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Aetiology and risk factors related to traumatic dental injuries – a review of the literature

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Abstract – *Background/Aim:* During the past 30 years, the number of aetiologies of traumatic dental injuries (TDIs) has increased dramatically in the literature and now includes a broad spectrum of variables, including oral and environmental factors and human behaviour. The aim of this study is to present an international review of well-known as well as less well-known unintentional and intentional causes of TDIs. Moreover, some models that are useful in investigating contact sport injuries are presented.
Materials and methods: The databases of Medline, Cochrane, Social Citation Index, Science Citation Index and CINAHL from 1995 to the present were used.
Result: Oral factors (increased overjet with protrusion), environmental determinants (material deprivation) and human behaviour (risk-taking children, children being bullied, emotionally stressful conditions, obesity and attention-deficit hyperactivity disorder) were found to increase the risk for TDIs. Other factors increasing the risk for TDIs are presence of illness, learning difficulties, physical limitations and inappropriate use of teeth. A new cause of TDIs that is of particular interest is oral piercing. In traffic facial injury was similar in unrestrained occupants (no seat belts) and occupants restrained only with an air bag. Amateur athletes have been found to suffer from TDIs more often than professional athletes. Falls and collisions mask intentional TDIs, such as physical abuse, assaults and torture. Violence has increased in severity during the past few decades and its role has been underestimated when looking at intentional vs unintentional TDIs. There are useful models to prevent TDIs from occurring in sports. WHO Healthy Cities and WHO Health Promoting Schools Programmes offer a broad solution for dental trauma as a public health problem.
Conclusion: The number of known causes of TDIs has grown to alarming levels, probably because of increased interest of the causes and the underlying complexity of a TDI. Accepted oral, environmental and human aetiological factors must therefore be included in the registration of TDIs.

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To present the aetiology of a traumatic dental injury (TDI) is to present the cause. What happened or what induced a TDI? During the past 30 years, the number of aetiologies has increased dramatically in the scientific literature. The aetiology of TDIs today includes oral factors (e.g. overjet), environmental factors (e.g. material deprivation) and human behaviour (e.g. risk-taking), which can be further separated into unintentional and intentional TDIs (1). This progress shows the complexity of the aetiological relationships between oral, environmental and human factors and TDIs, which is a good reason to present the aetiologies in a separate study.

Children and adolescents spend a great deal of time participating in numerous recreational and sport activities. Canadian children between 5 and 12 years of age have been found to spend an average of 18 h in physical activity of a leisure nature per week and those between 13 and 17 years spend slightly less, i.e. 15 h (2). Physical leisure activities at home, in kindergartens, at playgrounds and in schools continue to account for a significant proportion of TDIs in young children (3–6); teenagers, on the other hand, are mostly injured during sport activities, traffic accidents and some forms of violence (e.g. fights, assault and battery) (7–9). The population-based study by Skaare and Jacobsen (10) in Norway is a good example in how to present the causes of TDIs in a region with both urban and rural areas. They reported that 8% of all TDIs in the age group 7–18 years were due to sport activities, representing 16% of TDIs in leisure time. More than half (59%) of the TDIs were related to ball sports and 40% of sports accidents in girls were sustained in team handball. TDIs in team handball may be explained by the sport's increasing popularity among girls in Norway. TDIs that are due to traffic accidents occurred in 10% of all injured individuals, especially in teenagers in urban areas; 8% of TDIs

were contributed to violent acts and occurred more frequently in urban areas.

The difference in the proportion of causes of TDIs probably depends on a number of factors, including population type, age group, culture, region in the world and the environment. For example, in a comparative study from the Sudan and Iraq, Baghdady et al. (11) found that violence (36% in Iraq and 71% in the Sudan) was the main cause of TDIs in 6–12 years old, which can be compared with only 3% (both studies) that were caused by sports (Table 1). In contrast, Uji and Teramoto (12) in Japan and Blinkhorn (5) in the UK reported sport to be among the main causes of TDIs in teenagers. In yet another study Marcenes et al. (13) found an almost equal occurrence of TDIs resulting from sports (19%) and violence (16%). A similar pattern was observed by Nicolau et al. (14) though to a much lesser extent (2% and 1.5% for sport activities and violence respectively). In the Nicolau et al. study the proportion of unknown causes of TDIs was 40%. If the number of unknown causes had been less, there would probably have been a greater distribution of other causes. Unknown causes might be a strategy used by an individual to conceal the real cause (e.g. violence) of the TDI. This means that violence, as a cause of TDIs, has probably been underestimated in many countries (13). Thus, the conclusion is that it is difficult to compare countries, but it is probably possible within a given country. The use of accepted aetiological factors would lead to a more consistent comparison of studies.

Therefore, the aim of this study is to present a broad international review of well-known as well as less well-known unintentional and intentional causes of TDIs. Oral predisposing factors, human behaviour, the environment and how we cope with the risk for a TDI are discussed in this study. The degree of exposure, where a short average exposure time in different sports until injury means a high risk for a TDI, is presented. Some useful models in investigating contact sports injuries are described.

