The associations between risk-taking behaviours, peer influence and traumatic dental injuries among Saudi adolescents

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I, Sultan Almalki, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature

Abstract

Background: Traumatic dental injuries (TDIs) are one of the most common body injuries and constitute an important public health problem. These injuries are considerably more common among adolescents, and can lead to pain, physical impairment, emotional distress and negative impact on the quality of life. Theories link most types of injuries to individual behaviours within a complex matrix involving both the physical and social environments. However, most of the aetiological studies on TDIs focus on proximal risk factors and overlook the underlying more distal determinants. This PhD thesis aimed to assess whether certain behavioural and psychosocial determinants were associated with the prevalence of TDIs among adolescents in Riyadh, Saudi Arabia, with a particular focus on the role of their risk-taking behaviours and peer influence.

Methods: A stratified two-stage cluster sample of 902 students (461 boys and 441 girls) was randomly selected from adolescents attending 1st and 2nd years of public and private secondary schools in Riyadh, using a self-weighting design for both sexes and school types. Data were collected through clinical examination and questionnaire. TDIs were clinically diagnosed using a modified version of the WHO classification for epidemiological studies. The clinical examination also included assessment of overjet and lip coverage. The questionnaire was based on the WHO Health Behaviour in School-Aged Children questionnaire and the CDC Youth Risk Behaviour Surveillance System, assessing exposures risk-taking behaviours and peer influence, as well as demographics, socio-economic status and physical activity. The differences in prevalence of TDIs between the different groups of the covariates and exposures were calculated. Then, Poisson regressions with a robust error variance were used to estimate adjusted prevalence ratios (relative risks) of TDIs between the different exposures to provide sequential adjustment for confounding factors. The models were further checked for interactions between the main exposure and the peer influence variables.

Results: Overall, 42.6% of adolescents had TDIs to their anterior teeth (Boys: 59.4%; Girls: 24.9%). After adjusting for age, sex, father's education, nationality, physical activity and overjet >3mm, smoking was significantly associated with TDIs among girls (RR 2.50; 95% CI 1.42–4.41), and the same was the case among boys for fights (RR 1.46; 95% CI 1.19–1.79), for spending time with friends after school on more than three days a week (RR 1.25; 95% CI 1.07–1.46) and for having peers who carried weapons (RR 1.19; 95% CI 1.01–1.40), compared to their counterparts. TDIs were also significantly associated with both boys and girls who carried weapons (RR 1.36; 95% CI 1.12–1.66), had multiple risk-taking behaviours (RR 1.44; 95% CI 1.20–1.72) and had less than three close friends (RR 1.19; 95% CI 1.00–1.42) compared to their counterparts. The risk of TDIs was intensified among adolescents who carried weapons and had multiple risk-taking behaviours when they lacked peer support (RR 2.18; 95% CI 1.05–4.57 and RR 2.18; 95% CI 1.05–4.57, respectively) compared to their counterparts who had supportive peers (RR 1.28; 95% CI 1.01–1.62 and RR 1.36; 95% CI 1.11–1.68, respectively).

Conclusions: Adolescents in Riyadh, particularly boys, had a very high prevalence of TDIs. Risk-taking behaviours (smoking, fights and carrying weapons) and negative peer influence (having peers who carried weapons) indicated an increased risk of TDIs among those adolescents independent of their age, socioeconomic status, physical activity and incisor overjet level. Negative peer influence (lack of peer support) intensified the association between risk-taking behaviours and TDIs.

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CI	Confidence Interval
CDC	Centers for Disease Control
FAS	Family Affluence Scale
HBSC	Health Behaviour in School-Aged Children
MVPA	Moderate-to-Vigorous Physical Activity
OR	Odds Ratio
P	*p*-value
SAU	Salman Bin Abdulaziz University (Currently known as Prince Sattam bin Abdul Aziz University)
SD	Standard deviation
RR	Relative Risk
TDI	Traumatic dental injury
UCL	University College London
UK	United Kingdom
USA	United States of America
WHO	World Health Organization
YRBSS	Youth Risk Behaviour Surveillance System

Chapter 1: Literature review

2.1.Introduction

Injuries are among the leading causes of mortality and morbidity worldwide and constitute a major and growing public health problem. Global data indicate that injuries constitute over 12% of the burden of disease attributable to all the health conditions, and deaths globally due to injury are predicted to increase by 28% between 2004 and 2030 (Blas and Kurup 2010; Krug et al. 2000; Sasser et al. 2005; World Health Organization 2008). Most injuries are related to road traffic injuries, violence, self-inflected injuries and falls (Figure 1). In Saudi Arabia, road traffic injuries are considered the leading cause of lost years of healthy life for males (Memish et al. 2014).

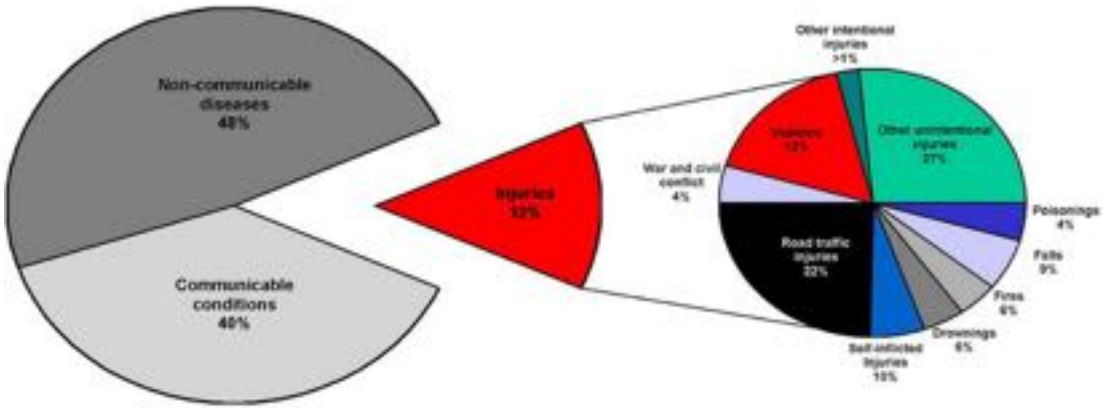

Figure 1: Proportion of burden of disease due to injuries and their causes (World Health Organization, 2008).

Injuries are not considered as accidents as they are largely predictable and preventable (Doege 1978; Doege 1999; Loimer and Guarnieri 1996; Rimsza et al. 2002). Thus, public health authorities and medical journals discourage the use of the word "accident" when referring to injuries (Davis and Pless 2001; Pless and Hagel 2005). The World Health Organization (WHO) defined intentional injuries as "Injuries that are purposely inflicted, either by the victims themselves (i.e. suicide and suicide attempts) or by other persons (i.e. homicide, assault, rape,

child abuse)", and unintentional injuries are defined as "Injuries that are not intentionally inflicted" (Sethi et al. 2004).

Despite the different types and classifications of injuries, the literature on the aetiology of injuries indicates that individual behaviours are linked to most injuries in different ways (Pickett et al. 2005a; Pickett et al. 2002a; Pickett et al. 2005b). In addition, major injury causation theories, such as Haddon's (1980), indicate that factors other than behaviours contribute to the incidence of injury. Haddon draws attention to a complex matrix of injury causation factors that considers both the physical and social environments. Indeed, social environments have an important impact on health in general (Black 1982; Marmot and Wilkinson 2006) and on injury in particular (Bahr et al. 2005; Kasen et al. 1998; Pickett et al. 2006).

As no effective action to tackle injuries can be developed without identifying the underlying root determinants of the problem (Watt 2007), research should be extended beyond the direct biological risk factors to cover the fundamental "causes of the causes" (Rose 1992). This includes interactions between psychological, behavioural and social factors. Such an approach implies the need for studies that provide a comprehensive assessment of a range of determinants to help map the key links between all possible factors that lead to injuries.

This literature review is a result of a search for published research in English and Arabic languages that was carried out in several electronic databases: ISI Web of Science, PubMed, Embase, Google Scholar, PsycINFO, Scopus, OVID Medline, Social Science Citation Index, Cochrane Database of Systematic Reviews and Science Citation Index. The search used appropriate free-text and thesaurus terms relating to injuries in adolescents and their physical, behavioural, social and environmental determinants that could be measured on adolescents: trauma*, injur*, traumati?ed teeth, tooth, dental, dentoalveolar, oral, prevalence, epidemiology, aetiology, incidence, review, behavio?r*, social, psychosocial, psychological, environmental, risk-tak*, risk behavio?r*, risk attitude*, high risk, peer influence, socialis*, violence, accident*,

substance use*, drug* use*. In addition, bibliographies were manually searched for relevant publications not identified through searching the electronic databases indexed. The review starts with an overview of the prevalence and incidence of traumatic dental injuries (TDIs) and then reviews the current evidence on their biological, clinical, behavioural, psychological, socioeconomic and environmental determinants.

2.1. Overview of TDIs among adolescents

TDIs are one of the most common body injuries (Eilert-Petersson et al. 1997). These injuries constitute an important dental public health problem, particularly among adolescents where over a third have TDIs (Table 1). These injuries can cause pain, physical impairment and emotional distress, which can lead to social and psychological impacts that negatively affect the quality of life of adolescents (Bendo et al. 2014; Cortes et al. 2002; Fakhruddin et al. 2008b; Lee and Divaris 2009; Locker 2005). In addition, the clinical management of TDIs can be very expensive for the individual and society (Borum and Andreasen 2001; Glendor 1998; Glendor et al. 2000a; Glendor et al. 2001; Pongpichit et al. 2008).

Despite their high prevalence, there are relatively few studies on the epidemiology and determinants of TDIs. Andersson and Andreasen (2011) stated that "The whole clinical fundament of dental traumatology rests on approximately 50 studies of satisfactory quality, a fact in grave contrast to the severity of the problem and the number of clinical questions that are still not documented."

The following section will review studies on the prevalence of TDIs among adolescents worldwide.

2.1.1. Prevalence and incidence of TDIs among adolescents

As stated earlier, TDIs are highly prevalent in adolescent populations throughout the world. Table 1 presents an overview of reported prevalence of TDIs in permanent teeth among adolescents in studies published between 1992 and 2015, which is corresponding to a 20 years

period (1992-2012) prior to the start of this research as well as the following three years of the research. For example, in Sweden, by the age of 16, 35% of the studied population had one or more TDIs to their primary or permanent teeth (Borssén and Holm 1997). A very recent Swedish study reported that the prevalence had increased to 37.6% (Oldin et al. 2015). In the UK, a national child survey in 2013 reported that 10% of adolescents aged 15 years had a TDI (Pitts et al. 2015), while in the United States of America (USA), two large national surveys reported that approximately 1 in 6 individuals aged 6 to 20 years had evidence of a TDI (Kaste et al. 1996; Shulman and Peterson 2004). In Latin America and the Caribbean region, a systematic review on the prevalence of TDIs among adolescents reported a pooled prevalence of 18.6% (Aldrigui et al. 2014). In Brazil, which is the main source of the recent relevant studies, the prevalence of TDIs in many of these studies was very high. Marcenes et al. (2001) reported a prevalence of 58.6% among a sample of 12-year-olds in Blumenau. More recent studies reported a prevalence of 37.1% among 12- and 15- year-old schoolchildren in Curitiba (Carvalho et al. 2010) and 34.8% among 12 year–old schoolchildren in the city of Porto Alegre (Damé‐Teixeira et al. 2013). In addition, many other studies from different cities reported prevalences between 20% and 30% (Cavalcanti et al. 2009; Jorge et al. 2012; Nicolau et al. 2003; Oliveira Filho et al. 2014; Reisen et al. 2013; Soriano et al. 2004).

In the UK, studies that evaluated the prevalence of TDIs among adolescents in local areas also reported a high prevalence. For example, the prevalence of TDIs was 44.2% among 14–15 year-old schoolchildren in Sheffield (Rodd and Chesham 1997), 43.8% among 14 year-old schoolchildren in London (Marcenes and Murray 2002), 34.4% among 11–14 year-old schoolchildren in Salford and Bury (Burden 1995), and 15% among 11–12 year-old schoolchildren in Northern Ireland (Burden 1995). TDIs were also prevalent in Thailand, Israel, Italy, Taiwan and Canada (Huang et al. 2009; Locker 2005; Malikaew et al. 2006; Petti and Tarsitani 1996; Sgan-Cohen et al. 2008).

On the other hand the prevalence of TDIs was low in some developing countries. Only 4% of 16 year-old schoolchildren had TDIs in Malaysia (Nik ‐ Hussein 2001), 5.5% among 12 year-old schoolchildren in Jordan (Rajab et al. 2013), 6% among 12 year-old schoolchildren in India (David et al. 2009), 6.1% among 6–13 year-old schoolchildren in Iraq (Noori and Al-Obaidi 2009), 6.4% among 11–13 year-old schoolchildren in South Africa (Naidoo et al. 2009), 7.1% among 8–12 year-old schoolchildren in China (Chen et al. 2014), and 8% among 9–12 year-old schoolchildren in Syria (Marcenes et al. 1999). Even within the same country, Brazil, where the prevalence was high in some cities, in others the prevalence was relatively low. For example, the prevalence of TDIs was 9.4% among 11–12 year-old schoolchildren in Rio de Janeiro (Castro et al. 2011) 9.7% among 12 year-olds in Santa Maria (Piovesan et al. 2010), 10.5% among 12 year-olds in Recife (Soriano et al. 2007) and 10.7% among 11–13 year-old schoolchildren in Biguaçu (Traebert et al. 2003a).

In Saudi Arabia there are only few studies related to the prevalence of TDIs among adolescents. However the available evidence indicates that there is a high prevalence of TDIs. Al-Majed et al. (2001) reported a 34% prevalence among male schoolchildren aged 12–14 years in Riyadh. A later study by Al-Majed (2011) reported a prevalence of 31.4% among schoolgirls aged 12 to 15 years in Riyadh as well.

While there is a considerable amount of literature on the prevalence of TDIs, there are very few that assessed its incidence. Borssén and Holm (1997) reported a yearly incidence rate of TDIs of 2.8% for a cohort in Sweden aged between 1 and 16 years. Another study among Swedish children aged from birth to 19 years reported an incidence rate of 1.3% per year (Glendor et al. 1996). A recent study among Swedish children aged 0 to 17 years reported a rate of 2.8% (Oldin et al. 2015), identical to that reported by Borssén and Holm (1997). In Norway, Skaare and Jacobsen (2003a) studied Norwegian children aged 7 to 18 years living in an urban and a rural areas and found a significantly higher incidence in urban (2.0%) than in rural areas (1.3%).

The differences between the incidence rates of these studies could be attributed to the different contexts of these studies, such as the inclusion of rural areas in the Norwegian study compared to the others, which highlights the importance of social and environmental factors as potential key determinants (Egan et al. 2008; Glendor 2008, 2009; Mytton et al. 2009; Pearce et al. 2012b). On the other hand, the wide variations in prevalence of TDIs among adolescents, both between and within countries suggests that there are important contextual factors affecting the prevalence of TDIs as the studies were conducted in a wide diversity of individual, physical, social and environmental contexts. Also, methodological differences between the prevalence and incidence studies could be a considerable contributor to these variations. For example, there were wide differences in studies in sampling approaches, diagnosis criteria for TDIs, as well as age groups.

Some studies, such as Rodd and Chesham (1997), Uzel et al. (2014) and Faus-Damia et al. (2011) used participants' self-reports to assess TDIs instead of clinical examination. Also, Oldin et al. (2015) used a combination of data from dental records and interviews to assess TDIs, while another study used mothers' reports (Käch et al. 2014). In addition, the comparability is hindered by the fact that some studies sampled only boys, such as the study by Al-Majed et al. (2001), while others referred only to girls, such as the study by Al-Majed (2011). Furthermore, these aforementioned studies varied considerably in terms of their quality and therefore the interpretation of their results should be done with caution.

Table 1: Reported prevalence of TDIs in permanent teeth among adolescents in studies published between 1992 and 2015

Authors (Year)	Country (region/city)	Year	Age	n size	Prevalence	Source of sample
Marcenes et al. (2001)	Brazil (Blumenau)	Unknown	12	652	58.6	Schools
Rodd and Chesham (1997)	UK (Sheffield)	Unknown	14–15	770	44.2*	Schools
Marcenes and Murray (2002)	UK (London)	1998–1990	14	411	43.8	Schools
Oldin et al. (2015)	Sweden	2008–2012	0–17	2363	37.6**	Dental clinics
Carvalho et al. (2010)	Brazil (Curitiba)	2005–2006	12/15	1581	37.1	Schools
Malikaew et al. (2006)	Thailand (Chiang Mai)	Unknown	11–13	2725	35.0	Schools
Borssén and Holm (1997)	Northern Sweden	1991	16	3007	35	Dental clinics
Damé‐Teixeira et al. (2013)	Brazil (Porto Alegre)	2009–2010	12	1528	34.8	Schools
Hamilton et al. (1997)	UK (Salford and Bury)	1990–1991	11–14	2022	34.4	Schools
Al-Majed et al. (2001)	Saudi Arabia (Riyadh)	1997	12–14	862	34***	Schools - Boys
Sgan-Cohen et al. (2008)	East Jerusalem	Unknown	10–12	453	33.8	Schools
Käch et al. (2014)	Switzerland	2009	0–16	1282	31.9****	Homes
Al-Majed (2011)	Saudi Arabia (Riyadh)	Unknown	12-15	255	31.4***	Schools - Girls
Paiva et al. (2014)	Brazil (Diamantina)	2013	12	588	29.9	Schools
Sgan-Cohen et al. (2005)	Jerusalem	Unknown	9–13	1195	29.6	Schools
Jorge et al. (2012)	Brazil (Belo Horizonte)	2009–2010	15–19	891	27.7	Schools
Reisen et al. (2013)	Brazil (Valinhos)	2012	13–19	379	27.1	Schools
Oliveira Filho et al. (2014)	Brazil (Diamantina)	2010	14–19	701	26.6	Schools
Prabhu et al. (2013)	India (Udumalpet)	2009	10–16	458	23.8	Schools
Marcenes and Murray (2001)	UK (London)	1995–1996	14	2242	23.7	Schools
Soriano et al. (2004)	Brazil (Recife)	Unknown	12	116	23.3	Schools
Cavalcanti et al. (2009)	Brazil (Campina Grande)	2007	7–12	448	21.0	Schools
Nicolau et al. (2003)	Brazil (Cianorte)	1999	13	652	20.4	Schools
Petti and Tarsitani (1996)	Italy (Rome)	Unknown	6–11	824	20.3	Schools
Huang et al. (2009)	Taiwan	2002	15–18	6312	19.9	Schools
De Frujeri et al. (2014)	Brazil (Brasilia)	2011–2012	12	1118	19.8	Schools
Traebert et al. (2003c)	Brazil (Florianópolis)	1999	12	307	18.9	Schools
Locker (2005)	Canada (Ontario)	2005	14	3010	18.5	Schools
Pattussi et al. (2006)	Brazil (Federal district)	2002	14–15	1302	13.5–18.5	Schools
Kaste et al. (1996)	USA	1996	6–20	3337	18.4	National survey
Ahlawat et al. (2013)	India (Panchkula)	Unknown	10–17	1052	18.2	Schools
Traebert et al. (2006)	Brazil (Herval D'Oeste)	2000	12	297	17.3	Schools
Livny et al. (2010)	Palestine	Unknown	11–12	804	17.7	Schools
Bendo et al. (2010)	Brazil (Belo Horizonte)	Unknown	11–14	1612	17.1	Schools
Agel et al. (2014)	UK (East London)	2005	15–16	728	17.0	Schools
Francisco et al. (2013)	Brazil (Anapolis)	Unknown	9–14	765	16.5	Schools
Al-Bajjali and Rajab (2014)	Jordan (Amman)	Unknown	12	1015	16.3	Schools
Cortes et al. (2001)	Brazil (Belo Horizonte)	2001	9–14	3702	8–16.1	Schools
Shulman and Peterson (2004)	USA	2004	6–20	6558	16.0	National survey
Marcenes et al. (2000)	Brazil (Jaragua do Sul)	Unknown	12	476	15.3	Schools
Hargreaves et al. (1995)	South Africa	1995	11	1035	15.4	Schools
Taiwo and Jalo (2011)	Nigeria	Unknown	12	719	15.2	Schools
Burden (1995)	UK (Northern Ireland)	Unknown	11–12	1137	15	Schools
Ankola et al. (2013)	India (Belgaum)	2010	6–11	1320	14.7	Schools
Årtun et al. (2005)	Kuwait	2005	13–14	1583	14.5	Schools
Dua and Sharma (2012)	India (Gulabgarh)	Unknown	7–12	880	14.5	Schools
Moysés et al. (2006)	Brazil (Curitiba)	2000	12	2026	14.4	Schools
Schatz et al. (2013)	Switzerland (Geneva)	2001-	6–13	1898	14.3	Schools
Bendo et al. (2012)	Brazil (Belo Horizonte)	2008–2009	11–14	1556	14.1	Schools
Moysés et al. (2003)	Brazil (Curitiba)	Unknown	12	1823	14.1	Schools
Hamdan and Rajab (2003)	Jordan	Unknown	12	1878	13.8	Schools
Delattre et al. (1995)	France (Rennes)	1991	6–15	2020	13.6	Schools
Holland et al. (1994)	Ireland	1989–1990	16–24	400	13.5	National survey
Chadwick et al. (2006)	UK	2003	15	1978	13	National survey
Goettems et al. (2014b)	Brazil (Pelotas)	2010	8–12	1210	12.6	Schools
Pitts et al. (2015)	UK	2013	12	2532	12	National survey
Skaare and Jacobsen (2003a)	Norway (Oslo and Nord-	1993	7–18	1275	12	Paediatric clinic
Fakhruddin et al. (2008a)	Canada (Ontario)	Unknown	12–14	2422	11.4	Schools
Chadwick et al. (2006)	UK	2003	12	2377	11	National survey
Otuyemi (1994)	Nigeria (Ile-Ife)	Unknown	12	1016	10.9	Schools

Traebert et al. (2003a)	Brazil (Biguaçu)	2001	11–13	2260	10.7	Schools
Jindal et al. (2015)	India (Patiala)	Unknown	7–14	842	10.7	Schools
Rambharos et al. (2014)	India (Central)	2012	12–14	2000	10.5	Schools
Soriano et al. (2007)	Brazil (Recife)	Unknown	12	1046	10.5	Schools
Chopra et al. (2014)	India (Panchkula)	2013	12–15	810	10.2	Schools
Uzel et al. (2014)	Turkey (Izmir)	Unknown	11–21	343	10.2*	Amateur soccer
Govindarajan et al. (2012)	India (Chidambaram)	Unknown	3–13	3200	10.1	Schools
Pitts et al. (2015)	UK	2013	15	2418	10.0	National survey
Thelen and Bårdsen (2010)	Albania	2006	16–18	2789	9.9	Schools
Murthy et al. (2014)	India (Bangalore)	Unknown	5–16	2140	9.7	Schools
Piovesan et al. (2010)	Brazil (Santa Maria)	2008	12	792	9.7	Schools
Castro et al. (2011)	Brazil (Rio de Janeiro)	2007–2008	11–12	571	9.4	Schools
Ferreira et al. (2011)	Brazil (Sao Paulo)	2001–2005	1–20	544	9.2	Special care clinic
Marcenes et al. (1999)	Syria (Damascus)	Unknown	9–12	1087	8	Schools
Çetinbaş et al. (2008)	Turkey (Ankara)	2005–2006	7–13	2570	7.4	Schools
Chen et al. (2014)	China (Beijing)	2012	8–12	5165	7.1	Schools
Naidoo et al. (2009)	South Africa	Unknown	11–13	1665	6.4	Schools
Faus-Damia et al. (2011)	Spain	Unknown	6–18	1325	6.2*	Schools
Noori and Al-Obaidi (2009)	Iraq	Unknown	6–13	4015	6.1	Schools
David et al. (2009)	India (South)	Unknown	12	838	6	Schools
Rajab et al. (2013)	Jordan	Unknown	12	2560	5.5	Schools
Nik‐Hussein (2001)	Malaysia	1997	16	4085	4.1	Schools

* TDIs were assessed using participants' self-reporting.
** TDIs were assessed combining data from dental records and interviews.
*** The sample of this study was single sex only.
**** TDIs were reported by mothers.

