were modified before the questionnaire was dispatched to the study population.

3.3.1 The Big Five Inventory

To measure the participants' psychometric properties adequately, a short instrument measuring the prototypical components of The Big Five personality traits was included in the questionnaire. Also known as the five-factor model (FFM), The Big Five comprise a taxonomy for different personality traits [168]. The five factors have been defined as openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism [168,169]. This taxonomy enables researchers to study and compare specified domains of related personality characteristics without having to analyse each

individual attribute of the subjects comprising the study population [169]. These dimensions do not represent a particular theoretical viewpoint but were instead derived from analyses of the different terms people use to describe themselves and others [169]. This will in turn simplify comparison and interpretation of study results.

The Big Five Inventory (BFI) uses short phrases based on the trait adjectives known to be prototypical markers of the Big Five [169]. The structure is based on short descriptive sentences and statements, such as ‘is talkative’ and ‘worries a lot’. This simplifies and limits ambiguity and multiple meanings of the statements. The original BFI consists of 44 items designed to measure the five factors in the FFM without the individual facets. This version is considered to accurately measure and capture the factors’ core elements, without losing relevance and becoming too difficult for the participants to understand [169,170].

To avoid a negative influence on the response of extensive personality mapping , a 20-item version of the BFI, validated in a Norwegian population [171], was incorporated into the questionnaire to measure psychometric properties in the study population. This 20-item version is suitable for larger scale surveys where time is limited. Self-assessments were made on a seven-point scale, with only the extremes having verbal descriptions (‘disagree strongly’ and ‘agree strongly’) [171].

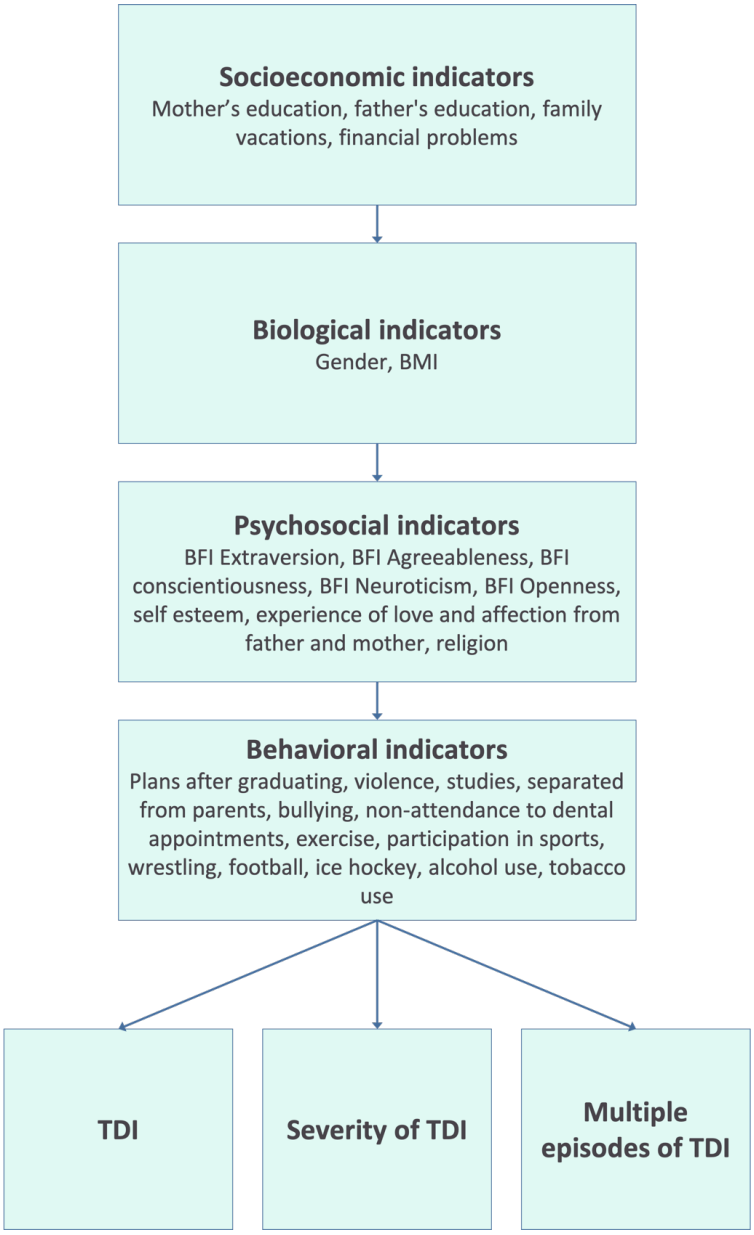

Fig. 4. *A hierarchical approach illustrating the theoretical framework of the study. BFI (Big Five Inventory); BMI (body mass index); TDI (traumatic dental injury).*

3.4 Ethical considerations

The study was carried out in close cooperation with the Public Dental Health Service and the School Administration in the former County of Hordaland. The project was approved by the Regional Committees for Medical and Health Research Ethics (REK) (Regional etisk komité, REK-Vest 2014/67). As the questionnaire was electronic, REK approved an exemption from the rules requiring informed written consent to collect relevant data from their Public Dental Health Service records. Participation by responding to the questionnaire was considered to be an acceptable form of consent. The participants were informed in writing that participation in the study was voluntary and that he or she could withdraw from the project at any time, without giving any reason and without any repercussions. They were also given the project organisers' contact information, in case they had any questions or wished to withdraw from the study. All students invited to participate in the study were over 16 years of age and according to Norwegian law were therefore legally able to provide consent on health issues [172].

Data collected were entered and securely stored in the SAFE database (secure access to research data and e-infrastructure), a solution developed by the University of Bergen (UiB) for secure processing of sensitive personal data in research [173]. To increase reuse of data and openness in research, the datasets and research data have been uploaded to UiB Open Research Data [174].

3.5 Statistical analyses

Data processing and analysis of the three papers constituting the present thesis were carried out using Stata (StataCorp) for Mac version 14 and 15. Detailed information about the different statistical methods used in each paper is presented in Table 5.

3.5.1 Drop-out analysis

The dropout analysis showed statistically significant uneven distribution between both gender and study direction in the final study sample. Girls were more likely than boys to respond to the questionnaire ($p < .01$). The response rate was also higher from

students pursuing general studies than for those enrolled in vocational studies ($p < .001$).

Table 5. *Statistical tests and methods used in the study.*

Statistical tests/methods	Paper I	Paper II	Paper III
Chi-square test	+	+	-
Bivariate logistic regression	+	-	+
Cohen's Kappa	-	-	+
Hierarchical multiple logistic regression	-	+	-
Coefficient of determination (R^2)	-	+	-
Kaplan-Meier estimator	-	-	+
Pairwise comparisons of marginal linear predictions	-	-	+
Log-rank test	-	-	+

4. Summary of results

4.1 Paper I

Traumatic dental injuries - prevalence and severity among 16-year-old students in western Norway

This paper assessed the prevalence, distribution and severity of TDI. Of the 5 184 pupils invited to participate in the study, a total of 2 354 accepted. However, 275 students only partly completed the questionnaire, and for 24 students the EPJ was unavailable (e.g., due to recent relocation to the county). These students were therefore excluded from further analysis. The final sample comprised 2 055 (48.4 per cent boys), a participation rate of 40 per cent. The median time required to answer the questionnaire was calculated to be 13 minutes. The prevalence of TDI was 16.4 per cent (338 students). The maxillary central incisors were most frequently affected (64.7 per cent of cases). A total of 637 teeth had sustained TDI, of which 58 had multiple diagnoses. Boys were more prone to injury than girls. The peak age for TDI was 8-10 years (50.9 per cent). Severity of TDI was: mild 563 (88.4 per cent), moderate 39 (6.1 per cent) and severe 35 (5.5 per cent). No significant seasonal effect was discerned on the occurrence of TDI.

4.2 Paper II

Traumatic dental injuries and experiences along the life course – a study among 16-yr-old student s in western Norway

This paper assessed risk factors for TDI by analysing different experiences along the life course. All eligible students (n = 2 055) were included in the analyses. Information on the occurrence of TDI and events during the life course were categorized as risk indicators. Socioeconomic, biological, psychosocial, and behavioural indicators were then analysed using the chi-squared test, and the variables with a significant bivariate association with three different dependent variables (presence, severity and multiple episodes of TDI) were tested in three separate hierarchical logistic regression analyses. TDI was more frequent among boys, adolescents with mothers/female guardians with

higher education, and adolescents with adverse psychosocial scores (low scores on conscientiousness, answering "yes" to the question "I like being the way I am" and reporting no plans after graduating from high school) and adverse behavioural scores (exercising 5-7 times per week). Moderate and severe TDIs were more frequent among adolescents with adverse psychosocial scores (reporting religion not being an important part of their life) and behavioural scores (failure to attend four or more dental appointments and those participating in the sport of wrestling). Multiple episodes of TDI were more frequent among adolescents with adverse psychosocial scores (reporting no love and affection from mother/female guardian) and adverse behavioural scores (moderate and severe TDI and participation in sporting activities).

4.3 Paper III

Traumatic dental injuries and pulp sequelae in an adolescent population

This paper investigates factors influencing the outcome of TDI, with special reference to factors related to development of complications. A total of 338 students had sustained TDI. The number with radiographs available for analysis in the EPJ was 308 (90.5 per cent). The total number of teeth available for analysis was 571. The prevalence of PN was 7.5 per cent. Moderate and severe TDI was associated with a higher frequency of PN. PCO and root resorption were found in 2.8 and 2.3 per cent respectively of teeth with TDI. Moreover, PCO was diagnosed only in teeth which had sustained a luxation injury. The median interval between the trauma and emergence of clinical and/or radiological manifestations of PN and PCO was two and 9.5 months, respectively. Complications developed more rapidly in teeth which had sustained moderate and severe TDI, according to Kaplan-Meier estimates. Dental hard tissue injuries were more prone to development of PN than luxation injuries and combination injuries. The relationship between stage of root development and the onset of PN was not statistically significant. There was no statistically significant difference between development of PN and place of emergency treatment.

4.4 Additional findings

Findings not included in Paper I-III relevant for the present thesis are presented here.

For validation purposes, additional information on gender distribution and prevalence of TDI among students not enrolled in public schools was obtained from the county of Hordaland. The prevalence of TDI for all pupils, including both the primary and the permanent dentition, was 25.7 per cent (n = 5 721). A total of 882 (60.1 per cent) with TDI were boys. Data related to TDI to the primary dentition was not presented in Paper I. Out of the 2 055 participants in the study, 175 had sustained TDI to the primary dentition. Thus, the total prevalence of TDI in the study population, including both the primary and the permanent dentition, was 25.0 per cent.

The relationship between independent variables from the questionnaire was explored. Alcohol consumption was linked with tobacco use ($p < 0.001$). In contrast to other students, those reporting alcohol consumption also reported having failed classes, ($p < 0.001$) and experiencing violence from family or friends ($p < 0.001$), These students had a DMFT score > 4 ($p < 0.01$). There was a statistically significant relationship between broken dental appointments and higher DMFT ($p < 0.001$).

4.4.1 Internal consistency reliability

To assess the internal consistency reliability of the questionnaire, Cronbach's alpha value was calculated for different sections of the questionnaire.

Table 6. *Measurement of internal consistency reliability using Cronbach's alpha [175].*

Test variables	Items in the scale	Cronbach's alpha	Average inter-item correlation
BFI-20: All items	20	0.76	0.13
- BFI-20: Extraversion	4	0.65	0.32
- BFI-20: Agreeableness	4	0.54	0.23
- BFI-20: Conscientiousness	4	0.52	0.21
- BFI-20: Neuroticism	4	0.73	0.40
- BFI-20: Openness to experience	4	0.61	0.28
"Self-concepts" (from Nicolau et al. [148])	16	0.74	0.15
Relationship with parents (from Nicolau et al. [148])	14	0.82	0.25

5. Discussion

5.1 Comments on the main findings

Oral health care policies and resource prioritization should be based on evidence of high quality. The present retrospective longitudinal study, which incorporates historical clinical data up to the time of data collection, is an appropriate and effective way of producing evidence of high quality with respect to different indicators of oral health in the population. This is the first comprehensive prevalence study on TDI to be conducted in Norway. Moreover, it is among the earliest studies to incorporate life course experiences into the evaluation of risk indicators related to TDI.

In Norway, organization of dental care for children and adolescents provides optimal conditions for large longitudinal studies, both retrospective and prospective. The results presented in this thesis are based not only on data from a questionnaire using a census approach, but also on relevant clinical data, retrieved from the participants' EPJ. The target population for the study comprised adolescents born in 1997, attending public high schools. Initially, a questionnaire was used for recruitment: by responding, the participants were permitting access to their dental EPJ. Descriptive data on the epidemiology of TDI were collected in a sample of 2055 students (Paper I). In Paper II, the data from the questionnaire were analysed, assessing risk indicators for TDI using experiences along the life course. Finally, relevant TDI data from the EPJ were collected and analysed, to assess TDI outcomes in affected students in the study population (Paper III).

In the following section, the findings of the present thesis are reviewed in the context of the applied study methodology and the existing literature related to TDI.

5.1.1 Prevalence, distribution and severity of TDI

Every year, several hundred million people worldwide suffer traumatic injuries [2]. As shown in a 2018 review and meta-analysis by Petti et al., TDI occurs frequently [41]. The authors concluded that over one billion people worldwide have sustained TDI at some time during their lives: thus, the estimated global prevalence of TDI in the

permanent dentition is 15.2 per cent. The results of Paper I are in accordance with these findings. Moreover, studies which include adolescents show a prevalence of TDI in the range of 10 to 20 per cent, which is comparable to the results presented here [13,26,74,76,80,82,87,89-92,94-96,98,100-102]. Combining TDI in the primary and permanent dentitions in the present study population results in a prevalence of 25 per cent. Data on all adolescents in the county, obtained from the County of Hordaland for validation purposes, show a prevalence of 25.7 per cent. This confirms that exclusion of adolescents who are not attending public schools did not affect the results of the present study. This is a major strength of the study, indicating consistency and accuracy in the data collection. Thus, the external validity of the study results is high.

Direct comparison of TDI prevalence reported in different studies is hindered by inconsistencies in inclusion criteria, classification systems, and cultural, geographical, environmental and socioeconomic differences. The present study used the WHO classification system, modified by Glendor et al. [2], which is not only widely accepted but also regarded as the gold standard. Thus, the present results are to some extent comparable with those of other studies using the same classification system. Moreover, as the study was conducted in Norway, the results are comparable with those of other Scandinavian countries with a similarly organized Public Dental Health Service.

To assess the prevalence of TDI, information from the participants' EPJ was analysed. Several studies have used only clinical or visual examination to record the presence of TDI [18,24,71,72,76,80,82] while other studies are based on retrospective dental records, similar to the present study [61,75,176]. Visual clinical examination alone does not cover all the diagnoses for TDI [2]. In particular, milder forms of luxation injuries could be underreported if prevalence was based on clinical examination alone. On the other hand, retrospective analysis of EPJs could exclude individuals who did not seek treatment after an incident of TDI. This could introduce measurement bias. However, the census approach used in the present study, as well as the organizational structure of the Public Dental Health Service, providing dental care, free of charge, for all children and adolescents from birth to 18 years of age, minimizes the risk of excluding those who did not seek treatment. In addition, this longitudinal retrospective

study is less subject to recall bias because the data were retrieved directly from the EPJ, rather than relying on the participants' later recollection of events [4]. Nevertheless, the results from similar studies using a longitudinal retrospective approach, remain largely dependent on high quality, accurate and consistent data in the EPJ.

The most common types of TDI, according to the literature, are uncomplicated crown fractures (e.g., enamel fractures and enamel-dentine fractures) [21,25,27,61,71,79,177]. This is also supported by the findings of the present study: 44.3 per cent of the registered diagnoses were uncomplicated crown fractures and infractions. An interesting finding is that compared with other studies, the occurrence of concussion and mild luxation injuries was relatively high [14,19,27]. Trauma registration in the patients' EPJ is organized in such a way that the operator is required to consider various elements when registering information related to the trauma, including information related to luxation injuries. This "streamlining" of data registration ensures consistent and reliable information and may account for the higher occurrence of mild luxation injuries in the present study.

Variations in luxation injuries reported in different studies are also closely linked to the classification systems used. Some classification systems are not designed to diagnose luxation injuries, thus deflating the actual occurrence. The results will also be influenced by variations in the clinical setting, the environment and equipment available when diagnosing TDI. Patients may also perceive mild luxation injuries as less important than more obvious, aesthetically disturbing dental hard tissue injuries. Thus, patients might be less likely to seek treatment for milder TDIs to the periodontal tissues [2]. It is therefore reasonable to assume that the true prevalence of mild luxation injuries is higher. This is especially true for studies using primarily visual examination as the basis for diagnosis, as the time elapsing between the injury and clinical examination may be considerable [124]. There is a relatively high probability that past luxation injuries will not be diagnosed by a clinical examination. However, if these injuries are registered during the emergency treatment, the retrospective use of EPJ data will record the prevalence of luxation injuries more appropriately, compared with a present-day clinical examination.

Several studies show unmet treatment need related to TDI, both in developed countries [53,84] and developing countries [8,33,178]. The reasons are unclear [1]. In developing countries, the majority of the population may be unable to afford private dental treatment, and the public services are unable to offer more comprehensive treatment [1]. Unmet treatment need can also be related to the availability and competence of care outside working hours [179]. One factor which could result in low rates of treatment is that TDI is not classified as a disease, and information and public health education about dental trauma is very limited [180]. As a result, patients and their parents or guardians may not attach much importance to TDI [1]. The individuals' different experiences with TDI, the current emergency situation and subsequent treatment will also affect the rates of treatment. Another factor which may also affect the outcome could be the dentist's lack of knowledge about management of dental trauma [181,182]. Previous studies have disclosed evidence of general worldwide inadequate knowledge among dentists with respect to managing and treating TDI [183-185]. In contrast, the Norwegian Public Dental Health Service is responsible for the dental health care of the population from birth up to the age of 18 years [186], ensuring that the patients included in the present study receive equal treatment of high quality and routine follow-up of TDI, regardless of time and place of injury, SES and residence. Moreover, the patients' EPJ includes a standardised trauma record, which, is therefore very likely to include notes on all, or almost all, episodes of injury. However, as stated previously, the prevalence of mild luxation injuries, such as concussions and subluxations, may be under-reported because people do not seek treatment [2]. In order to offer the patient the best treatment for TDI, a thorough diagnostic procedure which registers both luxation and fracture injuries is important [187].

Boys were significantly more prone than girls to TDI. This is widely acknowledged in the literature [9,25]. However, Glendor in 2008 [9] observed a relatively recent decline in gender-related differences in occurrence and this is confirmed by other studies [20,71,100,188]. The reason may be increasing exposure of girls to the same risks as boys, such as participation in sports [20,109].