Search methodology

The review started with an electronic search of Medline (PubMed), Cochrane, Social Citation Index, Science Citation Index and CINAHL (Nursing and Allied Health) databases from 1995 to the present, using the following search words: tooth injuries, tooth trauma, traumatized teeth, dental trauma, dentoalveolar trauma, oral trauma, epidemiology, aetiology, prevalence, incidence, prevention and review. Only reports in English were considered for inclusion in the review.

The search methodology in this review cannot guarantee that all articles pertinent to the topic have been included. This is because other databases than the ones used in the present study may also include information in the field of dental trauma. The majority of articles included in this review were found in Medline, probably because this database is the first choice when publishing material in dental traumatology. The quality of this research could therefore be regarded as good.

Oral predisposing factors

Among the earliest causes of TDIs described in the literature are increased overjet with protrusion and inadequate lip coverage (15–21). Even among children younger than 5 years of age, anterior open bite has recently been found to result in twice as many TDIs when compared with their counterparts (22).

In some studies the definition of protrusion begins at >3–3.5 mm (15, 18–20), whereas in others at >5.0 mm (16, 17, 21), which makes it difficult to compare studies. To make matters even more complicated, overjet with

Table 1. Frequency of causes (in per cent) of traumatic dental injuries

References	Region	Year	Age/age group (years)	Physical leisure activity	Collision	Fall	Sport	Traffic accident	Violence	Inappropriate use of teeth or biting a hard item	Other	Unknown
	Asia											
Uji and Teramoto[1] (12)	Japan	1988	6–18	–	–	37.7	29.2	1.6	7.9	–	23.6	–
Chen et al. (125)	Central Taiwan	1999	Mean 8.2	–	65.3	26.9	3.6	–	2.6	–	1.6	–
	Europe											
Blinkhorn[1] (5)	UK	2000	11–14	18.5	–	33.9	17.2	14.6	4.3	–	–	11.5
	Middle East											
Baghdady et al. (11)	Iraq	1981	6–12	–	–	54.0	3.0	2.4	35.8	–	–	4.9
Baghdady et al. (11)	Sudan	1981	6–12	–	–	18.3	3.3	2.8	70.6	–	–	5.0
Marcenes et al. (16)	Syria	1999	9–12	–	16.0	9.1	–	24.1	42.5	–	3.4	4.6
	South America											
Garćia-Godoy et al. (126)	Dom Rep.	1981	7–14	–	1.7	50.0	–	5.1	–	–	10.2	32.4
Garćia-Godoy[1] (127)	Dom Rep.	1984	5–14	36.6	–	–	49.4	14.0	–	–	–	–
Marcenes et al. (13)	Brazil	2000	12	–	6.8	26.0	19.2	20.6	16.4	–	9.6	1.4
Nicolau et al.[1] (14)	Brazil	2001	13	–	15.0	24.1	2.3	10.5	1.5	6.0	–	40.6
Traebert et al. (50)	Brazil	2003	12	–	37.5	47.9	–	2.1	–	2.1	–	10.4
Soriano et al. (21)	Brazil	2007	12	9.1	18.2	27.3	8.2	2.7	6.4	1.8	3.6	22.7

[1]Population.
The variables presented follow WHO nomenclature.

protrusion in some studies is combined with inadequate lip coverage (18). The Swedish Council on Technology Assessment in Health Care (SBU) presented a systematic overview in 2005 of the literature and concluded (Evidence 3) that there is an increased risk of a TDI to the upper front teeth if the patient has a pronounced overjet with protrusion in combination with inadequate lip coverage (23).

Shulman and Peterson (24) reported that after adjusting for age, gender and race-ethnicity, overjet was the only occlusal covariate significantly associated with maxillary incisor trauma, with the odds of trauma increasing markedly as overjet increased. Nguyen et al. (25) reported that age and gender confound the incisal trauma-overjet relationship. Thus, it appears that studies that do not adjust for these confounders may be biased. The discussion in many studies has been to examine to what extent increased overjet and inadequate lip coverage, separately or in combination, increase the risk for TDIs. Such discussions have become even more relevant as Marcenes et al. (13) in their study found contradictory results. These conflicting results may be due to the interaction between oral predisposing factors (e.g. overjet and lip coverage), environmental factors, (e.g. playground design) and behavioural factors (e.g. risk-taking). To date, very few studies have accounted for all these factors simultaneously. Thus, future research should attempt to develop methods that account for all of these factors at the same time. Also the additional information about 'Orthodontic management of the traumatized dentition' could be found (26).

Unintentional traumatic dental injuries

Falls, collisions and being struck by an object

Falls, collisions and being struck by an object are the major causes of TDIs. The home and its neighbourhood are the most common place of injury in preschool and school-aged children, whereas physical leisure activities, violent incidents and traffic accidents account for most TDIs among adolescents. Although it is important to determine what makes people, e.g. fall, fight or have a collision, it would also be pertinent to learn what makes certain risk-taking persons avoid sustaining a TDI. The answers to these questions lead to the environmental and behavioural causes of TDIs.