2.2. Determinants of TDIs

Since the introduction of the pivotal conceptual framework of Haddon (Haddon Jr 1968, 1980), the field of injury research has seen remarkable transformation and development in its approach. Researchers point to the complex web of causation of injury, which includes both the physical and social environments. One of the significant advancements on Haddon's framework is the ecological model which pays greater attention to the physical and social characteristics of where individuals live and the influences of these factors on their behaviours (Bronfenbrenner 1979). The ecological model explores the relationship between individual and contextual factors and acknowledges that human behaviour is influenced by an interaction of several factors, including social relationships and social environments (Figure 2). According to the model, each social sphere influences how individuals behave that can either increase or decrease their risk of injury. Therefore, individual behaviour should always be studied with reference to its broader social context.

While there is a relatively large literature relating to the rationale and assessments of determinants of many types of body injuries, there are few published studies on determinants of TDIs. In addition, studies tend to focus on biological risk factors of dental injuries, such as overjet and lip inadequacy, paying much less attention to behavioural, social and environmental factors. This ignores the fact that a injury event rarely occurs as a consequence of an isolated factor at only one level, but is usually determined by a combination of social and environmental factors along with behavioural responses of individuals (Peden et al. 2008)

Studies of TDIs and their determinants have most often been conducted in the absence of a valid theoretical base to guide the development of aetiological modelling (Andersson and Andreasen 2011; Bastone et al. 2000; Glendor 2008, 2009). This omission raises questions about the applicability of many of their conclusions. In contrast to studies on determinants of TDIs, there have been considerable advances in the field of general injury research. There are at least five helpful theories of causes of injuries; the epidemiological model (Gordon 1949), the Haddon matrix (Haddon Jr 1980), the ecological model (Bronfenbrenner 1979), the iceberg model (Hanson et al. 2005) and the life course model (Hosking et al. 2011).

These theories and frameworks are helpful for aetiological studies of TDIs in relation to understanding the risk factors of the occurrence of TDIs, including the social and environmental context in which they take place. The ecological model (Bronfenbrenner 1979) and its variations (Allegrante et al. 2010; Hanson et al. 2005) are a good example of this. The advantage of this model is its incorporation of a wide range of health determinants (Figure 2). It acknowledges that human behaviour is influenced by a complex interaction of several factors including individual, relationships, social, cultural, and environmental. Last (2001) defined human ecology as: “study of human groups as influenced by environmental factors, including social and behavioural factors”. In the ecological model, each social sphere influences how individuals behave that can either increase or decrease their risk of injury. Although the model was

originally designed for intentional injuries and used children's violence as its basis, it is helpful for the study of determinants of unintentional injuries (Bronfenbrenner 1979).

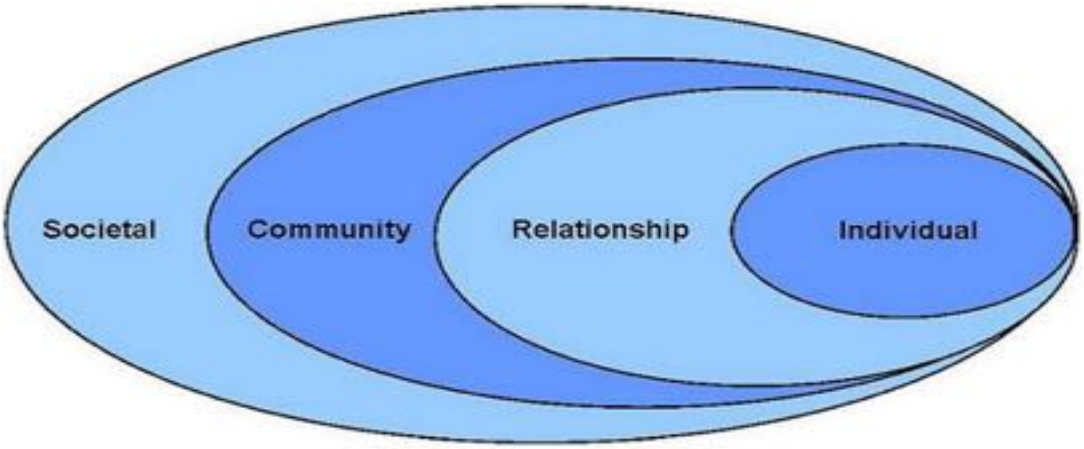

Figure 2: The ecological model (Krug et al. 2002)

The social environment leading to injury events is attracting more attention with the accumulating evidence from different contexts showing that a supportive social environment can act as a protective factor for health while lack of it can lead to poor health (Black 1982; Marmot and Wilkinson 2006). Social environments influence personal psychology and behaviours which in turn are linked to injuries (Bahr et al. 2005; Kasen et al. 1998; Pickett et al. 2006). Therefore, the psychosocial factors, which modify the behaviours and psychology of individuals, can be important moderators of the determinant factors of injuries.

Martikainen et al. (2002) introduced a psychosocial model similar to the ecological model but incorporating psychosocial factors; how individuals translate their "macro- and meso-level" social processes into behaviours. In their model, Martikainen et al. (2002) proposed that psychosocial factors influence processes acting between the social and the individual levels. This perspective distinguishes psychosocial factors from being purely structural characteristics of societies or psychological characteristics of individuals (Figure 3). The psychosocial approach can be a valuable tool that directs research to the pathways and mechanisms mediating the influences of the social determinants on health. However, it is crucial for psychosocial

determinants research to be guided by sound theoretical assumptions of the underlying pathways to enable valid interpretations of the events generated by these processes.

Figure 3: Schematic representation of psychosocial pathways (Martikainen et al. 2002)

In an attempt to better understand the multilevel system of the ecological approach to injury determinants, Hanson et al. (2005) proposed the "Injury Iceberg Model" using a visual metaphor. This model explores the relationship of the person to the physical and social environment with different levels of potential interactions starting from the proximal intra-personal levels, such as individual behaviours, to inter-personal level, such as social interactions, and to the broader community and society levels. Putting the individual at the visible tip of the iceberg, the model infers that the individual is only a part of a multilevel ecological system, though potentially the most visible component of this system, and that many important determinants of injuries are "hidden below the waterline" (Hanson et al. 2005). The clear emphasis of this model on the interaction between the three dimensions; individual, physical and social environment puts into perspective the ecological context of the individual within the environment. Therefore, studies on individual injury behaviours must consider the underlying physical and social factors (Allegrante et al. 2010; Porter et al. 2010). The complex web of causation provided by Hanson's model can be helpful for mapping the key links to an injury and identifying most of the upstream and downstream causative factors. The most relevant aspects of

the Hanson's injury framework will now be used to review studies that assessed determinants of TDIs.

The Injury Iceberg Model has five levels, the intrapersonal, the interpersonal, organisational, community and lastly, society (Hanson et al. 2005). In this thesis it was decided to only focus upon some of the levels, namely, the intrapersonal, the interpersonal and certain aspects of the Community level, such as social class and school environments, as the organisational and societal levels were beyond the scope of the proposed study. Figure 4 outlines a conceptual framework of key determinants of TDIs that is based upon the broader Hanson et al. (2005) model. The key elements of this new framework will now be reviewed below.

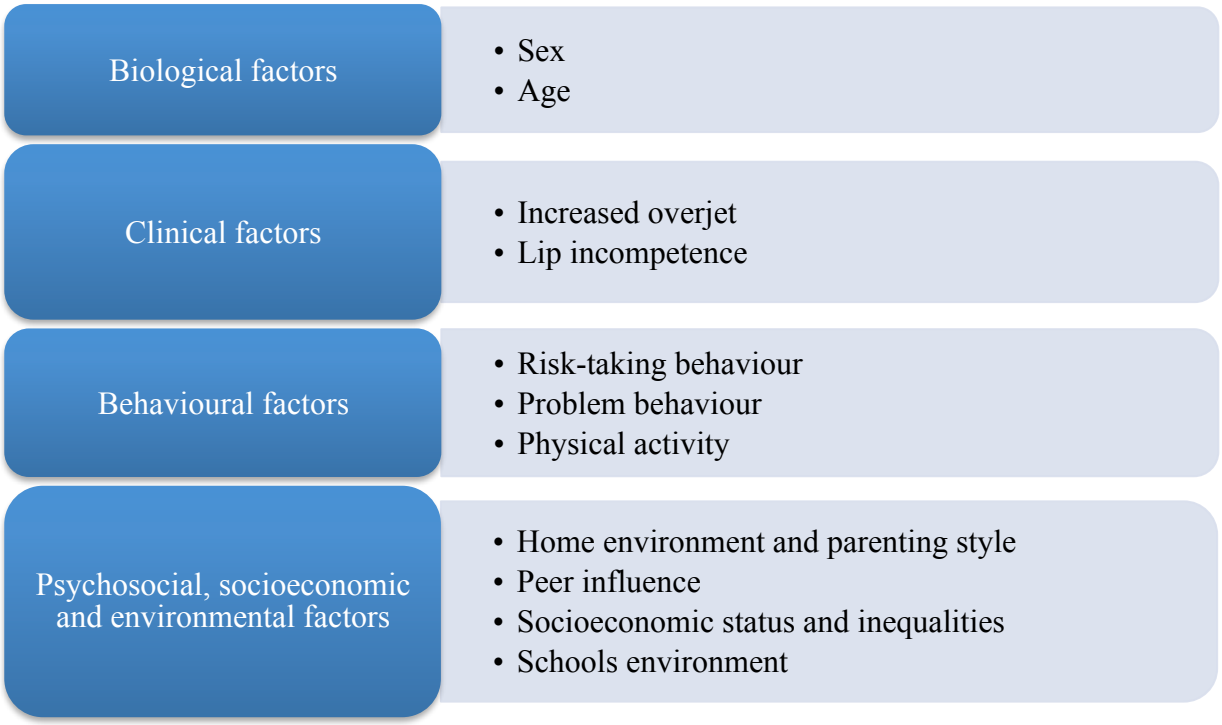

Figure 4: Conceptual framework of key determinants of traumatic dental injuries that will be reviewed based on Hanson et al (2005)

2.2.1. Biological factors

Biological risk factors are commonly studied in relation to TDIs. Age and sex are some of the most commonly studied biological factors.

Age

The majority of TDIs occur in adolescence; it is estimated that 71–92% of all TDIs sustained in a lifetime occur primarily among adolescents (Bastone et al. 2000; Glendor 2009). In the UK, the results from the national Children's Dental Health Survey in 2003 showed an increase of the prevalence of children sustaining TDIs to their incisors with age from 5% at age 8 to 13% by age 15 (Chadwick et al. 2006), although a recent report for the 2013 survey reported relatively similar prevalences between the 12- and 15-year-olds (12% and 10%, respectively) (Pitts et al. 2015). Yet, data from several other countries have reported similar results; older adolescents had higher chances of having TDIs than the youngest (Bücher et al. 2013; Cortes et al. 2001; Goettems et al. 2014b; Rodrigues Campos Soares et al. 2014; Schatz et al. 2013; Yassen et al. 2013).

The peak prevalence of TDIs among adolescents has several explanations. First, adolescents increase their risk-taking behaviours, which increase the chances of incurring injuries (de Looze et al. 2012; Hammig et al. 2001; Pickett et al. 2005a; Pickett et al. 2002a; Pickett et al. 2005b; Senterre et al. 2014; Turner et al. 2004). In addition, adolescents in that sensitive age might be more prone to psychosocial influences from peers, home, school or neighbourhood, that increase their chances of involving in a more injury-risk activities and situations (Smith et al. 1992; Smith et al. 1990).

Sex

There are consistent sex differences in childhood and adolescent injury rates for most types of injuries. Boys consistently experience more frequent injuries than girls (Centers for Disease Control and Prevention 2011a; Chen et al. 2005; Kozik et al. 1999; Mytton et al. 2009; Soubhi et al. 2004). Similarly, in majority of studies carried out in different setting more boys than girls had TDIs (Al-Bajjali and Rajab 2014; Ankola et al. 2013; Årtun and Al-Azemi 2009; Bastone et al. 2000; Bendo et al. 2010; Borzabadi-Farahani and Borzabadi-Farahani 2011; Bücher et al. 2013; Cavalcanti et al. 2009; Çetinbaş et al. 2008; Chadwick et al. 2006; Damé‐Teixeira et al.

2013; De Frujeri et al. 2014; Glendor 2008, 2009; Goettems et al. 2014b; Huang et al. 2009; Kovács et al. 2012; Murthy et al. 2014; Naidoo et al. 2009; Nicolau et al. 2003; Noori and Al-Obaidi 2009; Oliveira Filho et al. 2013; Pitts et al. 2015; Rambharos et al. 2014; Rodrigues Campos Soares et al. 2014; Taiwo and Jalo 2011; Thelen et al. 2011; Yassen et al. 2013). A systematic review by Aldrigui et al. (2014) reported a positive summary association of TDIs among boy adolescents in Latin America and Caribbean with a pooled OR of 1.72 (95% CI 1.57–1.89) to indicate their increase odds of TDI compared to female adolescents.

In an investigation into sex differences in general injuries, various potential explanations were highlighted. Morrongiello (1997) and Morrongiello and Rennie (1998) found that boys differ from girls in cognitive appraisal of risks. Others have reported differences in emotional reactions to risk (Morrongiello and Lasenby-Lessard 2007; Morrongiello and Matheis 2004). Parents also reacted differently to risk taking by boys and girls (Morrongiello and Dawber 1999; Morrongiello and Hogg 2004). These findings highlight the importance of behavioural as well as psychosocial factors as key players in this kind of relationship.

Some studies found non-significant association between TDIs and sex while a few others found a decreased risk of TDIs among boys (Burden 1995; De Carvalho Rocha and Cardoso 2001; Jorge et al. 2012; Marcenes et al. 1999; Oldin et al. 2015; Petti et al. 1997; Traebert et al. 2003a). Beside the possible sampling and methodological variations, girls in these societies are notably becoming more involved with sports and outdoor activities, which could partly explain their increased risk of TDIs compared to the other societies in which boy adolescents had the higher risk of these injuries.

2.2.2. Clinical conditions

Increased overjet and lip incompetence

Increased overjet and lip incompetence were commonly examined clinical factors in relation to TDIs, but with large differences in the methods used and findings reported (Glendor 2008, 2009; Nguyen et al. 1999; Petti 2014). A meta-analysis by Nguyen et al. (1999) concluded that

children with an overjet larger than 3 mm were approximately twice as much at risk of injury to anterior teeth than children with an overjet smaller than 3 mm, with less effect of this factor among boys than girls. A later meta-analysis of the evidence on this relationship among adolescents in Latin America and Caribbean region from 24 studies reported that the presence of TDIs was associated with inadequate lip coverage and increased overjet (Aldrigui et al. 2014). Another meta-analysis recently published by Petti (2014) analysed 45 worldwide primary studies published between 1990 and 2014, and covered all ages including adults. The authors reported higher pooled ORs for TDIs among individuals with large overjet compared to their counterparts without such overjet and suggested that overjet attributes to 21.8% of global TDI cases.

Different studies from various countries had similar findings. For example, in a population-based sample of young Arabic adolescents from Kuwait, Årtun et al. (2005) reported an increased odds of maxillary incisor TDIs in children with overjet over 6.5 mm. The risk of maxillary incisor trauma on those children was higher by 13% for every extra millimetre in overjet (Årtun et al. 2005). In Nigeria, Taiwo and Jalo (2011) reported a significantly higher prevalence of TDIs among 12 year-old children who had an overjet over 6mm. In Brazil, studies reported a statistically significant association between TDIs and overjet and between TDIs and inadequate lip coverage (Cavalcanti et al. 2009; Cortes et al. 2001; De Frujeri et al. 2014; Francisco et al. 2013; Paiva et al. 2014; Soriano et al. 2007; Traebert et al. 2006). Similar findings were also reported from India (Ankola et al. 2013; Chopra et al. 2014; Prabhu et al. 2013; Rambharos et al. 2014) and Saudi Arabia (Al-Majed 2011; Al-Majed et al. 2001).

Some other studies showed mixed results. For example, studies among adolescents in Jordan (Al-Bajjali and Rajab 2014) and in Brazil (Goettems et al. 2014b) found TDIs significantly associated with inadequate lip coverage but not with incisor overjet. Other studies from Brazil (Jorge et al. 2012; Kovács et al. 2012; Traebert et al. 2003a; Traebert et al. 2006) have findings that contradicted those previously mentioned, as TDIs were shown to be significantly associated with incisor overjet but not with inadequate lip coverage.

Looking at these inconclusive findings, it is plausible that there are other factors interacting with these clinical factors that have not been considered yet. Although some studies, such as Shulman and Peterson (2004) reported that overjet was the only variable significantly associated with maxillary incisor trauma after adjusting for age, gender and race-ethnicity, the systematic review by Nguyen et al. (1999) reported that age and gender confound this relationship. There might also be an interaction between clinical predisposing factors and behavioural, social or environmental factors that is contributing to these different findings. Studies accounting for all these factors simultaneously are limited. Thus, there is a need to develop a model that takes into account these broader factors all together.

TDIs among those with previous TDI experience

Another pattern is TDIs occurring among those with previous TDI experience (Borssén and Holm 1997; Glendor et al. 2000b; Goettems et al. 2014b; Skaare and Jacobsen 2003a). In a prospective cohort study, Ramos-Jorge et al. (2008), found that children who had experienced a TDI were 4.85 times more likely to have a new TDI than those with no prior TDI. In addition, Glendor et al. (2000b) reported that a first episode of TDI occurring at age of 9 years, increases the risk of experiencing multiple TDIs was 8.4 times higher than if it occurred later in childhood. Also, the authors reported that having a TDI when aged between 6–10 years increased the chance of having another one later in adolescence by 14.9% to 30.0%, compared to a risk of 0–7.4% if the first TDI was after the age of 10.

Although previous episodes of TDIs seem to be a predictor of future injuries, it could also be a sign of other important behavioural and psychosocial factors such as risk-taking behaviours and influence from home and peer groups which all could affect the risk of TDIs. Therefore, looking into previous episodes as a predictor of TDIs should not be looked at an isolation but within a framework that involve the broader behavioural and psychosocial determinants of injury to better understand the underlying determinants of such a factor.

2.2.3. Behavioural factors

In aetiological research on general injury, behaviour is considered one of the most proximal events to injury (Girasek 2012). The importance of behaviour as a risk factor is based on the accumulating evidence pointing to the key role of individual behavioural factors and their social contexts in provoking diseases and injury events, particularly among adolescents (Pickett et al. 2006). One of the influential theories suggested that problem behaviour during adolescence could be related to aspects of adolescent lifestyle whereby engaging in one behaviour increases susceptibility to engage in another (Jessor and Jessor 1977). This tendency to adopt or change a specific behaviour is arguably a result of a assessing advantages and disadvantages of this process from various aspects, including individual perceptions of the susceptibility, severity, benefits and barriers of the behaviour or threat, and a trigger to initiate the alteration in this behaviour (Becker 1974).

The WHO "Health Behaviour in School-aged Children (HBSC)" network consists of international researchers collaborating on cross-national surveys of school students, collecting data every four years on 11-, 13- and 15-year-old adolescents' health and well-being, social environments and health behaviours (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996). These studies focus on understanding how the social context factors influence adolescents' health. This research network involves a wide range of expertise in areas such as epidemiology, public health, paediatrics, psychology, sociology and public policy and now includes 44 countries and regions across Europe and North America that use an international standard questionnaire produced for every survey cycle (http://www.hbsc.org/publications/).

In addition, the Centers for Disease Control and Prevention (CDC) in the United States developed a similar study called the Youth Risk Behavior Surveillance System (YRBSS) (Centers for Disease Control and Prevention 2011b). This survey monitors key health risk behaviours that contribute noticeably to the leading causes of mortality, morbidity, and social

problems among representative samples of 9th through 12th grade students in the United States. It includes behaviours that contribute to unintentional injuries and violence, alcohol and other drug use, tobacco use and inadequate physical activity. Since 1991, the YRBSS has collected data from more than 2.6 million high school students in more than 1100 separate surveys (http://www.cdc.gov/healthyyouth/data/yrbs/index.htm).

Health behaviours are either health promoting or health compromising (Alzahrani et al. 2014; Jessor 1991; Jessor et al. 1997). The latter are often referred to as risk behaviours. Individual risk behaviours are linked to injury in numerous ways. A systematic review on this relationship concluded that there is some evidence that risk-taking behaviour is linked to a greater chance of sustaining an injury, but the authors argued that it is difficult to draw specific conclusions on this finding without a conceptual framework for examining risk-taking behaviour and injury (Turner et al. 2004). In addition, previous research found that risk behaviours cluster among adolescents (Alzahrani et al. 2014; Jessor 1991; Wiefferink et al. 2006). This clustering is an important determinant for injury as many international studies showed a strong dose-response relationship between multiple risk behaviours and injury cases (de Looze et al. 2012; Pickett et al. 2006; Pickett et al. 2002a). For example, smoking, cannabis use, seatbelt use and safety helmet use were all associated with higher risk of adolescent injury (de Looze et al. 2012; Pickett et al. 2005a; Pickett et al. 2002a; Pickett et al. 2005b; Senterre et al. 2014). Also, physical fighting and weapon use were both significantly associated with higher risks of injuries among adolescent across many countries (Hammig et al. 2001; Lowry et al. 1998; Pickett et al. 2005a; Pickett et al. 2005b; Senterre et al. 2014; World Health Organization 2005).