The maxillary incisors were the most affected teeth, which is in accordance with the literature [9,17,18,71,73,75,80,177,189]. A major reason is the vulnerable position of these teeth in the dental arch [9,17], together with the well-established link with oral predisposing factors, such as increased overjet with protrusion and inadequate lip coverage [4,109,110,114]. The peak age for TDI was found to be 8-10 years of age, which is also in accordance with the literature [15,21,59,177]. Furthermore, Paper I disclosed no statistically significant difference in seasonal occurrence of TDI. There is no consensus in the literature on this question. Some studies show that TDI occurs more frequently during the summer [75,92,190,191], others show a higher occurrence during the winter [15,113,192], and others show no statistically significant difference in seasonal occurrence [15,20,27]. This may be related to climate differences, where certain seasonally dependent activities or sports dominate in certain geographical areas [2].

Most studies of prevalence and risk factors are conducted on subjects aged 10 to 14 years (Table 3). According to the literature, the age group in the present study is not frequently studied. This also highlights the need for similar studies. In addition, most prevalence studies include different age ranges within their study population, whereas the present study concentrates on a specific age group, using a census approach. Moreover, in the present study, the retrospective longitudinal design ensures that all injuries sustained before the time of data collection will also be registered.

According to Norwegian law, those aged 16 years or more are legally able to provide consent on health issues [172]. Including subjects under 16 years of age would require parental consent for participation in the study and this would result in the need for considerably more data collection and a higher probability of non-response.

5.1.2 Life course experiences in relation to TDI

To date, only one study has applied the life course approach to further elucidate the causes of TDI: Nicolau et al., 2003, with data from Brazil [148]. In the present study, gender and adverse scores for behavioural and psychosocial parameters were associated with increased risk of TDI. This is in agreement with the above-cited study

by Nicolau et al. However, the sociodemographic, cultural, and environmental differences between the study populations make it difficult to compare the results.

Few studies on TDI have included information on SES, and the results are contradictory. Some studies report increased risk of TDI associated with lower SES [73,193], whereas others report greater prevalence among adolescents from higher socio-economic groups [98,118]. In the present study, the risk of TDI was increased in adolescents with mothers or female guardians with higher education, a finding which is supported in the literature, with Marcenes et al. in a study from 2001 arguing that the greater risk of dental injuries among children with higher SES may be related to their readier access than low SES children to expensive, high-risk sporting activities [118] .

The severity of TDI was associated with participants who reported that they considered religion/beliefs as unimportant in their personal life. This finding is difficult to interpret, as there are no data available in the literature for comparison. Studies show that 22 per cent of the Norwegian population believe in a god or deity. According to research conducted by TNS Opinion & Social at the request of the European Commission, as well as official statistics from Statistics Norway, this makes Norway one of the least religious countries in western Europe [194,195]. Between 2009 and 2019 the number of baptisms in Norway decreased by 34.3 per cent [196]. In the present study, 17.4 per cent of participants reported religion to be an important aspect of their personal life. This is also confirmed in the literature, where studies show that adolescents and younger people are less religious than the general population [195,197]. In addition, risk taking is also found to be inversely associated with religion [198]. This might explain the increased number of moderate and severe TDI in this group. In this context, however, it should be noted that some participants may have perceived the topic of religion as sensitive [199].

The participants whose sport was wrestling were found to be more prone to moderate and severe TDI. The literature reports high injury rates for wrestling [200-202] particularly injuries to the face, head and neck [203-205]. However, in the present study, only a few subjects reported participating in wrestling and the results should

therefore be interpreted with caution. In this context, a further obstacle to comparison of studies is the lack of a standardized classification of severity of TDI.

The study revealed an association between moderate and severe TDI and broken dental appointments. This finding should be interpreted with caution, as the results were based only on a count of non-attendance. Adolescents who sustain a TDI require a number of dental appointments, for treatment and follow-up. This in turn may lead to a relatively higher risk of broken appointments than for those without TDI. However, from a socioeconomic perspective, multiple broken appointments by those with TDI could impact direct and indirect treatment costs [206].

There are few studies of multiple episodes of TDI [61,207] and only limited information is available about associated risk factors. In the present study, a total of 43 participants (2.1 per cent) had experienced multiple episodes of TDI. This represents 12.7 per cent of the those with TDI in the study population. Thus, multiple episodes are relatively infrequent. An association was found between multiple episodes of TDI and participation in sporting activities and severity of TDI. According to the literature, participation in different sporting activities is one of the most commonly reported risk factors for TDI [4,25] and this could explain the association with multiple episodes of TDI. Severity of TDI is also associated with participation in sporting activities [93,208].

As well as analysis of the TDI-related data from the questionnaire, the relationship between the independent variables was explored and disclosed a link between alcohol consumption and tobacco use, failed classes, violence and high DMFT scores. A study by Robbins & Bryan (2004) linked alcohol and tobacco use with behavioural problems and revealed that higher impulsivity is a predictor of alcohol problems, alcohol use and cigarette smoking [209]. In the present study, no association was found between TDI and smoking and/or use of alcohol. Questions related to alcohol consumption and substance abuse are regarded as sensitive topics by the respondents, not least because the study participants were below the legal drinking age in Norway [210,211]. The results are therefore difficult to interpret and generalize.

5.1.3 Pulpal responses and complications following TDI

Both severe injuries and pulpal sequelae were relatively infrequent in the present study. Although previous studies show that mild and moderate TDI infrequently results in PN, [189,212,213] it is important to note that such injuries may still need treatment or follow-up, to monitor possible long-term sequelae in the teeth, bones and soft tissues [1]. Sequelae can emerge several years after the incident [1]. Emergency treatment is of importance to the long-term prognosis of the affected teeth. However, even with adequate treatment and follow-up, loss of teeth may be inevitable [214-216]. In contrast, some studies report a low frequency of moderate and severe injuries [160] which in turn results in relatively low frequencies of PN and other complications.

In the present study, the prevalence of PN was 7.53 per cent, which is comparable to the findings of Borssén & Holm in 2000 and Wang et al. in 2014 [217,218]. It was of interest to note that dental hard tissue injuries were associated with higher frequency of PN. This is in contrast to the literature, where luxation injuries are reported to have a higher risk of developing PN [124]. However, the different studies cover a wide range of severity of TDI, from mild concussions to severe intrusions. In the literature, severity of TDI is associated with development of PN [121,122,134,219-222]. Further, the literature shows that the risk of developing PN after luxation injuries ranges from 15 to 59 per cent [124], which illustrates the heterogeneity of the different outcomes of the different injuries.

The high prevalence of PN associated with dental hard tissue injuries could include undiagnosed luxation injuries or undiagnosed pulpal exposure associated with enamel-dentine injuries and infractions. Thus, the number of undiagnosed injuries would inflate the reported occurrence of PN for dental hard tissue injuries. A clinical examination, to complement the collection of data from the participants' EPJ, would strengthen the study design.

The literature affirms the relationship between the stage of root development and the occurrence of PN: mature teeth are more at risk of developing PN than immature teeth [134,223]. It was of interest to note that in the present study, there was no statistically

significant difference between the two groups with respect to the occurrence of PN. However, this result should be interpreted with caution, given the small number of cases with PN and severe TDI in the study population.

PCO was found in 2.8 per cent of teeth with TDI, a lower prevalence than reported in the literature [124]. However, it was of interest to note that all teeth with PCO had sustained a luxation injury, confirming the proposal that coronal fractures and dental hard tissue injuries *per se* do not cause PCO [124], as reported in the Swedish study by Stålhane & Hedegård [128] in 1975. The mechanism underlying the development of PCO is not fully understood, but it is assumed to be associated with disruption to the neurovascular supply of the pulp at the time of injury [224], which also supports the hypothesis that PCO are related to luxation injuries.

Generalisability and impact of the findings

Using the numbers presented here, the results from the meta-analysis by Petti et al. in 2018 [41] would imply that globally, a total of 75 million teeth affected by TDI need endodontic treatment. A study by Glendor et al. (2001) of Swedish children and adolescents, aged between 1 and 17 years, reported that TDI results in both direct and indirect costs, determined primarily by the severity of the injury [46]. Based on the finding that the frequency of sequelae related to TDI in the present study was low, and the number of potential individuals affected by TDI worldwide, [41,46] it could be argued that both the societal and individual impacts of TDI are limited. However, generalisation of results is problematic, because of the limited number studies to date on the outcome and severity of TDI, and cultural, geographical and eco-epidemiological differences in the different study populations.

Radiography is essential for appropriate diagnosis and prognosis and for planning treatment and follow-up of TDI. In this study, the radiographs were of high quality (Paper III). However, variations in intra-oral radiographic techniques at different clinics (n = 54) could introduce bias when interpreting and analysing data, especially in determining the stage of root development and PAI-scoring. A suggestion for future research would be to analyse the potential impact of intra-oral radiographic techniques

and operator variables such as the clinician's age, experience and gender on the outcome variables related to TDI.

5.2 Methodological issues

5.2.1 Comments on the study design

Various life-course concepts and models are described in the literature [144,145,225,226] and most include both positive and negative incidents and experiences over time. Among the strengths of the present study are the historical clinical data from early childhood to the time of data collection, linked to the cross-sectional design of the questionnaire. However, the notion of time becomes important in analysis of changes in the life course indicators studied (socioeconomic, biological, psychosocial, and behavioural indicators). While the questionnaire used in the present study collected relevant data from the respondents up to the present, only one measurement-point was used when collecting data. This limits the potential for creating trajectories and studying intra-individual development and changes [227,228]. Moreover, in contrast to the data from the questionnaire, the outcome variables used to study risk related to TDI (prevalence, severity, and multiple episodes of TDI) cover a period of time. As a result, some TDIs sustained at an early age might not be explained by indicators measured at the present time. However, most factors with the potential to influence adolescent health and well-being (socio-economic, biological, psychosocial and behavioural) are established during childhood and early adolescence [229]. Nevertheless, because data on each participant are recorded only once it would be difficult to infer a temporal association between a risk factor and the outcome [227,230]. Determination of causality is therefore challenging [230,231].

A disadvantage of multiple measurement-points is that compared with cross-sectional designs, the process itself is resource demanding and slow to produce long-term later life course outcomes [228]. The result is a limited effect on policy and practice. Moreover, a cross-sectional design allows recording of exposure to many risk factors and assessment of more than one outcome [230].

5.2.2 Reliability and validity

Reliability

Reliability is defined as the consistency or stability of a measure of behaviour [232,233]. (Figure 5). Test-retest reliability is assessed by measuring the same individuals at two points in time. A correlation coefficient can then be calculated to determine the relationship between the first- and second test scores [232].

Cronbach's alpha [175] was measured for the different scales and items used in the questionnaire (Table 6). The results confirmed acceptable to good internal consistency reliability for the different items [234]. However, there are a number of limitations to applying Cronbach's alpha to a test or scale. One requirement is that all items must be equally good indicators of the single construct they share, so-called tau-equivalence. This is a difficult requirement to fulfil, and alpha may not provide an accurate estimate of the scale's true reliability. Moreover, if the number of items is too small, the "true" reliability will be underestimated [235] whereas too many items will inevitably inflate the alpha. Thus, alpha should be calculated individually for each of the concepts in the test [234]. In the present study, ordinal scales were used to analyse psychometric properties, personality characteristics and behavioural and attitudinal variables. However, a disadvantage of alpha as a reliability coefficient is that it is not optimized for asymmetrical or ordinal data [235]. The computations involved in determining alpha rely on continuous data [166]. When analysing ordinal data, such as the data from the scales used in the questionnaire in the present study, where the response options are graded on an ascending scale, from less to more agreement, it cannot be assumed that the increases marked on the scale represent equal-interval increases of the variable [166]. When measuring the adolescent-parent relationship in the questionnaire using a 4-point scale ("not at all", "a little", "quite a lot", "a great deal"), it cannot be assumed that the increment in relationship quality represented by the difference between choosing "a little" rather than "not at all" is the of the same magnitude as the difference between "a great deal" and "quite a lot".

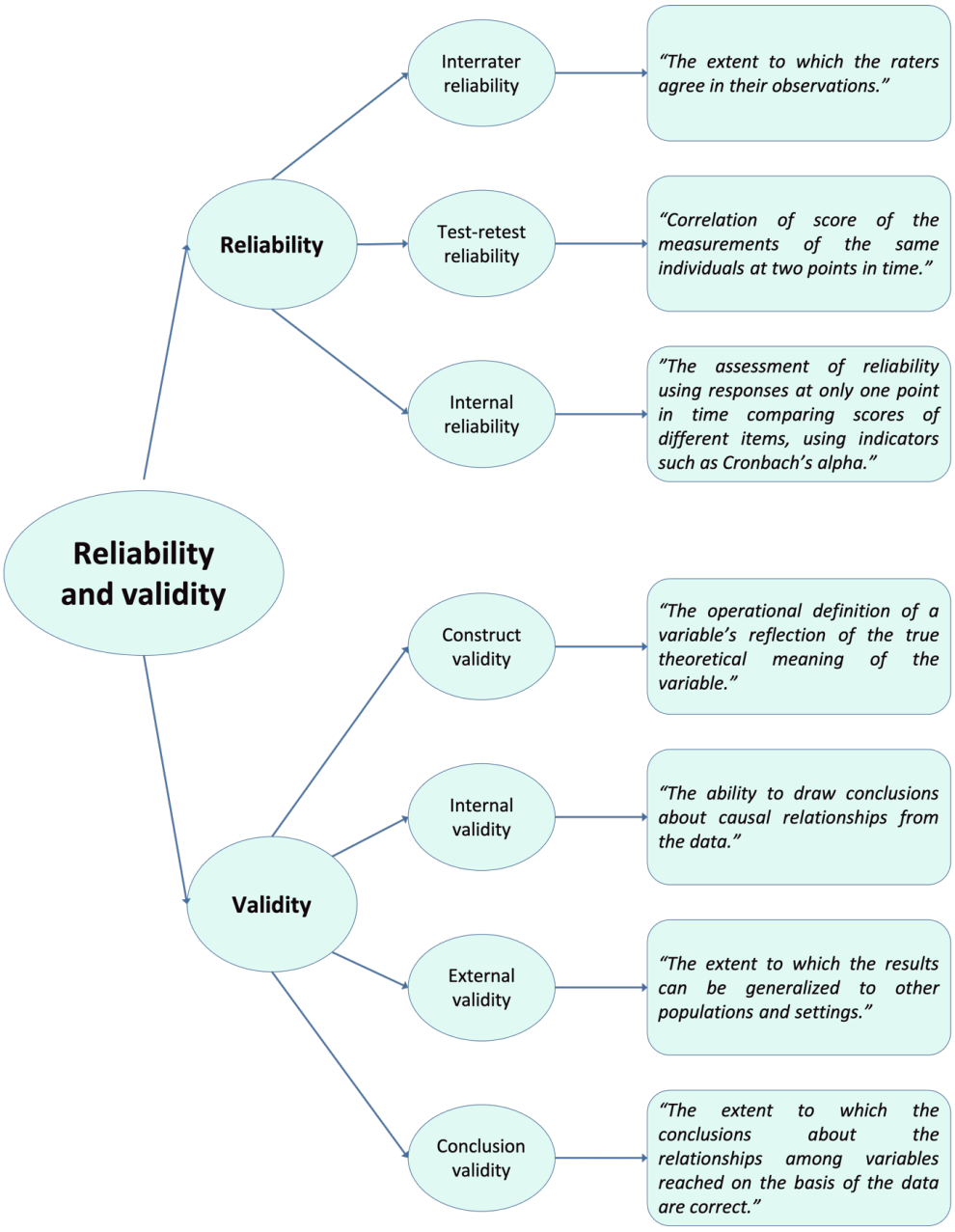

Fig. 5: *Assessing reliability and validity in research. Adopted from Cozby (2009) [232].*

When describing the relationship of a scale's items to the latent variable, it should also be noted that a relatively high alpha is no guarantee that all the items reflect the influence of a single latent variable [166]. Factor analysis is a useful analytical tool which can determine empirically, in a way that reliability coefficients cannot, how many constructs, latent variables or factors underly a set of items [166]. It can also be used to condense information into fewer variables. Finally, it can provide information on the meaning of the latent variables, by identifying groups of items that covary with one another and appear to define meaningful underlying latent variables [166]. To further evaluate and develop the methodology and the dataset produced in the present study, a factor analysis of the items in the questionnaire would be appropriate for future analyses. This may strengthen the reliability of the questionnaire, by eliminating redundant variables or adding relevant variables.

The interrater reliability for the interpretation of PAI-scores, PAI-score calibration and the stage of root development, were estimated using Cohen's Kappa coefficient. The PAI [161] was used to calibrate observers assessing periapical pathology on radiographs. Cohen's Kappa values were in the range of 0.68 to 0.91 (Table 4). According to Landis & Koch these results are considered solid to almost perfect [163].

Validity

Whereas reliability shows how much a variable influences a group of items, validity discloses whether the variable is the underlying cause of item covariation [166,236]. The adequacy of a scale as a measure of a specific variable (e.g., perceived psychological stress) is a topic of validity [166].

As shown in Figure 5, some authors have assigned a broader or narrower meaning to the term validity [164,237]. According to the more conventional, traditional interpretation, validity is inferred by determining how well a domain has been covered by a specific set of items reflecting a content domain (content validity), its ability to predict specific events or success rates (predictive- or criterion validity), or how well the test measures the traits it is supposed to measure (construct validity) [164,166]. Moreover, in recent decades, it has been accepted that construct validity subsumes

several aspects of validity, such as criterion-, content-, face- and concurrent validity [232,237,238]. During the design phase of the present study, the face validity of the questionnaire was tested on a group of upper secondary school students (n = 6) [164,165]. Based on the information received, some minor changes were made to the variables in the questionnaire. Internal validity refers to the relationship between the dependent and independent variable and the ability to draw conclusions about causal relationships, while external validity refers to the generalizability of the results to other populations and settings [232]. Finally, conclusion validity is the extent to which the conclusions about the relationships among the variables reached on the basis of the data are correct, often referring to statistical aspects of the results [232].

Appropriate outcome measures are important to ensure external validity and to allow the conclusions to be extrapolated to populations other than that in the specific study [239,240]. Outcome measures should not only capture clinically meaningful change, but should also facilitate comparison of studies [239]. This can only be done efficiently if there is consistency in choice of outcome measures and the manner in which they are recorded and presented [239].

The development of the COS by the IADT will enable researchers to better compare and combine data from clinical studies and trials, leading to improved research outcomes. This may facilitate the compilation of future treatment guidelines for TDI [55]. The present study was conducted prior to the construction of the COS by IADT. Due to the retrospective longitudinal design of the study, it would not have been possible to implement all elements of the COS. However, several aspects are covered, such as injury activity, physical consequences of the disease, functional status and health resource utilisation. Moreover, combining and merging future research data with the present dataset could facilitate the inclusion of further elements of the COS in the study, such as trauma-related dental anxiety, quality of life and other patient-related outcomes.