Environmental determinants

Material deprivation

A major environmental determinant of TDIs is material deprivation. Hamilton et al. (27) and Marcenes and Murray (28) reported 34–44% prevalence of dental injuries in the UK in deprived areas (the overall prevalence was 15%) (29). The authors also found that the more deprived the area, the higher prevalence of dental trauma. Marcenes and Murray (28, 30) observed in two separate studies in the UK that overcrowding was the major environmental factor related to dental injuries. This finding seems logical as deprived areas have more unsafe playgrounds, sport facilities, schools, etc. Dangerous environmental conditions facilitate falls and collisions.

Human behaviour

Risk-taking children tend to have more dental traumas than non-risk-taking children. Odoi et al. (31) demonstrated that children who were being picked on or bullied by other children experienced more dental traumas than other children. On the other hand, children with prosocial behaviour were less injured with TDIs. Lalloo (32) reported that hyperactive children were injured more often than non-hyperactive children, whereas Odoi et al. found no such relationship. Davidson et al. (33) examined the hyperactivity in school-aged boys and subsequent risk of all types of injury, i.e. not only TDIs. They found no relationship between hyperactivity and subsequent childhood injuries. The difference may be that the environment plays a more important role than human behaviour in the sense that a hyperactive child can express his or her hyperactivity with less risk if the environment is safe. Wazana (34) stressed the importance of modifying the environment in order to reduce injuries among children. In practice, this entails advising parents not only of the role of supervision and low family stress but also of the importance of reducing the children's exposure to unsafe environments. It is especially important for parents living in poorer and more crowded neighbourhoods to find safe routes to and from school and play areas free of danger and away from streets.

Emotionally stressful states

Dental trauma has been linked to emotionally stressful conditions. Nicolau et al. (35), applying the life-course approach to elucidate the causes of dental trauma, concluded that adolescents who experienced adverse psychosocial environments along the life course had more dental trauma than adolescents who experienced more favourable environments. These adverse environments included living in a non-nuclear family and experiencing high levels of paternal abuse.

Recently, the association between attention-deficit hyperactivity disorder (ADHD) and dental trauma has been studied in 8- to 17-year-old children (36). This study suggests that ADHD in children is a predisposing factor for TDIs. In another study, Sabuncuoglu (37) concluded that the risk for TDIs is more pronounced before young patients with ADHD have received treatment and their excess behaviours normalised.

Petti and Tarsitani (38) showed that obese schoolchildren were significantly more prone to dental trauma than non-obese children. Similar results have been reported by Nicolau et al. (14), Granville-Garcia et al. (39) and Soriano et al. (21). Soriano et al. used values of obesity according to National Center for Health Statistics procedures while other studies used body mass index. An increase in safe physical activity would help overweight children to loose weight and make them more skilful (e.g. by being less likely to fall) (14). This strategy might also be applied to overweight adults. Perheentupa et al. (40) showed that obesity in adults

was a risk factor in dental trauma. Moreover, mental distress has been found to be a risk factor in dental trauma in adults.

Presence of illness, learning difficulties or physical limitations

Epilepsy
Concerning epilepsy, Bessermann (41) reported that 52% of epileptic patients had suffered dental trauma, many of which were of a repetitive nature. Epileptic seizures have been shown to be the third most common medical incident in dental surgeries (42, 43).

Cerebral palsy
The prevalence of TDIs in a group of individuals with cerebral palsy (CP) has been found to be much higher (57%) than in healthy populations despite that CP individuals do not take part in violent sport activities as do healthy individuals (44). Uncontrolled head movements seemed to be a more important factor causing a TDI among CP individuals than increased overjet.

Learning difficulties
A very high frequency of TDIs has been found among patients with learning difficulties (45, 46), a phenomenon probably related to various factors, such as a lack of motor co-ordination, crowded conditions in institutions or concomitant epilepsy.

Hearing or visual impairment
Alsarheed et al. (47) noted that hearing-impaired children, in comparison with visually impaired children, had significantly more dental trauma. This difference is probably because hearing-impaired children can play and move around more freely than visually impaired children.

Inappropriate use of teeth

Few studies have included the category 'inappropriate use of teeth'. However, many individuals have injured their teeth when using them as a tool to open hair clips, fix electronic equipment, cut or hold objects or opening bottles of soda or beer. Malikaew et al. (48) found that 18.7% of TDIs were caused by inappropriate use of teeth. Others have also reported this phenomenon though the figures were lower: Nicolau et al. (14) (6%), Tapias et al. (49) (8.5%) and Traebert et al. (50) (3.3%).

Oral piercing

A quite new category is TDIs that result from piercing of the tongue and lips, which is a popular and fashionable trend in the Western world. This new category of dental injuries and complications first emerged as case reports about a decade ago, and has been found to be a practice that is gaining acceptance as a sign of individuality, marginality, decoration or group membership (51), but also for its sexual and spiritual benefits (52).