The role of risk-taking behaviours in TDIs

Far too little attention has been paid on the role of risk-taking behaviours on TDIs. In a literature review of the aetiology of TDIs, Glendor (2009) asserted that risk-taking children tended to increase their chances of sustaining TDIs. However, the two studies that support this argument were either related to specific behaviours such as bullying among children (Odoi et al. 2002) or

to hyperactivity behaviour (Lalloo 2003). Odoi et al. (2002) attempted to explore this association as one of the problem behaviours tested in a case control study using the "Strengths and Difficulties Questionnaire" (Goodman 1997) among young patients who experienced TDIs. The authors found that not all types of the tested behaviours were linked to TDIs. The main one was related to violence. On the other hand, Lalloo (2003) assessed the risk factors for injuries to the face and teeth and found that injury among hyperactive children occurred significantly more often than in non-hyperactive children.

Adolescent violent behaviour is widely accepted as a public health problem, and several aspects of violent behaviour such as fighting and carrying a weapon are well-established markers of risk-taking behaviour (Brener et al. 1999; Dishion and Loeber 1985; Pickett et al. 2005a). In addition, violent behaviour is a cause of TDIs (Skaare and Jacobsen 2003a). Critics argue that the role of violent behaviour on TDIs has been substantially underestimated (Glendor 2008; Traebert et al. 2003b). The most important of these criticisms is that victims often tend to hide the real cause if it was related to violence, categorising them as either falls or collisions. For example, TDIs from pushing falls might be recorded as unintentional falls if not reported correctly by the victim. This might explain why some studies may not have found significant associations between the rates of TDIs and these behaviours (Odoi et al. 2002).

This mis-reporting also applies in assessing injuries associated with children's physical abuse, in which face and teeth are a common target (da Fonseca et al. 1992). Health risk-behaviours are seen as indicators for higher rates of these injuries. An investigation into this relationship found that excessive alcohol or substance use were indicators of facial injuries (Murphy et al. 2009). However, the study's small sample size and the non-probability sampling method limit the generalizability of these findings. Also, the high non-response rate raised a question about whether respondents systemically differ from adolescents who did not participate.

Only a few studies have looked at the relationship between TDIs and alcohol use among adolescents. Oliveira Filho et al. (2013) evaluated the relationship between TDIs and alcohol use

among 14–19 year-old schoolchildren in Diamantina, Brazil. Even after controlling for age, sex, incisor overjet, and type of school, there was a significantly higher risk of TDIs among adolescents with hazardous alcohol use. These findings were confirmed in a study among 12 year-old schoolchildren in Brazil; TDIs were significantly higher among adolescents who engaged in binge drinking (Oliveira Filho et al. 2013; Paiva et al. 2014). However, a study by Jorge et al. (2012) among adolescents aged 12–15 year in Belo Horizonte, Brazil, did not find a statistically significant association between alcohol use and TDIs. Even fewer studies are available on the relationship between illicit drug consumption and TDIs. Oliveira Filho et al. (2014) assessed this relationship and found that TDIs were higher among adolescents using illicit drugs, independent of age, sex, and incisor overjet. However, Jorge et al. (2012) found no significant associations between the use of such illicit drugs and TDIs among 12–15 years-old adolescents.

Physical activity and TDIs

The influence of levels of physical activity on TDIs were also tested in several studies, with mixed results (Dhillon et al. 2014; Goettems et al. 2014a). Çetinbaş et al. (2008) assessed levels of physical activity among public schoolchildren in Turkey and found significantly more TDIs among children who were involved in sports activities more than once a week compared to those who were less active. Årtun and Al-Azemi (2009) assessed physical activities among adolescents in Kuwait and found significant associations between TDIs and participation in those activities. However, other studies report opposite results; TDIs were significantly higher among less active adolescents (Perheentupa et al. 2001; Petti et al. 1997). A study by Josefsson and Karlander (1993) indicated that athletic sports do not necessary increase the risk of TDIs as recreational physical activities. It is also argued that because increased physical activities improve motor skills among adolescent (Barnett et al. 2009), those adolescents could be at reduced risk of sustaining such injuries (Goettems et al. 2014a).

2.2.4. Psychosocial, socioeconomic and environmental factors

Beside the biological, clinical and behavioural factors, adolescent's risk of injury is also influenced by psychosocial, socioeconomic and environmental factors. Although these appear to be distinct factors, there are no clear boundaries between them as some of their elements interfere with each other. For example, home environment share some psychosocial and socioeconomic elements. Also, schools environment include psychosocial, socioeconomic and environmental elements. Therefore, and for the classification purpose the following section will discuss all of these factors collectively in relation to TDIs.

Home environment and parenting style

There is a relationship between housing quality and children's risk of injury. Preschool children who lived in a flat or bedsit and those who lived in houses with a higher number of adults had higher risk of injury (Reading et al. 2008). A cohort study found that children of lone parents were more likely to be injured than those with conventional families, as were those living in socially rented accommodation compared with owned or mortgaged homes (Pearce et al. 2012b). Children experienced lower odds of injury when residential environments were protective (Pickett et al. 2006). Bendo et al. (2012) found that the prevalence of TDIs were significantly higher among those from regions of high social vulnerability.

Parenting style is a crucial factor in understanding and preventing child injury, particularly among young children (Morrongiello 2005; Morrongiello et al. 2006; Saluja et al. 2004; Schnitzer et al. 2014). Parental supervision is one of the important determinant factors that might reduce children's injuries. TDIs are no exception. In an early attempt to explore this subject, Nicolau et al. (2003) found that high levels of paternal punishment were significantly associated with TDIs. On the other hand, parenting style can also enhance children's protection. For example, Schwebel et al. (2004) reported that positive parenting, parents who invest sufficient quality time with their children, was associated with a lower rate of injury among children who were at-risk.

In addition to parents' tasks in safeguarding the environments used by their children, active supervision is hypothesised to include three aspects: proximity, which is the physical intimacy of the parents towards the child; attention, which can be both visual and oral focus on the child's behaviours; and continuity, which ranges from constant to regular to absolutely no monitoring of the child's behaviour's (Morrongiello 2005; Saluja et al. 2004). Along with the parents' effort to safeguard children's surroundings, these three elements of supervision, which can be invariably affected by an array of guardian factors, contribute significantly to the children's risk of injury (Schwebel and Gaines 2007).

Moreover, children of anxious parents (Bradbury et al. 1999), single parents (Weitoft et al. 2003) and those suffering from depression (Russell 1998) were at increased likelihood of injury, probably due to the insufficient supervision offered by such parents (Morrongiello et al. 2006). On the other hand, a more careful parental character helps to protect children against injuries (Morrongiello and House 2004; Morrongiello et al. 2006; Schnitzer et al. 2014).

Finally, communication between parents and their children is a key building blocks of the family as a developmental context and can acts as an important protective factor in adolescence (Currie et al. 2008a). Especially relevant is the role of parents in the development of the child's communication skills, attitudes and behavioural patterns. Ease of communication with parents is considered to be an indicator of both social support from parents and family connectedness, with parents remaining an important source of support throughout the adolescent period (Laursen 1995). The importance of positive relationships with parents has been well documented, particularly in relation to reduced levels of antisocial behaviour (Bogard 2005; Youniss et al. 1999), depression (Young et al. 2005) and health-risk behaviour (Resnick et al. 1997). Adolescents who report easy communication with their mothers are more likely to report excellent or good self-rated health and are less likely to be current smokers (Andersen et al. 2002; Murberg and Bru 2004) or frequent alcohol drinkers (del Carmen et al. 2002; Zambon et al. 2006).

An important finding from recent research suggests that unlike young children, adolescents may not be significantly influenced by their parents. A study by Schwebel and Brezausek (2010) assessed the role of parents on injury risk among young adolescent. The authors found that the most significant factor was the positive father–son relationship, with no other maternal traits or other parenting characteristics found as statistically significant predictors. This might be because of the independence from parents' supervision that children seek during this age. Nevertheless, it is argued that parenting quality and style at an earlier age could influence the behaviour of adolescents at this stage, while this role is replaced gradually by their peers' influence (Morrongiello et al. 2008; Schwebel and Brezausek 2010).

Peer influence

Peer influence is an important psychosocial construct that considerably contributes to adolescents' increased risk of injuries. A large body of literature has identified social contacts, including friendships and peer relationships, as important determinants of attitudes and behaviours, especially during adolescence (Crosnoe et al. 2003; Fishbein and Ajzen 1975; Glaser et al. 2010; Ladd 2005; Maisto et al. 1999; Oetting and Beauvais 1987; Simons-Morton and Farhat 2010; Urberg 1992). Social contacts are ways of satisfying the need to feel loved and accepted by a group (Baumeister and Leary 1995; Osterman 2000). So, peer relationships in particular can play an important role in helping adolescents to establish autonomy, form identity and develop social competence (Currie et al. 2008a; Currie et al. 2012).

Behaviours of adolescents are very often similar to the behaviours of their peers (Brechwald and Prinstein 2011). This influence has also been shown to increase in the case of closer and stronger connections (Allen et al. 2006; Duncan et al. 2000). Similarities between behaviours among peers are explained by several theories which suggest that association is either related to selection or socialisation (Brechwald and Prinstein 2011). However, studies that attempted to determine the presence of both effects among different behaviours of adolescents generally showed a more consistent influence from socialisation, which is commonly known as peer

influence (Brechwald and Prinstein 2011; Dishion and Owen 2002; Giletta et al. 2012; Hall and Valente 2007; Prinstein et al. 2010; Simons-Morton and Chen 2006). Peer influence can be a direct influence on an adolescent to engage in certain behaviours or as an indirect influence through the perceptions of the adolescent himself/herself about their groups' beliefs, norms and anticipations (Simons-Morton and Chen 2006).

Despite there being a wide variation in research designs applied to studying peer influence, most recent studies concerned with social contact have utilised several common constructs. The first of these constructs is to measure the establishment of peer relationships as it is a critical developmental task for adolescents that may have a long-term effect on their social adjustment (Poulin and Chan 2010) and a unique social context for gaining essential social competencies (Hartup 1996). Therefore, adolescents with few friends were more prone to become victims of bullying (Larson and Richards 1991). Another construct is the assessment of adolescents' perception of their peers' engagement in risk behaviours, as social comparison and behaviour approximation effects showed a strong link to peer influence (Brechwald and Prinstein 2011). The assumption here is that the perceptions of adolescents that their peers are engaging in certain behaviours increase the chances of their engagement in the same or similar behaviours. In addition is the assessment of adolescents' perception of their peer group characteristics in relation to school experiences and organised activities. These characteristics were shown to influence the development of adolescents' self-esteem and health-risk behaviours (Bidstrup et al. 2008; Bradshaw and Keung 2011; Fletcher et al. 2008; Harel-Fisch et al. 2011; Hartup 2005; Zambon et al. 2010). A further construct is the assessment of the frequency of evenings that adolescents spend together with their friends. Data from several sources have identified that the chance of adolescents reporting health-risk behaviours is directly proportional to the number of reported nights out with their friends (Brown et al. 2001; Kuntsche et al. 2009). Fifth is the assessment of electronic media contact, as intensive use of this type of communication has been associated with poorer perceptions of health (Simetin et al. 2011) and engagement in risk

behaviours (Huebner et al. 2004). Finally is the assessment of perceived classmate support, as low levels of perceived support have been linked to bullying (Nansel et al. 2004) and a greater prevalence of smoking and drinking (Samdal et al. 2000).

Studies that assessed the influence of peers from socialisation process on health-risk behaviours and violence have shown a strong association with risk taking, such as smoking (Kobus 2003; Tyas and Pederson 1998); alcohol use (Borsari and Carey 2001; Bray et al. 2003); substance use (Ennett et al. 2006; Simons-Morton and Chen 2006); violent behaviours (Dishion et al. 1997); and non-suicidal self-injury (Heilbron and Prinstein 2008). However, very little is known about the effect of peer influence on TDIs. Odoi et al. (2002) started exploring this association as one of the problem behaviours of TDIs. Although the study provided one of the first indications that peer relationship problems are significantly associated with higher levels of TDIs, a question that needs to be asked is whether the measure use in this study, namely the Strengths and Difficulties Questionnaire, was able to reflect the different aspects of peer influence among adolescents because this measure was built to provide only a brief coverage of multiple behavioural and emotional constructs among children and their relationships (Goodman 1997). In addition, the use of hospital-based sample makes it hard to precisely define the population from which the TDIs cases arose. Moreover, using parents' reports to predict children's problem behaviours might introduced a further limitation as parents lack the proper judgment of children's peer relationship interactions (Stone et al. 2010).

In conclusion, considerable research has been carried out to show the role of peer influence on the adolescents' risk of different types of body injuries as well as its impact on other health risk behaviours. However, very little is known about the role peer influence in relation to TDIs. Therefore, addressing the potential of peers to influence each other beyond the similarities between them in relation to TDIs is key for understanding the broader determinants of these injuries and the impact of these determinants on the more direct causes associated with TDIs.

Socioeconomic status and inequalities

Socioeconomics of both individuals and their societies can have considerable impact on people health and wellbeing (Corna 2013; Elo 2009; Hanson and Chen 2007; Starfield et al. 2002). Controlling for socioeconomic status has special importance to the study of injuries because SES had a consistent association with them (Baker 1992; Engström et al. 2002; Pearce et al. 2012a; Simpson et al. 2005). One of the key factors considered in relation to adolescents' injuries is socioeconomic status of the family. In a review by Bendo et al. (2009) of nine good quality studies, only four had statistically significant associations between TDIs in permanent teeth and high socioeconomic status. Cortes et al. (2001) assessed this relationship among 9–14 years old Brazilian schoolchildren. They showed that children from high socioeconomic backgrounds, based on their parents' years of schooling, were more likely to have TDIs than their lower socioeconomic status counterparts. After adjusting for overjet, lip coverage, gender and age, the results showed that children with high socioeconomic status were 1.4 times (95% CI 1.15–1.79) more likely to have TDIs than those with low socioeconomic status. Similar findings were reported among 12 year-old Brazilian schoolchildren (Moysés et al. 2003).

However, many other studies found a higher prevalence of TDIs among children from lower SES families. Årtun and Al-Azemi (2009) concluded that high family income was actually a protective factor for TDIs among adolescents in Kuwait. Malikaew et al. (2006) reported similar findings among 11 to 13 year-old Thai schoolchildren; TDIs rates were higher in children with unemployed parents. Further evidence is from a study carried out a geographical analysis of TDIs among adolescents in Brazil and found that prevalence of TDIs were higher in areas with unfavourable socioeconomic status, including lower area income and lack of coverage by the primary healthcare centres, compared with area with more favourable socioeconomic status (Carvalho et al. 2010). Similar findings were reported in a population-based sample of schoolchildren in south Brazilian schools where the prevalence of TDIs was higher among adolescents from low socioeconomic status families (Damé‐Teixeira et al. 2013). In the UK,

Hamilton et al. (1997) found a significant relationship between TDIs in children and social class; children from low-income residents with poor quality housing had more injuries than those from higher socioeconomic status groups. Díaz et al. (2010) also reported that the majority of subjects who had TDIs were from families with the lowest social class in Chile.

A study that looked at this relationship among adolescents in Brazil did not find such a significant association (Oliveira Filho et al. 2014). Other studies showed similar results with no significant relationship between socioeconomic indicators and TDIs (Marcenes et al. 2000; Marcenes et al. 2001). Also, a case-control study among 12–14 years Canadian children included socioeconomic measures such as household income and educational level of mother, and found no significant relationship with TDIs (Fakhruddin et al. 2008a). Similar findings were reported among children and adolescents in Brazil (Bendo et al. 2010; Nicolau et al. 2003; Soriano et al. 2007) and Jordan (Al-Bajjali and Rajab 2014). It should be noted the results in the study by Fakhruddin et al. (2008a) presented incorrect calculations for the risk of TDIs and socioeconomic level by using socioeconomic level in each category of TDIs for the calculations instead of TDIs in each category of the socioeconomic level. However, recalculating the right set of numbers still yielded in non-significant results.

Different explanations have been put forward for these relationships. For example, the authors of studies that observed that higher socioeconomic status children had more TDIs commonly related their findings to the assumption that these children, particularly in developing countries, have more access to different types of contact sports, swimming pools and leisure tools (Tuna and Ozel 2014). Årtun and Al-Azemi (2009) suggested that the lower prevalence of TDIs in children from the high-income group is the children was them being socially secure, and at less risk of reacting violently in stress-related situations.

In addition, the importance of parent education as one of the key elements influences the overall health of people might also extended to TDIs. A growing body of literature has reported on this factor. There were significant associations with TDIs from different aspects of education.

Malikaew et al. (2006) assessed this relationship on a sample of 11 to 13 year-old Thai schoolchildren and reported that TDIs were higher in children with lower educated parents. Similar findings were also found among 7–12 year-old children in Jordan (Jamani and Fayyad 1991), 11 to 14 year-old British schoolchildren (Hamilton et al. 1997), and 1–15 year-old children in Chile (Díaz et al. 2010) and 12–15 adolescents in Brazil (Ramos-Jorge et al. 2011).

However, the link between TDIs and education of parents might not be as direct as many think, and other factors could be playing a key part in this relationship. This is because other studies found differing findings. While some studies reported higher prevalence of TDIs among children with higher educated parents (Huang et al. 2009; Ramos-Jorge et al. 2008), others showed no significant relationship between socioeconomic indicators and TDIs. For example, a study among Palestinian schoolchildren also did not find any significant association between TDIs and parents' education level, occupation or employment status (Livny et al. 2010). Also, a case-control study among 12–14 years Canadian children included mother's educational level as one of the socioeconomic measures found no significant relationship with TDIs (Fakhruddin et al. 2008a). Similar findings were also found among children and adolescents in Brazil (Bendo et al. 2010; Nicolau et al. 2003; Soriano et al. 2007).

In addition, area economic status is another key element in relation to TDIs as it showed links to the differences in rate of these injuries among adolescents in different populations (Bastone et al. 2000; Chan et al. 2011; de Amorim et al. 2011; Díaz et al. 2010; Glendor 2009; Noori and Al-Obaidi 2009). Area deprivation was assessed in several studies and showed significant relationship with TDIs. Hamilton et al. (1997) reported that the more deprived the area, the higher there was the prevalence of TDIs. Marcenes and Murray (2001) assessed TDIs among 14 year-old schoolchildren in Newham, which is a neighbourhood in London classified as one of the most deprived areas in the UK, and found that the prevalence of TDIs in this area was significantly and considerably higher than the overall prevalence in the UK. In a further study on the same population, Marcenes and Murray (2002) found that area-based measures of

deprivation, such as an overcrowded household, were predictors of TDIs. Similarly, Thelen and Bårdsen (2010) found a significantly higher level of TDIs in adolescents who were living in low socioeconomic areas compared to those living in high socioeconomic areas. On the other hand, Kahabuka et al. (2001) found a higher percentage of TDIs among Tanzanian children in the district with relatively high socioeconomic status compared to children in the other two districts with low and medium, even after controlling for differences in age and sex.

Schools physical and social environment

Schools physical and social environment are important determinants of TDIs (Chan et al. 2011; de Amorim et al. 2011; Díaz et al. 2010; Glendor 2009). Half of the injuries amongst school-aged children occurred during school hours (Skaare and Jacobsen 2003b). However, many aspects of the relationship between school's environment and TDIs have not yet been studied.

The relationship between TDIs and the type of school attended by the child has been examined in several studies but with no conclusive findings. For example, a study carried out among 12 year-old Brazilian schoolchildren, found no significant differences in TDIs between children attending public and those attending private schools (Soriano et al. 2007). Similar findings were reported in various studies (Goettems et al. 2014b; Oliveira Filho et al. 2013). However, other studies from different populations found significantly more TDIs among children attending public schools, such as in Dominican Republic (Garcia-Godoy et al. 1986) and in India (Murthy et al. 2014) while even others from these countries found it higher in private schools (Garcí-Godoy 1984; Jamani and Fayyad 1991; Jorge et al. 2012). The differences between these findings could be due to other social and environmental factors interacting with this relationship, as previously mentioned.

In addition, schools can play important psychosocial role in adolescent's health, such as with increasing adolescents' academic achievement (Currie et al. 2008a; Samdal et al. 2004). This kind of achievements in childhood is in turn associated with critical future health outcomes, such adult morbidity and premature mortality (Suldo et al. 2006). In addition, perceived lower school

performance was associated with risk-taking behaviours, such as bullying (Nansel et al. 2001) and smoking (Ravens-Sieberer et al. 2004). In regards to TDIs, academic achievement showed playing a considerable role; schoolchildren who perceived having good marks at school as unimportant experienced double the risk of TDIs compared with those who considered it important (David et al. 2009). Nicolau et al. (2003) also found that children who had failed a grade at school had almost double the odds of having TDIs. In addition, Malikaew et al. (2003) found that boys in school with lower social support had significantly more TDIs than boys in other schools, even after controlling for physical environments and different demographic, biological, and parental confounding factors. On the other hand, girls showed having more effect by the physical environment as girls with better physical environment in schools had fewer TDIs than those in less favourable physical environment (Malikaew et al. 2003). Moysés et al. (2003) found that children in supportive schools were more likely to have fewer TDIs. The support included the availability of a comprehensive curriculum and the commitment towards health and safety at school. The more comprehensive the curriculum applied at school, the less the chances of having TDIs were observed among children. These findings suggest that promoting health and safety measures in schools may play an important role in preventing TDIs.

2.3. Summary and gaps in the literature

A considerable body of literature from around the world report a high prevalence and incidence of TDIs among adolescents. Although previous research has emphasised the importance of identifying the underlying determinants of injuries, the reviewed literature highlighted considerable gaps in knowledge on these subjects. Despite its importance, there is a lack of robust scientific theoretical models in relation to assessing the determinants of TDIs. Many of the previous studies of TDIs gave little consideration to existing theories or conceptual approaches in determinants of injury that could structure research questions based on existing evidence and guide the choices of measurement. Exploiting models of injury causation can help to map a broad range of the key factors of TDIs from the most noticeable and proximal level,

such as the intra-personal level, to the broader community and society levels that adolescents interact with, directly and indirectly.

The review also showed the consistent evidence indicating that injuries are related to a combination of behavioural responses of individuals and their surrounding social environments. However, many of the studies on determinants of TDIs tended to focus on biological risk factors, such as increased overjet and lip incompetence, and overlook the underpinning determinants of TDIs. Although the very few studies on the determinants of TDIs have contributed in broadening understanding on this problem, the existent accounts report inconsistent findings, which might suggest missing other key underlying risk factors that influence these results. Thus, studies on determinants of TDIs need to consider behavioural and psychosocial factors simultaneously for a better and broader understanding of the key elements associated with this issue.

The reviewed literature indicates that risk-taking behaviour is one of the commonly omitted factors that are plausible explanations of many of the differences in findings of TDIs among adolescents as they showed links to many other types of injuries. The importance of studying behavioural determinants is shown by the accumulating evidence that point to the key role of behavioural factors in provoking injury events, particularly among adolescents. This is supported by multiple influential theories suggesting that problem behaviour during adolescence could reflect adolescent lifestyle that is influenced by their judgment and perception of the susceptibility, severity, benefits and barriers of that behaviour or threat.