In the present study, the respondent's SES was based on the level of education of the mother/female guardian and father/male guardian. This is a potential limitation to both

internal and external validity. The Hollingshead Four Factor Index of Social Position is a well-documented index used for these purposes [241], and there are translations which have been validated in a Scandinavian population [242,243]. However, over time, measuring the level of education has become the most commonly used measure of SES in epidemiological studies [244,245]. According to a review of the literature by Liberatos et al., information about parental educational levels is relatively easy to obtain from the participants and is associated with a variety of outcome variables [244].

Around 10 per cent of Norway's population lives in the county of Vestland, including in Bergen, Norway's second largest city [156]. Outside the Bergen metropolitan area, the county is mainly rural and sparsely populated. The average household income of families in the county is similar to the national average [246]. Thus, Vestland can be considered a representative region for epidemiological research in Norway and Scandinavia.

5.2.3 Non-response bias, confounding and drop out analyses

Most violations of internal validity can be classified into one of three general categories: confounding, selection bias and information bias [58,167,247]. A potential threat to the internal validity of the study is non-response bias, whereby adolescents who had experienced TDI would be more likely to participate in the study than those with no TDI experience. This may be a result of the effect of "demand characteristics". The participants may have their own interpretation of the purpose of the study and subconsciously change their behaviour to fit that interpretation [248,249]. However, data on prevalence of TDI for all adolescents in the entire county were acquired from the county government and affirm that these potential biases have not affected the results of the present study.

The phenomenon "demand characteristics" partially overlaps with the term acquiescence bias (agreement bias), which is defined as the tendency of participants to agree with statements presented to them [250]. Also, all studies based on information from questionnaires and interviews rely on human knowledge and memory and are therefore subject to error [251]. While electronically administered questionnaires avoid

interviewer influence on responses, the response rates are typically lower than to personal interviews and may not be suitable for obtaining complex information [251,252]. Because of the validity of the different items used in the questionnaire, it is considered unlikely that the above-mentioned factors have had any significant effect on the results.

The response rate and the risk of selection bias may also be influenced by the fact that people place different levels of importance on various attributes associated with the survey request, the so-called leverage-saliency theory [253,254]. For instance, if the topic of the questionnaire has low leverage for the participant, he/she may not be adequately motivated to agree to participate [253]. In most cases, an incentive, often monetary, is introduced to increase the leverage and thus the probability of the person responding to the questionnaire. In the present study, a monetary incentive, in the form of a raffle of three tablet computers, was introduced to improve the response rate. If a sample person views an incentive positively, this may tip the scales towards a decision to participate.

A major strength of the study is that the census approach reduced the risk of selection bias. However, it should be noted that there is a potential risk of unintentional selection bias when administering the questionnaire. The electronic administration of the questionnaire relies on accurate contact information and e-mail addresses for each person in the target population, and also equal accessibility to internet and e-mail services [255]. Compared with paper surveys, web-based surveys have substantially higher rates of non-delivery [256,257] and lower response rates [256-258]. In recent years, however, the differences in response rates between the two methods have decreased [259]. Moreover, adolescents in today's technology-driven society are more open and responsive to electronically administered questionnaires than to paper-based questionnaires.

In addition to the clinical data from the EPJ, all the papers (Papers I-III) are, to different degrees, based on data and information collected from the electronically administered questionnaire. Some participants may perceive self-reported data on behaviour,

psychosocial characteristics and SES (Paper II) as sensitive [199]. People feel a need to present themselves in a favourable light and to appear more altruistic and society-oriented than they essentially are. “Socially desirable responding” is the tendency of individuals to deny socially undesirable actions and behaviours (drug abuse, sexual behaviour, political and religious questions), and to admit to socially desirable ones [199,260,261]. Some studies show that topic sensitivity influences response rate [262,263]. However, most empirical research has instead focused on the effect of topic saliency, which has been shown to be a major determinant of response rate [199,264].

The data acquired from the county administration about gender distribution and prevalence of TDI among students who were not enrolled in public schools show very similar prevalence in the two populations. Conversely, the dropout analysis showed a skewed distribution, where girls and students in the general studies courses were more likely to respond to the questionnaire. This finding is presented and discussed in Paper II.

Thus, the overall external validity of the study is strong, and the participants are considered to be representative of 16-year-olds in the County of Hordaland.

6. Conclusions

The present thesis, based on a retrospective longitudinal census study, provides important information about the occurrence of TDI, relevant risk factors along the life course and sequelae to TDI in Norwegian adolescents. Occurrence is moderate and influenced by life course experiences. Adverse sequelae are infrequent.

The following conclusions are drawn from the results:

- The occurrence of TDI among Norwegian adolescents is moderate: mild injuries are more frequent than moderate and severe injuries.
- Gender and age are risk factors for TDI, with boys and the age group 8-10 years being at risk.
- Adolescents whose mothers have higher educational levels are at higher risk of TDI.
- Adverse psychosocial scores are associated with higher risk, greater severity and multiple episodes of TDI.
- Adverse behavioural scores are associated with higher risk, greater severity and multiple episodes of TDI.
- Experiences along the life course is important in the evaluation of risk indicators related to TDI.
- Among adolescents with TDI, the occurrence of PN, PCO and root resorption is low.
- The severity of TDI and the presence of dental hard tissue injuries are risk factors for developing PN.
- Development of PCO was related to luxation injuries.

7. Implications and future perspectives

This thesis presents new knowledge about the occurrence of TDI in Norwegian adolescents, risk factors for TDI and risk factors for different sequelae to TDI. Studies of the risk of TDI in a non-traditional perspective may influence health authorities in the development of appropriate preventive measures and could also help to improve patients' knowledge of TDI.

The use of a single measurement point when establishing risk factors related to TDI limits the potential for creating trajectories in oral health indicators and therefore limits policy implications of the study [225]. Thus, further follow-up and additional studies are needed to establish causality. Studies incorporating a life course approach will be important in the evaluation of risk indicators related to TDI.

The prevalence of TDI indicates the need for preventive measures. As trends in other oral diseases, such as caries incidence, decrease, resources should be reallocated for education and treatment of TDI. As almost 40 per cent of the injuries occurred during school hours, schools are strategic platforms for delivering preventive programmes [114,265,266]. Schools provide an efficient and effective means of reaching large numbers of the target population [265]. The results of this study will give dentists managing TDI a more solid basis for preventive measures and treatment and thus improve the prognosis of the affected teeth.

The literature affirms that 7 to 25 per cent of dental injuries are to different degrees preventable, and preventive measures such as helmets and mouthguards are indicated when practicing contact sports and traffic activities (bicycle and motor cycle) [267]. The introduction of protective gear such as facemasks and helmets have virtually eliminated oral and dental injuries from sports like American football [268]. However, there are limited data available on the actual effectiveness of the different protective devices [267]. Thus, there is a need for epidemiological studies on prevention of sports injuries and the value of protective devices.

Reporting the economic burden is important in evaluating the societal relevance of preventing and addressing oral disease [269]. In the literature, the number of studies on the economic impact of TDI is limited [206]: hence there is a need for further research, into both the societal and individual economic burden of TDI.

Factor analysis can be used to disclose the latent variables or factors underlying a set of items [166]. A factor analysis of the items in the questionnaire is currently in progress.

Operator-related bias is introduced when different techniques and equipment are used to diagnose TDI. There is a need to investigate the impact of different intra-oral radiographic techniques and operator variables related to TDI among dental personnel in the Public Dental Health Service in Norway. Another relevant factor is the recent introduction into dentistry of machine learning and deep learning, a sub-domain of artificial intelligence (AI). This offers enormous opportunities within dental research, the development of image analysis, diagnosis and record keeping [270]. Dental educators need to acknowledge the introduction of clinical AI solutions by encouraging digital literacy in future dentists and dental personnel [270].

Finally, an additional important preventive measure is to map the impact of non-traditional causes of TDI. A good example is the recent introduction of mass-sharing of stand-up electric scooters (e-scooters) in different countries and the increased risk of injury. In a preliminary report from Norway, including 815 individuals who sustained injuries from e-scooter use, a total of 333 (41 per cent) were under the influence of alcohol at the time [271]. In most countries, there are regulations and legal consequences for driving motorized vehicles while intoxicated, but current laws do not include the use of non-motorized road vehicles, including e-scooters [272]. The few studies to date on the topic of e-scooters report an increased risk of injury, including dental and craniofacial injuries [273-276]. Lack of awareness of the potential risks of using e-scooters, and limited use of safety equipment are associated with increased risk of injury [273,277,278].

In a report by Chalmers and Glasziou (2009) [240] it was reported that fewer than 50 per cent of research studies conducted worldwide are accepted for publication [240]. It is vital that results, including those which confirm the results of earlier studies, are published. This is especially true for research related to dental trauma, where most of the studies are conducted in Denmark by the Copenhagen group [119]. In the last two decades, over two-thirds of the scientific publications related to TDI are published by the top ten countries [279]. To reduce reporting bias within the dental trauma literature, increasing the number of studies as well as encouraging studies from other research groups worldwide will help to reinforce the knowledge base. It is, however, crucial that future research is of the highest possible quality. The use of validated survey instruments, standardized classification systems and a standardized set of outcomes is highly encouraged.

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9. Table and figure legends

- **Table 1.** Different classifications used for TDI, based on Petti et al., (2018) [41] updated for 2020.
- **Table 2.** Incidence (yearly, per cent) and causes of TDI in different countries. (n.a = not available).
- **Table 3.** Prevalence (per cent) and causes of TDI in different countries (n.a = not available).
- **Table 4.** Cohen's Kappa coefficient (95 per cent CI) for the intra- and inter-observer agreement in the interpretation of PAI-scores (calibration) at the first (R1) and the second (R2) readings.
- **Table 5.** Statistical tests and methods used in the study.
- **Table 6.** Measurement of internal consistency reliability using Cronbach's alpha [175].

- **Fig. 1.** Environmental and behavioural causes of TDI, from Glendor et al. (2019) [2].
- **Fig. 2.** Hypothetical causal life course models with exposures operating at different points along the life course, modified from Kuh et al. (2003) [145].
- **Fig. 3.** Sampling and number of participants in Paper I-III.
- **Fig. 4.** A hierarchical approach illustrating the theoretical framework of the study. BFI (Big Five Inventory); BMI (body mass index); TDI (traumatic dental injury).
- **Fig. 5:** Assessing reliability and validity in research. Adopted from Cozby (2009) [232].

10. Original Papers I – III

I

Bratteberg M, Thelen DS, Klock KS, Bårdsen A.

Traumatic dental injuries - prevalence and severity among 16-year-old pupils in western Norway. **Dent Traumatol. 2018;34:144-150.**

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ORIGINAL ARTICLE

WILEY Dental Traumatology

Traumatic dental injuries—Prevalence and severity among 16-year-old pupils in western Norway

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Abstract

Background/Aims: Published data on prevalence and severity of traumatic dental injuries (TDI) in Norway are limited. The aims of this study were to assess prevalence, distribution and severity of TDI in the permanent dentition of 16-year-old pupils in western Norway.

Material and methods: A retrospective longitudinal study, including historical clinical data, was conducted among 16-year-old high school pupils in the County of Hordaland, western Norway. First-grade pupils attending high school, born in 1997, were invited to participate (n = 5184). Consent was given to access their dental records in the Public Dental Health Service in Hordaland, where information regarding TDI (diagnosis and treatment) and radiographs was interpreted. Only TDIs to anterior teeth were recorded (canine to canine in the maxilla and mandible) and classified using a modified version of the WHO's classification.

Results: A total of 2055 participants were included (response rate 40%). TDI prevalence was 16.4% (338 pupils), with the maxillary central incisors most affected (64.7%). A total of 637 teeth were involved. Boys were more prone to injury than girls ($P < 0.05$). Severity of TDI was divided into 3 groups (mild, moderate and severe), with the following distribution: 563 mild (88.4%), 39 moderate (6.1%) and 35 severe (5.5%). Peak age for TDI was 8-10 years (50.9%).

Conclusions: Prevalence of TDI among Norwegian adolescents was moderate. Milder injuries were more frequent than moderate and severe injuries. Age and gender were risk factors with regard to TDI. Seasonal influence on the occurrence of TDI was not statistically significant.

KEYWORDS
adolescents, prevalence, severity, traumatic dental injuries

1 | INTRODUCTION

Traumatic dental injuries (TDI) primarily affect children and adolescents,[1–3] but may occur at any age.[1,4,5] TDI may entail long and complex treatment with poor knowledge of the long-term prognosis. Furthermore, TDI involves direct and indirect costs that may be a burden on the affected individuals, their respective families and society.[2,6–9] Studies show varying results regarding the influence of social class on TDI.[10–16]

Traumatic dental injuries represent an acute condition with pain and discomfort. Severe cases of TDI may result in extensive loss of teeth and supporting soft and hard tissues. This, in turn, may lead to interference with normal occlusion. Hence, the ability to chew, speak and smile can be influenced. This has a negative psychological effect on victims[17–19] and impacts on oral health-related quality of life.[20–24] Cortes et al.[23] reported in 2002 in Brazil that children with untreated TDI were 20 times more likely to report impacts on Oral

Health-Related Quality of Life (OHRQoL) compared with children who had not experienced TDI. Thelen et al.[21] reported in 2011 that TDI among Albanian adolescents with unmet treatment need after experiencing TDI is associated with reduced OHRQoL.

Studies on the incidence of TDI are few.[11,25–30] There is no evidence that the incidence of TDI is increasing, and studies suggest that the global incidence of TDI is <5% per year, as reported in a literature review by Lam in 2016.[31] Studies from Scandinavia indicate an annual incidence of TDI in the range of 1.3%-3.0% among 7-19-year-olds.[26,28,32] Severity of TDI among Norwegian children and adolescents aged 8-17 years was reported by Skaare et al.[33] From a total of 1275 injured individuals, mild, moderate and severe injuries comprised 89%, 7% and 4% per year, respectively.

Prevalence of a disease is the proportion of the population with the disease at a specified time.[34] The prevalence of TDI gives information on the proportion of total exposure of TDI in a given population. This information is important when making guidelines on prevention of TDI and planning preventive strategies and when creating educational campaigns aimed for health personnel and the public. The prevalence of TDI among 12-year-old children in Brazil is as high as 1 in 3 children, as reported by Dame-Teixera et al.[35] in 2013. In Sweden, Borssén et al.[36] reported a similar result in 1997 among 16-year-olds. In Canada, the proportion is close to 1 in 5 for the same age group, as reported by Locker in 2005,[37] and in Turkey, the prevalence was close to 1 in 10, as reported by Altun et al.[38] in 2009. Thelen et al.[39] reported a prevalence of 9.9% in an Albanian adolescent population in 2010 (16-18 years of age). In a systematic review published in 2015, the average prevalence of TDI among children and adolescents was calculated to be 17.5%.[40] Differences in sampling method, age groups and classification systems of TDI used in the different studies give variations in prevalence in different studies.[41] No comprehensive prevalence studies of TDI have been conducted in Norway.

The maxillary central incisor has been reported to be the most affected tooth.[2,8,16,25,28,38,42,43] However, the severity of injury related to relevant cause and impact is not clear.

Boys are more at risk of TDI than girls, as reported in several studies.[5,10,11,25,37] At the same time, some studies show that the increased involvement of girls in sporting activities may lead to a decline in gender disparities with regard to TDI.[2,3,29]

The aim of this study was to assess the prevalence, distribution and severity of TDI in the permanent dentition of 16-year-old high school pupils in Hordaland, western Norway.

2 | MATERIAL AND METHODS

The study was carried out in Hordaland, western Norway. The county population is 498.135 persons of all socio-economic backgrounds.[44] The county government is responsible for the public upper secondary education. The Public Dental Health Service is responsible for the dental health care for all children and adolescents up to the age of 18 years (free of charge).[45] Thus, this study was conducted among pupils in first grade in the public upper secondary education system and carried out in close collaboration with relevant government departments of Hordaland.

In the first grade of the upper secondary education of the school year 2013/2014, there were 6983 pupils including both general studies and vocational studies in 58 different public high schools. The target group was 16-year-old pupils (born in 1997). Pupils older than this, but in the same grade, were excluded from participating. Data and information on school and educational structure, as well as names and number of registered pupils, were acquired from the Hordaland School Administration. The total number eligible was 5184 children for the school year 2013/2014, with 50.8% and 49.2% following vocational studies and general studies, respectively. The gender distribution in the sample was 52.1% boys and 47.9% girls.

A recruitment letter with information about the aim of the study and a link to a closed-ended electronic questionnaire (SurveyXact) was sent by electronic mail and an SMS message to all 5184 pupils. After 2 weeks, a reminder was sent through the same channels. Information graphics were sent beforehand to headmasters of all 58 high schools with the purpose of increasing awareness of the study. In addition, 3 tablet computers were raffled between participating pupils with the intention of increasing the response rate.

By returning the electronic questionnaire, the respondents gave their consent to the use of information from their electronic patient journal (EPJ) in the Public Dental Health Service. The questionnaire was used for recruitment purposes, and assessed socio-economic, biological, psychosocial and behavioural indicators. However, only clinical data extracted from the EPJ were used in this study.

The Public Dental Health Service has used EPJ (Opus Dental) since 1998 (Opus Systemer AS©). From 2001, TDI has been covered in a separate trauma section in the EPJ. As a result, all pupils born in 1997 should have TDIs on permanent teeth registered in the EPJ. Internationally accepted classifications of TDI are used in the EPJ.[46] Data were collected from a total of 54 different public dental clinics. When all data were collected, the data set was anonymized. No clinical examination or intervention was conducted.

Diagnosis of injury was obtained from the participant's EPJ, and was divided into groups based on the WHO classification system, modified by Glendor et al.[46] This classification was also used in the studies of Skaare et al.[25,33] TDIs were then subgrouped into 3 different categories of severity; mild, moderate and severe injuries, according to clinical significance. Severity was classified according to Skaare et al.[33]

A total of 5184 pupils in the first year of public high school and born in 1997 were available through the records of the Hordaland School Administration. An anticipated prevalence of TDI of 10%, as reported by Thelen et al.,[39] would result in 520 pupils with TDI in the county. This prevalence is the lowest found in Europe in the relevant age group, and was used in the calculations to secure an adequate sample size. Assuming a response rate of 40%, this conservative estimate of prevalence of TDI required 5000 individual participants to provide an adequate sample. Thus, a census study was considered favourable. All 5184 pupils were invited to participate in the study.

Based on the response rate and the assumed 10% prevalence of TDI, approximately 200 pupils will have experienced TDI. The 95% confidence limits for the expected prevalence, based on a sample size of 2000, would be approximately 8.7%-11.3%. The 95% confidence limit was considered to be sufficiently narrow to give a precise estimate of the prevalence of TDI in this population.

All data were entered and analysed using SPSS for Windows/MAC version 23.0 (SPSS Inc., 2015). Descriptive, bivariate analyses were used, as well as simple bivariate logistic regression analyses ($P < .05$).