Tongue piercing consists of a stud with two balls screwed onto each end, which is allowed to move because the length of the bar is greater than the thickness of the tongue. The principle is the same for lip piercing. Both types of piercing are removable. Research has shown that lip and tongue piercing may lead to chipping and fracturing of teeth and restorations, pulp damage, cracked tooth syndrome, tooth abrasion, pain, swelling and infections (53–55). In some cases, this practice has led to the transmission of hepatitis B and C, herpes simplex virus, Epstein–Barr, candida and HIV. In addition, tongue piercing has caused Ludwig's angina and hypotensive collapse (56–60). The proportion of different complications varies between 17% and 70% (61, 62). It has been reported that 50% of university undergraduates have some type of piercing (62). Levin et al. (63) reported that of 400 patients aged 18–24 years and randomly visiting a military dental office for dental examination during 2004, 81 (20.3%) had some form of oral piercing. More than half of these patients were unaware of the dangers in wearing an intra-oral piercing ornament. Table 2 presents postpiercing and other complications that are caused by lip or tongue piercing. The results must be considered with some caution because the material and the number of studies are rather small. Lip piercing has been found to increase the risk of gingival recession of the lower incisors (64, 65). Leichter and Monteith (65) also reported that gingival recession is almost 7.5 times as likely in a pierced individual wearing a labret than in an unpierced individual. This study also observed an increase in the incidence and severity of gingival recession in relation to the length of time the labret was worn. Infections and subsequent oedema have been found to be commonly recorded as complications of tongue piercing, but no difference has been observed in the occurrence of complications between professional (doctor or dentist) or non-professional (other sources) operators (64). Campbell et al. (66) reported a prevalence of chipped teeth of 19.2% among individuals wearing tongue piercing. In conclusion, dentists and other healthcare providers should be aware of the increasing number of patients with oral piercing and the risk of complications.

Iatrogenic injuries

Traumatic dental injuries also occur as iatrogenic procedures because of prolonged intubation. The incidence of perianaesthetic TDIs has been found to vary from 0.04% to 12% (67) and is the most frequent anaesthesia-related cause of claims in the UK, representing approximately one-third of all confirmed claims (68). Most TDIs are probably inadvertently caused by direct pressure during laryngoscopy and intubation, resulting in the fracture of crowns and roots and luxations or avulsions.

Traffic accidents

Traffic accidents include pedestrian-, bicycle- and car-related injuries. This trauma group is dominated by multiple dental injuries, injuries to the supporting bone and soft-tissue injuries. Gassner et al. (69) recently showed that children in traffic accidents have a more than twofold risk of facial bone fractures when

Table 2. Types of complication in patients with oral piercing

References	Region	Year	Number of individuals with piercings	Postpiercing complications	Swelling/ infection	Bleeding	Pain	Lymph-adenopathy	Gingival recession	Abnormal tooth wear
	Middle East									
Levin et al. (63)	Israel	2005	79	–	41	36	–	–	21	11
	Australia									
Kieser et al. (64)	New Zealand	2005	43	15	12	–	6	1	24	12
Leichter and Monteith (65)	New Zealand	2006	91	–	–	–	–	–	62	–
			54[1]	–	–	–	–	–	12	–

[1]Controls without piercing.
Some individuals have more than one type of complication.

compared with other injury types. A study in Nigeria reported that rear-seat occupants of commercial vehicles were the most likely to sustain maxillofacial injuries (70). Roccia et al. (71) and Mouzakes et al. (72) demonstrated that new types of facial trauma occur from airbag explosion in cars. Cox et al. (73) reported that front seat occupants in the USA restrained with a seat belt only or a seat belt and an air bag showed a significantly reduced risk of facial injury when compared with completely unrestrained occupants. An important finding in this study was that facial injury was similar in unrestrained occupants and occupants restrained only with the air bag. From these findings, the authors concluded that air bag deployment alone does not offer any protection against facial injury to unrestrained drivers in a car accident.

Acton et al. (74) reported that 31% of children under the age of 15 years with facial injuries as a result of bicycle accidents had a TDI. Thompson et al. (75) noted that bicycle helmets reduce the risk of facial injuries by 65%, but the users are still at high risk of dental trauma because of lack of protection of the lower face and jaw. Chapman and Curran (76) concluded that wearing bicycle helmets not only reduces the incidence and severity of head and brain injuries and their long-term consequences but also decreases facial injuries and some dental trauma. Linn et al. (77), however, found that TDIs occurred slightly more often among helmet users than among non-users though this difference was not statistically significant. According to Chapman and Curran, the dental profession could contribute to safety campaigns, but there must be a modification of helmet design to improve facial and dental protection. Experience from other countries suggests that education is insufficient in changing helmet-wearing behaviour and that the best way to increase the use of helmets is through legal statute.

Sports injuries

Although organised sport is one of the main causes of TDIs, the rates vary considerably depending on type of sport, selected group of athletes, geographical location, age of athlete, sample size, level of competition, whether the data were collected from coaches or from hospital emergency rooms or dental clinics (78) and the use of protective equipment, which is mandatory in some sports.