Although adolescents' injuries are linked to many risk behaviours, including tobacco and cannabis smoking, seatbelt and helmet use and carrying weapons and fights, far too little attention has been paid to the role of risk-taking behaviours on TDIs. Further research is needed to investigate the role of these injury markers on the risk of TDIs using a sound conceptual framework among a population-based sample in order to overcome the current limitations of studies and to comprehensively assess the potential role of these behaviours. It is also plausible

to assess the role of risk behaviours clustering among adolescents, as that is common among this age group.

Moreover, peer influence has attracted little attention in TDI research, even though it has been shown to play a major role in influencing adolescents' behaviours and choices during their development. During adolescence, the degree of parents' supervising decreases and the role of their peers increases, which makes adolescents more prone to peer influence. Research showed that peer relationships are ways of satisfying the need to feel loved and accepted by a group and can play an important role in helping adolescents to establish autonomy, form identity and develop social competence and are therefore considered a valued social contact that can influence adolescents' behaviours. Regardless of what hazardous activities adolescents take part in, their decisions are strongly influenced by their peers. This makes influence of peers one of the key risk factors during adolescence. However, there is very little research to explore the effects of peer influence on TDIs among adolescents. Therefore, the impact of peer influences on adolescent risk-taking and injury events needs to be examined. To better understand this complex behavioural and psychosocial process, different aspects of peer influence should be assessed with a sound conceptual framework.

There is also a need to consider the difference between sexes when assessing the prevalence and determinants of TDIs. The reviewed literature highlighted remarkable sex differences in injury rates among adolescent; boys consistently experience more injuries than girls. These sex differences have been linked to different factors such as males being more risk-taking and females more risk-averse. However, the difference in rates of TDIs between girls and boys by countries suggests that other cultural and social differences could play a part.

In conclusion, TDIs are a public health issue that is more common among adolescents who are susceptible to risk taking and negative peer influences. However, detailed dental studies on these factors are lacking. Most of the existing relevant literature has overlooked the underlying behavioural and psychosocial determinants of TDIs. A key insight from this review is that more

studies are needed that look at behavioural and psychosocial determinants of TDIs and the interaction between them. Focused research with sound theoretical frameworks is needed to further our understanding on key elements of these potential determinants of TDIs, such as the role of risk-taking behaviours and peer influence. That is what this PhD seeks to explore.

2.4. Hypotheses

Hypothesis 1: The prevalence of TDIs among adolescents in Riyadh, Saudi Arabia is high; male adolescents have a higher prevalence of TDIs than females.

Hypothesis 2: High-risk-taking adolescents have a significantly higher prevalence of TDIs than their low-risk-taking counterparts.

Hypothesis 3: The prevalence of TDIs in adolescents is significantly higher amongst those with increased negative peer influence.

Hypothesis 4: The association between risk-taking behaviours and TDIs in adolescents increases in those with negative peer influences.

2.5. Aims and objectives

The aim of this PhD is to assess whether certain behavioural and psychosocial determinants were associated with the prevalence of TDIs among adolescents, with a particular focus on the role of their risk-taking behaviours and peer influence.

The objectives of this study are:

1. To assess the prevalence of TDIs in adolescents attending schools in Riyadh in the Kingdom of Saudi Arabia.
2. To assess the association between risk-taking behaviours, namely smoking, cannabis use, weapon use, seatbelt use, safety helmet use and physical fighting, and TDIs among adolescents in Riyadh.
3. To assess the association between negative peer influence and TDIs among this population.
4. To assess the role of peer influence as a moderator of the association between adolescents' risk-taking behaviours and TDIs.

2.6. The Theoretical Framework

The diagram below illustrates the theoretical framework of the hypothesised relationships among risk-taking behaviours, peer relationships and TDIs in the study.

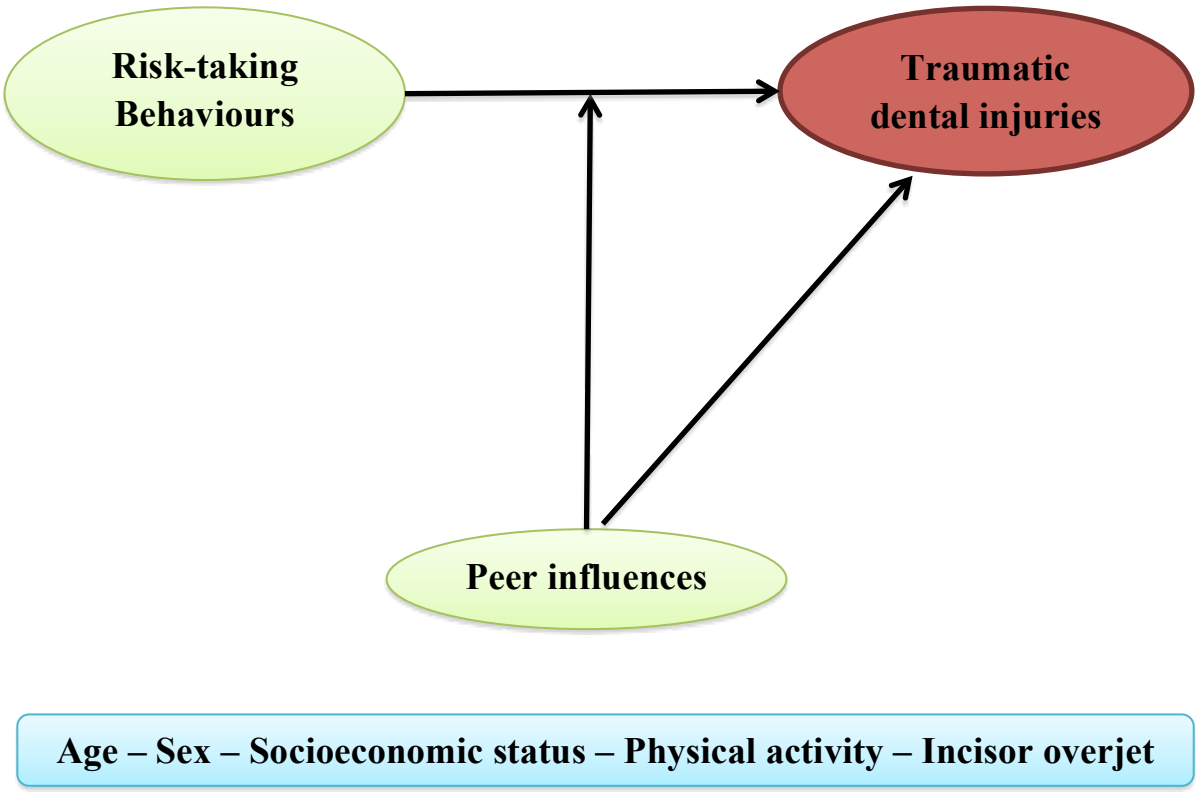

Figure 5: Theoretical framework of the hypothesised relationships in the study variables

Chapter 2: Methods

2.1. Study population and sampling frame

The study population consisted of male and female adolescents studying in the first and second grade of high schools in Riyadh, the capital city of Saudi Arabia. Riyadh is the biggest and most populated city in the country with a mixed structure and ethnicities, and a population of 5,254,560 (Saudi Arabian Central Department of Statistics and Information 2010). The compulsory education has three levels: primary, intermediate and secondary. Saudi Arabia has single-sex education, in which male and female students attend separate schools. Secondary education is the final general stage preceding higher education. During the year of this study, the secondary education had a gross enrolment ratio of 114%, indicating grade repetition and admission at different ages than the standard age at that grade level, and a net enrolment ratio of 90% (World Bank 2014). The gross enrolment ratio can be greater than 100% as a result of grade repetition and entry at ages younger or older than the typical age at that grade level

This educational stage includes three different levels, namely, grades 10 (age 15–16), 11 (age 16–17) and 12 (age 17–18, final grade). In Riyadh, there were 226,949 secondary education students, of whom 92,323 were girls (Saudi Ministry of Education 2012). Those students were studying in 311 schools for male and 284 schools for female. To improve the response rate and to decrease the possibility of including adults aged over 18 years in the sample, the final grade was excluded and the sample of the study therefore corresponded to students in both grades 10 and 11; the first and second years of secondary school. The sampling frame was the list of private and public schools in the city of Riyadh provided by the Saudi Ministry of Education.

The sample size was calculated after the pilot study. That and the sampling method will be described later (See Section 2.10).

2.2. Approvals and permissions

Ethical approvals were obtained from the Research Ethics Committee of University College London (UCL) in the UK (Appendix 1) and from College of Dentistry in Salman Bin Abdulaziz University (SAU) in Saudi Arabia (Appendix 2)[1]. In addition, the Saudi Ministry of Education has given permission to carry out the study in schools in Riyadh (Appendix 3). Permission for the pilot study was obtained from College of Dentistry in SAU and King Saud University (Appendix 4).

2.3. Resources and personnel

Because males were not permitted to work at girls' schools, the Saudi Ministry of Education was approached to get permission for participation of one qualified female dentist. She volunteered to carry out the field study in the schools for female (Appendix 5). The main researcher of this project (Sultan Almalki) carried out the field study in the schools for male. The calibration process for the examiners is discussed in Section 2.6.

Once the random selection of schools was carried out, the principals of the schools involved in the study were contacted to explain the study protocol and obtain their approval and cooperation with the study. They were asked to reserve the time needed and assign the head teacher for each involved class to organise their students and facilitate the implementation of the study.

2.4. Study measures

Data were collected through clinical examination and self-administrated questionnaire. The clinical examination measured the outcome (TDIs) and the questionnaire assessed exposures and covariates.

Most of the questions in the questionnaire were based on the WHO Health Behaviour in School-Aged Children (HBSC) questionnaire (Currie 2000; Currie et al. 2008a; Currie et al. 2004;

[1] In 2015, the name of Salman Bin Abdulaziz University has changed to "Prince Sattam bin Abdul Aziz University". In this thesis this University will be referred to as SAU.

Currie et al. 2012; King 1996) and the Youth Risk Behaviour Surveillance System (YRBSS) developed by the Centers for Disease Control and Prevention (CDC) in USA (Centers for Disease Control and Prevention 2011b). The HBSC is a cross-national study which has been carried out in 35 countries every four years since 1983/1984 with an overall goal of increasing understanding of young people's wellbeing, health behaviours and their social context. Most of the HBSC questions were recently used in a research project assessing clustering of health-related behaviours among Saudi Arabian adolescents (Alzahrani et al. 2014). The YRBSS includes national, state, and local surveys in the USA that have been conducted biennially since 1991 among representative samples of students aiming to monitor six types of health-risk behaviours: behaviours that contribute to unintentional injuries and violence; tobacco use; alcohol and other drug use; sexual-risk behaviours; unhealthy dietary behaviours; and physical inactivity. The pilot study also tested an additional 10-item measure of peer influence, developed by Steinberg and Monahan (2007), which aimed to assess the degree to which adolescents act autonomously in interactions with their peers of resistance. The following is a brief description of these variables. A detailed list of all these measures can be found in Appendices 6 to 9.

2.4.1. Outcome measures

Measuring the outcome (TDIs) was carried out using a modified version of the WHO classifications proposed by Glendor and colleagues (Glendor et al. 2007) (Table 2). This TDI classification is designed for epidemiological field screening, and is considered as the first option in assessing TDIs (Andersson and Andreasen 2011).

Table 2: Epidemiological classification of TDIs including codes of the WHO International Classification of Diseases to Dentistry and Stomatology (Glendor et al. 2007)

Code	Criteria	Criteria
Code 0	**No injury**	No evidence of treated or untreated dental injury.
Code 1	**Treated dental injury**	Composite restoration, bonding of the tooth fragment, crown, denture or bridge pontics replacing missing teeth due to TDI, restoration located in the palatal/lingual surface of the crown suggesting endodontic treatment and no evidence of decay or any other treatment provided due to TDI.
Code 2	**Enamel fracture only**	Loss of a small portion of the crown, including only the enamel.
Code 3	**Enamel-dentine fracture**	Loss of a portion of the crown, including enamel and dentine without pulp exposure.
Code 4	**Pulp injury**	Signs or symptoms of pulp involvement due to dental injury. It includes fractures with pulp exposure, dislocation of the tooth, presence of sinus tract and/or swelling in the labial or lingual vestibule without evidence of caries and discolouration of the crown. The examiner must check if pulp involvement was due to caries (presence of treated or untreated caries lesion), and ask the subject whether they have a history of a harmful incident involving the front teeth/mouth.
Code 5	**Missing teeth due to trauma**	Absence of the tooth due to a complete avulsion. This code should only be used for teeth judged to be missing due to trauma. A positive history of trauma is needed to record missing due to trauma and the examiner must ask the subject if the avulsion was due to a harmful incident involving the front teeth/mouth or have been extracted due to caries.
Code 9	**Excluded tooth**	Signs of traumatic injury cannot be assessed, i.e. presence of appliances or all permanent incisors missing due to caries.

The dental exam protocol and responsibilities of the dental examiner and dental recorder/assistant, before, during, and after the dental exams are summarised below:

- The dental exam was carried out for each participant after completing the questionnaire.
- The dental examiner arrived at the examining location about 10 minutes before the exams were scheduled to begin setting up the work area equipment and supplies,

including the chair and tables, sterilised disposable dental examination kit in a disposable plastic tray (dental mirror, dental explorer, dental shawl and dental tweezers), sterilisable periodontal probe, gauze swabs, disposable examination gloves, disposable face masks, pen- and head-torches and storage folders.

- The participant was escorted by the interviewer to the examination location, who also checked the completeness of the filled questionnaire.
- The examiner completed the visual dental exam of the participant and the assistant recorded the examiner's observations on the clinical examination form. The criteria for the diagnosis and coding are explained in the clinical exam form (Appendix 6). Each traumatised tooth was compared with its corresponding contralateral tooth. For the examination, the teeth were cleaned and dried with gauze and the crowns were examined with the aid of a mouth mirror under artificial light with the participant in the upright position. A plain front-surface mouth mirror and a blunt probe were used to identify the presence and extent of restorations or to remove debris.
- The examiner recorded the type of TDIs sustained and any treatment carried out. Upon finding evidence of a TDI, the examiner asks the participant about how, when and where this specific injury happened.
- If and evidence of multiple TDIs was observed in the same tooth, the most severe trauma was recorded. A tooth with enamel fracture only (Code 2) on one side and enamel-dentine fracture (Code 3) on the other side was recorded as Code 3. A tooth with enamel-dentine fracture (Code 3) on one side and Pulp Injury (Code 4) on the other side was recorded as Code 4.
- Incisor overjet was measured in millimetres with the tip of the periodontal probe with from the facial surface of the most lingual mandibular tooth to the middle of the incisal edge of the more facially positioned maxillary tooth.

- Lip coverage was assessed by observing the lip location in relation to both upper and lower incisors in relaxed position and selecting the appropriate codes (0 to 3). These codes were later combined for data analysis to indicate that lip coverage was either adequate (for the Upper/Lower combinations of 0/3, 1/2, 2/1 and 3/0) or inadequate (for any other combination).
- The examiner and recorder checked the form for completeness and edited it accordingly before the participant left the dental exam area.
- The assistant escorted the participant back to the class.

2.4.2. Measures of risk-taking behaviours

Six behaviours were used to measure risk-taking behaviour (Centers for Disease Control and Prevention 2011b; Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996). Participants were asked if they have engaged in the following behaviours: (1) smoked a cigarette; (2) used any illegal drug; (3) carried a weapon such as a gun, knife or club outside their homes; (4) been in a physical fight; (5) ridden in a car without wearing a seatbelt; and (6) ridden a bicycle or motorcycle without wearing a helmet.

Questions about smoking cigarettes asked the following: “Have you ever smoked tobacco?” “How often do you smoke tobacco at present” and “At what age did you first smoke a cigarette (more than a puff)?” The questions about using illegal drugs asked the followings: “Have you ever smoked other drugs in your life?” and “Have you ever smoked other drugs in the last 12 months?” (Brener et al. 2013; Centers for Disease Control and Prevention 2011b; Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996).

For the assessment of helmet use, a question asked “When you rode a bicycle during the past 12 months, how often did you wear a helmet?” while the question assessing the use of seatbelt asked “How often do you wear a seat belt when riding in a car driven by someone else?” In

relation to physical fights, the question was "During the past 12 months, how many times were you in a physical fight?" while the questions assessing weapons use asked "During the past 30 days, on how many days did you carry violent tools?" and "During the past 30 days, on how many days did you carry violent tools?" (Brener et al. 2013; Centers for Disease Control and Prevention 2011b; Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996).

These behaviours are already well-established measures of risk-taking behaviour (Brener et al. 1999; Centers for Disease Control and Prevention 2011b; Currie 2000; Currie et al. 2008a; Dishion and Loeber 1985; Pickett et al. 2005a; Rasanathan et al. 2008; Sosin et al. 1995). The rationale behind assessing these behaviours was discussed previously (Sections 1.3 and 1.4) and further details of these measures can be found in Appendices 7 and 8.

2.4.3. Measures of peer influence

Six constructs were used to measure peer influence among adolescents: establishment of peer friendships, adolescents' perception of their peers' engagement in risk behaviours, adolescents' perception of their peer group characteristics in relation to school experiences, organised activities and relationships with their families, the frequency of days and evenings that adolescents spend with friends, electronic media contact and perceived classmate support (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996). The rationale behind assessing these constructs was discussed in Sections 1.3 and 1.4.

The questions assessed these constructs started with asking "At present, how many close friends do you have?" and also asked included the following questions: "How many days a week do you usually spend time with friends right after school?" "How many evenings per week do you usually spend out with your friends?" "How often do you talk to your friend(s) on the phone or send them text or email messages?" "How easy is it for others to join your group?" (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996).

The questionnaire also asked about different characteristics of the group of friends with whom adolescents spend most of their leisure time with, specifically: “How many of the group like school?” “How many of the group do well at school?” “How many of the group smoke cigarettes? “How many of the group have used drugs to get stoned?” “How many of the group carry weapons, like knives?” “How many of the group participate in organised sports activities with others (eg. sports teams, sports clubs, golf)?” “How many of the group participate in organised activities other than sports (e.g., clubs, Scouts)?” and “How many of the group get along well with their parents?” (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996).

The adolescents were also were asked about how much do they agree with the following statements: “Most students in the school treat your group with respect?” “When someone is feeling down, others in the group are there for him or her.” Finally, the adolescents were introduced to the following question: “How easy is it for you to talk to the following persons about things that really bother you? a) Father; b) Stepfather; c) Mother; d) Stepmother; e) Elder brother(s); f) Elder sister(s); g) Best friend; and h) Other Friends” and were asked to provide an answer for each element of the question individually (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996).

All the questions were based on the WHO HBSC questionnaire (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996) which showed a good coverage of a wide range of important predictors of adolescent health behaviour including peer influence constructs (Brechwald and Prinstein 2011; Burk et al. 2012; Currie 2000; Currie et al. 2008a; Currie et al. 2004; Ladd 2005). Further details of these measures can be found in Appendices 7 and 8.

In addition to measuring these aspects of peer influence, a 10-item measure of resistance to peer influence (Steinberg and Monahan 2007) was also tested in the pilot study; this assesses the degree to which adolescents act autonomously in interactions with their peers. The scales of this

measure have shown adequate internal psychometric properties (Monahan et al. 2009; Steinberg and Monahan 2007) but have never been tested among adolescents in Saudi Arabia. Participants read two conflicting scenarios (e.g. "Some people go along with their friends just to keep their friends happy" but "Other people refuse to go along with what their friends want to do, even though they know it will make their friends unhappy") and were asked to select which statement is more like them and then assess the strength of their endorsement ("sort of true" or "really true"). Each of the ten scenarios examines a different dimension of possible influence, such as going along with friends, fitting in with friends, and knowingly doing something wrong. Higher scores indicate less susceptibility to peer influence (Steinberg and Monahan 2007). Further details of these measures can be found in Appendix 9.

2.4.4. Covariates

The age of the participants was determined by asking each student about their month and year of birth. Participants were free to provide these dates in either the Gregorian or Hijri calendar, and this was later converted to standard year/age. This process was important to decrease the possibility of information bias, as it is common in Saudi Arabia that students might only know their date of birth according to the Hijri calendar, which is the only date that is used in many forms of official identification documents in that country. The questionnaires also included questions about sex, nationality and education level (1st or 2nd secondary level).

Physical activity was assessed using the 60-minute Moderate-to-Vigorous Physical Activity measure (MVPA), which was developed to provide a reasonable method for assessing participation in overall physical activity (Prochaska et al. 2001). This measure contained two questions, which are the followings: "Over the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?" "Over a typical or usual week, on how many days are you physically active for a total of at least 60 minutes per day?" The MVPA has been found adequate to be used as a general research instrument (Currie et al. 2008a; Currie

et al. 2001; Viner et al. 2012). Further details of these measures can be found in Appendices 7 and 8.

Socioeconomic status of adolescents was measured by three different aspects, which were family affluence scale (FAS), parent education, and school type (public or private). Contrary to parental occupation measures, the family affluence measure has shown to have a low percentage of missing responses and therefore has more potential for comparability (Boyce et al. 2006; Currie et al. 1997; Torsheim et al. 2004; Torsheim et al. 2006). Participants were classified according to the summative score of the FAS, which is a measure based on a set of questions on the material conditions of the homes in which adolescents live (Currie et al. 2008b). The questions covered car ownership, bedroom occupancy, holidays and home computers and asked the following questions: "Does your family own a car, van or truck?" "Do you have your own bedroom for yourself?" "During the past 12 months, how many times did you travel away on holiday (vacation) with your family?" "How many computers does your family own?". The overall score was recoded to give values of low, middle and high family affluence (Currie et al. 2008a; Currie et al. 2004). Beside FAS, parental education was assessed using two questions: "What education level is your father" and "What education level is your mother". Also, school type was assessed by asking the question: "What type of school you currently in?"

All these measures have previously been used among adolescents studying in Riyadh and showed fair properties (Alzahrani et al. 2014). Further details of these measures can be found in Appendices 7 and 8.

2.5. Translation and adaptation of the questionnaire for adolescents in Saudi Arabia

The questionnaire went through forward and backward translation (Currie et al. 2010; World Health Organization 2010) by three independent people. First, two Arabic native speakers and proficient in English worked independently to produce forward translations of the original

questionnaire into Arabic. Those translators were health professional and familiar with terminology covered in the research area. Once obtained, a consensus version was established by reconciling the differences between the translated versions. The consensus version was then backward translated into English by an independent native speaker of English who is proficient in Arabic and who was not involved in the forward translation process. The resulted backward translation was then checked for discrepancies with the original English version, which revealed no discrepancies, no incorrect response categories and no missing words/phrases. Therefore, the interpretations of the original questions were judged as adequate and the resulted Arabic translation was adopted for the study.

The other study documents were also translated from English to Arabic, including the study feedback form (Appendix 10), student and parent information sheets (Appendices 11 to 14), student and parent consent forms (Appendices 15 and 18) and the instruction sheet for the field researcher (Appendix 19). All documents that aimed to be sent to the participants were translated into two separate translations, one for the boys and the other for the girls. The difference between the two versions was only in the linguistic formula as the Arabic language addresses males and females in two different forms of the same verb.