The study was carried out by the authors, in close cooperation with the Public Dental Health Service and the Hordaland School Administration. The project was approved by the Regional Committees for Medical and Health Research Ethics (REK) (Regional etisk komité, REK-Vest 2014/67). All pupils invited to participate in the study were above the age of 16 years; therefore, they were legally able to provide consent regarding health issues, according to Norwegian law.[47]

The respondents were informed about the aim of the study and their right to withdraw, without reason, from the study at any time. As the questionnaire to the pupils was electronic, an exception from the rules of informed and written consent to collect relevant data from their record in the Public Dental Health Service was approved by REK. Pupils were informed in writing in an attached recruitment letter that participation by responding to the questionnaire was considered an acceptable alternative to written consent.

3 | RESULTS

Of the 5184 pupils invited to the study, a total of 2354 agreed to participate. However, 275 pupils only partly completed the questionnaire and were therefore excluded. This resulted in a response rate of 40% (2079 pupils). The median time for answering the questionnaire was 13 minutes.

In addition, the EPJ was not available for 24 pupils, so the final sample comprised 2055 pupils; 48.4% were males and 51.6% females. A total of 892 pupils (43.4%) were following vocational studies and 1163 pupils (56.6%) general studies. Dropout analysis showed significant differences in participation: boys were less likely to respond to the questionnaire than girls ($P < .01$). The pupils attending vocational studies were also less likely to respond than those attending general studies ($P < .001$).

The prevalence of TDI in the permanent dentition was 16.4% (338 pupils), and a total of 637 teeth were involved. Boys (n = 193) were significantly more affected than girls (n = 145; $P < .05$), with a ratio boys : girls of 1.33: 1.

TDI was classified as mild in 283 participants (83.7%), moderate in 32 participants (9.5%) and severe in 23 participants (6.8%). With regard to gender, boys accounted for 36 of the moderate to severe injuries, while girls accounted for 19. There was no significant difference in gender with regard to severity of TDI. The distribution of severity of injury on the affected teeth (n = 637) was as follows: 563 mild (88.4%), 39 moderate (6.1%) and 35 severe (5.5%). Of the 637 involved teeth, a total of 695 diagnoses were registered, with 58 teeth registered with 2 diagnoses (Table 1).

TABLE 1 Distribution of diagnoses of traumatic dental injuries (TDI) in a sample of 2055 pupils (n = 24 660 teeth)

Diagnosis	Severity*	Frequency	Relative frequency per thousand
Injuries to the hard dental tissues and the pulp			
Enamel infraction	Mild	27	1.1
Enamel fracture	Mild	139	5.6
Enamel-dentin fracture	Mild	142	5.8
Complicated crown fracture	Moderate	13	0.5
Uncomplicated crown-root fracture	Moderate	2	0.1
Complicated crown-root fracture	Severe	2	0.1
Root fracture	Moderate	6	0.2
Injuries to the periodontal tissues			
Concussion	Mild	247	10.0
Subluxation with horizontal mobility	Mild	83	3.4
Subluxation with horizontal and vertical mobility	Severe	4	0.2
Extrusive luxation	Severe	4	0.2
Lateral luxation	Severe	17	0.7
Intrusive luxation	Severe	2	0.1
Avulsion	Severe	7	0.3
Total		695	28.2

*Classification of severity according to Skaare et al.[33]

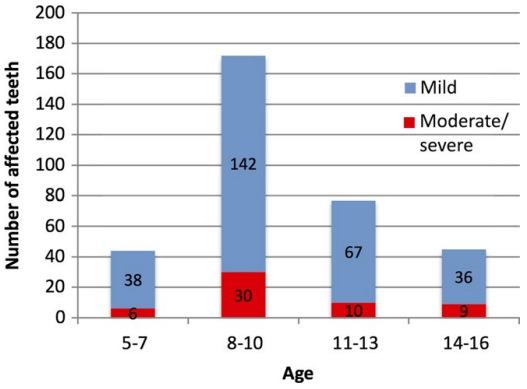

FIGURE 1 Severity of TDI according to age when affected (n = 338)

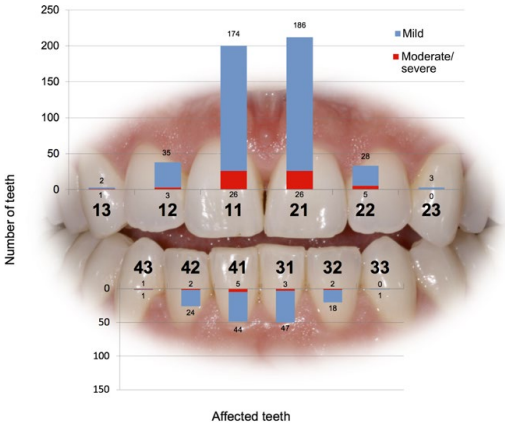

FIGURE 2 Distribution of TDI and severity in maxillary and mandibular anterior teeth (n = 637)

The peak age for experiencing TDI in the present study was 8-10 years (50.9%; Figure 1). Logistic regression analysis showed no significant difference in severity of TDI in the different age groups. The maxillary central incisors were most affected (64.7%), both for moderate and severe injuries (Figure 2). The mandibular central incisors were the second most affected teeth (15.5%). Of the 338 pupils reporting TDI, 46.4% (157 pupils) had a single traumatized tooth (Figure 3), while 43 pupils had experienced 2 or more trauma episodes. Five pupils had experienced TDI to 6 or more teeth. The seasonal distribution of TDI is presented in Figure 4. No significant seasonal effect on the occurrence of TDI was found. Logistic regression analysis showed no significant difference in severity of TDI and seasonal influence.

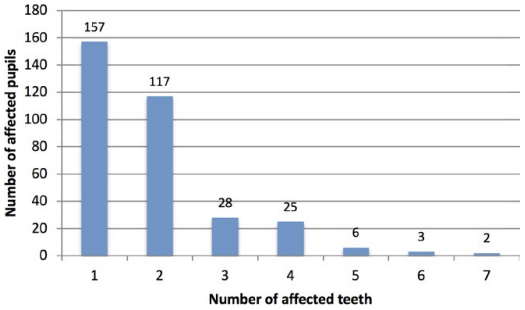

FIGURE 3 Number of teeth with trauma per pupil who reported a TDI (n = 637)

4 | DISCUSSION

This prevalence study covered TDI affecting 16-year-old adolescents in the County of Hordaland, which has a population approximately 10% of the total Norwegian population. The age group in this study is not studied frequently in the literature, which also underlines the need for similar studies. Most publications include different age ranges within the study population when conducting prevalence studies. This study, however, focused on a specific age group.

To ensure high external validity, a census design was considered favourable. The final study sample was within the estimated required sample size to estimate the correct prevalence, as shown above. The dropout analysis showed a statistically significantly uneven distribution between the genders among the invited participants compared with the final study sample. In addition, there was a higher response rate among pupils attending general studies than among those following vocational studies. In addition, 18.4% of the total population of 16-year-old adolescents in Hordaland did not attend a public school,[48] and were therefore not included in the study. Of all the pupils attending upper secondary education in Hordaland in the school year 2013/2014 (grades 1-3), 15.7% attended private

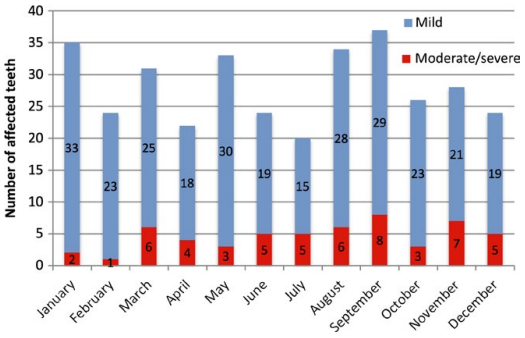

FIGURE 4 Seasonal distribution of TDI according to month of occurrence (n = 338)

schools.[49] However, the participants in the study are considered representative of 16-year-old adolescents attending public school in Hordaland.

As the Public Dental Health Service in Norway offers free dental care for children and adolescents from birth up to the age of 18 years[45] and the children have regular dental check-ups, the trauma records in the patients EPJ are very likely to include all, or almost all, occurrences of injury. Thus, the results from this study will be comparable with other Scandinavian countries with a similarly organized Public Dental Health Service. The categorization of diagnosis according to the WHO classification system modified by Glendor et al.[46] ensures that the results from this study are easily compared with similar prevalence studies conducted using the same classification system. In addition, this organisational structure has allowed collaboration and consistency in data collection. The standardized set-up of the EPJ, including the standardized trauma form, ensured reliable and valid clinical data (historical data from EPJ). An advantage of the study is that recall bias with regard to the clinical data is minimized due to data collection methods (EPJ), which strengthens the outcome of the present study. TDI occurred more frequently than estimated in the sample size calculations, which were based on a 9.9% prevalence of TDI.

The adolescents who had experienced TDI would be more likely to participate in the study, compared with the adolescents with no prior experience of TDI, which may produce an exaggerated reported prevalence. This may be due to the effect of demand characteristics, where the participant in a study might form an interpretation of the purpose of the investigation and subconsciously change behaviour to suit that interpretation.[50]

A recent systematic review and meta-analysis by Azami-Aghdash et al.[40], including 44 papers, determined an average TDI prevalence of 17.5% within the age group 6-18 years. Studies within the same age group as the present study show a TDI prevalence in the range of 12% to 20.4%.[10,36,51–53] Thus, a moderate occurrence of TDI was discovered (16.4%) in this study. boys were found to be significantly more affected by TDI than girls, which is, to a certain extent, analogous with results of previous studies, with a male : female ratio from between 1.3:1 to 2.3:1.[5,10,11,25,37] The relatively low ratio with regard to gender found in this study might be due to increased participation in different sporting activities by Norwegian adolescent girls, especially in recent years.[54]

The results in the present study support the findings in the incidence study of Skaare & Jacobsen,[33] where the rate of moderate and severe injuries amounted to 7% and 4%, respectively. Previous observations also identified milder forms of TDI as more frequent than moderate to severe TDI.[26,28,43]

The maxillary central incisors were found to be the most affected teeth, which is also in accordance with the literature.[2,8,25,42,43] No difference in frequency of TDI to right or left incisor was found in the present study. Peak age for TDI was 8-10 years, as reported in previous studies.[25,55,56]

Concussion was the most frequently reported diagnosis. This may be explained by study design (retrospective longitudinal study including historical data from EPJ.) Most epidemiological studies related to the prevalence TDI are cross-sectional and not linked to historical clinical data, so most concussions and subluxations will be underestimated; these injuries are not visible days after the injury. The structural design of the study allowed for a more precise estimation of the true TDI prevalence in the population, due to the inclusion of historical clinical data in the analysis and interpretation of the individual participants' radiographs. Furthermore, the prevalence of mild injuries to the periodontal tissue may be under-reported, as these injuries sometimes are unnoticed beside the more visible but potentially less damaging injuries, such as the enamel-dentin fractures and uncomplicated crown fractures.[46] In addition, patients might be less likely to report milder TDIs to the periodontal tissue. These injuries may be perceived as less important to tooth survival compared with the mild, more visible and aesthetically important injuries.

In western Norway, seasons are not very distinct but spring, summer, autumn and winter weather are different. In this study, an influence of seasonal variations on TDI was not found. The literature shows different results with regard to seasonal differences and its influence on occurrence of TDI. Whereas some studies show an increase of TDI in the winter,[43,57] other studies show an increase in the summer.[58,59] In some countries, seasonal differences are large.

To conclude, the prevalence of TDI in the permanent dentition in this Norwegian adolescent population was found to be moderate, with boys more prone to injury than girls. Milder injuries were more frequent, and the peak age of injury was 8-10 years of age. The maxillary central incisors were the most affected teeth and single tooth incidents were most common. Seasonal influence on the occurrence of TDI was not significant.

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CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest.

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II

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Traumatic dental injuries and experiences along the life course – a study among 16-yr-old pupils in western Norway

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The study assessed risk factors for traumatic dental injuries (TDI) using experiences along the life course. A retrospective longitudinal study, including historical clinical data, was conducted on 16-yr-old pupils in western Norway. All first-grade pupils born in 1997 and attending public high schools were invited to participate (n = 5,184). Participants responded to an electronically administered closed-ended questionnaire (39.6%, n = 2,055). Information on the occurrence of TDI and events during the life course (categorized as socio-economic, biological, psychosocial, and behavioural indicators) was collected. Variables with a significant bivariate association with three different dependent variables (TDI, severity of TDI, and multiple episodes of TDI) were tested in a hierarchical logistic regression analysis. Traumatic dental injuries were more frequent among boys, adolescents of higher socio-economic status, and adolescents with adverse psychosocial and behavioural scores. Moderate and severe TDIs were more frequent among adolescents with adverse psychosocial and behavioural scores and among adolescents participating in the sport of wrestling. Multiple episodes of TDI were more frequent among adolescents with adverse psychosocial and behavioural scores and among adolescents participating in sports activities. Incorporation of different life-course indicators is important in evaluating TDI severity and repeated incidents.

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Key words: adolescents; dental trauma; exposure; questionnaire; risk indicators

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Most studies on the epidemiology and risk factors related to traumatic dental injuries (TDIs) have traditionally been limited to factors such as gender, age, and oral and behavioural characteristics (1–4). Among the oral predisposing factors, overjet with protrusion and inadequate lip coverage are two of the earliest established direct causes of TDI (5). The main location for sustaining TDI is the patients' home (1) closely followed by school (1). Based on a Norwegian incidence study from 2003 including both urban and rural areas, Skaare & Jacobsen (6) reported that 48.0% of the TDIs in the age group 16–18 yr occurred during social events, while 23.0% occurred during sporting activities.

Material deprivation is a major environmental determinant of the prevalence of TDI, as shown in two studies from the UK (7,8). However, studies have reported conflicting results on the relationship between TDI and socio-economic status, as reported in a systematic review by Bendo *et al.* (9). In the UK in 1997, Hamilton *et al.* (7) showed that children of lower socio-economic status were more prone to TDI as a result of behaviour and environmental factors. By contrast, Marcenes *et al.* (10) reported, in a study from Brazil in 2001, that more privileged children had a higher occurrence of TDI because of their greater likelihood of participating in different sports activities.

The current aetiology of TDI shows a complex interaction between oral (e.g., overjet), environmental (e.g., material deprivation), and human (e.g., risk-taking) factors (4). Studies on TDI therefore have to consider a number of parameters to determine its occurrence and how it may be prevented. Violence, sports, traffic incidents, and falls are commonly cited in the literature as causes of TDI (1–4, 11). However, the 'causes of the causes' of TDI are rarely cited in the literature. Therefore, a life-course approach can be utilized to understand the circumstances that cause TDI. The life-course approach has been defined as the study of long-term effects on later health or disease risk of physical or social exposures during gestation, childhood, adolescence, young adulthood, and later adult life (12,13). Several life-course theoretical models have been developed. The chain-of-risk model refers to a sequence of linked exposures that raise disease risk (13). Social, biological, and psychological chains

of risk are possible and involve mediating and modifying factors (12,13).

Studies using the life-course approach have concluded that negative behaviour, socio-economic position, and adverse environmental conditions, both early and later in life, increase the risk of chronic disease and mortality (14,15). A few studies using the life-course approach have tested causative factors related to oral conditions, such as caries and periodontal disease (16,17). Traumatic dental injury is not a chronic pathological condition, but it is determined by some of the same risk factors as several chronic diseases (18). To date, only one study has tested a life-course model linking the chains of causation related to TDI, in which a range of causative factors related to TDI were tested (18). The study was conducted among 13-yr-old Brazilians and concluded that adolescents who experienced adverse psychosocial environments along their life course had a higher incidence of TDI than their counterparts who experienced more favourable environments. These adverse environments comprised living in non-nuclear families and experiencing high levels of paternal abuse (18).

As there are few studies exploring experiences, along the life course, that are related to TDI, the aim of the present study was to assess risk factors for TDI and related life-course experiences among Norwegian adolescents. It aimed to test the hypothesis that the occurrence of TDI in the permanent dentition is affected by socio-economic, biological, psychosocial, and behavioural experiences along the life course.

Material and methods

The study was carried out in the County of Hordaland, western Norway, a county with almost 500,000 inhabitants from all socio-economic backgrounds (19). Each county government is responsible for public secondary education in their respective counties in Norway, and the Public Dental Health Service in each county is responsible for the dental health of all adolescents up to the age of 18, with all treatments performed free of charge (20). The study was conducted among high-school pupils in the County of Hordaland and was carried out in close collaboration with both the county government and the Public Dental Health Service.

There were 58 public high schools in Hordaland in 2014. Our target group was pupils born in 1997 (16 yr of age at the time of invitation). A total of 5,184 pupils in first grade, including both general studies and vocational studies, were invited to participate (i.e., a census approach). Data and information on school and educational structure, as well as the names of all registered pupils, were acquired from the School Administration. In this population, 52.1% were boys.

Sample size calculation

The sample size calculations are presented in a previous paper related to the prevalence of TDI (21). A response rate of 40% required 5,000 individual participants to provide an adequate sample. The 95% confidence limits for the expected prevalence (10%), based on a sample size of 2,000, would be approximately 8.7%–11.3%. The 95% confidence limit was considered to be sufficiently narrow to give a precise estimate of the prevalence of TDI in this population. The sample size was confirmed as satisfactory for estimating risk factors for TDI. In a 2×2 contingency table, a sample size of 2,000 will be sufficient to discover ORs higher than 1.48 for variables with an equal distribution between two categories ($n_1 = 1{,}000$ and $n_2 = 1{,}000$) with a power of 80% and a 5% level of significance. For variables with a skewed distribution, larger ORs would be needed to maintain the same power. In a logistic regression analysis, the same would apply for a single categorical variable. The calculations were performed in the statistical package 'R' using the Hmisc library (Hmisc: Harrell Miscellaneous; Frank E Harrell Jr, Nashville, TN, USA).

Recruitment and questionnaire

To collect data on socio-economic, biological, psychosocial, and behaviour-related indicators, a close-ended electronic questionnaire (SurveyXact; Rambøll, Oslo, Norway) was sent to each participant via e-mail and SMS. If the questionnaire was not opened or only partially completed, a reminder was sent out after 2 wk. In advance, information graphics were sent out to each school. In addition, three tablet computers were raffled among participating pupils to increase the response rate.

To explore the effect of experiences along the life course and their influence on TDI, the different topics from the questionnaire were grouped into different risk indicators. The questionnaire used in this study covered 51 topics, using a total of 135 questions, and collected relevant data from early childhood to the present day. The questionnaire assessed socio-economic indicators (parents' level of education ['lower' education defined as upper secondary education; 'higher' education defined as university or college degree]), number of family-owned vehicles, and frequency of family vacations), biological indicators (gender and anthropometric data), psychosocial indicators (relationship with parents, family structure, personality characteristics) and behavioural- and attitudinal-related indicators (school grades, degree of attendance to dentist appointments, frequency of exercise, participation in sports activities, experience with violence, sleeping habits, television viewing habits, experience with tobacco and alcohol, oral-hygiene routines, use of fluoride, experience with orthodontic treatment), as well as experience and cause of TDI.