Recently, a US Department of Health and Human Services report indicated that approximately 33% of all TDI episodes and up to 19% of injuries to the head and face were sports related (79–82). Tuli et al. (83) reported that 32.2% of patients with a TDI visiting a university clinic did so because of sports injuries.

Federation Dentaire International places organised sports into two categories based on risk of TDIs: High-risk sports (such as American football, hockey, ice hockey, lacrosse, martial sports, rugby, inline skating, skateboarding and mountain biking) and medium-risk sports (such as basketball, soccer, team handball, diving, squash, gymnastics, parachuting and water polo) (84). Characteristic of high-risk sports is team sports in which rough contact between the players is allowed or in which a ball, puck or stick is used, but also some individual sports where good balance is required. Medium-risk sports include team sports in which rough contact between the players is not allowed, but there is still a risk of contact or falling. Horse riding is a popular activity, but one that is relatively dangerous. Injuries in connection with handling of horses are frequent and sometimes very severe. In studies presenting horse-related injuries the extent of TDIs is not shown. Instead, injuries to different parts of the body, such as head, neck and upper and lower extremities, are shown (85, 86). This makes it difficult to present TDIs in connection with horse riding. Ueeck et al. (87) found that horse riding and facial injuries were often associated with other types of injury. Therefore, one way to show TDIs in connection with horse riding is to show injuries to the head. In two national surveys, head injuries in association with horse riding occurred in 20.0–23.2% of the cases (85, 86). To prevent injuries to the head the use of approved safety helmets has been recommended. However, Ueeck et al. (87) found that wearing a helmet did not add any protection to the face.

Table 3 presents TDIs that occur in various international sports. Because of differences in methods and definitions, it is difficult to make comparisons whether between countries or between sports. In general, however, the occurrence of TDIs among athletes is high. Rugby, for example, has a very high rate of TDIs, irrespective of region. Other sports with a high rate of TDIs are team handball and basketball. When it comes to soccer, substantial variations of TDIs have been reported. In Europe and the Middle East the rates of TDIs seem to be lower than those in Asia and North and

Table 3. Proportion (%) of amateur or professional athletes with traumatic dental injuries in different sports and regions

References	Region	Year	Age/age group (years)	Sample size	Oro-facial injuries in %						
					Basketball	Baseball	Bicycle	Team handball	Ice hockey	Rugby	Soccer
	Asia										
Teo et al.[1] (128)	Singapore	1995	12–17	246	19	–	–	–	–	–	20
Yamada et al.[3] (129)	Japan	1998	16–17	2670	–	–	–	–	–	56.5	32.3
	Australia										
Jolly et al.[2] (130)	Australia	1996	16–44	2611	–	–	–	–	–	25–31	–
Cornwell et al.[3] (131)	Australia	2003	12–15, ≥18	496	23	–	–	–	–	–	–
	Europe										
Kujala et al.[4] (132)	Finland	1995	All ages	54 186	5.2	–	–	–	7.1	–	2.8
Emshoff et al.[5] (133)	Austria	1997	All ages	712	–	–	25.4	–	–	–	8.9
Blinkhorn[6] (5)	UK	2000	11–14	2022	–	–	13.6	–	–	–	–
Gábris et al.[6] (134)	Hungary	2001	1–18	590	–	–	13	–	–	–	–
Lang et al.[3] (135)	Switzerland/Germany	2002	–	112	–	–	–	10.7	–	–	–
Muller-Bolla et al.[7] (136)	France	2003	–	3034	–	–	–	–	–	29.6	–
Çaglar et al. (137)	Turkey	2005	15–29	37	–	–	–	–	29.7	–	–
Keçeci et al.[3] (138)	Turkey	2005	–	62	–	–	–	25.8	–	–	–
Perunski et al.[3] (139)	Switzerland	2005	–	331	16.6	–	–	–	–	–	–
	Middle East										
Levin et al.[4] (140)	Israel	2003	18–19	943	7.2	–	6.3	–	–	–	6.6
	North America										
Gomez et al.[3] (141)	USA	1996	14–18	890	14	–	–	–	–	–	–
Diab and Mourino[8] (142)	USA	1997	School children	1800	19	17	–	–	–	–	11
Kvittem et al.[3] (143)	USA	1998	High school	–	55.4	–	–	–	–	–	27.6
	South America										
Marcenes et al.[6] (13)	Brazil	2000	12	476	–	–	19.2	–	–	–	13.7
Ferrari and Ferreira de Medeiros[3] (144)	Brazil	2002	18–30	1189	36.4	–	–	37.1	11.5	–	23.1

[1]Sport-playing schoolboys.
[2]Amateur football players.
[3]Athletes.
[4]Sport activity.
[5]Mandibular fractures.
[6]Schoolchildren.
[7]Elite rugby players (trauma to the lower or middle part of the face).
[8]Reported by parents.