2.6. Examiners' training and calibration

Communication with several staff members in both dental clinics of King Saud University and SAU revealed that gathering TDI patients for calibration was not feasible for the following reasons:

- There was no available clinical system or protocol that allowed for such patients to be gathered into groups on specific dates or times.
- There were no specialised clinics that specifically treated or followed up those patients, and therefore it would be not practically feasible to find enough patients for calibration in one working day.

- The limited availability of the female examiner, due to her job nature and responsibilities, made it practically not feasible to overcome the low flow of patients with TDIs by increasing the frequency of visits to the clinic and individually recruiting walk-in patients for this process.

Therefore, it was decided to calibrate using colour slides instead. This method is commonly used in these types of studies to overcome logistical issues and ethical concerns in recruiting patients with TDIs (Dutra et al. 2010; Jorge et al. 2009; Jorge et al. 2012). The male and female examiners also performed a calibration for overjet measurement through occlusal examinations of 20 children (who were not included in the main study sample) on two different occasions, with a several weeks interval between the first and second assessments. Their ratings were compared with those of a dentist with experience in traumatology (gold standard). Inter-examiner agreement was determined using the Kappa index and with a Kappa of 0.91 it showed excellent agreement according to Fleiss's guideline (Fleiss et al. 2003), with a Kappa of 0.91. Intra-examiner agreement was assessed by each examiner repeating the tests a few weeks later. The Kappa indexes for the intra-examiner agreement showed good to excellent agreements for both examiners, with a Kappa of 0.75 for one examiner and a Kappa of 0.91 for the other examiner.

2.7. Pilot study

2.7.1. Objectives

The pilot study was carried out in secondary schools for male and female in Riyadh and from the same grade level as the target population.

The objectives of the pilot study were as follows:

1) to test the adequacy, feasibility and appropriateness of the research instruments by assessing understanding of children to the questions contents and their ability to answer all of them;

2) to assess the applicability of the questionnaire by administering it to the pilot sample in the same way as it would be administered in the main study and then receiving feedback to identify potential issues;

3) to identify and resolve any logistical problems that might occur when using the proposed methods, including ensuring that the study instructions were comprehensible, the examiners were sufficiently skilled and trained for the procedures, the allocated resources were sufficient to complete the study; and

4) to estimate variability in the study main outcome variables to help determining the minimum sample size required to provide sufficient study power for testing all of the study's objectives.

2.7.2. Methods

The pilot study used similar methods to the main study and was carried out after all the preparations were done and the ethics approvals were granted from the Research Ethics Committee of UCL (Appendix 1) and College of Dentistry in SAU (Appendix 2). The pilot study was carried in April 2012. The grant of these approvals was at the end of March 2012, which was during a formal 10-day holiday for Saudi schools. Therefore, preparations was initiated during the two weeks preceding the school holiday so that the pilot study could be carried out directly after the schoolchildren returned to school in the first week of April 2012.

Information sheets and consent forms were sent to the participants and their parents/guardians a week prior to the date of collection. The participants and their parents/guardians were asked for valid consent. Any refusal received from either the participant or the parent/guardian led to excluding the related participant from participation in the pilot study.

The fieldwork of the pilot study started by updating the related Saudi authorities and then carrying out the final arrangements of the pilot study in Saudi Arabia, including providing the study materials and calibrating the dental examiners. After all the related arrangements for each school were finalised, the questionnaire and clinical examinations were carried out.

The study utilised a dental examination for TDIs and a questionnaire including the study questions, feedback questions and dental examination sheet. The study was carried out in two secondary schools in Riyadh. Invitations to enrol in the study with information sheets and consent forms were sent to 200 parents of adolescents – 100 for a male private school and 100 for a female public school. The schools were then contacted on daily basis for one week to register the response rate. Students who had returned the positive consents of them and their parents completed the study questionnaire and went through the dental examination for TDIs. The paper-based outputs of both schools were transferred to Stata software for analysis (STATA Corp, College Station, TX, USA) and underwent a validation procedure by another reviewer who compared the transferred data to the original data.

2.7.3. Key pilot study results and implications

The majority of the parents in the school for female (97%) returned their consent forms compared to only 75% in the school for male. However, the rate of parents' agreement was only 56% in the school for female compared to 89% in the school for male. The detailed results are provided in Appendix 20, which includes response profile, sample distribution and characteristics of the sample related to the outcomes, exposures and covariates.

From a total of 80 responses to the general feedback question, 67 comments (83.8%) were positive. The remaining 13 comments (16.2%) indicated individual cases of different aspects, mainly being bored from answering the questions, feeling that some questions are not related to oral health, finding that some questions take long time to answer and feeling that some questions were not culturally appropriate. Examples of positive comments included "It's the first time someone has asked me such questions. Thank you for your concern", "Nice and interesting, a change from the daily routine in school" and "The questions are varied, nice and not hard to answer."

Negative comments included the following: “Question 27 was very confusing”, “Please do not ask about my personal life”, “The questions are not related to the topic” and “I could not understand the relation of some questions to the study, but thank you”.

Further exploring question 27 (Resistance to peer influence), the concerns referred to two different aspects. First, the question was perceived as difficult; some quotes from the feedback were “Difficult to understand”, “Hard” and “Could not understand it well”. Second, the question contained ambiguous expressions. This was reflated in several comments, such as “Not clear at all”, “Very confusing” and “I could not understand which one to choose”. Lists of all the other comments and further details on this section are provided in Appendix 20.

Apart from the 10-item measure of resistance to peer influence (Appendix 9), which showed high difficulties, non-response rate and boredom reports among the participants, the remaining reported difficulties were minor and manageable. The findings suggests that students’ reasons for reporting difficulties in questions 10, 11, 12, 13 and 17 (Measures of smoking and cannabis and weapon use) seem to be a normal variety of responses toward sensitive questions for adolescents that did not reach a level to prevent them from answering the questions (99% response rate). Difficulties reported in the remaining questions can be considered as normal variations in response as it only reported once each, beside it had very high response rate (99%). Therefore, no further intervention was needed. A summary of all the reasons that led to difficulties in this question, from the students’ perspective, can be found in Appendix 20.

The assessment of the questionnaire length and the capacity for completion within a reasonable time indicated that the majority of the participants did not experience any difficulty with the length of the questionnaire (Appendix 20). In contrast, the majority of the comments emphasised that most of the participants actually enjoyed the type and style of the questions. The mean average time spent for completing the questionnaire was 17.4 minutes (SD 6.8). Boys, however, spent significantly more time completing the questionnaire ($p=0.0078$), with an average mean of 18.9 minutes (SD 7.6) compared to 15.5 minutes (SD 5.1) for girls.

The wording of the questionnaire was mostly acceptable and readable by the participants. However, the main situation with wording appeared during carrying out the study in the school for female where the principal of school for female reacted strongly to the questions asking about smoking and cannabis and weapon use. The original questionnaire for female adolescents was therefore terminated until agreement with the Saudi Ministry of Education was made to enable minor modifications in the wordings and style to make the questions more acceptable (and also less specific) in terms of language, mainly replacing the word "cannabis" in questions 13 and 19 by the phrase "other materials besides tobacco" and the word "weapon" in questions 17, 18 and 19 by the phrase "sharp or aggressive tools". To retain the validity of the questions, the Ministry of Education agreed to leave an open-ended question at the end of each question asking about the details of the "other materials besides tobacco" and the "sharp or aggressive tools" so further analysis of these responses could be done later in the analysis stage, which enables the elimination of any unrelated answer.

Analysis of the notes and feedback related to adequacy of the research protocol that were collected from all the involved persons before, during and after the study administration, including school teachers and principals and the authorities in the SME, indicated that the research protocol could adequately serve the objectives of the study. Some of the main helpful notes and recommendations that could help to improve the study were as follows:

1. Students were much more collaborative and manageable when they were approached in the early morning rather than in the last hours of the school day.
2. In the school for male adolescents, conducting the study in a quiet meeting room was more efficient and easier for managing the students than the classroom. In contrast, the administrator of the school for female reported that the classroom was more efficient. This might be because the administrator of the school for females had the advantage of an assistant helping her control the classroom; such help was not available in the boys' school study.

3. The pilot study in the school for female had less cooperation than usual from the students and their head teacher as they were very busy preparing for the final exams that were due only two weeks after the visiting day. This might also have influenced the number and the behaviours of the respondents as students with less interest in education tend to miss the last days of school before the exams.

2.8.Study materials

The materials for the main study included the following:

- 1000 sterilised disposable dental examination kit in a disposable plastic tray, including dental mirror, dental explorer, dental shawl and dental tweezers;
- 771 sterilisable periodontal probe (to be returned to the Dental College of SAU after use);
- 1000 pieces of 10x10cm gauze swabs;
- 1100 pairs of disposable examination gloves;
- 1000 disposable face masks;
- 1000 photocopies of the questionnaire;
- 10 photocopies of study documents and permissions;
- 2 pen- and 2 head-torches;
- 10 storage files and folders.

2.9. Sampling methods

A stratified two-stage cluster sample design was used to improve the precision and representativeness of the study population. The stratification process included dividing the sample into schools for male and female. In each stratum, public and private schools were separated as clusters, and each school within these clusters was regarded as the primary unit of sampling. The clustered design adopted to increase the efficiency of the sampling method by allocating the limited resources to the randomly selected clusters instead of sampling randomly

from the entire population of adolescents, which would have implied visiting many more schools as only a few adolescents may have been randomly selected from each school. In order to have a sample that is representative to the relative population in Riyadh, a self-weighting sample was used to select the proportions of students from each cluster with the same proportion as in the general population (Peters and Eachus 1995). Schools were selected from each cluster by simple random sampling. Then, all the students of grades 10 and 11 within the selected schools were invited to participate in the study.

2.10. Sample size

Sample size was calculated for each objective separately to make sure that the study had enough power to test all of the objectives. The available studies during the planning phase of this study that assessed the prevalence of TDIs among adolescents in Riyadh, Saudi Arabia, reported a prevalence of 34.3% among boys aged 12 to 14 years (Al-Majed et al. 2001) and 31.4% among girls aged 12 to 15 years (Al-Majed 2011). However, neither of these studies nor others assessed variations of TDIs by the level of risk taking or peer influence between groups. Therefore, the pilot study data were used to obtain estimates of the probability of TDIs in both male and female adolescents, higher-risk takers and lower-risk takers and higher and lower peer influence of the study population. This was to provide a better estimate of the minimum sample size required to test all of the study objectives.

For all the relevant sample size estimations, the significance level (α) was considered at 5% and the power (1-β) of 95% for the prevalence objective and 80% for the others. Two formulae were used to estimate the sample size needed (Altman 2010; Kirkwood et al. 2003). First, to test differences in the TDIs between groups of adolescents with higher- and lower-risk takers and those with higher and lower peer influence, the following formula was used:

$$\eta = \frac{\left[Z_{1} - \alpha/2\sqrt{\left[2\overline{P}(1-\overline{P})\right]}\right] + Z_{1} - \beta\sqrt{\left[p_{1}(1-P_{1}) + P_{2}(1-P_{2})\right]}^{2}}{(P_{1} - P_{2})^{2}}$$

Where: $\overline{P} = \frac{(P_1 - P_2)}{2}$

Second, the sample size estimation for the prevalence rate of TDIs among male and female adolescents was calculated using the following formula:

$$\eta = \frac{Z^2 P(1-P)}{d^2}$$

Where: η = sample size, Z = Z statistic for a level of confidence, P = expected prevalence or proportion and d = precision.

The pilot study findings showed that the TDI prevalence among this population was 47.9%. However, male adolescents had a significantly higher prevalence (69.2%) compared to females (22.2%). However, a lot of the reported cases of TDIs that was coded as enamel fractures (code 2) were very slight cracks that could be a result of peeling nuts with anterior teeth, which is a very common eating behaviour among Saudi Arabians. Therefore a more conservative estimations of the sample size were adopted by excluding code 2 TDIs cases during the sample size calculation and only consider the more severe cases (code 3, 4 and 5) in addition to the treated TDI cases (code 1). The main assumptions therefore were that the prevalence of TDIs for Codes 1, 3, 4 and 5 were 12.3% among boys and 5.6% among girls. Also it was assumed that 6.7% of boys and 2.3% of girls tried smoking, 17.5% of the sample involved in fights, 16.1% never carried weapons, 8.5% had more than three close friends, 15.4% spend 6 or more nights a week with friends and 33.3% disagreed that they have good peer support. Appendix 21 shows the detailed results of the sample size calculations using the conservative method and including the adjustments of both the non-response rates and the clustering factors,

The sample size calculations suggest that the minimal required sample size for testing the prevalence of TDIs after adjustments for non-response and clustering factor is 829 participants; 382 male and 447 female participants. However, more participants were needed to further investigate the other objectives related to risk-taking and peer influences associations. Although

the findings suggested that an estimated sample of 484 participants from each sex were needed to assess the differences related to one variable (days that adolescents spend time out with friends after school), it also showed that a sample of 294 from each schools of male and female was producing enough power to test all the main and remaining objectives.

Based on the aforementioned estimations of sample sizes for the different objectives, the latter sample size obtained was taken to accommodate all study objectives. To compensate for the clustering effect, a correction factor of 1.2 was established. Also, considering the response profile of the pilot study (Section 2.7.3), an additional 33% for schools for male and 46% for the school of female is added to the total sample to compensate for possible non-response and refusals. Therefore, the adjusted minimal required sample size resulted was 988 participants, divided into 469 participants from the schools for male and 519 participants from the schools for female. Table 3 summarises the distribution of the sample from each cluster based on the self-weighting in relation to the proportion of student in the general population.

Table 3: Distribution of the selected sample from each cluster

Cluster/Stratum	Number of school	Total Number of students		Allocated sample	Proportions in final sample
		n	%		
Public male	196	87,824	65.2%	306	31.0%
Private male	115	46,802	34.8%	163	16.5%
Total male	**311**	**134,626**	**100.0%**	**469**	**47.5%**
Public female	180	71,297	77.2%	401	40.6%
Private female	104	21,026	22.8%	118	12.0%
Total female	**284**	**92,323**	**100.0%**	**519**	**52.5%**
Total	595	226,949	-	988	100.0%

2.11. Fieldwork procedures

Information sheets (Appendices 11 to 14) and consent forms (Appendices 15 to 18) were sent to the participants and their parents/guardians a week prior to the data collection day. Both the participants and their parent/guardian were asked for positive consent. Any refusal received from either the participant or the parent/guardian led to excluding the related participant from the study.

Administration of the questionnaires was done while considering confidentiality and objectivity throughout the process, which was applied through a strict protocol (Appendix 19). Students were assured that their responses were completely anonymous and that they would only be seen by research staff working on the data, while the study assessors had detailed guidelines on how to maintain confidentiality. In addition, the field researchers gathered information related to student non-response and included absentees and refusals by both students and parents (Appendix 22).

2.12. Analysis plan

With the outcome being used as a dichotomous variable (yes/no TDIs), the differences in prevalence of TDIs between the different groups of the covariates (demographic, socioeconomic, physical activity) was initially assessed through chi squared test (for binary covariates, such as age group and sex) and chi squared for trend (for ordinal covariates, such as FAS). The associations between the dichotomous outcome (yes/no TDIs) and behavioural risk factors was assessed initially through chi squared tests, as all behavioural risk factors were binary and the same was the case for the respective associations for the different variables on peer influence.

As different variables of peer influence were available in the questionnaire with some having high correlations between them, three options were assessed as potential analysis strategies for use in the analyses of these variables: 1) to use theoretical basis for selecting some of the measured variables in the regression analyses based on their associations with injuries and risk-taking behaviours (i.e. smoking, illegal drug use, fighting, carrying weapon and seatbelt use); 2) to create a composite score by summing the measured variables and use them as either a count variable (score) or as an ordinal variable, depending on the distribution of scores; and 3) to reduce the number of variables to a smaller number of principal components by statistically testing and determining the dimensions of peer influence variables that account for most of the variance. Further details on these analyses are presented in Appendix 23. Reviewing the results

of these preliminary analyses and weighing the advantages and disadvantages of each approach, the first option was adopted as the main strategy for the analyses of peer influence variables. This use of the first approach should allow evaluating peer influence variables relevant to each risk behaviour variable individually in order to determine whether the association with both risk-taking behaviours and TDIs act in accordance with theoretical expectations. Imposing statistical controls on those variables could eliminate ambiguity of interpretation and provides perspectives on the magnitude of peer influence by assessing the extent to which associations between TDIs and risk-taking behaviour remain intact after controlling for peer relationship variables (Appendix 23).

The second option was used as a supplementary analysis to provide further evidence as well as assessment of reliability of the main analyses (Appendices 23 and 30). The second approach constructed two scales central to adolescent peer relationships as proposed and implemented in the Canadian National Survey of Health Behaviour in School-Aged Children, the World Health Organization cross–national study (Boyce 2004). The first scale, social integration (SI; alpha = 0.58), consisted of items that assessed: (a) the number of close friends; (b) the degree of interaction; and (c) the ease of communication and comfort with friends. The second scale, peer influence (PI; alpha = 0.59), assessed: (a) the extent to which friends were involved in risk behaviours; and (b) friends' attitudes toward parents and school. Combinations of high and low levels on these two scales created four categories of students. These categories were: (1) high SI and positive PI; (2) high SI and negative PI; (3) low SI and positive PI; and (4) low SI and negative PI. Further details about the methods and psychometric properties of these scales are presented in Appendix 23 and the results are presented in Appendix 30.

To fully address the second and third objectives, a set of regression models were run for each of the associations between TDIs (outcome) and risk taking behaviours and peer influence respectively (main exposures). The model building strategy aimed to provide sequential adjustment for confounding factors according to the broad groups of confounders identified in

the objectives. The selection of variables to be included in the models was based on conceptual grounds, but statistical significance of the crude associations was also taken into account. More specifically, associations with a p-value over 0.25 were considered for redundancy, providing the variables were not important to be included for conceptual reasons based on the literature.

The initial univariate analysis of each variable with the outcome helped identify the most suitable format (dichotomous, ordinal, count) for the exposures and was the first step towards building the final models to address the objectives of the study. Then, the crude models were adjusted for risk-taking behaviours (objective 2). The same process was followed for the adjustment for peer influence variables (objective 3); however, separate models were run adjusting for the aggregate peer influence variable(s). All aforementioned models were sequentially adjusted for: 1) demographic variables (age, sex and nationality), 2) socioeconomic status (parent education), 3) physical activity (MPVA), and 4) incisors overjet. Once a model was established with all relevant variables, further consideration was taken in relation to whether interaction terms had to be added providing that categories or linearity assumptions have been verified for polychromous and continuous variables. Finally, to address the fourth objective the selected models (with behavioural risk taking as the main exposure) were further checked for interactions between the main exposure and the peer influence variables.

As the outcome was going to be used primarily as dichotomous variable, logistic regression models with odds ratio were initially considered. However, the initial analyses showed a high prevalence of TDIs, so Poisson regressions with a robust error variance were used to estimate adjusted prevalence ratios. This approach was preferred because it provides more accurate estimates than the odds ratio provided by the logistic regressions when the binary outcome is common. In such cases, the odds ratio could considerably overestimate the actual prevalence ratios (Barros and Hirakata 2003).

Chapter 3: Results

3.1. Descriptive statistics

3.1.1. Section overview

This section describes the distribution of the sample as per its demographics, socioeconomic status indicators, physical activity and clinical measures. It also presents the distribution of risk-taking behaviours and the characteristics of the peer relationships in the study sample.

The section is divided into six parts. The first part describes the response profile, including the size of the sample, the participant and school response rates and the reasons behind non-response. The second part describes the distribution of the sample according to demographic indicators, which included age, sex, school grade and nationality and socioeconomic status indicators, which in turn included father's education, mother's education, type of school and family affluence. The third part describes the distribution of the sample according to physical activity, which referred to the recommended daily sixty minutes of MVPA. The fourth part describes the distribution of the sample according to the clinical measures, which were incisor overjet and lip coverage.

The fifth part describes the distribution of the study sample's risk-taking behaviours. These behaviours included smoking tobacco and other drugs, physical fighting, carrying weapons in general and to school, not using seatbelts and not wearing helmets. The last part describes the characteristics of the peer relationships in the study sample. These characteristics included the number of close friends, the frequency of going out with friends after school and in the evenings, the frequency of communicating with friends electronically, the ease with which others were able to join the peer group and the peer group's mutual respect and supportiveness.

3.1.2. Response profile

In total, 902 questionnaires were completed and dental examinations conducted (91.3% student response rate) in 11 schools (100% school response rate). The sample comprised 461 boys and 441 girls. 60 (69.8%) cases of the non-responders were because of lack of parental consent, while the remaining 26 (30.2%) cases were adolescents refusing to participate in the study. Due to school rules and limitations of resources, the proportion of students from each strata and cluster related to the adopted self-weighting sample were slightly changed. Boys from public schools constituted 36.1% of the study sample and girls comprised 35.4%, compared to the original target of 31.0% and 40.6%, respectively. Boys from private schools constituted 15% of the sample and girls comprised 13.5%, compared to the original target of 16.5% and 12.0%, respectively.

3.1.3. Demographic and socioeconomic characteristics of study sample

Table 4 presents the demographic and socioeconomic status indicators of the study population. The majority of the sample was between 15 and 17 years old; the mean age of the boys was 16.2 (SD = 0.84) years and for girls 16.1 (SD = 0.88) years. The majority of both boys and girls were of Saudi nationals; 87.0% boys and 74.1% girls respectively, while the home country of the majority of the others was within the Middle East. 71% of the boys and 72.3% of the girls in the sample were enrolled in public schools.

In terms of parents' education, 13.9% of the boys' fathers and 18.6% of the girls' fathers had postgraduate degrees, while only 6.9% of the boys' mothers and 6.8% of the girls' mothers had completed this level of education. More than half the fathers, 51.2% of the boys' fathers and 64.6% of the girls' fathers, had completed education between the secondary and university level. This was also the case for 44.3% of the boys' mothers and 64.4% of the girls' mothers. It was further seen that 34.7% of the boys and 33.3% of the girls belonged to families with relatively high affluence.