The Big Five personality traits, also known as the five-factor model (FFM) comprise a taxonomy for personality traits (22). The five factors have been defined as openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. The Big Five Inventory (BFI) uses short phrases based on the trait adjectives known to be prototypical markers of the Big Five (23). The format consists of short descriptive statements, such as 'is talkative' and 'worries a lot'. The purpose of this format is to limit ambiguity without losing relevance and becoming difficult to understand (23,24). The original questionnaire consists of 44 items designed to measure the five factors in the FFM without individual facets. A 20-item version of the BFI, validated in a Norwegian population (25), was incorporated in the questionnaire with the purpose of adequately measuring the participants' psychometric properties. Self-assessments were performed using a seven-point scale, with only the

extremes having verbal descriptions ('disagree strongly' and 'agree strongly').

The adolescent–parent relationship was measured using validated questions derived from the study of Nicolau *et al*. (18). Items from their questionnaire were translated to Norwegian and cross-culturally validated. A back translation of the questionnaire was performed by colleagues not previously involved in the project and who did not have any prior knowledge of the study objectives and background. A pilot study was carried out among pupils ($n = 6$) in upper secondary education in the county with the purpose of testing the face validity and reliability (26,27) of the questionnaire. The items passed the face content validity during this phase. The average time spent on completing the questionnaire was less than 15 min. Additionally, a review of the questions and items in the questionnaire was undertaken by a select group of colleagues with competence in epidemiological research (construct validity testing) (27,28). As a result, two questions from the questionnaire were modified.

By responding to the electronic questionnaire, respondents also consented to the use of information from their electronic patient journals (EPJs) in the Public Dental Health Service. The Public Dental Health Service in Hordaland has used electronic patient records (EPR) since 1998 (Opus Dental; Opus Systemer, Oslo, Norway). From 2001, TDI registration has been covered in the EPR, using internationally accepted classifications of TDI (11). Thus, all TDIs registered in the permanent dentition for this selected age group were available and were extracted from their EPJ. Three different variables – presence of TDI, severity of TDI, and presence of multiple episodes of TDI – were used as measures of outcome. Data on TDI in the EPR covers all erupted permanent anterior teeth, thus, data include TDI experienced before 16 yr of age.

Data were collected from a total of 54 different public dental clinics where information related to TDI (time and place of injury, age at incidence, and dental clinic responsible for treatment) was collected. Information on TDIs for maxillary and mandibular incisors and canines ($n = 12$ teeth for each pupil) were registered. In addition, data on health status, caries experience [decayed, missing, and filled teeth (DMFT)], information on missed dental appointments, and orthodontic status were also collected from the EPJ. The data set was anonymized when all data were entered into the database. No clinical examination or intervention was conducted. Body mass index (BMI) was calculated from self-reported height and weight using the formula $y = w/h^2$, where w and h are weight (in kg) and height (in m), respectively (29). Body mass index calculations were adjusted for age (30). Traumatic dental injuries were divided into three different categories of severity – mild, moderate, and severe – according to Skaare & Jacobsen (6). The prevalence and frequency distribution of TDI and descriptive analyses have been presented in detail in a previous paper (21).

Ethical consideration

The study was carried out in close cooperation with the Public Dental Health Service and the Hordaland School Administration. The project was approved by the Regional Committees for Medical and Health Research Ethics (REK) (Regional etisk komité, REK-Vest 2014/67). As the questionnaire was electronic, exemption from the rules of informed and written consent to collect relevant data from patients' records in the Public Dental Health Service was given by REK. Pupils were informed of entry into the study in writing, and their acceptance of participation by responding to the questionnaire was considered an acceptable alternative to written consent. All pupils invited to participate in the study were above the age of 16 yr, and therefore according to Norwegian law are legally able to provide consent regarding health issues (31). The respondents were informed about the aim of the study and their right to withdraw from the study at any time, without reason.

Statistical analyses

Data were entered and analysed in STATA version 15.0 for Mac (StataCorp, College Station, TX, USA). The independent variables were grouped and tested (using the chi-square test) to select the best predictors at each level. Then, the variables were introduced in a hierarchical multiple regression analysis from distal to proximate determinants of TDIs. To estimate the OR for the each of the three TDI outcome variables (experienced TDI, severity of TDI, and multiple episodes of TDI), hierarchical multiple logistic regression (marginal model with robust variance estimates) was used to derive ORs, *P*-values, and 95% CIs for the effects of socio-economic, biological, psychosocial, and behavioural variables on the outcomes. R-squared values (32) are included in the tables. Pupils with multiple teeth involved in a trauma episode and pupils with multiple trauma episodes were controlled for. Statistical level of significance for all analyses was set at $P < 0.05$.

A hierarchical approach was used to explain the theoretical framework of the study (Fig. 1). The variables were subgrouped into four different steps (socio-economic, biological, psychosocial, and behavioural), with each step representing determinants of traumatic dental injuries. Each variable was tested against the dependent variables using the chi-square test, and variables with an association with the dependent variables were then tested in three separate hierarchical logistic regression analyses (presence of TDI, severity of TDI, and presence of multiple episodes of TDI). Gender was included as a biological indicator in all three regression analyses regardless of an existing association with the dependent variables.

Results

Among the 5,184 pupils invited to participate, 2,079 pupils accepted (39.6% response rate). For 24 pupils who had recently moved to the County of Hordaland, EPJ data were not available; therefore, these pupils were excluded from the analysis. The final sample comprised 2,055 pupils.

Based on drop-out analyses, the response rates differed statistically significantly according to both gender and education programme. Boys were less likely to participate than girls ($P < 0.005$), and pupils attending vocational studies were less likely to respond than those attending general studies ($P < 0.001$).

Sociodemographic characteristics of the sample are presented in Table 1. The study sample included 48.4% boys and 51.6% girls.

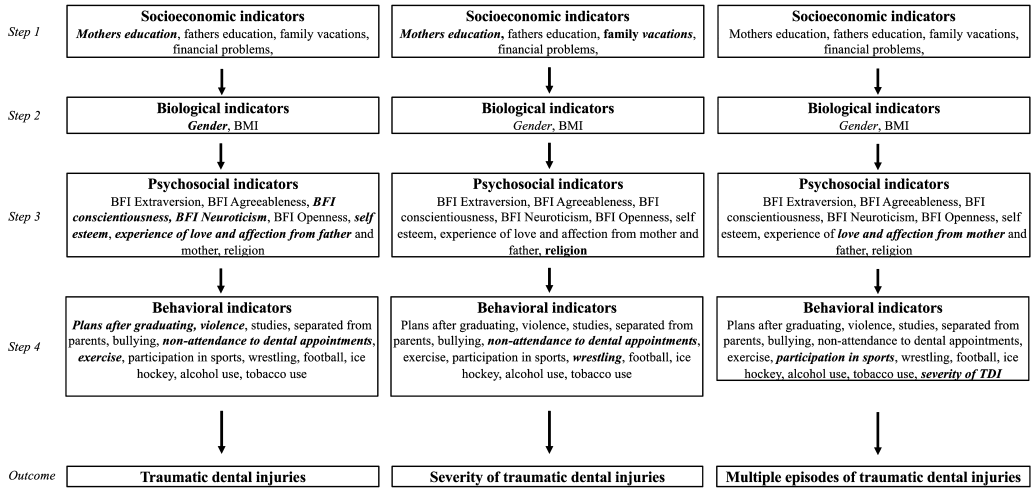

Fig. 1. Theoretical framework of the study. Indicators included in further statistical analysis are shown in italics. BFI, Big Five Inventory; BMI, body mass index; TDI, traumatic dental injury.

As presented in Table 2, hierarchical logistic regression, with or without TDI as the dependent variable (n = 2,055), showed that the experience of TDI was more frequent among adolescents responding 'yes' to the question 'I like being the way I am', among adolescents reporting lack of plans after graduating from high-school, among boys, among adolescents scoring low on conscientiousness (BFI), among adolescents reporting high frequency of exercise, and among those having mothers/female guardians with higher education.

In Table 3, the same analysis as described above was performed but was confined to those having experience with TDI (n = 338), this time contrasting moderate/severe versus mild TDI in the dependent variable. Traumatic dental injuries were classified as mild in 283 (83.7%) participants and as moderate/severe in 55 (16.3%). Logistic regression analyses showed that pupils reporting religion/beliefs as unimportant in their personal life, pupils who are active in wrestling, and pupils with four or more missed dental appointments have a significantly higher risk of severe TDI.

Table 4 shows the logistic regression analyses with multiple versus single episodes of TDI as the dependent variable (n = 338). A total of 43 (2.1%) pupils had experienced multiple episodes of TDI. Multiple episodes of TDI were more frequent among adolescents reporting lack of love and affection from mother/female guardian, among adolescents participating in sporting activities, and among adolescents with moderate/severe TDI.

Discussion

The present study assessed risk factors for TDI and related life-course events among Norwegian adolescents. For this purpose, a well-designed retrospective longitudinal census study was conducted. Gender and adverse scorings on behavioural and psychosocial parameters among the participants influenced the risk of TDI, which is in accordance with the study of Nicolau *et al*. (18). However, it is difficult to compare the results of these studies in view of the sociodemographic, cultural, and environmental differences in the study populations.

There are different life-course concepts and models described in the literature. Most models include positive and negative incidences and experiences over time. The questionnaire used in the present study collected relevant data from early childhood to the present day. Thus, the information collected (socio-economic, biological, psychosocial, and behavioural indicators) is useful in a life-course perspective. However, the outcome variables used (prevalence of TDI, severity of TDI, and multiple episodes of TDI) are covered over a period of time (data including TDI before 16 yr of age). As some TDIs sustained at an early age might not be explained by indicators measured at the present time, the results from the present study must be interpreted with caution. However, most mediating risks related to adolescents' health and well-being (i.e., socioeconomic, biological, psychosocial and behavioural) are established during childhood and early adolescence (33). Therefore, responses to the questionnaire should also be considered as representative for younger adolescents experiencing TDI in this study.

In regard to non-response bias in the present study, adolescents who had experienced TDI would be more likely to participate in the study compared with adolescents with no TDI experience. This may be a result of the effect of demand characteristics, whereby the participant in a study might form an interpretation of the purpose of the investigation and subconsciously change

Table 1

Sociodemographic characteristics of the study population (n = 2055)

Variables	Gender		
	Male (*n*)	Female (*n*)	Total (*n*)
TDI			
Yes	193	145	338
No	802	915	1717
Birth place			
Norway	943	979	1922
Outside Norway	52	81	133
Residence			
With parents	954	1018	1972
Away from parents	41	42	83
Studies			
General studies	478	685	1163
Vocational studies	517	375	892
Siblings			
≤2	715	771	1486
>2	280	289	569
Mother's education			
Lower (≤ secondary education)	414	449	863
Higher (university or college degree)	581	611	1192
Father's education			
Lower (≤ secondary education)	503	519	1022
Higher (university or college degree)	492	541	1033
Family vacations			
No	126	109	235
Yes	869	951	1820
BMI*			
<23.5	685	783	1468
23.5–27.9	242	222	464
>27.91	68	55	123
Participation in sports activities			
Yes	618	606	1224
No	377	454	831
Part-time job			
Yes	438	505	943
No	557	555	1112
Regular alcohol consumption			
Yes	132	149	281
No	863	911	1774
Regular tobacco use			
Yes	38	20	58
No	957	1040	1997
DMFT			
<4	646	656	1302
≥4	349	404	753

*World Health Organization classification of body mass index (BMI), adjusted for age (30).
DMFT, decayed, missing and filled teeth; TDI, traumatic dental injury.

their behaviour to suit that interpretation (34), which in turn would result in an inflated estimate of the prevalence of TDI in the study population. The drop-out analysis showed that girls were more likely than boys to respond to the questionnaire. In addition, there was a higher response rate among pupils attending general studies than among those following vocational studies. Low response rates can affect the validity of results; thus, assessment of response is important in the critical appraisal of health research. Therefore, strategies to increase response rate were implemented to improve the study quality (35). The participants in the study are considered as representative of 16-yr-old adolescents attending public school in Hordaland, as reported in a previous paper (21).

The low R-squared values in the logistic regression analyses may be explained by the factors studied. Studies trying to predict human behaviour typically have low R-squared values. The interpretations of the significant variables are the same for both high and low R-squared models (36).

As the Public Dental Health Service in Norway offers free dental care for children and adolescents from birth up to the age of 18 yr, and the children have regular dental check-ups, the trauma records in patients' EPJs are very likely to include all, or almost all, occurrences of injury. However, the prevalence of mild injuries to the periodontal tissue may be under-reported because of persons not seeking treatment for mild TDI (11,21). In addition, the data collected in this study were registered by calibrated dentists using internationally accepted classifications of TDI (11).

Boys were discovered to have higher rates of TDI than girls (Table 2), which is widely supported in the literature (37–39). The male/female ratio related to TDI in this population was 1.33:1, as reported in a previous paper (21). The male/female ratio related to TDI ranges from 1.3–2.5:1 according to a recent review (1) in which some studies report a recent ratio decline (5,40). This decline has, in Brazil, been explained by the increased interest in different sports activities among girls (41). In Norway, the number of girls participating in sporting activities increased by 7.8% from 2010 to 2016, while the increase was only 2.5% among boys (42). This trend could be explained by the fact that Norway is one of the highest-ranking countries in the world in regard to gender equality (43). Skaare & Jacobsen (6) reported that 40.0% of sports-related TDIs among Norwegian adolescent girls occurred during team handball.

In this study, TDIs were more frequent among adolescents with mothers/female guardians with a high level of education. High frequency of exercise was also linked to a high level of education among mothers/female guardians. This emphasizes the significance of mothers/female education as an important socio-economic risk factor for TDI. Conversely, there are inconsistent findings in relation to socio-economic status and TDI (9,44). This may be a result of the heterogeneity of the methods and the small number of published papers, making comparison difficult. The higher risk of TDI among children from families of higher socio-economic status in developing countries, such as Brazil, may be related to greater access to sporting equipment, swimming pools, skateboarding, roller-skating, and horseback riding compared with children from low socio-economic status families (44). In Norway, one study suggested that greater differences in participation of sports by adolescents according to occupation and education level are a result of increasing costs and increased professionalization of different sports (45).

Table 2

Hierarchical logistic regression (marginal model with robust variance estimates) for the association between life-course indicators and traumatic dental injuries (TDIs) (experienced TDI or not) in a population of 16-yr-old adolescents in western Norway (n = 2055). Independent variables with a statistically significant effect on the outcome are shown in bold

Indicators	Step 1 (Socio-economic) OR (95% CI)	Step 2 (Biological) OR† (95% CI)	Step 3 (Psychosocial) OR† (95% CI)	Step 4 (Behavioural) OR† (95% CI)
Education, female guardian				
Lower education (≤ secondary education)	1	1	1	1
Higher education (university or college degree)	1.34 (1.01–1.77)*	1.33 (1.01–1.76)*	1.41 (1.05–1.89)*	1.40 (1.05–1.88)*
	$R^2 = 0.01$			
Gender				
Female		1	1	1
Male		1.89 (1.45–2.48)**	1.70 (1.27–2.28)**	1.64 (1.22–2.20)**
		$R^2 = 0.01$		
Big Five Inventory–20: Sum of 'Conscientiousness'				
High (16–28)			1	1
Low (4–15)			1.57 (1.11–2.23)*	1.58 (1.11–1.26)*
Big Five Inventory–20: Sum of 'Neuroticism'				
Low (4–25)			1	1
High (26–28)			1.48 (0.91–2.40)	1.37 (0.83–2.27)
I worry a lot				
Yes			1	1
No			0.98 (0.71–1.35)	0.96 (0.70–1.32)
I like being the way I am				
No			1	1
Yes			1.79 (1.13–2.83)*	1.77 (1.12–2.82)*
Love and affection (father)				
A little to a great deal			1	1
Not at all			1.62 (0.93–2.76)	1.56 (0.88–2.78)
Plans after graduating high school				
Plans			1	1
I don't know/no point in planning			1.65 (1.16–2.35)**	1.68 (1.18–2.39)**
Reason/motivation for violence?				
No			1	1
Yes			1.25 (0.90–1.73)	1.24 (0.89–1.71)
Do you know violent persons?				
No			1	1
Yes. Some			0.87 (0.64–1.18)	0.85 (0.62–1.16)
Yes. Quite a few			1.44 (0.81–2.55)	1.38 (0.77–2.45)
			$R^2 = 0.03$	
Non-attended dental appointments				
≤3 times				1
3 times				1.38 (0.94–2.04)
How often do you exercise?				
≤4 times a wk				1
5–7 times a wk				1.47 (1.07–2.01)*
				$R^2 = 0.03$

†Adjusted OR.
*$P < 0.05$, **$P < 0.01$.

The strongest predictor for experiencing TDI was adolescents responding positively to the question 'I like being the way I am' and adolescents reporting lack of plans after high school or not seeing the point in planning (Table 2). These items from the questionnaire were used to describe the participants' self-concepts and personality. These items were similar to those in the study by Nicolau *et al.* (18). An explanation for the higher risk of TDI in these pupils could be an indirect association through development of risky and spontaneous behaviour, which increases the risk of TDI (18).

The BFI is among the most widely used personality tests based on the FFM (23). The shortened version of BFI used in the present study achieves satisfactory levels in measurements of psychometric properties, which is useful in this setting as optimal measurement of personality is not required (25). Adolescents reporting low levels of conscientiousness were more at risk of TDI. Persons with low scores on conscientiousness are described as being more disorganized, reckless, and laid back, and prefer not to make long-term plans (46). The link between a low-level conscientious personality and a higher risk of different types of injuries, accidents,

Table 3

*Hierarchical logistic regression (marginal model with robust variance estimates) for the association between life-course indicators and severity of traumatic dental injuries (TDIs) (mild vs. moderate/severe) in a population of 16-yr-old adolescents in western Norway (*n = *338). Independent variables with a statistically significant effect on the outcome are shown in bold*

Indicators	Step 1 (Socio-economic) OR (95% CI)	Step 2 (Biological) OR† (95% CI)	Step 3 (Psychosocial) OR† (95% CI)	Step 4 (Behavioural) OR† (95% CI)
Family vacations last 12 months				
None	1	1	1	1
≥1	2.18 (0.96–4.94)	2.19 (0.96–5.00)	2.17 (0.93–5.03)	1.88 (0.83–4.27)
Education, female guardian				
Lower education (≤ secondary education)	1	1	1	1
Higher education (university or college degree)	0.93 (0.47–1.83)	0.94 (0.48–1.85)	0.89 (0.45–1.75)	0.99 (0.49–2.01)
	R^2 = 0.01			
Gender				
Female		1	1	1
Male		1.27 (0.69–2.41)	1.30 (0.69–2.46)	1.26 (0.67–2.34)
		R^2 = 0.02		
Religion, important part in life				
Yes			1	1
No			4.31 (1.53–12.18)**	4.54 (1.61–12.78)**
			R^2 = 0.04	
Non-attended dental appointments				
≤3 times				1
>3 times				2.58 (1.28–5.17)**
Wrestling				
No				1
Yes				4.13 (1.91–8.96)**
				R^2 = 0.07

†Adjusted OR.
*P < 0.05, **P < 0.01.