South America. Bicycling has quite a high rate of TDIs despite the effort in some countries to introduce helmets. An increased interest in mountain biking may account for this high rate. The results in Table 3 should be viewed with caution because of differences in methodology.

In Sweden, FOLKSAM (an insurance company) has followed TDIs in nine sports over a period of several years (88). Some of the sports have been followed from 1976 to 1997 (Fig. 1). From Fig. 1, it is obvious that a team sport, such as ice hockey, in which rough contact between the players is allowed and a puck and sticks are used accounts for a high risk of TDIs. New sports or recreational activities are continuously being introduced, such as downhill cycling, snowboarding, inline skating, skateboarding, wakeboarding and micro-scooter riding.

To prevent an increase in TDIs in new sports it is necessary to introduce these new sports among other organised sports in order to keep abreast with legislation and present appropriate prevention devices. At the same time, it is important not to prohibit spontaneity and joy in play, which is fundamental to all sports because the fascination with new skills, increased speed, experimenting with new tricks and competing are impossible to prohibit. The provision of a well-fitting mouth guard or helmet with protection of the face should dramatically reduce the occurrence of TDIs. However, there is still insufficient evidence that planned intervention is effective

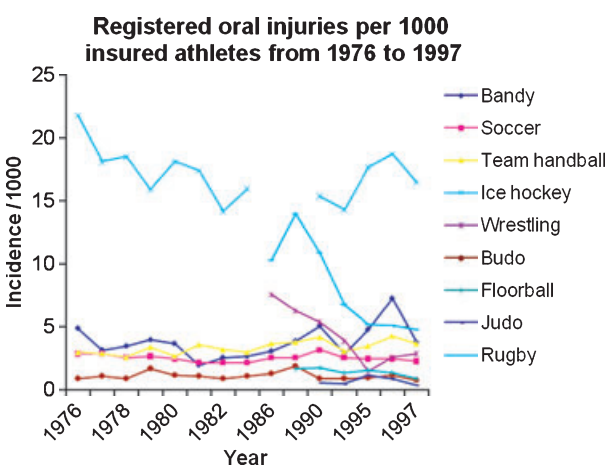

Fig. 1. Registered oral injuries per 1000 insured athletes from 1976 to 1997 [from Glendor et al. (88)].

in reducing the prevalence or incidence of sport-related injuries to the mouth and face (89). Thus, much remains to be done regarding attitude and effective use of protective equipment (82).

Risk exposure in various sports

Amateur athletes more often suffer from maxillofacial injuries than professional athletes. Mourouzis and Koumoura (90) showed that only 10% of the patients suffering from maxillofacial injuries during sports were professional athletes and Ueeck et al. (87) found that only 15% of the patients who suffered from maxillofacial injuries related to interaction with horses were injured during competition or work. According to these authors, the probable reason why amateur athletes suffer more often from maxillofacial injuries is that they do not use preventive measures and lack 'the professional athletic skill'.

The risk of suffering from a TDI differs not only regarding the type of sport but also the player's gender, the level of competition and time of exposure. A study was performed in Sweden to examine the risk of sustaining a TDI by studying exposure in different sports (Table 4). Soccer, team handball and ice hockey indicated a higher injury rate in lower divisions. Furthermore, in both soccer and team handball the injury rate was high in females and in some divisions the injury rate was even higher in females than in males (88). The results of this study were later confirmed by those of Ueeck et al. (87), Mourouzis and Koumoura (90) and Lim et al. (91), i.e. that the less professional athletes have a higher rate of TDIs.

Intentional traumatic dental injuries

The international literature on TDIs indicates that physical leisure activities account for most of the TDIs among adolescents, with falls and collisions tending to be the most prevalent events associated with these injuries. These very broad categories may mask the actual causes of TDIs because they do not assess intention. For instance, a fall from tripping (unintentional) differs from a fall from pushing (intentional). The latter is a form of violence. If intent had been assessed in earlier studies, these events would have been recorded as bullying or minor violence. Traebert et al. (50) suggest that the role of violence has been substantially underestimated. Another problem is that victims tend to report the cause as unknown even though the injury is directly related to violence.

Table 4. Injury rate per 1000 h of training and competing

	Premier league	Divisions 2–3	Division 4	Juniors
Soccer				
Male	0.011	0.019	0.013	0.002
Female	0.005	0.026	0.006	0.002
Team handball				
Male	0.023	0.028	0.040	0.006
Female	0.038	0.020	–	–
Ice hockey				
Male	0.060	0.120	0.180	0.001

Obtained from reference Glendor et al. (88).

Child and elderly physical abuse

The over-representation of accidents at home may be related to the difficulty in assessing injuries associated with child and elderly physical abuse. The face is a common target in assault. Consequently, dentists and oral surgeons are in a unique position to observe such injuries. da Fonseca et al. (92) found that 75% of all children subjected to physical abuse and taken to a major county hospital in the USA suffered injuries to the head, face, mouth or neck.