Table 4: Distribution of sample by demographic factors and socioeconomic status indicators

	Boys (n=461)	Girls (n=441)	All (n=902)
Age in years [a]			
	16.2 (0.84)	16.1 (0.88)	16.2 (0.86)
Age group [b]			
< 15	0.7 (0 to 1.4)	0.9 (0 to 1.8)	0.8 (0.2 to 1.3)
15 to 17	95.2 (93.3 to 97.2)	95.5 (93.3 to 97.4)	95.3 (94.0 to 96.7)
> 17	4.1 (2.3 to 5.9)	3.6 (1.9 to 5.4)	3.9 (2.6 to 5.1)
School grade [b]			
First	55.1 (50.5 to 59.7)	47.4 (42.7 to 52.1)	51.3 (48.1 to 54.6)
Second	44.9 (40.5 to 49.4)	52.6 (47.9 to 57.2)	48.7 (45.4 to 51.9)
Saudi nationality [b]			
	87.0 (83.9 to 90.1)	74.1 (70.1 to 78.2)	81.0 (78.4 to 83.6)
School type [b]			
Public	71.0 (66.8 to 75.2)	72.3 (67.9 to 76.3)	71.5 (68.5 to 74.4)
Private	29.3 (25.3 to 33.6)	27.7 (23.7 to 32.0)	28.5 (25.7 to 31.5)
Father education [b]			
Illiterate	4.1 (2.6 to 6.9)	1.8 (0.9 to 3.6)	2.99 (2.1 to 4.3)
Can only read and write	9.8 (7.4 to 12.8)	3.4 (2.1 to 5.6)	6.65 (5.2 to 8.5)
Primary school	8.2 (6.0 to 11.1)	2.9 (1.7 to 5.0)	5.65 (4.3 to 7.4)
Intermediate school	11.3 (8.7 to 14.5)	6.1 (4.2 to 8.8)	8.76 (7.1 to 10.8)
Secondary school	27.3 (23.4 to 31.6)	19.3 (15.8 to 23.2)	23.39 (20.7 to 26.3)
University	23.9 (20.2 to 28.0)	45.3 (40.7 to 50.0)	34.37 (31.3 to 37.5)
Postgraduate	13.9 (11.0 to 17.4)	18.6 (15.2 to 22.5)	16.19 (13.9 to 18.7)
Missing	1.5 (0.7 to 3.2)	2.5 (1.4 to 4.5)	2.00 (1.3 to 3.1)
Mother education [b]			
Illiterate	13.9 (11.0 to 17.4)	4.5 (2.9 to 6.9)	9.3 (7.6 to 11.4)
Can only read and write	11.3 (8.7 to 14.5)	5.4 (3.7 to 8.0)	8.4 (6.8 to 10.4)
Primary school	10.8 (8.3 to 14.0)	4.5 (2.9 to 6.9)	7.8 (6.2 to 9.7)
Intermediate school	11.9 (9.2 to 15.2)	11.1 (8.5 to 14.4)	11.5 (9.6 to 13.8)
Secondary school	19.7 (16.3 to 23.6)	27.9 (23.9 to 32.3)	23.7 (21.1 to 26.6)
University	24.5 (20.8 to 28.7)	36.5 (32.1 to 41.1)	30.4 (27.5 to 33.5)
Postgraduate	6.9 (4.9 to 9.7)	6.8 (4.8 to 9.6)	6.9 (5.4 to 8.7)
Missing	0.9 (0.3 to 2.3)	3.2 (1.9 to 5.3)	2.0 (1.3 to 3.1)
Family Affluence Scale [b]			
Relatively deprived	25.6 (21.6 to 29.6)	22.4 (18.5 to 26.4)	24.1 (21.3 to 26.9)
Relatively medium	39.0 (34.6 to 43.5)	43.8 (39.1 to 48.4)	41.4 (38.1 to 44.6)
Relatively affluent	34.7 (30.4 to 39.1)	33.3 (28.9 to 37.7)	34.0 (30.9 to 37.1)
Missing	0.7 (0 to 1.4)	0.5 (0 to 1.1)	0.6 (0.1 to 1.0)

[a] Data are presented as mean (Standard deviation).
[b] Data are presented as proportion estimate (95% confidence interval).

3.1.4. Physical activity

Only 14.7% of the adolescents met the recommended daily sixty minutes of MVPA for five days or more a week (Table 5). This recommendation was met among 15.6% of the boys and 13.6% of the girls.

3.1.5. Clinical measures of overjet and lip coverage

The results of dental examinations showed that 6.1% of the boys and 4.5% of the girls had incisor overjet of more than 5mm. The majority of the adolescents (72.7% of the boys and

75.2% of the girls) had incisor overjet of between 0 and 3mm, while the remaining adolescents (21.3% boys and 20.2% girls) had incisor overjet of over 3mm but less than 5mm. The examination of lip coverage indicated that 5.4% of the boys and 4.1% of the girls had inadequate lip coverage (Table 5).

Table 5: Sample distribution by physical activity and clinical measures

	Boys (n=461)	Girls (n=441)	All (n=902)
MVPA [a, b]			
< 5 days a week	84.2 (80.8 to 87.5)	85.7 (82.4 to 89.0)	85.3 (82.8 to 87.5)
5 days or more a week	15.6 (12.3 to 18.9)	13.6 (10.4 to 16.8)	14.7 (12.5 to 17.2)
Missing	0.2 (0 to 0.6)	0.7 (0 to 1.4)	0.4 (0.2 to 1.2)
Incisor overjet [a]			
0–3mm	72.7 (68.4 to 76.6)	75.2 (71.0 to 79.1)	73.9 (71.0 to 76.7)
4–5 mm	21.3 (17.7 to 25.2)	20.2 (16.7 to 24.2)	20.7 (18.2 to 23.5)
> 5 mm	6.1 (4.2 to 8.7)	4.5 (2.9 to 6.9)	5.3 (4.0 to 7.0)
Inadequate lip coverage [a]			
	5.4 (3.7 to 7.9)	4.1 (2.6 to 6.4)	4.8 (3.5 to 6.4)

[a] Data are presented as proportion estimate (95% confidence interval).
[b] MVPA refers to daily 60 minutes of moderate-to-vigorous physical activity.

3.1.6. Risk-taking behaviours

Table 6 presents the distribution of risk-taking behaviours in the study population. When the subjects were asked about smoking, 34.7% of the boys and 7.3% of the girls reported having smoked tobacco. 21.5% of the boys and 2.3% of the girls reported that they were still smokers, and 15.9% of the boys and 0.7% of the girls reported smoking at least once a week during the period of the study. Only 1.7% of the boys and 0.2% of the girls reported having smoked other drugs during their lifetime.

Overall, 56.4% of the boys and 57.1% of the girls reported that they had never used a seatbelt. Further, 48.8% of the boys and 42.9% of the girls reported that they had not worn a cycle helmet in the year preceding the study. However, a considerable proportion of the sample reported that they did not ride a bicycle during this period (44.9% of the boys and 51.2% of the girls).

When the subjects were asked about their involvement in fights, 54.7% of the boys and 43.1% of the girls reported having had physical fights more than 3 times during the year preceding the study. Questions about their use of weapons revealed that 21.1% of the boys had carried a weapon during the 3 months preceding the study, while only 3.6% of the girls reported the same.

Only 6.3% of boys and 1.8% of girls reported carrying a weapon to school during the 3 months preceding the study.

Considering these three risk behaviours, smoking tobacco, physical fighting and carrying of weapons, as indicators of risk behaviours, the results indicated that 34.6% of the boys and 43.2% of the girls had one risk behaviour, while 27.1% of the boys and only 2.7% of the girls exhibited more than one risk behaviour.

Table 6: Sample distribution by risk-taking behaviour variables

	Boys	Girls	All
Ever smoked tobacco [a]	**(n=461)**	**(n=439)**	**(n=900)**
	34.7 (30.5 to 39.2)	7.3 (5.2 to 10.1)	21.3 (18.8 to 24.1)
Current tobacco smoking patterns [a]	**(n=461)**	**(n=439)**	**(n=900)**
Every Day	11.1 (8.5 to 14.3)	0.2 (0 to 1.6)	5.8 (4.4 to 7.5)
Once a week	4.8 (3.1 to 7.1)	0.4 (0 to 1.8)	2.7 (1.8 to 3.9)
Less than once a week	5.6 (3.9 to 8.2)	1.6 (0.4 to 3.3)	3.7 (2.6 to 5.1)
Do not smoke	78.5 (74.5 to 82.0)	97.7 (96.3 to 98.8)	87.9 (85.6 to 89.9)
Tobacco initiation (in years) [b]	**(n=132)**	**(n=20)**	**(n=152)**
	14.4 (1.72)	13.5 (4.26)	14.3 (2.22)
Smoked other drugs Lifetime [a]	**(n=461)**	**(n=439)**	**(n=900)**
	1.7 (0.9 to 3.4)	0.2 (0 to 1.6)	1.0 (0.5 to 1.9)
Smoked other drugs last 12 months [a]	**(n=461)**	**(n=439)**	**(n=900)**
	0.6 (0.2 to 2.0)	0.2 (0 to 1.6)	0.4 (0.2 to 1.2)
Drugs using groups [a,g]	**(n=461)**	**(n=439)**	**(n=900)**
Non users	98.3 (96.6 to 99.1)	99.8 (98.4 to 100)	99.0 (98.1 to 99.5)
Discontinued/ Experimenters	1.1 (0.5 to 2.6)	0.2 (0 to 1.6)	0.7 (0.3 to 1.5)
Regular/Heavy users	0.7 (0.2 to 2.0)	0	0.3 (0.1 to 1.0)
Using seatbelt [a,c]	**(n=461)**	**(n=441)**	**(n=902)**
Never	56.4 (51.9 to 60.9)	57.1 (52.5 to 61.7)	56.8 (53.5 to 60.0)
Sometimes	24.7 (21.0 to 28.9)	24.7 (20.9 to 29.0)	24.7 (22.0 to 27.7)
Rarely	11.9 (9.3 to 15.0)	12.9 (10.1 to 16.4)	12.4 (10.4 to 14.7)
Most of the time	3.7 (2.3 to 5.9)	2.9 (1.7 to 5.0)	3.3 (2.3 to 4.7)
Always	3.3 (2.0 to 5.3)	2.3 (1.2 to 4.2)	2.8 (1.8 to 4.1)
Wearing helmet [a,f]	**(n=461)**	**(n=441)**	**(n=902)**
Never	48.8 (44.2 to 53.4)	42.9 (38.3 to 47.5)	45.9 (42.7 to 49.2)
Rarely	2.4 (1.3 to 4.3)	2.5 (1.4 to 4.5)	2.4 (1.6 to 3.7)
Sometimes	2.0 (1.0 to 3.7)	1.4 (0.6 to 3.0)	1.7 (1.0 to 2.7)
Most of the times	0.7 (0.2 to 2.0)	0.2 (0 to 1.6)	0.4 (0.2 to 1.2)
Always	1.3 (0.6 to 2.9)	1.8 (0.9 to 3.6)	1.6 (0.9 to 2.6)
Did not ride	44.9 (40.4 to 49.5)	51.2 (46.6 to 55.9)	48.0 (44.8 to 51.3)
Physical fight [a,f]	**(n=461)**	**(n=441)**	**(n=902)**
Never	45.3 (40.8 to 49.9)	56.9 (52.3 to 61.5)	51.0 (47.7 to 54.3)
One time	21.3 (17.7 to 25.2)	17.0 (13.8 to 20.8)	19.2 (16.7 to 21.9)
Two times	11.5 (8.9 to 14.8)	8.8 (6.5 to 11.9)	10.2 (8.4 to 12.4)
Three times	9.8 (7.4 to 12.8)	2.7 (1.5 to 4.7)	6.3 (4.9 to 8.1)
Four times or more	12.1 (9.5 to 15.5)	14.5 (11.5 to 18.1)	13.3 (11.2 to 15.7)
Carried a weapon [a,d,e]	**(n=457)**	**(n=439)**	**(n=896)**
1–5 days	10.3 (7.8 to 13.4)	1.8 (0.9 to 3.6)	6.1 (4.7 to 7.9)
More than 5 days	10.7 (8.2 to 13.9)	1.8 (0.9 to 3.6)	6.4 (4.9 to 8.2)
Did not carry a weapon	79.0 (75.0 to 82.5)	96.4 (94.1 to 97.8)	87.5 (85.2 to 89.5)
Carried a weapon on school property [a,d,e]	**(n=457)**	**(n=439)**	**(n=896)**
1–5 days	5.0 (3.4 to 7.5)	1.4 (0.6 to 3.0)	3.2 (2.3 to 4.6)
More than 5 days	1.3 (0.6 to 2.9)	0.5 (0.1 to 1.8)	0.3 (0.4 to 1.8)
Did not carry a weapon	93.7 (91.0 to 95.9)	98.2 (96.4 to 99.1)	95.9 (94.3 to 97.0)
Multiple risk behaviours [a,h]	**(n=457)**	**(n=437)**	**(n=894)**
No risk behaviours	38.3 (33.9 to 42.9)	54.0 (49.3 to 58.6)	46.0 (42.7 to 49.3)
1 risk behaviour	34.6 (30.3 to 39.1)	43.2 (38.7 to 48.0)	38.8 (35.7 to 42.1)
Multiple risk behaviours	27.1 (23.2 to 31.4)	2.7 (1.6 to 4.8)	15.2 (13.0 to 17.7)

[a] Presented as proportion estimate (95% confidence interval);
[b] Presented as mean (Standard deviation);
[c] When riding in a car driven by someone else.
[d] Weapons include guns, knives, clubs, blades, scissors and stunt guns;
[e] During the last month before the study; [f] During the last year before the study;
[g] Discontinued/ Experimenters used drugs at least once lifetime or 1–2 times last 12 months, Regular/Heavy users used drugs more than 2 times last 12 months;
[h] Out of 3 risk-behaviours: Smoking tobacco, fighting and carrying weapons.

3.1.7. Peer relationships

Distribution of the sample based on peer relationships characteristics is shown in Tables 7, 8 and 9. When the subjects were asked about the number of close friends they had, 83.5% of the boys and 68.0% of the girls reported having three or more close friends. Also, going out with friends was not uncommon among boys; 31.7% of them reported going out with friends for more than three days a week after school. The case was different for the girls, with only 7.8% of them reporting spending three days a week with their friends after school. The same pattern was seen when adolescents were asked about the number of evenings per week they usually spend with their friends; 28.4% of the boys reported spending more than three evenings with friends while only 10.0% of the girls reported the same. In response to the question about electronic communication with friends, 63.5% of boys and 63% of girls reported communicating electronically with their friends every day (Table 7).

When the subjects were asked about the ease with which others could join their group, 74.5% of girls and 63.4% reported feeling comfortable with letting others join their groups. Also, most of the adolescents (80.3% of the girls and 74.4% of the boys) agreed that their groups were treated with respect and that peer members were supportive (80.0% of the boys and 90.7% of the girls).

When asked about their peer characteristics, 41.2% of adolescents reported that none of their peers like school, while 27.9% of the participants reported that none of their friends were doing well at school. In addition, 27.3% of the adolescents reported that some or all of their peers smoked tobacco, while only 8.5% reported that some or all of their peers smoked other drugs and 19.0% reported that some or all of their peers carried weapons (Tables 8).

In response to questions about the ease with which they can talk to family members and peers, adolescents reported difficulties in talking to their fathers and mothers (41.4% and 16.0%, respectively). While difficulties in talking to their best friends were less prevalent, with only 10.0% of the adolescents reporting this, more than half the adolescents (51.3%) reported difficulties in talking to their other friends (Table 9).

Table 7: Sample distribution by peer relationships characteristics

	Boys	Girls	All
Close friends [a]	**(n=461)**	**(n=441)**	**(n=902)**
None	3.0 (1.8 to 5.1)	3.2 (1.9 to 5.3)	3.1 (2.2 to 4.5)
One	3.7 (2.3 to 5.9)	9.8 (7.3 to 12.9)	6.7 (5.2 to 8.5)
Two	9.5 (7.2 to 12.6)	18.8 (15.4 to 22.8)	14.1 (12.0 to 16.5)
Three or more	83.5 (79.8 to 86.6)	68.0 (63.5 to 72.2)	75.9 (73.0 to 78.6)
Missing	0.2 (0 to 1.5)	0.2 (0 to 1.6)	0.2 (0 to 0.9)
Days out with friends after school [a, b]	**(n=461)**	**(n=441)**	**(n=902)**
None	23.9 (20.2 to 28.0)	46.0 (41.4 to 50.7)	34.7 (31.7 to 37.9)
One day	13.7 (10.9 to 17.1)	30.6 (26.5 to 35.1)	22.0 (19.4 to 24.8)
Two days	17.1 (14.0 to 20.9)	11.3 (8.7 to 14.7)	14.3 (12.2 to 16.7)
Three days	13.2 (10.4 to 16.7)	3.6 (2.2 to 5.9)	8.5 (6.9 to 10.5)
Four days	4.1 (2.6 to 6.4)	1.8 (0.9 to 3.6)	3.0 (2.1 to 4.3)
Five days	27.3 (23.4 to 31.6)	5.9 (4.0 to 8.5)	16.9 (14.5 to 19.4)
Missing	0.7 (0.2 to 2.0)	0.7 (0.2 to 2.1)	0.7 (0.3 to 1.5)
Evenings out with friends [a, b]	**(n=461)**	**(n=441)**	**(n=902)**
None	21.9 (18.4 to 25.9)	54.2 (49.5 to 58.9)	37.7 (34.6 to 40.9)
One evening	17.8 (14.5 to 21.6)	25.4 (21.5 to 29.7)	21.5 (18.9 to 24.3)
Two evenings	20.6 (17.1 to 24.6)	8.2 (5.9 to 11.1)	14.5 (12.4 to 17.0)
Three evenings	10.8 (8.3 to 14.0)	1.6 (0.7 to 3.3)	6.3 (4.9 to 8.1)
Four evenings	6.5 (4.6 to 9.2)	1.1 (0.5 to 2.7)	3.9 (2.8 to 5.4)
Five evenings	5.4 (3.7 to 7.9)	3.2 (1.9 to 5.3)	4.3 (3.2 to 5.9)
Six evenings	3.0 (1.8 to 5.1)	1.1 (0.5 to 2.7)	2.1 (1.3 to 3.3)
Seven evenings	13.2 (10.4 to 16.7)	4.5 (2.9 to 6.9)	9.0 (7.3 to 11.0)
Missing	0.7 (0.2 to 2.0)	0.7 (0.2 to 2.1)	0.7 (0.3 to 1.5)
E-communication with friends [a]	**(n=461)**	**(n=441)**	**(n=902)**
Rarely	10.2 (7.7 to 13.3)	7.7 (5.6 to 10.6)	9.0 (7.3 to 11.0)
1–2 days	9.8 (7.4 to 12.8)	11.3 (8.7 to 14.7)	10.5 (8.7 to 12.7)
3–4 days	10.6 (8.1 to 13.8)	11.3 (8.7 to 14.7)	11.0 (9.1 to 13.2)
5–6 days	5.9 (4.0 to 8.4)	6.6 (4.6 to 9.3)	6.2 (4.8 to 8.0)
Every day	63.1 (58.6 to 67.4)	62.6 (58.0 to 67.0)	62.9 (59.7 to 66.0)
Missing	0.4 (0.1 to 1.7)	0.5 (0.1 to 1.8)	0.4 (0.2 to 1.2)
Easiness for others to join the group [a]	**(n=461)**	**(n=441)**	**(n=902)**
Very easy	21.3 (17.7 to 25.2)	24.0 (20.3 to 28.3)	22.6 (20.0 to 25.5)
Easy	41.9 (37.4 to 46.4)	50.1 (45.4 to 54.8)	45.9 (42.7 to 49.2)
Difficult	23.6 (20.0 to 27.8)	20.6 (17.1 to 24.7)	22.2 (19.6 to 25.0)
Very difficult	12.8 (10.0 to 16.2)	4.8 (3.1 to 7.2)	8.9 (7.2 to 10.9)
Missing	0.4 (0.1 to 1.7)	0.5 (0.1 to 1.8)	0.4 (0.2 to 1.2)
Peer group treated with respect [a, c]	**(n=461)**	**(n=441)**	**(n=902)**
Strongly agree	33.4 (29.2 to 37.9)	31.1 (26.9 to 35.6)	32.3 (29.3 to 35.4)
Agree	41.0 (36.6 to 45.6)	49.2 (44.5 to 53.9)	45.0 (41.8 to 48.3)
Neither/nor	18.9 (15.5 to 22.7)	16.8 (13.6 to 20.6)	17.8 (15.5 to 20.5)
Disagree	3.5 (2.1 to 5.6)	1.6 (0.8 to 3.3)	2.5 (1.7 to 3.8)
Strongly disagree	3.3 (2.0 to 5.3)	1.4 (0.6 to 3.0)	2.3 (1.5 to 3.5)
Peer group is supportive [a, d]	**(n=461)**	**(n=441)**	**(n=902)**
Strongly agree	48.2 (43.6 to 52.7)	61.0 (56.3 to 65.5)	54.4 (51.2 to 57.7)
Agree	31.9 (27.8 to 36.3)	29.7 (25.6 to 34.2)	30.8 (27.9 to 33.9)
Neither/nor	13.0 (10.2 to 16.4)	6.3 (4.4 to 9.1)	9.8 (8.0 to 11.9)
Disagree	3.5 (2.1 to 5.6)	2.0 (1.1 to 3.9)	2.8 (1.9 to 4.1)
Strongly disagree	3.5 (2.1 to 5.6)	0.9 (0.3 to 2.4)	2.2 (1.4 to 3.4)

[a] Data are presented as proportion estimate (95% confidence interval);
[b] Per week;
[c] By most students in the school;
[d] Support to each other when a peer group member is feeling down.

Table 8: Sample characteristics of perceived peer behaviours

	None	Less than half of them	About half of them	More than half of them	All of them	Don't know
Peers like school (n=902) [a]	41.2	20.1	11.6	4.5	7.3	15.2
Peers doing well at school (n=902) [a]	27.9	36.1	13.3	6.9	3.1	12.6
Peers smoke tobacco (n=902) [a]	60.3	14.0	6.2	5.0	2.1	12.4
Peers smoke other drugs (n=902) [a]	77.2	6.1	1.1	1.1	0.2	14.3
Peers carry weapons (n=902) [a]	63.0	12.0	3.0	2.1	1.9	18.1
Peers participate in organised sports (n=902) [a]	24.2	27.1	14.5	10.4	9.5	14.3
Peers participate in organised activities (n=902) [a]	39.8	24.8	8.3	4.1	2.9	20.1
Peers get along well with their parents (n=902) [a]	2.1	5.0	4.0	15.6	56.0	17.3

[a] Data are presented as proportion estimate.

Table 9: Sample characteristics of measures of ability to communicate with family and peers

	Easy	Very Easy	Difficult	Very difficult	Don't have or see this person
Talk to father (n=893) [a, b]	38.1	16.2	26.8	14.7	4.3
Talk to mother (n=893) [a, b]	37.3	44.7	11.4	4.6	2.0
Talk to elder brother (n=894) [a, b]	26.1	17.8	16.6	9.1	30.5
Talk to elder sister (n=893) [a, b]	28.1	24.3	9.7	7.2	30.7
Talk to best friend (n=893) [a, b]	37.6	50.7	7.7	2.2	1.7
Talk to other friends (n=894) [a, b]	34.7	11.0	34.1	17.2	3.0

[a] Talk about things that really bother them.
[b] Data are presented as proportion estimate.