Table 4

*Hierarchical logistic regression (marginal model with robust variance estimates) for the association between life-course indicators and experience of multiple episodes of traumatic dental injuries (TDIs) (one episode vs. multiple episodes) in a population of 16-yr-old adolescents in western Norway (*n = *338). Independent variables with a statistically significant effect on the outcome are shown in bold*

Indicators	Step 1 (Socio-economic) OR (95% CI)	Step 2 (Biological) OR† (95% CI)	Step 3 (Psychosocial) OR† (95% CI)	Step 4 (Behavioural) OR† (95% CI)
Not applicable	1	1	1	1
Gender				
Female	1	1	1	1
Male		1.66 (0.84–3.26)	1.64 (0.83–3.25)	1.49 (0.74–2.98)
		R^2 = 0.01		
Love and affection (mother)				
A little, to a great deal			1	1
Not at all			2.72 (1.17–6.31)*	2.77 (1.17–6.55)*
			R^2 = 0.03	
Severity of TDI				
Mild				1
Moderate/severe				2.24 (1.05–4.80)*
Participation in sports activities				
No				1
Yes				2.25 (1.05–4.82)*
				R^2 = 0.06

†Adjusted OR.
*P < 0.05, **P < 0.01.

and mortality, is supported in the literature (47,48). Surprisingly, there was no association observed between the occurrence of TDI and the other factors in the FFM. In addition to a low score on conscientiousness, extraversion and a low score on agreeableness are reported to be valid and generalizable predictors of

accident involvement (47). Clarke & Robertson (47) argued, in a meta-analytic review, that neuroticism might be related to occupational accident involvement because of its strong association with stress and greater distractibility from the ongoing task. Personality aspects of TDI are rarely discussed in the literature. Further development of research questions linking personality and TDI would add significantly to our knowledge of the risks and causes of TDI.

Adolescents reporting frequent participation in sports activities were also found to be more at risk of TDI. These findings are supported in the literature (6,49). In addition, frequent participation in sports activities was also associated with multiple episodes of TDI.

Adolescents reporting religion as less important in their personal life were more prone to moderate/severe TDI. These findings are difficult to interpret as no data are available for comparison. Reports have shown that Norway is one of the least religious countries in western Europe, with only 22.0% of the population believing in a god or deity (50), and this number is further declining (51). In this study, 17.4% of all the participants reported religion as an important aspect in their personal life, which confirms the above-mentioned trends. This may be explained both by the relatively young age of the participants (52), and the relationship with religious salience and risky behaviour (53). However, regarding church ceremonies, a total of 57.9% of all 15-yr-old adolescents in Norway were confirmed according to the Church of Norway. The Church of Norway covers 70.6% of Norway's total population (51). It is important to remember that questions regarding these sensitive topics are considered as intrusive by some (54), and should be interpreted with caution.

Moderate/severe TDI was associated with a high number of non-attended dental appointments. This particular finding should be interpreted with caution as the results were merely a count of non-attendance. Adolescents sustaining TDI are subject to a high number of compulsory dental appointments (treatment and follow-up etc.), which in turn may lead to a higher chance of non-attendance than for a person without TDI who is only required to attend once a year at most. However, from a socio-economic perspective, high levels of non-attendance in relation to TDI treatment could increase societal costs and could also impact tooth and treatment prognosis (55,56). Higher DMFT in addition to higher non-attendance is used as an indicator of 'lack of awareness and neglect' by the Norwegian Child Welfare Services (57,58). The association between non-attendance and higher DMFT suggests that this group requires additional resources in terms of follow-up and preventive measures (57).

Wrestling was found to be associated with the occurrence of moderate/severe TDI. The general injury rates in wrestling are very high (59,60), and there is no reason for dental trauma rates to be any different. A reasonable explanation for the greater risk of moderate/severe TDI in wrestling is the high-energy impacts of the sport. One study reported that 16.5% of the injuries sustained among wrestlers affected the head and/or face (60).

A few studies have reported data on multiple episodes of TDI (55,61). However, there are a limited number of published papers on risk factors related to multiple episodes of TDI. Multiple episodes of TDI lead to a high number of follow-up appointments and treatments required (55), which in turn increases individual and societal costs. Participants reporting lack of love and affection from their mother/female guardian were more at risk of experiencing multiple episodes of TDI (Table 4). Severity of TDI was also associated with multiple episodes of TDI, which may be explained by inadequate lip coverage, increased horizontal overjet with protrusion (5,62), and high-energy impacts.

The findings from this and other studies may give health authorities in Norway (and elsewhere) important information on strategies for preventing TDI. The life-course perspective on health and well-being has played a significant role in the change from curative to preventive medicine (33). Information related to prevention and treatment of TDI of different levels of severity may improve the prognosis for treatment. Educational campaigns can help the public to comprehend the importance of oral health, and dentists treating TDIs will also have a better fundament for their preventive strategies. Information on safety (such as the use of mouth guards and helmets), and preventing risk-seeking behaviour in general when playing sports, may help reduce the risk of TDI.

To conclude, TDIs were found to be more frequent among boys, adolescents reporting a higher socio-economic level, and adolescents with adverse scorings on behavioural and psychosocial parameters. Moderate and severe TDIs were more frequent among adolescents reporting religion as unimportant in their personal life, adolescents with higher non-attendance to dental appointments, and adolescents participating in the sport of wrestling. Lastly, multiple episodes of TDI were more frequent among adolescents reporting little or no love affection from their mother/female guardian, adolescents sustaining moderate or severe TDI, and adolescents participating in sports activities. Findings from this study confirm the hypothesis that the risk of experiencing TDI in the permanent dentition is affected by some experiences along the life course. Rather than causes of TDI alone, incorporation of life-course experiences is important in the evaluation of risk indicators related to TDI.

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III

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Traumatic dental injuries and pulp sequelae in an adolescent population

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Abstract

Background/Aims: Traumatic dental injuries (TDI) occur frequently and may result in pulp sequelae. This includes pulp necrosis with infection, pulp canal obliteration and root resorption. The aim of this study was to assess the prevalence and risk factors of pulp sequelae after TDI among Norwegian adolescents.

Material and methods: A retrospective longitudinal study, including historical clinical data, was conducted with 16-year-old pupils in western Norway. All first-grade pupils, born in 1997 (n = 5184), attending public high schools, were invited to participate and to respond to an electronically administered closed-ended questionnaire (response rate 39.6%, n = 2055). Consent was given to access the dental records in the Public Dental Health Service in Hordaland, where information regarding TDI (diagnosis and treatment) and radiographs were interpreted. Only TDIs to anterior teeth were recorded (canine to canine in the maxilla and mandible). Outcome variables of TDI were registered and analysed using logistic regression, Kaplan-Meier survival estimates and log-rank test.

Results: The prevalence of TDI in the sample population was 16.4% (338 pupils), with a total of 637 teeth involved. The number of included teeth for analysis was 571 (90.5%). The prevalence of pulp necrosis with infection was 7.5%. Moderate and severe TDI was associated with a higher frequency of pulp necrosis with infection. Pulp canal obliteration and root resorption were found in 2.8% and 2.3% of teeth with TDI, respectively. Dental hard tissue injuries were more prone to the development of pulp necrosis than luxation injuries and combination injuries. The relationship between root development stage and development of pulp necrosis with infection was not statistically significant.

Conclusions: Occurrence of different pulp sequelae among teeth affected with TDI was low. Moderate and severe TDI were more at risk of developing pulpal complications and hard tissue injuries were at higher risk of developing pulp necrosis with infection.

KEYWORDS

adolescents, outcome, pulp canal obliteration, pulp necrosis, sequelae, traumatic dental injuries

1 | INTRODUCTION

Traumatic dental injuries (TDI) vary in prevalence and severity.[1–3] For patients and operators, it is important to have knowledge related to the prognosis and potential sequelae of TDI.[4] The literature shows a correlation between emergency treatment and outcome of TDI.[5–9] Assessing different pulp reactions after TDI is essential in treatment planning.

Damage to, or interference with the neurovascular supply can lead to altered pulp function. Reactions such as pulp necrosis with infection (PN), pulp canal obliteration (PCO), and root resorption reflect these changes. Several studies show that mild TDI (eg enamel infractions and enamel fractures) rarely lead to adverse pulp reactions and are considered less important in regard to tooth survival.[10,11] Moderate and severe TDI (eg complicated crown fractures, lateral luxation, extrusive luxation, intrusion and avulsion), however, represent a higher risk for several adverse sequelae, such as PN, root resorption and loss of alveolar bone.[12,13]

In teeth with exposed pulps, a good prognosis for pulp healing can be expected if an early intervention, such as pulp capping or pulpotomy, is performed.[6,12,14] In more severe situations in which the apical vascular supply of the pulp is severely disturbed, revascularization of the pulp may be possible. The final healing outcome of this condition is primarily related to the size of the apical foramen and the prevention of pulp space infection.[13] Also, for moderate or severe luxation injuries and avulsed teeth, the diameter of the apical foramen is an important predictor for the development of PN.[13] The greater the apical diameter, the better the chance for revascularization.[13,15,16] Intrusive luxation is associated with the development of PN due to its damage to the blood supply of the pulp[17–19] Other factors related to development of PN are combined injuries (ie crown fractures and luxation injuries),[13] length of the pulp,[20] degree of compression of the pulp by bone (during intrusion),[21] external contaminants (following avulsion, dentin and pulp exposure),[20,22] rupture or stretching of the pulp at the level of a root fracture[23] and the precision of repositioning following root fracture injuries.[12,13]

Pulp canal obliteration is also a common sequela after TDI. This condition is interpreted as a sign of pulp survival and is found more frequently in immature teeth than in mature teeth.[24] Approximately 4%–24% of traumatized permanent incisors can develop PCO,[25] depending on the extent of the injury and the stage of root formation. Studies also show that mild TDI are more likely to develop PCO due to the increased probability of pulp survival compared with more severe injuries, although with possible neurovascular disturbances.[24,26–28]

Other sequelae after TDI are different types of root resorption.[29–32] Infection-related (inflammatory) resorption, related to infection of the root canal system, may occur after TDI.[33,34] This type of resorption is observed more frequently in moderate and severe luxation injuries due to the damage to the PDL and the presence of PN and infection of the root canal space, or periodontal infection.[33,34]

The aim of the present study was to assess the prevalence and risk factors of different pulp sequelae after TDI among Norwegian adolescents. A further aim was to test the hypothesis that the frequency of pulp complications is associated with the severity of the TDI.

2 | MATERIALS AND METHODS

The study was carried out in the county of Hordaland, western Norway, among pupils in the public upper secondary education system. The Public Dental Health Service is responsible for the dental health care from birth and up to the age of 18 years (free of charge),[35] and the county government is responsible for the public upper secondary education.[36] Thus, this study was conducted in cooperation with relevant county government departments.

The study target group was 16-year-old pupils attending first grade (born in 1997). There were 6983 pupils from 58 different public schools attending first grade upper secondary education in the school year 2013/2014 in the county of Hordaland, including both general studies and vocational studies. Pupils older than 16 years of age were excluded. Data and information on school and educational structure, as well as names of pupils and number of registered pupils, were acquired from the Hordaland School Administration. The total number of eligible pupils was 5184 for the school year 2013/2014, with 50.8% and 49.1% following vocational studies and general studies, respectively. Boys made up 52.1% of the population. The proportion of boys attending vocational studies was 60.8%.

By responding to an electronic questionnaire, respondents consented to the use of information from their electronic patient journals (EPJ) in the Public Dental Health Service. Only clinical data extracted from the EPJ were used in the present study, and no clinical examination or intervention was conducted. Data were collected from a total of 54 different public dental clinics. The data registered were anonymized after statistical analyses were completed.

The Public Dental Health Service in Hordaland has used an EPJ since 1998 (Opus Dental; Opus Systemer, Oslo, Norway). From 2001, TDI registration has been covered in the EPJ, using the classification system by the World Health Organization (WHO), as modified by Andreasen et al.[10] Data on TDI in the EPJ cover all erupted permanent anterior teeth. Thus, the data include TDI experienced before 16 years of age. Diagnoses related to TDI were sub-grouped into three different categories of severity; mild, moderate and severe injuries, according to clinical significance. Severity was classified according to Skaare et al.[2]

Clinical data were analysed and information on the pulp status was acquired from the EPJ and available dental radiographs. Outcome variables, such as PN, PCO, root resorption and onset of different sequelae, were analysed. Criteria for PN were as follows: Lack of pulp sensibility, tenderness to percussion, colour change of the crown (grey/blue) and periapical radiolucency. Criteria for PCO were as follows: Yellow discoloration of the crown, radiographic signs of reduction in the size of the pulp chamber. Criteria for root

resorption were as follows: Metallic percussion sound (replacement resorption), lack of mobility (replacement resorption) infra-occlusion (replacement resorption), radiographically visible loss of hard tissue (repair-related resorption, replacement resorption, internal/external infection-related resorption or cervical invasive resorption), presence of apical periodontitis (internal/external infection-related resorption) and pink discoloration of the crown (cervical invasive resorption).[33,34]

The sample size calculations have been presented in previous papers related to the prevalence and risk factors for TDI.[1,37] The present study was restricted to relevant data from participants who had experienced TDI.

Data were entered and analysed in Stata version 15.0 for Mac (StataCorp, College Station, TX, USA). Frequency distribution, Chi-square analysis as well as simple bivariate logistic regression analyses were used for relevant variables. Kaplan-Meier estimator was used to estimate pulp survival. The statistical level of significance for all analyses was set at $P < .05$. To ensure higher validity of results, Cohen's kappa coefficient was used to measure inter- and intra-observer reliability for root development stage. The periapical index (PAI)[38] was used to calibrate observers when assessing periapical pathosis radiographically. Cohen's Kappa values for intra- and inter-observer reliability for PAI-score calibration, PAI-scores and determination of root development stage were in the range of 0.68 to 0.91. These results are considered substantial to almost perfect.[39]

The study was carried out by the authors, in close cooperation with the Public Dental Health Service and the Hordaland School Administration. The project was approved by the Regional Committees for Medical and Health Research Ethics (REK) (Regional etisk komité, REK-Vest 2014/67). All pupils invited to participate in the study were 16 years old or above and were therefore legally able to provide consent regarding health issues without involvement from parents or guardians, according to Norwegian law.[40]

The recruitment letter and questionnaire were electronic, and an exception from the rules of written consent to collect relevant data from their record in the Public Dental Health Service was approved by REK. The respondents were informed about their right to withdraw from the study at any time, without reason.

Data collected were entered and securely stored in the SAFE database (secure access to research data and e-infrastructure), a solution developed by the University of Bergen (UiB) for secure processing of sensitive personal data in research.[41] In addition, in order to increase reuse of data and openness in research, the authors have uploaded data sets and research data to UiB Open Research Data.[42]

3 | RESULTS

A total of 2055 pupils participated in the study (questionnaire response rate 39.6%). Prevalence of TDI in the population was 16.4% (n = 338), with a total of 637 affected teeth. Among all pupils experiencing TDI, 90.5% (n = 306) had available radiographs for analysis, covering 571 teeth. A total of 2273 radiographic images were analysed.

The distribution of teeth and the frequency of different pulp reactions are shown in Table 1. A total of 43 teeth (7.5%) had PN and 16 teeth (2.8%) had PCO. A statistically significant difference in occurrence of PN between dental hard tissue injuries and luxation injuries ($P < .001$) was found, where PN occurred more frequently in dental hard tissue injuries than with luxation injuries and combination injuries. From the teeth with PN, 62.8% (n = 27) were experienced by boys.

The median time for clinical and/or radiographic manifestations of PN and PCO was two months (SD 25.06) and 9.5 months (SD 26.70), respectively. Injuries occurring after school hours comprised 328 teeth (57.4%), out of which 29 teeth (8.8%) resulted in PN. However, no statistically significant difference was found in occurrence of PN when comparing the frequency of injuries occurring during and after school hours. Further, there was no difference regarding the severity of TDI between these groups. Of the injuries resulting in PCO, all teeth (n = 16) had experienced a luxation injury, alone or in combination with a dental hard tissue injury.

The majority (75.1%) of the emergency treatment was provided by the Public Dental Health Service (excluding the public after-hours emergency dental clinic). The proportion of moderate and severe TDI among injuries treated by the Public Dental Health Service was 11.2% compared with 29.6% of moderate or severe TDI treated at hospitals or the emergency dental clinic. PN developed in 16.3% of the TDIs treated at hospitals or the emergency dental clinic. For TDIs treated at clinics within the Public Dental Health Service, the proportion was 6.2%. However, there was no statistically significant difference between development of PN and the place of emergency treatment.

The distribution and frequency of PN according to severity and root development stage are presented in Table 2. Among teeth with severe TDI, a higher proportion of immature teeth developed PN (9 out of 13 teeth) compared with mature teeth (7 out of 22 teeth). However, in the pairwise comparisons of marginal linear predictions of PN according to severity and root development stage (Table 3), there was no statistically significant association for root development stage. Further, Table 3 shows a statistically significant difference in occurrence of PN among moderate and severe TDI compared with mild TDI.

Information on the development of PN according to the severity of TDI using Kaplan-Meier survival estimates is presented in Figure 1. The x-axis of Figure 1 is truncated at 60 months. Further, Table 4 shows the results from the log-rank test comparing survival distribution in regard to severity. A statistically significant association between the severity of TDI and onset of PN was discovered ($P < .001$). In addition, a tendency towards luxation injuries resulting in PN earlier than dental hard tissue injuries was identified. However, no statistically significant difference was found between the groups.