Dentists and physicians have a special responsibility to report this kind of TDI. However, the evidence suggests that many dentists do not report such physical abuse injuries (93, 94). Out of 16–29% of dentists who had claimed to have seen or suspected such a case, only 6–14% reported it. Bewly et al. (95) estimated that women, on average, experienced 35 episodes of domestic violence before seeking professional help. Cairns et al. (96) have recently confirmed this finding by showing that, although in 28% of cases dental practitioners suspected abuse, they sought advice and help in only 8% of the cases. Reasons for failure to refer were negative impact on their practice, family violence towards the child, violence directed against the dentists and litigation. The authors recommended training in assessment of suspicious indicators and dentist involvement in inter-agency child protection measures.

It must be kept in mind that it is not the primary task of the healthcare practitioner to give advice to individuals experiencing domestic violence on what direct action they should take. Women who suddenly leave their partners may be exposed to an increased risk of assault (97). Practitioners should instead provide information on how to contact the appropriate local services (98). Also the additional information about 'Child physical abuse' could be found (26).

Assaults

Violence often results in maxillofacial injuries. In a study in the UK 62% of all injuries to the face were due to assaults (99). In a Finnish study, the authors suggested that the incidence of maxillofacial fractures resulting from assaults is unlikely to increase (100). The same study reported that violence between individuals increased in severity from 1981 to 1997. In 1981, nearly 30% of assaults from kicking resulted in maxillofacial fracture; in 1997, this rate increased to 40%.

Violence has been shown to be the direct cause of TDIs in 5% of individuals in the age group 7–18 years in the county of Nord-Tröndelag and in 9% in the capital city of Oslo, Norway (10). Acts of violence were more frequently observed in the city when compared with rural areas and increased with age. In 16- to 18-year olds violence was recorded as the direct cause in 23% of the injured individuals.

Torture

The use of torture is of growing concern with the face as a common target area. Data on torture are scarce, but

working groups of dentists and physicians in co-operation with Amnesty International have been formed to document torture.

Prevention of traumatic dental injuries

There is little agreement in the literature concerning whether TDIs are preventable. This situation may partly be related to the traditional view that TDIs are unavoidable accidents. However, such a position does not take into account that there are many oral (e.g. excessive overjet of maxillary teeth), environmental and human factors (e.g. unsafe playgrounds and high-risk sports). Skaare and Jacobsen (10) reported on the observations of those dentists who registered and treated the TDI as to whether the dental injury could be preventable. These dentists believed that a third of the TDIs, which were of a severe nature, were preventable. Nevertheless, these TDIs, which were due to violence, sports, bicycling or other school and leisure-time activities, were only 1% of the total TDIs. Despite these observations, many causal factors may be prevented that could be of benefit, particularly regarding severe TDIs. Skaare and Jacobsen also concluded that changes in attitude and behaviour were the most important factors to reduce severe TDIs. Their report also involved recommendations for improved supervision in school yards and the use of intra-oral mouth guard protection. Educational efforts directed specifically to children, parents, teachers and physical trainers may have the best effect on the prevention of TDIs. Unfortunately, there are too few scientific studies demonstrating the success of such educational efforts to prevent from TDIs.

Malikaew et al. (48) stressed the need to target action particularly at older school boys from more deprived backgrounds. Moysés et al. (101) pointed out that TDIs are less likely to occur in schools that have a supportive social and physical environment. In a later study, Moysés et al. (102) showed that the physical environment component and the public social policies component were both related to TDI reduction. The social cohesion component, on the other hand, was not significantly associated with TDIs.

Sport injuries are rarely attributed to a single risk factor; rather, many factors play a role leading to an injury (103). Actions to prevent sports injuries should be based on the knowledge of aetiological factors that contribute to an increased risk of injury (104). Various authors have described operational models to investigate contact sport injuries, assessed causative factors in sport injuries and presented frameworks for injury control. One such operational model is Haddon's Matrix, which consists of two axes (105). The first axis includes elements of the epidemiological triad, host, agent and environment; this axis likens injury to disease. The second axis includes three time intervals: pre-event, event and postevent. This method could be combined with the Public Health Approach in addressing injury, which consists of a hierarchy of four levels (surveillance, risk factor identification, intervention evaluation and programme implementation) (105). Gissane et al. (106) introduced an operational cyclical model to investigate contact sports injuries. This model focuses on such areas as intrinsic risk factors in the healthy/fit player, primary prevention, exposure to external risk factors, factors regarding the mechanisms of injury, treatment and rehabilitation and outcome of the event. Such a model would also be suitable for TDIs.

Traditional approaches in the epidemiological investigation of sports injuries have tended to focus on the incidence and prevalence of injury, applied both to individual sports and to overall national statistics. The operational cyclical model of Gissane et al. (106) aims to expand this traditional approach by considering a multitude of factors that may predispose to injury and that may determine the ultimate outcome of the injury for the athlete in a contact sport.