3.1.8. Summary of Findings

- The sample consisted of 902 adolescents (91.3% response rate for the students) from 11 schools in Riyadh (100% response rate for the schools), divided into 461 boys and 441 girls.
- The majority were between 15 and 17 years old (mean age of 16.2 years for boys and 16.1 years for girls), of Saudi nationality (87.0% of the boys and 74.1% of the girls), and enrolled in public schools (71% of the boys and 72.3% of the girls).
- More than half the fathers (51.2% of the boys' fathers and 64.6% of the girls' fathers) had completed education between the secondary and university level, and 34.7% of the boys and 33.3% of the girls belonged to families with relatively high affluence.
- 72.7% of the boys and of the 75.2% girls had incisor overjet of between 0 and 3mm, and only 5.4% of the boys and 4.1% of the girls had inadequate lip coverage.
- 34.7% of the boys and 7.3% of the girls smoked tobacco, 21.5% and 2.3% of them, respectively, were still smokers; only 1.7% of the boys and 0.2% of the girls reported having smoked other drugs during their lifetime.
- 56.4% of boys and the 57.1% girls had never used a seatbelt; 48.8% of the boys and 42.9% of the girls had not worn a helmet during cycling in the year preceding the study, but considerable proportion of the sample did not ride a bike during this period (44.9% of the boys and 51.2% of the girls).
- 54.7% of the boys and 43.1% of the girls had physical fights more than three times during the year preceding the study; 21.1% of the boys had carried a weapon during the three months preceding the study, while only 3.6% of the girls reported the same.
- 34.6% of the boys and 43.2% of the girls exhibited one of three risk behaviours (smoking tobacco, physical fighting and carrying of weapons), while 27.1% of the boys and only 2.7% of the girls exhibited multiple risk-taking behaviours.

- 83.5% of the boys and 68.0% of the girls had 3 or more close friends, but only 31.7% and 7.8% of them, respectively, went out with them for more than 3 afternoons a week.
- 27.3% of the adolescents reported that some or all of their peers smoked tobacco, and 19.0% reported that some or all of their peers carried weapons.
- Considerable numbers of adolescents reported difficulties in talking to their fathers and mothers (41.4% and 16.0%, respectively), while only 10.0% reported difficulties in talking to their best friends.

3.2. Prevalence and characteristics of traumatic dental injuries

3.2.1. Section overview

This section reports results of the prevalence of TDIs among the sample divided into three parts. The first part describes the prevalence of TDIs in the study sample and the different types of these injuries. The second part describes the characteristics of these injuries in relation to their location and time of occurrence as well as the activities the adolescents were doing at the time.

3.2.2. Prevalence of TDIs

42.6% of this sample had TDIs in their anterior permanent teeth (Table 10). 59.4% of the boys and 24.9% of the girls had TDIs. The most common type of TDIs was enamel fracture; 46.2% of the boys and 19.5% of the girls. Treated dental injuries were the second most common type among both boys (6.1%) and girls (4.3%) along with enamel-dentine fractures seen among 6.1% of the boys.

Table 10: Prevalence of TDIs in study sample

	Boys (n=461)	Girls (n=441)	All (n=902)
Prevalence of all types of TDIs	59.4 (54.9 to 63.8)	24.9 (21.1 to 29.2)	42.6 (39.4 to 45.8)
Prevalence of TDIs by type			
Treated dental injury	6.1 (4.2 to 8.7)	4.3 (2.8 to 6.7)	5.2 (3.9 to 6.9)
Enamel fracture only	46.2 (41.7 to 50.8)	19.5 (16.1 to 23.5)	33.1 (30.1 to 36.3)
Enamel-dentine fracture	6.1 (4.2 to 8.7)	1.8 (0.9 to 3.6)	4.0 (2.9 to 5.5)
Pulp Injury	5.0 (3.3 to 7.4)	0.5 (0.1 to 1.8)	2.8 (1.9 to 4.1)
Missing due to trauma	0.9 (0.3 to 2.3)	0	0.4 (0.2 to 1.2)

Data are presented as proportion estimate (95% confidence intervals).

3.2.3. Location, activities and time of occurrence of TDIs

The adolescents' homes were the most common reported location of the occurrence of their TDI; 18.6% of boys and 50.0% of girls reported that their TDI had occurred inside their home or in its yard (Table 11). The second most common location differed between boys and girls. Among boys, the street or a parking lot came second (7.3%), while the location was their school in the case of girls (9.1%).

Sports were the most common reported activity related to TDIs in case of both sexes. 20.4% of the boys and 23.6% of the girls reported being engaged in sports activities when the TDIs occurred. Eating or peeling hard foods was the second most common reported activity related to TDIs in both sexes (6.9% of the boys and 20% of the girls). 42.7% of the girls and 19.0% of the boys reported that TDIs occurred during their primary school years. However, more than half the sample reported that they could not remember the answers to all three questions.

Table 11: Sample characteristics by locations, activities and time related to TDIs

	Boys (n=274)	Girls (n=110)	All (n=384)
TDI location			
At home/in yard	18.6 (14.4 to 23.7)	50.0 (40.6 to 59.4)	27.6 (23.3 to 32.3)
School, including school grounds	5.1 (3.0 to 8.5)	9.1 (4.9 to 16.2)	6.3 (4.2 to 9.2)
At a sports facility or field	1.5 (0.5 to 3.8)	0.9 (0.1 to 6.3)	1.3 (0.5 to 3.1)
In the street/road/parking lot	7.3 (4.7 to 11.1)	1.8 (0.4 to 7.1)	5.7 (3.8 to 8.6)
Could not remember	67.5 (61.7 to 72.8)	38.2 (29.5 to 47.7)	59.1 (54.1 to 63.9)
TDI activity			
Cycling/playing sport/skating	20.4 (16.0 to 25.7)	23.6 (16.5 to 32.6)	21.4 (17.5 to 25.7)
Walking/running (not for sport)	2.9 (1.5 to 5.8)	5.5 (2.4 to 11.7)	3.6 (2.2 to 6.1)
Eating/pealing hard food/nuts	6.9 (4.5 to 10.6)	20.0 (13.5 to 28.7)	10.7 (7.9 to 14.2)
Biting on bottle/pen/metal/nail	2.6 (1.2 to 5.3)	6.4 (3.0 to 12.9)	3.6 (2.2 to 6.1)
Others	7.3 (4.7 to 11.1)	14.5 (9.0 to 22.6)	9.4 (6.8 to 12.7)
Could not remember	59.9 (53.9 to 65.5)	30.0 (22.1 to 39.4)	51.3 (46.3 to 56.3)
Time when TDI occurred			
During secondary school	4.7 (2.8 to 8.0)	6.4 (3.0 to 12.9)	5.2 (3.4 to 7.9)
During intermediate school	10.9 (7.7 to 15.3)	25.5 (18.1 to 34.6)	15.1 (11.8 to 19.1)
During or before primary school	19.0 (14.7 to 24.1)	42.7 (33.7 to 52.2)	25.8 (21.6 to 30.4)
Could not remember	65.3 (59.5 to 70.1)	25.5 (18.1 to 34.6)	53.9 (48.9 to 58.9)

Data are presented as proportion estimate (95% confidence intervals).

3.2.4. Section summary

- The prevalence of TDIs in the anterior permanent teeth was very high (42.6%), especially among the boys (59.4%). The prevalence among girls was 24.9%.
- Homes were the most common reported location of TDI occurrence (18.6% of the boys and 50.0% of the girls), and sport was the most common activities being conducted at the time of the TDI's occurrence among both the boys (20.4%) and girls (23.6%).
- Most TDIs occurred when they were in primary school (42.7% of the girls and 19.0% of the boys).

3.3. Bivariate analysis

3.3.1. Section overview

This section reports results of the bivariate analyses related to the second and third research objectives, namely, to investigate the associations of risk-taking behaviours and peer influence with the prevalence of TDIs. The section is divided into three parts. The first part presents the results of crude associations between TDIs and demographics (age, sex, school grade and nationality), socioeconomic status indicators (father's education, mother's education, school type and family's affluence), physical activity and clinical measures (incisor overjet and lip coverage). The second part presents the results of crude associations between TDIs and risk-taking behaviours, including tobacco and drugs smoking, not using seatbelt and helmet, physical fights and carrying weapons. The third part presents the results of crude associations between TDIs and peer influence variables. These variables included the number of close friends, frequency of going out with friends after school and in the evenings, frequency of communicating electronically with friends, the ease with which others can join the peer group and the peer group's mutual respect and supportiveness.

3.3.2. Bivariate analysis of demographic, socioeconomic, physical activity and clinical factors associated with TDIs

There were no significant differences in prevalence of TDIs between the sample age groups in both sexes (p=0.279 for boys and p=0.190 for girls) (Table 12). The differences in prevalence of TDIs between Saudis and other adolescents in the sample of other nationalities were not statistically significant in both sexes (p=0.852 for boys and 0.370 for girls). This was also the case between school types among girls; there were no significant differences in the prevalence of TDIs between adolescents in public or private schools (p=0.114 for girls). However, the prevalence of TDIs was significantly higher among boys attending private schools (67.4%) compared to boys attending public schools (56.1%; p=0.025).

TDIs were significantly less prevalent among adolescents in the whole sample whose fathers and mothers had a higher level of education, except when the parents had postgraduate degrees as compared to undergraduate degrees. Also, TDIs were significantly lower among boys with incisor overjet exceeding 3mm (50.8%) compared to those with less than 3mm of incisor overjet (62.7%; p=0.020), but this relationship was not statistically significant among girls (p=0.726). Finally, the results of lip coverage measurements indicated no statistically significant differences in the prevalence of TDIs between the group of adolescents with adequate and inadequate lip coverage (p=0.174).

Table 12: Distribution of TDIs by demographic factors, socioeconomic status indicators, physical activity and clinical measures

	TDIs					
	Boys		Girls		All	
	N (%)	*P*	n (%)	*P*	n (%)	*P*
Age group	(n=461)		(n= 441)		(n=902)	
≤ 15	55 (64.0)	0.279 [b]	26 (25.0)	0.190 [c]	81 (42.6)	0.701 [b]
16	120 (61.5)		43 (21.4)		163 (41.2)	
≥ 17	99 (55.0)		41 (30.2)		140 (44.3)	
Nationality	(n=461)		(n= 441)		(n=902)	
Saudi	239 (59.6)	0.852 [b]	78 (23.9)	0.370 [b]	317 (43.5)	0.227 [b]
Non-Saudi	35 (58.3)		32 (28.1)		67 (38.5)	
School type	(n=461)		(n= 441)		(n=902)	
Public	**183 (56.1)**	**0.025** [b]	86 (27.0)	0.114 [b]	269 (41.7)	0.404 [b]
Private	**91 (67.4)**		24 (19.7)		115 (44.7)	
Father education	(n=454)		(n= 430)		(n=884)	
Up to primary	62 (60.8)	0.896 [b]	10 (27.8)	0.757 [b]	**72 (52.2)**	**0.002** [b]
Intermediate-Secondary	107 (60.1)		30 (26.8)		**137 (47.2)**	
University	62 (56.4)		48 (24.0)		**110 (35.5)**	
Postgraduate	39 (60.9)		17 (20.7)		**56 (38.4)**	
Mother education	(n=457)		(n= 427)		(n=884)	
Up to primary	99 (59.6)	0.818 [b]	18 (28.1)	0.560 [b]	**117 (50.9)**	**0.010** [b]
Intermediate-Secondary	90 (61.6)		40 (23.3)		**130 (40.9)**	
University	63 (55.8)		37 (23.0)		**100 (36.5)**	
Postgraduate	19 (59.4)		10 (33.3)		**29 (46.8)**	
MVPA [a]	(n=460)		(n= 438)		(n=898)	
< 5 days a week	234 (60.3)	0.330 [b]	97 (25.6)	0.346 [b]	331 (43.2)	0.326 [b]
5 days or more	39 (54.2)		12 (20.0)		51 (38.6)	
Family affluence	(n=458)		(n= 439)		(n=897)	
Relatively affluent	70 (59.3)	0.795 [b]	21 (21.2)	0.291 [b]	91 (41.9)	0.783 [b]
Middle affluence	111 (61.7)		45 (23.3)		156 (41.8)	
Relatively deprived	93 (58.1)		43 (29.3)		136 (44.3)	
Incisor overjet	(n=461)		(n= 441)		(n=902)	
0 - 3mm	**210 (62.7)**	**0.020** [b]	84 (25.3)	0.762 [b]	294 (44.1)	0.123 [b]
> 3mm	**64 (50.8)**		26 (23.9)		90 (38.3)	
Lip Coverage	(n=461)		(n= 441)		(n=902)	
Adequate	262 (60.1)	0.231 [b]	108 (25.5)	0.264 [c]	370 (43.1)	0.174 [b]
Inadequate	12 (48.0)		2 (11.1)		14 (32.6)	

[a] Refers to the daily 60 minutes of moderate-to-vigorous physical activity.
[b] Pearson's chi-squared test.
[c] Fisher's exact test.

3.3.3. Bivariate analysis of risk taking behaviours associated with TDIs

The crude associations between risk-taking behaviours and TDIs are presented in Table 13. There was a significantly higher prevalence of TDIs among girls who have tried smoking tobacco (40.6%) compared to those who never smoked (23.6%; p=0.032). Girls who were current tobacco smokers also had significantly a higher prevalence of TDIs (60.0%) compared to non-smokers (24.0%; p=0.009). An exposure–response relationship was observed with tobacco smoking status among the girls; the prevalence of TDIs gradually increased from those who had never smoked (23.6%) to ex-smokers (31.8%) to current smokers (60.0%; p for trend <0.0001). In contrast, the exposure–response relationship among the boys was not statistically significant. Also, among both boys and girls, there were no significant differences in the prevalence of TDIs in relation to the year they started smoking tobacco (boys p=0.438; girls p=0.329) and whether they smoked drugs (boys p=0.569; girls p=0.1.000), used seat belts (boys p=0.296; girls p=0.357) or wore helmets when cycling (boys p=0.924; girls p=0.223).

However, a significant difference, with an exposure–response relationship, was observed in the prevalence of TDIs between the different levels of boys' involvement in physical fights (p for trend < 0.001). The prevalence of TDIs among boys increased from 51.2% among those had never been involved in a physical fight during the preceding year, to 63.8% among those who had been involved in fights between one and three times during the same period, to 75.0% among boys who had been involved in fights on more than five occasions during the same period (p for trend <0.001).

Significant differences were also observed in the prevalence of TDIs in relation to carrying weapons among boys (p=0.034). Boys who had not carried weapons during the month preceding the study had a TDI prevalence of 56.2%, while those who reported carrying weapons during the same period had significantly higher prevalence of TDIs (72.3% among those who carried weapons in less than five days and 69.4% among those who carried them in more than five days). Also, boys who carried weapons to school had a higher prevalence of TDIs (66.7% among

those who carried weapons and 87.0% among those who carried them to school on less than five days) compared to those who did not carry weapons to school. They had a TDI prevalence of 57.7% (p=0.020). On the other hand, the differences observed between these categories among girls were not statistically significant.

Among the boys, the prevalence of TDIs increased from 49.1% among boys who had no risk-taking behaviours, to 61.4% among those who had any of the three risk-taking behaviours, to 71.0% among those who had multiple risk-taking behaviours, indicating an exposure–response relationship (p for trend <0.0001). Among girls, the prevalence of TDIs was similar for those who did not engage in any risk-taking behaviours and for those who had any one of the three risk-taking behaviours (23.7% and 23.3%, respectively). However, the prevalence of TDIs among those with multiple risk-taking behaviours was significantly much higher (58.3%; p=0.022).

Table 13: Bivariate analysis between TDIs and risk taking behaviours, by sex

	TDIs					
	Boys		Girls		All	
	n (%)	*P*	n (%)	*P*	n (%)	*P*
Ever smoked	(n=461)		(n=439)		(n=900)	
No	174 (57.8)	0.329 [c]	**96 (23.6)**	**0.032 [c]**	**270 (38.1)**	**<0.001 [c]**
Yes	100 (62.5)		**13 (40.6)**		**113 (58.9)**	
Current tobacco smoking	(n=461)		(n=439)		(n=900)	
No	209 (57.7)	0.155 [c]	**103 (24.0)**	**0.009 [c]**	**312 (39.4)**	**<0.0001 [t]**
Yes	65 (65.7)		**6 (60.0)**		**71 (65.1)**	
Smoking status	(n=461)		(n=439)		(n=900)	
Never smoked	174 (57.8)	0.363 [c]	**96 (23.6)**	**0.009 [t]**	**270 (38.1)**	**<0.0001 [t]**
Ex-smoker	35 (57.4)		**7 (31.8)**		**42 (50.6)**	
Current smoker	65 (65.7)		**6 (60.0)**		**71 (65.1)**	
Tobacco initiation	(n=132)		(n=20)		(n=152)	
Before age 12	6 (60.0)	0.438 [c]	0	0.329 [v]	6 (42.9)	0.154 [c]
Between age 12–14	36 (67.9)		1 (50.0)		37 (67.3)	
After age14	39 (56.5)		6 (42.9)		45 (54.2)	
Smoked other drugs lifetime	(n=461)		(n=439)		(n=900)	
No	269 (59.4)	0.569 [c]	109 (24.9)	1.000 [v]	378 (42.4)	0.428 [c]
Yes	5 (62.5)		0		5 (55.6)	
Smoked other drugs last 12 months	(n=461)		(n=439)		(n=900)	
No	273 (59.61)	0.356 [c]	109 (24.89)	1.000 [v]	382 (42.63)	0.641 [v]
Yes	1 (33.33)		0		1 (25.00)	
Used seatbelt [a]	(n=461)		(n=441)		(n=902)	
Yes	114 (56.7)	0.296 [c]	43 (22.8)	0.357 [c]	157 (40.3)	0.220 [c]
Never	160 (61.5)		67 (26.6)		227 (44.3)	
Wear helmet [b]	(n=461)		(n=441)		(n=902)	
Never	132 (58.7)	0.924 [c]	54 (28.6)	0.223 [v]	186 (44.9)	0.418 [c]
Yes	18 (62.1)		4 (15.4)		22 (40.0)	
Did not ride	124 (59.9)		52 (23.0)		176 (40.7)	
Physical fights [b]	(n=461)		(n=441)		(n=902)	
Never	**107 (51.2)**	**<0.001 [t]**	62 (24.7)	0.802 [c]	**169 (36.7)**	**<0.001 [t]**
1–3 times	**125 (63.8)**		30 (23.8)		**155 (48.1)**	
More than 3	**42 (75.0)**		18 (28.1)		**60 (50.0)**	
Carried weapons [d, e]	(n=457)		(n=439)		(n=896)	
Didn't carry weapon	**203 (56.2)**	**0.034 [c]**	102 (24.1)	0.242 [c]	**305 (38.9)**	**<0.0001 [c]**
1–5 days	**34 (72.3)**		4 (50.0)		**38 (69.1)**	
More than 5 days	**34 (69.4)**		2 (25.0)		**36 (63.2)**	
Carried weapons at school [d, e]	(n=457)		(n=439)		(n=896)	
Didn't carry weapon	**247 (57.7)**	**0.020 [c]**	107 (24.8)	1.000 [v]	**354 (41.2)**	**0.003 [v]**
1–5 days	**20 (87.0)**		1 (16.7)		**21 (72.4)**	
More than 5 days	**4 (66.7)**		0		**4 (50.0)**	
Multiple risk behaviours [f]	(n=457)		(n=437)		(n=894)	
No risk behaviours	**86 (49.1)**	**<0.001 [t]**	**56 (23.7)**	**0.022 [c]**	**142 (34.6)**	**<0.0001 [t]**
1 risk behaviour	**97 (61.4)**		**44 (23.3)**		**141 (40.6)**	
Multiple risk behaviour	**88 (71.0)**		**7 (58.3)**		**95 (69.9)**	

[a] When riding in a car driven by someone else.
[b] During the last 12 months before the study.
[C] Pearson's chi-squared test.
[d] During the last 30 days before the study.
[e] Weapons include guns, knives, clubs, blades, scissors and stunt guns
[f] Considering three risk-behaviours: current tobacco smoking, physical fights and carrying weapons.
[t] Test for linear trend of the log odds.
[v] Fisher's exact test.
Significant associations are highlighted in bold type.

3.3.4. Bivariate analysis of peer influences associated with TDIs

The crude associations between peer influence variables and TDIs are presented in Table 14. The prevalence of TDIs among boys who reported that some or all of their peers smoked tobacco was significantly higher (63.1%) than those reporting that none of their peers smoked tobacco (52.9%; p=0.036). On the other hand, the girls showed no statistically significant differences in the prevalence of TDIs between these two groups (p=0.978). There was a significantly higher prevalence of TDIs among boys who reported that some or all of their peers carried weapons (68.0%) compared to 56.5% among the other groups who reported that none of their peers carried weapons (p=0.027). Again, there was no statistical difference in the prevalence of TDIs between these groups among the girls. Boys who reported meeting with friends after school for more than three days a week had a higher prevalence of TDIs (68.3%) compared to the other group who reported meeting with friends after school for less than four days a week (55.3%; p=0.008). However, differences in the prevalence of TDIs between these groups were not significant among girls (p=0.296).

Other significant differences in the prevalence of TDIs were evident among the sample as a whole, but not when each sex was analysed separately. Adolescents who reported that some or all of their peers smoked other drugs had a significantly higher prevalence of TDIs compared to the other group who reported that none of their peers smoked drugs (59.7% and 39.8% respectively; p=0.001), while the differences were not statistically significant when each sex were analysed separately (boys p=0.264; girls p=0.617). The prevalence of TDIs was significantly higher (53.5%) among adolescents who reported spending four or more evenings with their friends each week compared to 40.0% among adolescents who reported spending less than four evenings with their friends each week during the same period (p<0.0001). However, these differences were not statistically significant when each sex were analysed separately (boys p=0.423; girls p=0.728).

There was a higher prevalence of TDIs among adolescents who reported that it was difficult for others to join their group (47.9%) compared to 40.3% among the other groups who reported no difficulties in this regard (p=0.034), while the differences were not statistically significant when each sex were analysed separately (boys p=0.831; girls p=0.212). Also, adolescents who reported that their peers did not support each other in difficult situations had a higher prevalence of TDIs (50.4%) compared to the other group who reported having supportive peers (41.2%; p=0.049). However, these differences were not statistically significant when each sex were analysed separately (boys p=0.754; girls p=0.769). There was a higher prevalence of TDIs among adolescents who reported that some or all of their peers participated in sports activities (47.0%) compared to 34.9% among the other groups who reported that none of their peers did so (p=0.002), but the differences were not statistically significant when each sex were analysed separately (boys p=0.432; girls p=0.803).