A total of 13 teeth had radiographic signs of root resorption, all in teeth with PN. Seven teeth had root resorption not directly related to the pulp status (five cases with replacement resorption, one case with

TABLE 1 Distribution and frequency of pulp survival (PS), pulp canal obliteration (PCO) and pulp necrosis (PN) among different variables (n = 571)

		Luxation injuries (n = 293)			Dental hard tissue injuries (n = 220)			Combination injuries (n = 58)		
Variable	**Scoring**	**PS**	**PCO**	**PN**	**PS**	**PCO**	**PN**	**PS**	**PCO**	**PN**
Gender	Boys	165	6	9	124	0	12	35	1	6
	Girls	100	9	4	73	0	11	15	0	1
Root dev. stage	1-4	94	8	7	54	0	7	16	0	4
	5-6	171	7	6	143	0	16	34	1	3
Age at incident	5-7 y	42	1	3	19	0	0	2	0	2
	8-10 y	115	8	8	107	0	13	32	0	3
	11-13 y	73	3	1	47	0	4	12	0	1
	14-16 y	35	3	1	24	0	6	4	1	1
Occurrence of sequela	0-6 mo	-	4	10	-	0	11	-	1	4
	>6 mo	-	11	3	-	0	12	-	0	3
Place of injury	School	123	4	5	57	0	7	23	0	1
	Outside school	137	11	8	123	0	15	27	1	6
	No information	5	0	0	17	0	1	0	0	0
Severity	Mild	251	10	1	191	0	12	30	1	1
	Moderate	1	1	0	6	0	10	18	0	3
	Severe	13	4	12	0	0	1	2	0	3
Treatment	Observation	253	10	0	49	0	0	17	0	0
	Composite	0	0	0	147	0	0	31	1	0
	Endo. treatment	0	0	7	0	0	20	0	0	5
	Splinting	12	5	0	1	0	0	2	0	0
	Other (ortho, autotr., impl.)	0	0	6	0	0	3	0	0	2
Emergency treatment	No treatment	32	1	1	9	0	3	1	0	0
	Public Dental Health Service	199	8	7	157	0	13	40	0	5
	Private	0	0	0	9	0	0	0	0	0
	Emergency dental clinic	30	6	3	17	0	5	8	1	1
	Hospital	4	0	2	5	0	2	1	0	1

TABLE 2 Distribution and frequency of pulp necrosis (PN) according to severity and root development stage (n = 571)

	Root dev. stage 2-4						Root dev. stage 5-6							
	SEVERITY						SEVERITY							
	Mild		Moderate		Severe		Mild		Moderate		Severe		Total	
Pulp necrosis	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
No	161	96.99	7	63.64	4	30.77	322	97.28	19	67.86	15	68.18	528	92.47
Yes	5	3.01	4	36.36	9	69.23	9	2.72	9	32.14	7	31.82	43	7.53
Total	166	100.00	11	100.00	13	100.00	331	100.00	28	100.00	22	100.00	571	100.00

repair-related surface resorption and one case with cervical invasive resorption). The remaining six teeth with root resorption were classified as external infection-related resorption, with infection originated from the pulp. Due to the small sample size of teeth and the diversity within types of root resorption, no statistical analysis was performed using root resorption as a dependent or independent variable.

4 | DISCUSSION

The main findings from the present study were that the occurrence of PN, PCO and root resorption was 7.5%, 2.8% and 2.3%, respectively, with the majority of PN occurring after moderate or severe

TABLE 3 Pairwise comparisons of marginal linear predictions of pulp necrosis (PN), severity and root development stage (n = 571)

Severity	Root dev. stage	Mild 2-4 (n = 166)	Mild 5-6 (n = 331)	Moderate 2-4 (n = 11)	Moderate 5-6 (n = 28)	Severe 2-4 (n = 13)	Severe 5-6 (n = 22)
Mild	2-4						
	5-6	0.997					
Moderate	2-4	0.015	0.003				
	5-6	0.013	<0.001	0.998			
Severe	2-4	<0.001	<0.001	0.776	0.365		
	5-6	0.055	<0.001	0.996	1.000	0.397	

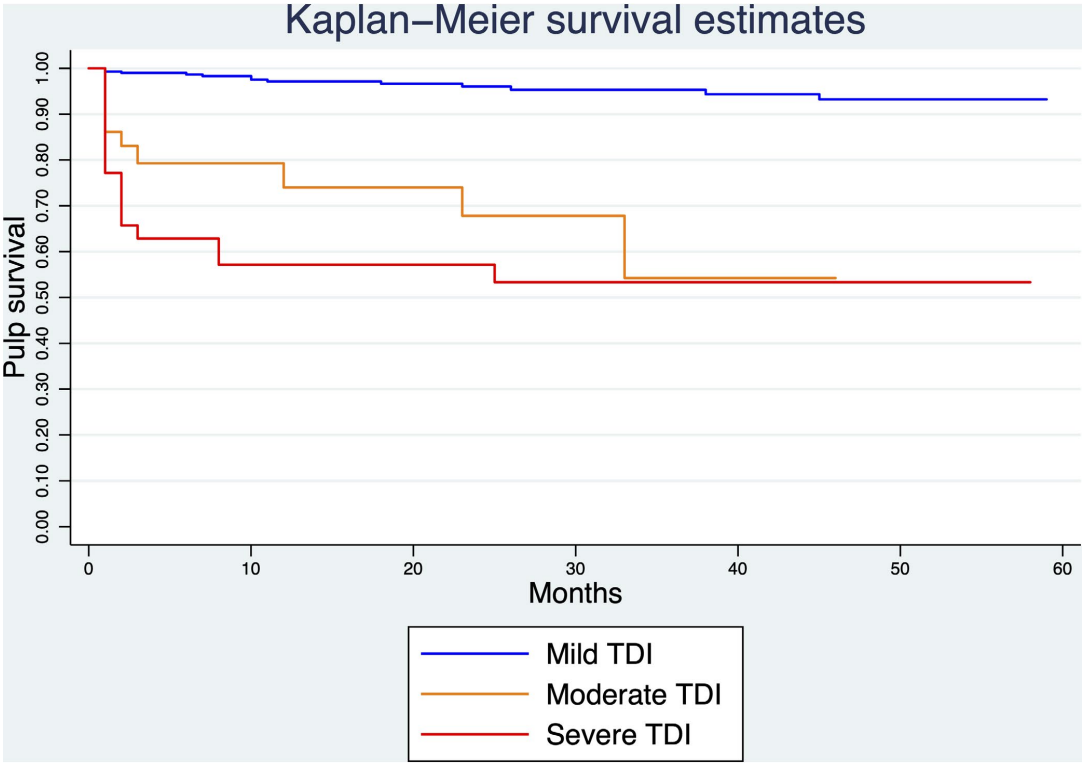

FIGURE 1 Development of pulp necrosis according to severity of TDI (n = 571). Kaplan-Meier survival estimates

TABLE 4 Log-rank test for equality of survivor functions for development of pulp necrosis according to severity of TDI (n = 571)

Severity of TDI	Events observed	Events expected
Mild	14*	36.53
Moderate	13*	3.59
Severe	16*	2.88
Total	43	43.00

*$P > .001$.

TDI. Dental hard tissue injuries were statistically significantly more prone to the development of PN.

The prevalence of PN reported in the present retrospective longitudinal study is comparable with other similar studies.[43,44] However, in the present study, 4.4% of the teeth with luxation injuries and 10.5% of the teeth with dental hard tissue injuries developed PN, respectively. The frequency of PN after luxation injuries in the permanent dentition has been found to range from 15% to 59%, according to the literature.[25] Studies have shown that mild TDI have more favourable outcomes compared with moderate and severe TDI[5] and

that a healthy pulp has a better prognosis than a pulp with a damaged neurovascular supply. Healthy pulps are more resistant to bacterial invasion through the dentinal tubules.[5,45] The term "luxation injury" comprises a wide range of severity of TDI, which could lead to very different study results, depending on which luxation injury is the prime focus of the study, or which injury is more prevalent. A higher prevalence of severe luxation injuries would result in a higher prevalence of PN in the study population. In the present study, mild luxation injuries were more prevalent than moderate and severe injuries. Previous studies show a prevalence of PN between 1% and 6% for enamel-dentin fractures.[11,15,46] A higher prevalence of PN among dental hard tissue injuries in this study could include non-diagnosed luxation injuries or combination injuries, or undiagnosed pulp exposure for enamel-dentine injuries and infractions. Thus, the occurrence of PN among dental hard tissue injuries would be inflated.

Severity of TDI was associated with development of PN, which is in accordance with the literature.[16,47–50] Pulp survival is linked to the extent of periodontal ligament injury caused by the luxation injury.[22,50] Studies by Andreasen & Pedersen and Andreasen et al show that the stage of root development is an important predictor for PN.[16,51,52] In the present study, the development of PN in teeth with severe TDI was more frequent among immature teeth than in mature teeth (Table 2). However, the pairwise comparison analysis of immature and mature teeth according to severity and root development stage showed no statistically significant difference in occurrence of PN within the two groups (Table 3). Due to the small number of cases with PN and severe TDI in the study population, these findings should be interpreted carefully.

In regard to observation time, PN tended to occur relatively soon after injury (median two months after injury) and PN developed earlier in moderate and severe TDI. This is also in accordance with the literature.[16,44] There was no statistical difference in observation time and development of PN between the luxation injuries and dental hard tissue injuries. However, a tendency for dental hard tissue injuries to develop PN later was discovered. This may be due to breakdown of coronal restorations, which is one of the major causes of restoration failure.[53,54] According to the literature, the time from trauma to onset of PN is longer in very immature and mildly intruded teeth due to the increased probability of revascularization.[55] The TDI found in the present study population did not include a sufficient number of intrusive luxation injuries and other severe luxation injuries to compare with the results from previous studies regarding different variations of luxation injuries and the onset of PN.

The time of examination where PN was discovered was set as the onset time of PN. Some injuries were sustained in the year the pupil turned 16 years of age (n = 9),[1] shortly before data collection and would therefore have a censored follow-up time in regard to the development of sequelae. However, recall bias in regard to the clinical data is minimized due to the data collection methods (EPJ), which in total strengthens the quality of outcome variables.

The log-rank test assumes that the effects of the predictor variables on the risk of PN are constant within the considered time period.[56] This assumption becomes more problematic, depending on the duration of the time period in question. A similar study analysed TDI with sequelae occurring only within the first 24 months, arguing that PN usually occurs within the first two years after the trauma.[47] PN diagnosed more than two years after the time of trauma is most likely not directly related to the trauma, but rather a result of breakdown of the coronal restorations.[47,54] However, this development of PN is still related to the original TDI. Due to this, the observation time in the survival analysis (Figure 1) was truncated at 60 months.

The prevalence of PCO was less than reported in the current literature.[25] At the same time, in the present study, all teeth with PCO had experienced a luxation injury, which confirms the results from similar studies, where PCO almost exclusively occur when a luxation injury had occurred.[15,24,25] Based on the literature, crown fractures *per se* do not cause PCO.

According to the systematic review by de Souza et al, the severity of TDI is one of the most important predictors of root resorption.[57] In the present study, root resorption was discovered in only 2.3% of the teeth with TDI. The low prevalence of root resorption in the study population is most likely due to the small number of severe injuries.

The Public Dental Health Service in Norway is responsible for the dental health care from birth and up to the age of 18 years (free of charge).[35] Every patient has regular dental check-ups, and therefore, patients included in this study are ensured treatment of high quality and routine follow-up of TDI, regardless of the time and place of injury, socio-economic status and residence. In addition, a standardized trauma record was utilized in the patients' EPJs, and is therefore likely to include all, or almost all, occurrences of injury. However, the prevalence of mild luxation injuries, such as concussion and subluxation, may be under-reported because the person does not seek treatment.[1,10] The Public Dental Health Service has followed the applicable IADT guidelines for the evaluation and management of TDI, and access to these guidelines was provided to all clinics.

The data collected in this study were registered by calibrated dentists using internationally accepted classifications of TDI[10] and the use of a standardized trauma form, which ensured reliable and valid clinical data (historical data from EPJ). Thus, the results from this study will be comparable with those from other countries with similarly organized treatment routines, follow-up regimes and data availability. The organizational structure of the Public Dental Health Service, in regard to calibration and routine follow-up, as well as the organizational structure of the School Administration, allowed efficient collaboration and consistency in data collection.

Mild TDI were more prevalent than moderate and severe TDI, which resulted in lower occurrences of pulp sequelae in the study population. Due to the small sample size, the results from the present study should be interpreted with caution. Another possible limitation of this study is that the study population only comprised adolescents attending public high school. By including adolescents not attending school, the heterogeneity of the study population would increase.

The findings from this and other studies may give health authorities in Norway and elsewhere important information on the occurrence and prevention of severe sequelae after TDI. Information related to treatment and outcomes of mild, moderate and severe TDI improves the prognosis for individual treatment. Dentists treating TDI will also have a better basis for their treatment strategies and it is critical that operators are aware of the timescale in which PN generally occurs. The low occurrence of PN in the study population is likely related to the high quality of the organizational structure of the Public Dental Health Service, as well as standardized follow-up routines and calibration. In addition, adolescents in the county of Hordaland have easy access to emergency treatment at public emergency clinics at no cost, also organized by the Public Dental Health Service. Emergency treatment performed shortly after an incident reduces the probability for adverse sequelae after TDI.[9] Lastly, affected individuals and their parents or guardians will also have increased awareness of the potential complications related to TDI.

To conclude, the occurrence of PN, PCO and root resorption among Norwegian adolescents following TDI was relatively low, compared with previous studies. Teeth with moderate or severe TDI were found to be more at risk of developing PN. Only teeth with luxation injuries developed PCO. In addition, teeth with dental hard tissue injuries were more prone to the development of PN, and this occurred earlier in teeth with moderate or severe TDI, compared with mild TDI. Findings from this study confirm the hypothesis that the frequency of pulp sequelae, in terms of PN, is associated with the severity of TDI.

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CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest.

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Appendix I

UNIVERSITETET I BERGEN
Det medisinsk-odontologiske fakultet

Informasjonsskriv

Prosjekt: Tannskader blant elever i videregående skole i Hordaland fylke

Kjære elev i VG1,

I regi av Universitetet i Bergen vil vi, i samarbeid med Hordaland fylkeskommune (opplæringsetaten og tannhelsetjenesten), studere omfanget av tannskader, skadetyper, og særlig risikofaktorer for slike tannskader blant elever i VG1 i Hordaland fylke.

For å gjennomføre dette har vi en undersøkelse i tre trinn:

1. Elektronisk spørreskjema til elever i VG1
2. Spørreskjema til foreldre/foresatte. Dette vil være et relativt kortfattet spørreskjema hvor hensikten er å innhente informasjon relatert til hendelser tidlig i din oppvekst.
3. For de elevene som returnerer spørreskjema (punkt 1), vil vi hente inn informasjon fra journal i Den offentlige tannhelsetjenesten relatert til mulig tannskade. Dette for å sjekke type tannskade, alvorlighetsgrad og lære mer om eventuelle senskader.

Ved å svare på spørreskjemaet samtykker du til deltagelse, og gir tilgang til informasjon fra din journal i Den offentlige tannhelsetjenesten i Hordaland relatert til mulige tannskader. All informasjon vil bli behandlet konfidensielt. Dette gjøres ved at ansatte i tannhelsetjenesten i Hordaland gir oss nødvendig informasjon anonymisert og kodet. Ingen deltagere, verken barn eller foresatte, vil kunne identifiseres i rapporter fra undersøkelsen. Kodede navnelister holdes adskilt fra forskningsdata i innsamlingsperioden, og lagres i samsvar med Universitetet i Bergen sine interne retningslinjer for sikker datalagring. Når alle data er samlet inn vil datasettet bli helt anonymisert. Deltagelse er frivillig og du har rett til innsyn og sletting av innsamlede opplysninger før anonymisering.

Det vil ikke være noen form for inngrep eller kliniske undersøkelser i denne studien. Du vil også kunne trekke deg fra studien når som helst. Prosjektet er godkjent av Regional komité for medisinsk forskningsetikk (2014/67/REK Vest). Alle elever som returnerer fullstendig utfylt spørreskjema, inkludert svar fra dine foreldre/foresatte (trinn 1 og 2), vil automatisk være med i trekningen av **3 stk. iPad Air**

Link til spørreskjema: [SURVEYXACT LINK]

Takk for at du tar deg tid til å delta i denne undersøkelsen!

Er det noe du lurer på vedrørende undersøkelsen, vennligst kontakt
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Appendix II

UNIVERSITETET I BERGEN
Det medisinsk-odontologiske fakultet

Tannskader blant elever i videregående skole i Hordaland fylke

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2. Spørreskjema til foreldre/foresatte. Dette vil være et relativt kortfattet spørreskjema hvor hensikten er å innhente informasjon relatert til hendelser tidlig i din oppvekst.

3. For de elevene som returnerer spørreskjema (punkt 1), vil vi hente inn informasjon fra journal i Den offentlige tannhelsetjenesten relatert til mulig tannskade. Dette for å sjekke type tannskade, alvorlighetsgrad og lære mer om eventuelle senskader.

Ved å svare på spørreskjemaet samtykker du til deltagelse, og gir tilgang til informasjon fra din journal i Den offentlige tannhelsetjenesten i Hordaland relatert til mulige tannskader. All informasjon vil bli behandlet konfidensielt. Dette gjøres ved at ansatte i tannhelsetjenesten i Hordaland gir oss nødvendig informasjon anonymisert og kodet. Ingen deltagere, verken barn eller foresatte, vil kunne identifiseres i rapporter fra undersøkelsen. Kodede navnelister holdes adskilt fra forskningsdata i innsamlingsperioden, og lagres i samsvar med Universitetet i Bergen sine interne retningslinjer for sikker datalagring. Når alle data er samlet inn vil datasettet bli helt anonymisert. Deltagelse er frivillig og du har rett til innsyn og sletting av innsamlede opplysninger før anonymisering.

Det vil ikke være noen form for inngrep eller kliniske undersøkelser i denne studien. Du vil også kunne trekke deg fra studien når som helst. Prosjektet er godkjent av Regional komité for medisinsk forskningsetikk (2014/67/REK Vest).

Alle elever som returnerer fullstendig utfylt spørreskjema, inkludert svar fra dine foreldre/foresatte (trinn 1 og 2), vil automatisk være med i trekningen av

3 stk. iPad Air!

Du kommer i gang ved å trykke på "neste" nede i høyre hjørne. Du kan bevege deg frem og tilbake i spørreskjemaet uten at svarene forsvinner. Hvis du blir avbrutt i løpet av besvarelsen, kan du senere fortsette der du var kommet.

NB! Husk å trykke "Avslutt" på siste side.

Det vil ta ca. 10-15 minutter å fullføre spørreskjemaet.

Takk for at du tar deg tid til å delta i denne undersøkelsen!

Er det noe du lurer på vedrørende undersøkelsen, vennligst kontakt

Magnus Bratteberg: **magnus.bratteberg@student.uib.no** eller telefon **46959765**

Vennlig hilsen

Magnus Bratteberg (Forskerlinjekandidat) og Asgeir Bårdsen (Professor)

Institutt for klinisk odontologi

Det medisinsk-odontologiske fakultet, UiB

Noen bakgrunnsopplysninger om deg:

Kjønn:

- ☐ Gutt
- ☐ Jente

Hvor er du født?

- ☐ Norge
- ☐ Utenfor Norge, men i Europa
- ☐ Afrika
- ☐ Nord-Amerika
- ☐ Sør-Amerika
- ☐ Asia
- ☐ Oseania

Hvor mange søsken har du?