Weaver et al. (107) propose a scheme for sport injury prevention that combines with Haddon's matrix to examine host, agent and environment. Using the three Es of injury prevention (engineering, education/behaviour change and enforcement), the scheme suggests that sport and recreational injuries should be preventable by (i) ensuring that the design, development and maintenance of sport and recreational equipment and facilities meet safety standards, (ii) influencing attitudes towards, and promoting uptake of, protective behaviours or equipment (e.g. wearing protective equipment and physical conditioning) and (iii) adapting playing rules to the participants regarding, skills, fitness, etc. and ensuring their enforcement. Unfortunately, most studies in this field have been with adults: what works for an elite 26-year old may not work for a 16- or 9-year-old player (108). Therefore, future studies should be designed to take into account the above-mentioned factors. Also the additional information about 'Prevention of dental and oral injuries' could be found (26).

A model to prevent TDIs from happening, irrespective of cause, would be the WHO Healthy Cities Programme, where a healthy city is defined as one that continually creates and improves the physical and social environment and expands community resources for enabling the mutual support among populations/groups for living (109). The WHO Health Promoting Schools Programme offers a broad solution for dental trauma as a public health problem. A Health Promoting School constantly strengthens its capacity as a healthy setting for living, learning and working (110). A wide range of actions and policies are possible, including personal and social education aimed at developing life skills, school policy against bullying and violence, physical environment, school health policy, alcohol policy, the provision of equipment (e.g. mouth guards) and links with health services (111). Moysés et al. (101) showed that 10% fewer children in Brazil had TDIs in health promoting schools that had a firm commitment towards health and society.

Traumatic dental injuries are frequent and expensive

Prevention of TDIs is essential because of its frequency throughout the world. The prevalence of TDIs to primary teeth in the 0–6 year segment varies from 11% to 30% (112–116). In the UK, O'Brien (29) demonstrated that one in five children had experienced a TDI to

their permanent anterior teeth before leaving school. Two large national surveys in the USA indicated that approximately one in six adolescents and one in four adults showed evidence of a TDI (24, 117). These results suggest that almost every third child with primary teeth and every fourth adult show some evidence of a TDI.

In addition to a high trauma frequency, TDIs are expensive to treat. A prospective and longitudinal study carried out in Sweden estimated a total cost (including direct and indirect costs) of US$ 3.3–4.4 million per million individuals per year in the age interval 0–19 years (118). In Denmark, the annual cost of treatment of TDIs ranged from US$ 2 to 5 million (standard and pessimistic estimate) per million inhabitants per year, irrespective of age (119).

Compared with many other outpatient injuries, TDIs are more time-consuming and costly to treat. For example, the average number of visits treated on an outpatient basis during 1 year because of TDIs to permanent teeth has been shown to range from 1.9 to 9.1 (120–122), which exceeds the average number of 1.5 visits that are due to other accidental bodily injuries also treated on an outpatient basis during 1 year (123). In Sweden, the average outpatient treatment costs of a non-oral accidental injury in all ages have been calculated to US$ 88 during 1 year (123). This figure should be compared with US$ 926 to 1490, which is the average standard or pessimistic treatment cost in Denmark of a complicated TDI to a permanent tooth (119). Also the additional information about 'Economic Aspects of Traumatic Dental Injuries' could be found (26).

Traumatic dental injuries have also been found to alter facial appearance. Cortes et al. (124) showed that children with untreated fractured teeth were highly dissatisfied with the appearance of their teeth and experienced a negative impact on their daily life than children without a TDI. Also the additional information about 'Socio-Psychological Aspects of Traumatic Dental Injuries' could be found (26).

Conclusions

The number of known causes of TDIs presented in the literature has grown to alarming levels during the past few decades. The reason for this phenomenon probably lies in an increased interest of the causes, but also to show the complexity underlying a TDI. It is not, e.g. overjet and lip coverage alone that increases the risk for TDIs. Instead, it is a complex interaction between the patient's oral situation, the design of public parks and school playgrounds and human behaviour. Studies in dental traumatology, therefore, have to consider a number of parameters, including oral predisposing factors, environmental determinants and human behaviour to determine why TDIs come about and how they should be prevented. The question is to what extent these factors together or separately influence the risk of a TDI.

Most TDIs are unintentional injuries, with falls, collisions and being struck by an object as the most dominating causes. Unfortunately, unknown causes are a strategy to conceal the real cause (e.g. physical abuse and assaults) of a TDI. Thus, it is reasonable to suspect that the proportion of unintentional TDIs, in comparison with intentional TDIs, is overestimated. The dramatic increase in the severity of violence (i.e. intentional trauma) among individuals concerning TDIs is another alarming factor.

To continually catch up with the changes in dental trauma it would be of great value if every dental clinic performed a simple ongoing registration of TDIs to determine whether there has been any TDI during the last treatment period and the severity of that trauma. This simple registration, earlier presented by Glendor (145) could indicate that a traditional retrospective or prospective study, including both epidemiological and aetiological parameters, should be performed.

A model to prevent TDIs from happening, irrespective of cause, would be the WHO Healthy Cities and the WHO Health Promoting Schools Programmes, which offer a broad solution for dental trauma as a public health problem.

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