- ☐ Jeg er enebarn
- ☐ Ett søsken
- ☐ To søsken
- ☐ Tre søsken
- ☐ Fire eller flere søsken

Hva er din nåværende vekt (kg)?

_____

Hva er din nåværende høyde (i cm)?

_____

Her kommer noen spørsmål om skole:

Hvilken studieretning går du?

- ☐ Yrkesfaglig
- ☐ Studiespesialiserende

Hvor bor du vanligvis nå som du har begynt på VGS?

- ☐ Hjemme, med foreldre/foresatte
- ☐ Hybel/leilighet
- ☐ Annet

Jeg liker å involvere meg i aktiviteter på skolen

- ☐ Ja
- ☐ Nei

Ta stilling til følgende utsagn om deg selv. Sett ett kryss for hvert utsagn.

	Helt enig	Ganske enig	Verken enig eller uenig	Ganske uenig	Helt uenig
Jeg føler at skolen er bortkastet tid	☐	☐	☐	☐	☐
Jeg er stille i klasserommet og jobber med mitt	☐	☐	☐	☐	☐
Jeg synes hjemmelekser er kjedelig	☐	☐	☐	☐	☐
Jeg synes det er vanskelig å fokusere på skolearbeidet mitt	☐	☐	☐	☐	☐
Jeg tar aldri skole alvorlig	☐	☐	☐	☐	☐
Jeg trives ikke på skolen	☐	☐	☐	☐	☐
Jeg synes ikke det er noe poeng å planlegge fremtiden; ta det som det kommer	☐	☐	☐	☐	☐
Jeg er villig til å støtte opp om det læreren sier og gjør	☐	☐	☐	☐	☐

Hvilke planer har du etter videregående skole?

- ☐ Studere ved universitet/høyskole
- ☐ Friår, så studere ved universitet/høyskole
- ☐ Militæret
- ☐ Begynne å jobbe

- ☐ Jeg vet ikke
- ☐ Jeg synes ikke det er noe poeng å planlegge fremtiden; jeg tar det som det kommer

Har du noen gang strøket i et fag på skolen?

- ☐ Ja, flere ganger
- ☐ Ja, en gang
- ☐ Nei

Her kommer noen generelle spørsmål om tannhelse:

Har du noen gang fått en tannskade eller flere (ved f.eks. et uhell, fall, slag/spark, idrettsskade osv.), som har resultert i behandling og/eller oppfølging av tannhelsepersonell?

- ☐ Ja, brukket del av en tann
- ☐ Ja, slått løs en tann
- ☐ Ja, slått ut en tann av munnen
- ☐ Ja, slått en tann inn i kjeven
- ☐ Ja, kombinasjoner av overnevnte alternativer
- ☐ Nei

Hva var årsaken til tannskaden?

- ☐ Har ikke hatt tannskade
- ☐ Fall/uhell
- ☐ Vold
- ☐ Idrettsskade
- ☐ Annet
- ☐ Vet ikke/husker ikke

Hvor fikk du tannskaden?

- ☐ Har ikke hatt tannskade
- ☐ På skolen/i skoletiden
- ☐ Utenfor skolen/utenfor skoletiden

Noen spørsmål om munnhygiene, sett ett kryss for hvert utsagn:

	En eller flere ganger for dagen	Flere ganger i uken, men ikke hver dag	Flere ganger i måneden, men ikke hver uke	Sjelden	Aldri
Jeg pusser tennene mine	☐	☐	☐	☐	☐
Jeg bruker tanntråd	☐	☐	☐	☐	☐
Jeg bruker munnskyll/fluorskyll	☐	☐	☐	☐	☐

Har du problemer med dårlig ånde?

- ☐ Ja, ofte
- ☐ Ja, noen ganger
- ☐ Nei

Når var du sist på tannhelsekontroll (hos tannlege/tannpleier)?

- ☐ 1 år eller mindre
- ☐ Mer enn 1 år, og til og med 2 år siden
- ☐ Mer enn 2 år, og til og med 3 år siden
- ☐ Mer enn 3 år siden

Vedrørende tannregulering:

	Ja	Nei
Jeg har tannregulering	☐	☐
Jeg har hatt tannregulering tidligere	☐	☐
Jeg skal få tannregulering en gang i fremtiden	☐	☐
Jeg burde hatt tannregulering, men har ikke mulighet	☐	☐
Jeg trenger ikke tannregulering	☐	☐

Man kan ha forskjellige holdninger til sine tenner. Her følger noen påstander og synspunkter som kan forekomme. Vi ber deg oppgi om du er enig eller uenig i disse påstandene.

	Helt enig	Enig	Uenig	Sterkt uenig
"Å ha pene og perfekte tenner er svært viktig for hvordan folk oppfatter deg"	☐	☐	☐	☐
"Mindre skjønnhetsfeil på tennene har ingen betydning, bare de fungerer"	☐	☐	☐	☐
"En tannluke/manglende tann som vises bør man skjemmes over"	☐	☐	☐	☐
"Det spiller ingen rolle hvordan man ser ut i munnen, bare man kan tygge maten man liker"	☐	☐	☐	☐

Her kommer noen spørsmål om familiesituasjonen din:

Hvilken høyest fullførte utdanning har din mor/kvinnelige foresatt?

- ☐ Ungdomsskole
- ☐ Videregående skole
- ☐ Universitet/Høyskole

Hvilken høyest fullført utdanning har din far/mannlige foresatt?

- ☐ Ungdomsskole
- ☐ Videregående skole
- ☐ Universitet/Høyskole

Har en av dine foreldre/foresatte vært arbeidsledige når de ønsket å jobbe?

- ☐ Ja
- ☐ Nei
- ☐ Vet ikke

Har familien din hatt økonomiske problemer?

- ☐ Ja
- ☐ Nei
- ☐ Vet ikke

Eier familien din bil?

- ☐ Ja, en bil
- ☐ Ja, to eller flere biler
- ☐ Nei

Har du ditt eget soverom?

- ☐ Ja
- ☐ Nei

I løpet av de siste 12 månedene, hvor mange ganger har du reist på ferie med familien din?

- ☐ Har ikke reist på ferie
- ☐ En gang
- ☐ To ganger
- ☐ Flere enn to ganger

Hvor mange datamaskiner (PC, Mac, iPad, tablet) eier familien din?

- ☐ Ingen
- ☐ En
- ☐ To
- ☐ Flere enn to

Har du vært adskilt fra en av foreldrene dine i et år eller lengre?

- ☐ Ja
- ☐ Nei

Hva var grunnen til adskillelsen?

- ❑ Har ikke vært adskilt
- ❑ Foreldrene mine er skilt
- ❑ Mor/far er død
- ❑ Mor/far er syk
- ❑ Fosterhjem
- ❑ Adopsjon
- ❑ Andre årsaker

Religion/livssyn spiller en viktig rolle i livet mitt

- ❑ Ja
- ❑ Nei

Ta stilling til følgende spørsmål om din *mor* eller den kvinnen som har hatt mest å si for oppveksten/oppdragelsen din. Sett *ett* kryss for hvert spørsmål:

	I stor grad	I ganske stor grad	I noen grad	Ikke i det hele tatt
I hvilken grad forstår hun problemene og bekymringene dine?	❑	❑	❑	❑
I hvilken grad kan du betro deg til henne om ting som plager deg?	❑	❑	❑	❑
I hvilken grad gir hun deg kjærlighet?	❑	❑	❑	❑
I hvilken grad gir hun deg tid og oppmerksomhet når du trenger det?	❑	❑	❑	❑
I hvilken grad er hun streng med regler/grenser?	❑	❑	❑	❑
I hvilken grad blir du straffet av henne?	❑	❑	❑	❑
I hvilken grad forventer hun at du gjør ditt beste?	❑	❑	❑	❑

Ta stilling til følgende spørsmål om din *far* eller den mannen som har hatt mest å si for oppveksten/oppdragelsen din. Sett *ett* kryss for hvert spørsmål:

	I stor grad	I ganske stor grad	I noen grad	Ikke i det hele tatt
I hvilken grad forstår han problemene og bekymringene dine?	❑	❑	❑	❑
I hvilken grad kan du betro deg til han om ting som plager deg?	❑	❑	❑	❑
I hvilken grad gir han deg kjærlighet?	❑	❑	❑	❑
I hvilken grad gir han deg tid og oppmerksomhet når du trenger det?	❑	❑	❑	❑
I hvilken grad er han streng med regler/grenser?	❑	❑	❑	❑
I hvilken grad blir du straffet av han?	❑	❑	❑	❑
I hvilken grad forventer han at du gjør ditt beste?	❑	❑	❑	❑

Nedenfor finner du en rekke påstander som passer mer eller mindre godt for ulike mennesker. Kryss av i den ruten som *passer best for deg* slik du vanligvis er. Ikke tenk for mye på hver oppgave, men sett et kryss i ruten du umiddelbart synes stemmer best. Sett *ett* kryss per utsagn.

1 = Passer ikke
7 = Passer helt

	Passer ikke 1	2	3	4	5	6	Passer helt 7
Er pratsom	❑	❑	❑	❑	❑	❑	❑
Kan være kald og fjern	❑	❑	❑	❑	❑	❑	❑
Gjør en grundig jobb	❑	❑	❑	❑	❑	❑	❑
Er deprimert, nedtrykt	❑	❑	❑	❑	❑	❑	❑
Er orginal, kommer med nye ideer	❑	❑	❑	❑	❑	❑	❑
Har en tendens til å være stille av seg	❑	❑	❑	❑	❑	❑	❑
Er hjelpsom og uegoistisk i forhold til andre	❑	❑	❑	❑	❑	❑	❑
Har en tendens til å ha lite orden på tilværelsen	❑	❑	❑	❑	❑	❑	❑
Er avslappet, takler stress godt	❑	❑	❑	❑	❑	❑	❑
Har livlig fantasi	❑	❑	❑	❑	❑	❑	❑
Er utadvendt og sosial	❑	❑	❑	❑	❑	❑	❑
Kan noen ganger være uhøflig	❑	❑	❑	❑	❑	❑	❑
Legger planer og følger dem opp	❑	❑	❑	❑	❑	❑	❑
Bekymrer meg mye	❑	❑	❑	❑	❑	❑	❑
Liker å spekulere, leke med ideer	❑	❑	❑	❑	❑	❑	❑
Kan være syk og hemmet	❑	❑	❑	❑	❑	❑	❑

Er hensynsfull og vennlig overfor de fleste mennesker	☐	☐	☐	☐	☐	☐	☐
Kan være uforsiktig	☐	☐	☐	☐	☐	☐	☐
Blir lett nervøs	☐	☐	☐	☐	☐	☐	☐
Har få kunstneriske interesser	☐	☐	☐	☐	☐	☐	☐

Ta stilling til følgende utsagn. Sett *ett* kryss for hvert utsagn.

	Ja	Nei
Jeg bekymrer meg mye	☐	☐
Jeg har gode ideer	☐	☐
Jeg liker å være slik jeg er	☐	☐
Jeg havner ofte i trøbbel	☐	☐
Utseendet mitt plager meg	☐	☐
Jeg er sjenert	☐	☐
Jeg liker å få viljen min	☐	☐
Jeg føler ofte at jeg er ubrukelig	☐	☐
Alltid når jeg gjør noe, så føler jeg at det går dårlig	☐	☐
Jeg blir, eller har blitt, ertet/mobbet	☐	☐
Foreldrene mine forventer for mye av meg	☐	☐
Jeg blir nervøs når læreren spør meg om noe	☐	☐
Jeg synes at jeg er attraktiv	☐	☐
Jeg trives på skolen	☐	☐
Jeg får lett venner	☐	☐
Jeg liker å involvere meg i skolearbeid	☐	☐

Her kommer noen spørsmål om fritiden din, idrett, og eventuelt andre aktiviteter du bedriver utenfor skolen.

Hvor mange timer i uken bruker du eventuelt på deltidsjobb/frivillig arbeid ved siden av skolearbeid?

- ☐ Har ikke deltidsjobb/frivillig arbeid
- ☐ Mindre enn 3 timer i uken
- ☐ 3-6 timer i uken
- ☐ 7-11 timer i uken
- ☐ 12-15 timer i uken
- ☐ Mer enn 15 timer i uken

Er du aktiv med/i idrett?

- ☐ Ja
- ☐ Nei

Driver du med noen av disse idrettsaktivitetene?

	Ja	Nei
Fotball	☐	☐
Håndball	☐	☐
Basketball	☐	☐
Volleyball	☐	☐
Turn	☐	☐
Løping	☐	☐
Friidrett	☐	☐
Ishockey	☐	☐
Bryting	☐	☐
Boksing	☐	☐
Karate/judo - andre kampsporter	☐	☐
Sykling	☐	☐
Rugby/amerikansk fotball	☐	☐
Svømming	☐	☐
Skateboard/rollerblades/terrengsykling (inkl. BMX)	☐	☐
Stup	☐	☐
Langrenn	☐	☐

Alpint/slalåm/snowboard	☐	☐
Motorsport	☐	☐
Klatring	☐	☐
Ridning	☐	☐

Bruker du tannbeskytter når du praktiserer overnevnte idretter?

- ☐ Jeg driver ikke med noen av overnevnte idretter
- ☐ Ja, alltid
- ☐ Ja, noen ganger
- ☐ Nei

Har du noen gang vært voldelig med en person som står deg nær?

- ☐ Ja, en i familien/slekt
- ☐ Ja, en venn
- ☐ Nei

Har en person som står deg nær noen gang vært voldelig mot deg?

- ☐ Ja, en i familien/slekt
- ☐ Ja, en venn
- ☐ Nei

Ville du vært voldelig mot noen om du ble provosert?

- ☐ Ja
- ☐ Nei

Synes du vold alltid har en motivasjon/grunn?

- ☐ Ja
- ☐ Nei

Kjenner du personer som er voldelige?

- ☐ Ja, ganske mange
- ☐ Ja, noen få
- ☐ Nei

Drikker du alkohol?

- ☐ Ja, ofte
- ☐ Ja, jeg har prøvd noen få ganger
- ☐ Nei

Røyker du?

- ☐ Ja, regelmessig
- ☐ Ja, jeg har prøvd noen få ganger
- ☐ Nei

Hvor ofte trener du?

- ☐ 5-7 ganger i uken
- ☐ 2-4 ganger i uken
- ☐ 1 dag i uken
- ☐ Mindre enn en dag i uken
- ☐ Aldri

Hvor viktig for deg er det at du føler deg i god form?

- ☐ Veldig viktig
- ☐ Ganske viktig
- ☐ Verken viktig eller uviktig
- ☐ Ganske uviktig

- [ ] Veldig uviktig

Hvordan kommer du deg til skolen?

- [ ] Jeg går
- [ ] Jeg sykler
- [ ] Jeg tar buss/offentlig transport
- [ ] Jeg kjører moped
- [ ] Jeg blir kjørt
- [ ] Andre måter

Hvor mange timer i døgnet sover du?

- [ ] Mer enn 9 timer
- [ ] 7-9 timer
- [ ] Mindre enn 7 timer

Hvor mange timer daglig bruker du foran skjermer (TV, PC, iPad, mobil osv.)?

- [ ] 8 timer eller mer
- [ ] Fra 6 timer, men mindre enn 8 timer
- [ ] Fra 4 timer, men mindre enn 6 timer
- [ ] Fra 2 timer, men mindre enn 4 timer
- [ ] Mindre enn 2 timer

Hvor ofte spiser du frokost hjemme?

- [ ] Alltid
- [ ] Ganske ofte
- [ ] Noen ganger
- [ ] Ganske sjelden
- [ ] Spiser frokost, men aldri hjemme
- [ ] Spiser ikke frokost

Appendix III

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK vest	Anne Berit Kolmannskog	55978496	27.02.2014	2014/67/REK vest
			Deres dato:	**Deres referanse:**
			21.01.2014	

Vår referanse må oppgis ved alle henvendelser

Asgeir Bårdsen
Universitetet i Bergen

2014/67 Tannskader - prevalens og risikofaktorer i et livsløpsperspektiv

Forskningsansvarlig: Universitetet i Bergen
Prosjektleder: Asgeir Bårdsen

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK vest) i møtet 13.02.2014. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikklovens § 4.

Prosjektomtale
Tannskader forekommer i alle aldre og er ikke begrenset til sosiale klasser. Slike skader kan føre til forringet livskvalitet. Formålet med denne studien er å undersøke prevalens av slike skader blant 16-åringer i videregående skole i Hordaland og identifisere risikofaktorer for tannskader i populasjonen. Elever og foreldre vil få tilsendt en forespørsel om å fylle ut et spørreskjema som omhandler erfaringer med tannskader og livstil. Opplysninger om den enkelte fra tannhelsetjenesten vil bli innhentet.

Vurdering
Komiteen mener søknaden er gjennomarbeidet og har ingen innvendinger til den vedlagte prosjektbeskrivelsen.

Samtykke
Kun samtykkekompetente personer skal delta i studien og rekrutteringsprosedyren synes forsvarlig lagt opp. Informasjonsskrivet til elever og foreldre må imidlertid forbedres.

Informasjonsskrivet
I vedlagt informasjonsskriv kommer det ikke klart frem at undersøkelsen er et forskningsprosjekt i regi av Universitetet i Bergen. At deltakelse i prosjektet er frivillig og at deltakerne har rett til innsyn og sletting av de innsamlede opplysningene før anonymisering, er heller ikke oppgitt. Videre må begrepene anonymt og avidentifisert benyttes korrekt. Dersom man beholder en koblingsnøkkel er datasettet avidentifisert. I en revidert utgave av informasjonsskrivet må disse opplysningene være på plass. REK har utarbeidet en egen mal for informasjonsskriv som ligger på REK sin hjemmeside under fanen «frister og skjema». REK Vest anbefaler at denne malen benyttes.

Informasjonssikkerhet
Forskningsdata skal lagres i samsvar med Universitetet i Bergen sine interne retningslinjer for sikker datalagring. Personidentifiserbare forskningsdata skal slettes eller anonymiseres straks det ikke lenger er behov for dem og senest ved prosjektslutt. Ved eventuelt behov for lengre oppbevaring, må det sendes en velbegrunnet endringssøknad til REK. Prosjektgodkjenningen gjelder til prosjektslutt satt til 31.12.2015.

Vilkår
Informasjonsskrivet må revideres. Det reviderte skrivet må sendes til REK Vest.

Vedtak
REK Vest godkjenner prosjektet på betingelse av at ovennevnte vilkår tas til følge.

Sluttmelding og søknad om prosjektendring
Prosjektleder skal sende sluttmelding til REK vest på eget skjema senest 30.06.2016, jf. hfl. 12. Prosjektleder skal sende søknad om prosjektendring til REK vest dersom det skal gjøres vesentlige endringer i forhold til de opplysninger som er gitt i søknaden, jf. hfl. § 11.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK vest. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK vest, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

Ansgar Berg
Prof. Dr.med
Komitéleder

Anne Berit Kolmannskog
sekretariatsleder

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