Table 14: Bivariate analysis between TDIs and peer influence variables, by sex

	TDIs					
	Boys		Girls		All	
	n (%)	*P*	n (%)	*P*	n (%)	*P*
Peers smoke tobacco	(n=408)		(n=382)		(n=790)	
None	**101 (52.9)**	**0.036** [c]	86 (24.4)	0.978 [c]	**187 (34.4)**	**<0.0001** [c]
Some or all	**137 (63.1)**		7 (24.1)		**144 (58.5)**	
Peers smoke other drugs	(n=379)		(n=394)		(n=773)	
None	183 (58.1)	0.264 [c]	94 (24.7)	0.617 [c]	**277 (39.8)**	**0.001** [c]
Some or all	42 (65.6)		4 (30.8)		**46 (59.7)**	
Peers carry weapons	(n=363)		(n=376)		(n=739)	
None	**117 (56.5)**	**0.027** [c]	81 (22.4)	0.325 [c]	**198 (34.9)**	**<0.0001** [c]
Some or all	**106 (68.0)**		5 (33.3)		**111 (64.9)**	
Number of close friends	(n=460)		(n=440)		(n=900)	
< 3 friends	48 (64.0)	0.392 [c]	42 (30.0)	0.098 [c]	90 (41.9)	0.784 [c]
≥ 3 friends	226 (58.7)		68 (22.7)		294 (42.9)	
Out with friends after school per week	(n=458)		(n=438)		(n=896)	
< 4 days	**173 (55.3)**	**0.008** [c]	104 (25.7)	0.296 [c]	**277 (38.6)**	**<0.0001** [c]
≥ 4days	**99 (68.3)**		6 (17.7)		**105 (58.7)**	
Evenings out with friends per week	(n=458)		(n=438)		(n=896)	
< 4 evenings	191 (58.2)	0.423 [c]	98 (24.9)	0.728 [c]	**289 (40.0)**	**<0.001** [c]
≥ 4 evenings	81 (62.3)		12 (27.3)		**93 (53.5)**	
E-communication with friends per week	(n=459)		(n=439)		(n=898)	
< 3 days	57 (62.0)	0.588 [c]	24 (28.6)	0.408 [c]	81 (46.0)	0.313 [c]
≥ 3 days	216 (58.9)		86 (24.2)		302 (41.8)	
Easiness for others to join	(n=459)		(n=439)		(n=898)	
Easy/Very Easy	172 (59.1)	0.831 [c]	77 (23.6)	0.212 [c]	**249 (40.3)**	**0.034** [c]
Difficult/Very Difficult	101 (60.1)		33 (29.5)		**134 (47.9)**	
Peer group treated with respect	(n=461)		(n=441)		(n=902)	
No	70 (59.3)	0.977 [c]	22 (25.3)	0.934 [c]	92 (44.9)	0.447 [c]
Yes	204 (59.5)		88 (24.9)		292 (41.9)	
Peer group is supportive	(n=461)		(n=441)		(n=902)	
No	56 (60.9)	0.754 [c]	11 (26.8)	0.769 [c]	**67 (50.4)**	**0.049** [c]
Yes	218 (59.1)		99 (24.8)		**317 (41.2)**	
Peers like school	(n=373)		(n=392)		(n=765)	
None	122 (63.2)	0.455 [c]	43 (24.0)	0.607 [c]	165 (44.4)	0.421 [c]
Some or all	107 (59.4)		56 (26.3)		163 (41.5)	
Peers doing well at school	(n=398)		(n=390)		(n=788)	
None	67 (56.8)	0.741 [c]	36 (26.9)	0.510 [c]	103 (40.9)	0.769 [c]
Some or all	164 (58.6)		61 (23.8)		225 (42.0)	
Peers participate in sports activities	(n=417)		(n=356)		(n=773)	
None	41 (55.4)	0.432 [c]	35 (24.3)	0.803 [c]	**76 (34.9)**	**0.002** [c]
Some or all	207 (60.4)		54 (25.5)		**261 (47.0)**	
Peers participate in organised activities	(n=356)		(n=365)		(n=721)	
None	109 (63.4)	0.225 [c]	51 (27.3)	0.496 [c]	160 (44.6)	0.317 [c]
Some or all	105 (57.1)		43 (24.2)		148 (40.9)	
Peers get along well with their parents	(n=371)		(n=375)		(n=746)	
Half or less	36 (55.4)	0.392 [c]	11 (31.4)	0.362 [c]	47 (47.0)	0.327 [c]
More than half	187 (61.1)		83 (24.4)		270 (41.8)	
Easy to talk to best friends	(n=444)		(n=434)		(n=878)	
No	31 (66.0)	0.354 [c]	7 (16.7)	0.184 [c]	38 (42.7)	0.984 [c]
Yes	234 (58.9)		102 (26.0)		336 (42.6)	
Easy to talk to other friends	(n=440)		(n=427)		(n=867)	
No	135 (62.5)	0.215 [c]	59 (24.3)	0.765 [c]	194 (42.3)	0.910 [c]
Yes	127 (56.7)		47 (25.5)		174 (42.7)	

Significant associations are highlighted in bold type.
[c] Pearson's chi-squared test.
[e] Fisher's exact test.

3.3.5. Section summary

- TDIs were lower among adolescents whose parents had completed a higher level of education, except when the parents had postgraduate degrees as compared to undergraduate degrees.
- Significant differences were observed in the relationship between TDIs and tobacco smoking among girls. The prevalence of TDIs was higher for each group with worse smoking behaviour (had never smoked: 23.6%; ex-smokers: 31.8%; and current smokers: 60.0%). In contrast, this was not statistically significant among boys.
- The prevalence of TDIs was significantly higher with higher involvement of boys' in physical fights, from 51.2% among boys who never had a fight during the last 12 months before the study, to 63.8% among those who were involved in a fight 1–3 times and 75.0% among those who were involved in this behaviour more than 3 times during the same period. However, the respective association for girls was not significant.
- Significant differences were also observed in the prevalence of TDIs in association with the habit of carrying weapons. Boys who reported carrying weapons on more than five days in the month preceding the study had higher TDIs (69.4%) than those who did not carry weapons (56.2%). Boys who were in the middle group (i.e. those who carried weapons but on less than five days in the month preceding the study) had the highest prevalence of TDIs among all the groups (72.3%). A similar pattern was observed among students who carried weapons to school. In contrast, these associations between TDIs and carrying weapons were not significant among girls.
- There was considerable and significant variation in the prevalence of TDIs according to the number of risk-taking behaviours observed in adolescents; 49.1% of boys who had no risk behaviours had TDIs, while this prevalence was 61.4% among those who had 1 risk-taking behaviour and 71.0% among boys with multiple risk-taking behaviours; girls with multiple

risk-taking behaviour had a 58.3% prevalence of TDIs while this prevalence was 23.7% among girls who had no risk behaviours and 23.3% among those who had 1 risk-taking behaviour.

- There was a higher prevalence of TDIs among boys who reported that some or all of their peers smoke tobacco (63.1%) and carry weapons (68.0%) compared to boys with peers who did not indulge in these behaviours (52.9% and 56.5%, respectively). This was not evident among girls.
- Boys who reported meeting with friends after school for more than 4 days a week had a higher prevalence of TDIs (68.3%) than their counterparts (55.3%), while this was not significant among girls.
- The prevalence of TDIs was higher among adolescents who reported that some or all of their peers smoked other drugs (59.7%) than adolescents whose peers did not smoke drugs (39.8%), and among adolescents who reported spending 4 or more evenings with their friends each week (53.5%) compared who spent less number of evenings (40.0%).
- A higher prevalence of TDIs was observed among adolescents who reported that it was difficult for others to join their group (47.9%), those who reported that their peers did not support each other (50.4%) and those with peers who regularly participated in sports activities (47.0%), compared to their counterparts (40.3%, 40.3% and 34.9%, respectively).

3.4. Assessing associations between TDIs and risk-taking behaviours and peer influence

3.4.1. Section overview

This section further addresses the second and third research objectives to investigate risk-taking behaviours and the association of peer influence with the prevalence of TDIs. The hypotheses were that high-risk-taking adolescents and those with increased negative peer influence had a significantly higher prevalence of TDIs than their counterparts, even after controlling for covariates that included demographic, socioeconomic, physical activity and clinical variables. The first part presents results of multivariable analysis of risk-taking behaviours associated with TDIs. This part explores whether levels of TDIs vary between adolescents with and without risk-taking behaviours (the second research objective) after adjusting for the covariates. The second part presents results of multivariable analysis of peer influence associated with TDIs. This part seeks to explore whether levels of TDIs vary between adolescents with and without increased negative peer influence (the third research objective) after adjusting for the covariates.

3.4.2. Multivariable analysis of risk-taking behaviours associated with TDIs

Table 15 presents the relative risks of associations between tobacco smoking as an indicator of risk-taking behaviour and TDIs. In the unadjusted model, the risk of TDIs was higher among adolescents who were smokers (RR 1.71; 95% CI 1.45–2.03) compared to those who had never smoked. After adjusting for age, sex, father's education, nationality, physical activity and incisor overjet exceeding 3mm, this relationship attenuated but yet remained marginally statistically significant (RR 1.20; 95% CI 1.002–1.43). However, the risk of TDIs among smokers differed significantly by sex (Table 16). In the fully adjusted model, girls had higher risk of TDIs if they were smokers compared to those who had never smoked (RR 2.50; 95% CI 1.42–4.41). This relationship was not significant among boys (RR 1.10; 95% CI 0.92–1.32).

The risk of TDIs for adolescents who were involved in more than three fights during the year preceding the study was higher in the unadjusted model (RR 1.32; 95% CI 1.06–1.64) compared

to those who had not had a fight in the same period (Table 17). This relationship was still statistically significant, after adjusting for age, sex, father's education, nationality, physical activity and incisor overjet exceeding 3mm (RR 1.33; 95% CI 1.09–1.63). When each sex analysed separately (Table 18), boys showed higher risk of TDIs if they had more than three fights (RR in the fully adjusted model 1.46; 95% CI 1.19–1.79) compared to those who did not have a fight in the same period, while this relationship was not significant among girls (RR 1.08; 95% CI 0.67–1.74). The increased risk among boys seems to represent an exposure-response relationship, as those who were involved in less than three fights were at a lower risk of TDIs in the fully adjusted model than those who had participated in more than three fights, when both were compared to boys who had not had a fight in the same period (RR 1.22; 95% CI 1.03–1.45).

There was a higher risk of TDIs associated with the risk-taking behaviour of carrying weapons (Table 19). Adolescents who carried weapons on one to five days during the month preceding the study had a significantly higher risk of TDIs in both the unadjusted model (RR 1.61; 95% CI 1.29–2.01) and the fully adjusted model (RR 1.36; 95% CI 1.12–1.66) compared to those who had not carried a weapon during the same period. Interestingly, this risk was lower among adolescents who had carried weapons on more than five days during the same period (RR in the fully adjusted model 1.24; 95% CI 1.00–1.53).

When the analyses were repeated separately for each sex (Table 20), girls who carried weapons on one to five days during the month preceding the study showed higher risk of TDIs (RR 2.19; 95% CI 1.04–4.58) than the same category of boys (RR 1.30, 95% CI 1.07–1.58), in the fully adjusted model. This relationship was not statistically significant among adolescents who had carried weapons on more than five days during the same period (RR for girls 1.04; 95% CI 0.32–3.32 and RR for boys 1.23; 95% CI 1.00–1.53), compared to the same reference categories.

Considering the existence of more than one of any of the three risk-taking behaviours (smoking tobacco, physical fighting and carrying weapons) as an indicator of multiple risk-taking

behaviours (Table 21), the risk of TDIs was higher among adolescents who had multiple risk-taking behaviours compared to those who had none of them. In the unadjusted model, the group of adolescents who had multiple risk-taking behaviours showed higher risk of TDIs (RR 2.00; 95% CI 1.68–2.38). In the fully adjusted model, the relationship attenuated but remained statistically significant when both sexes were compared to the same-sex group that had no risk behaviours (RR 1.44; 95% CI 1.20–1.72). When stratifying the analysis by each sex separately (Table 22), girls who had multiple risk-taking behaviours had a higher association with TDIs in the fully adjusted model (RR 2.50; 95% CI 1.46–4.28) as opposed to this association among boys (RR 1.41; 95% CI 1.17–1.71). Boys showed higher risk of TDIs if they had multiple risk-taking behaviours (RR in the fully adjusted model 1. 41; 95% CI 1.17–1.71) compared to those who did not have any risk-taking behaviours. The increased risk among boys seems to represent an exposure-response relationship, as those who had only one risk-taking behaviour were at a lower risk of TDIs, in the fully adjusted model, than those who had multiple risk-taking behaviours, when both were compared to boys who had no risk-taking behaviours (RR 1.22; 95% CI 1.00–1.48).

Table 15: Relative risk for associations between TDIs and tobacco smoking

	Model A (n=878)	Model B (n=878)	Model C (n=878)	Model D (n=878)	Model E (n=878)	Model F (n=878)	Model G (n=878)
Current tobacco smoking							
No	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Yes	**1.65*****	**1.65*****	**1.20***	**1.20***	**1.20***	**1.20***	1.19
	[1.40,1.95]	**[1.40,1.95]**	**[1.02,1.43]**	**[1.01,1.43]**	**[1.01,1.43]**	**[1.01,1.42]**	[1.00,1.41]
Tobacco smoking status							
Never Smoked	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Ex-smoker	**1.34***	**1.34***	1.06	1.05	1.05	1.05	1.05
	[1.06,1.69]	**[1.06,1.69]**	[0.84,1.33]	[0.84,1.33]	[0.84,1.32]	[0.83,1.32]	[0.84,1.32]
Current smoker	**1.71*****	**1.71*****	**1.22***	**1.21***	**1.21***	**1.21***	**1.20***
	[1.45,2.03]	**[1.44,2.03]**	**[1.02,1.45]**	**[1.02,1.45]**	**[1.02,1.45]**	**[1.01,1.44]**	**[1.00,1.43]**

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] During the last 12 months before the study; Model A crude; Model B adjusted for age; Model C additionally adjusted for sex; Model D additionally adjusted for father education; Model E additionally adjusted for nationality; Model F additionally adjusted for physical activity; Model G additionally adjusted for incisor overjet exceeding 3mm.

Table 16: Relative risk for associations between TDIs and tobacco smoking, stratified by sex

	Model A		Model B	
	Boys (n=453)	Girls (n=425)	Boys (n=453)	Girls (n=425)
Current tobacco smoking				
No	Referent	Referent	Referent	Referent
Yes	1.13	**2.57*****	1.10	**2.45****
	[0.95,1.34]	**[1.50,4.39]**	[0.93,1.31]	**[1.39,4.31]**
Tobacco smoking status				
Never Smoked	Referent	Referent	Referent	Referent
Ex-smoker	0.99	1.39	0.99	1.33
	[0.78,1.26]	[0.73,2.63]	[0.78,1.26]	[0.69,2.59]
Current smoker	1.13	**2.62*****	1.10	**2.50****
	[0.95,1.34]	**[1.53,4.49]**	[0.92,1.32]	**[1.42,4.41]**

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] During the last 12 months before the study; Model A crude; Model B adjusted for age, father education, nationality, physical activity and incisor overjet exceeding 3mm.

Table 17: Relative risk for associations between TDIs and physical fights

	Model A (n=880)	Model B (n=880)	Model C (n=880)	Model D (n=880)	Model E (n=880)	Model F (n=880)	Model G (n=880)
Had a fight [a]							
No	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Yes	**1.30*****	**1.30*****	**1.18***	**1.18***	**1.18***	**1.19***	**1.19***
	[1.11,1.52]	**[1.11,1.52]**	**[1.02,1.37]**	**[1.02,1.37]**	**[1.02,1.37]**	**[1.03,1.38]**	**[1.03,1.38]**
Frequency of Fights [a]							
No fighting	Referent	Referent	Referent	Referent	Referent	Referent	Referent
1–3 times	**1.29****	**1.29****	1.14	1.14	1.14	1.15	1.14
	[1.09,1.53]	**[1.09,1.53]**	[0.97,1.33]	[0.97,1.33]	[0.97,1.33]	[0.98,1.35]	[0.97,1.34]
> 3 times	**1.32***	**1.32***	**1.30****	**1.31****	**1.31****	**1.33****	**1.33****
	[1.06,1.64]	**[1.06,1.65]**	**[1.07,1.59]**	**[1.07,1.60]**	**[1.07,1.60]**	**[1.09,1.63]**	**[1.09,1.63]**

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] During the last 12 months before the study; Model A crude; Model B adjusted for age; Model C additionally adjusted for sex; Model D additionally adjusted for father education; Model E additionally adjusted for nationality; Model F additionally adjusted for physical activity; Model G additionally adjusted for incisor overjet exceeding 3mm.

Table 18: Relative risk for associations between TDIs and physical fights, stratified by sex

	Model A		Model B	
	Boys (n=453)	Girls (n=427)	Boys (n=453)	Girls (n=427)
Had a fight [a]				
No	Referent	Referent	Referent	Referent
Yes	**1.27****	0.98	**1.27****	1.00
	[1.08,1.49]	[0.70,1.37]	**[1.08,1.49]**	[0.71,1.40]
Frequency of Fights [a]				
No fighting	Referent	Referent	Referent	Referent
1–3 times	**1.22***	0.94	**1.22***	0.95
	[1.03,1.45]	[0.64,1.39]	**[1.03,1.45]**	[0.64,1.42]
> 3 times	**1.44*****	1.05	**1.46*****	1.08
	[1.18,1.77]	[0.65,1.69]	**[1.19,1.79]**	[0.67,1.74]

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] During the last 12 months before the study; Model A crude; Model B adjusted for age, father education, nationality, physical activity and incisor overjet exceeding 3mm.

Table 19: Relative risk for associations between TDIs and carrying weapons

	Model A (n=875)	Model B (n=875)	Model C (n=875)	Model D (n=875)	Model E (n=875)	Model F (n=875)	Model G (n=875)
Carried weapons [a]							
No	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Yes	**1.70*****	**1.70*****	**1.28****	**1.29****	**1.29****	**1.30****	**1.30****
	[1.44,1.99]	**[1.44,1.99]**	**[1.09,1.50]**	**[1.10,1.51]**	**[1.10,1.51]**	**[1.11,1.53]**	**[1.11,1.53]**
Frequency of carrying weapons [a]							
No	Referent	Referent	Referent	Referent	Referent	Referent	Referent
1–5 days	**1.78*****	**1.78*****	**1.34****	**1.35****	**1.35****	**1.37****	**1.36****
	[1.46,2.17]	**[1.46,2.18]**	**[1.10,1.64]**	**[1.10,1.65]**	**[1.10,1.65]**	**[1.12,1.67]**	**[1.12,1.66]**
> 5 days	**1.61*****	**1.61*****	1.21	1.23	1.23	**1.24***	**1.24***
	[1.29,2.01]	**[1.29,2.01]**	[0.98,1.50]	[0.99,1.52]	[0.99,1.52]	**[1.00,1.54]**	**[1.00,1.53]**

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] During the last month before the study; Model A crude; Model B adjusted for age; Model C additionally adjusted for sex; Model D additionally adjusted for father education; Model E additionally adjusted for nationality; Model F additionally adjusted for physical activity; Model G additionally adjusted for incisor overjet exceeding 3mm.

Table 20: Relative risk for associations between TDIs and carrying weapons, stratified by sex

	Model A		Model B	
	Boys (n=450)	Girls (n=425)	Boys (n=450)	Girls (n=425)
Carried weapons [a]				
No	Referent	Referent	Referent	Referent
Yes	**1.25****	1.60	**1.26****	1.60
	[1.07,1.47]	[0.83,3.08]	**[1.08,1.48]**	[0.84,3.05]
Frequency of carrying weapons [a]				
Never carried a weapon	Referent	Referent	Referent	Referent
1–5 days	**1.28***	**2.13***	**1.30****	**2.19***
	[1.05,1.57]	**[1.04,4.36]**	**[1.07,1.58]**	**[1.04,4.58]**
> 5 days	1.22	1.07	1.23	1.04
	[0.99,1.51]	[0.32,3.59]	[1.00,1.53]	[0.32,3.32]

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a] During the last moth before the study; Model A crude; Model B adjusted for age, father education, nationality, physical activity and incisor overjet exceeding 3mm.

Table 21: Relative risk for associations between TDIs and multiple risk behaviours

	Model A (n=873)	Model B (n=873)	Model C (n=873)	Model D (n=873)	Model E (n=873)	Model F (n=873)	Model G (n=873)
Risk-taking behaviours							
No risk behaviour	Referent	Referent	Referent	Referent	Referent	Referent	Referent
1 risk behaviour	1.15	1.15	1.12	1.12	1.12	1.13	1.12
	[0.96,1.39]	[0.96,1.39]	[0.94,1.34]	[0.94,1.34]	[0.94,1.34]	[0.94,1.34]	[0.94,1.34]
2–3 risk behaviour	**2.00*****	**2.00*****	**1.43*****	**1.43*****	**1.43*****	**1.45*****	**1.44*****
	[1.68,2.38]	**[1.68,2.38]**	**[1.19,1.70]**	**[1.19,1.72]**	**[1.19,1.72]**	**[1.21,1.73]**	**[1.20,1.72]**

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$;
Model A crude; Model B adjusted for age; Model C additionally adjusted for sex; Model D additionally adjusted for father education; Model E additionally adjusted for nationality; Model F additionally adjusted for physical activity; Model G additionally adjusted for incisor overjet exceeding 3mm.

Table 22: Relative risk for associations between TDIs and multiple risk-taking behaviours, stratified by sex

	Model A		Model B	
	Boys (n=450)	Girls (n=423)	Boys (n=450)	Girls (n=423)
Risk-taking behaviours				
No risk behaviour	Referent	Referent	Referent	Referent
1 risk behaviour	**1.23***	0.93	**1.22***	0.95
	[1.01,1.50]	[0.65,1.34]	**[1.00,1.48]**	[0.66,1.36]
Multiple risk behaviours	**1.42*****	**2.47*****	**1.41*****	**2.50*****
	[1.17,1.71]	**[1.45,4.21]**	**[1.17,1.71]**	**[1.46,4.28]**

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$;
Model A crude; Model B adjusted for age, father education, nationality, physical activity and incisor overjet exceeding 3mm.

3.4.3. Multivariable analysis of peer influence associated with TDIs

The risk of TDIs was higher among adolescents whose peers carried weapons compared to those whose peers did not (RR 1.21; 95% CI 1.03–1.43), those who spent time with their friends after school on more than three days a week, compared to those who spent less time with friends (RR 1.19; 95% CI 1.03–1.39) and those who had less than three close friends compared to those who had three or more close friends (RR 1.19; 95% CI 1.00–1.42), after adjusting for age, sex, father's education, nationality, physical activity and incisor overjet exceeding 3mm (Table 23). These associations with TDIs confirmed the evidence found in the unadjusted model in both carrying weapons among peers and spending time with friends after school, while the relationship with the number of close friends became statistically significant after initially showing no statistically significant relationship with TDIs in the unadjusted model.

When the analyses were repeated separately for each sex, the significant associations were seen among boys only (Table 24). In the fully adjusted model, the risk of TDIs was higher among boys whose peers carried weapons (RR 1.19; 95% CI 1.01–1.40) compared to those whose peers did not, and among boys who spent time with their friends after school on more than three days a week (RR 1.25; 95% CI 1.07–1.46), compared to those who spent less time with friends.

However, not all associations that were significant between TDIs and peer relationship variables in the unadjusted model kept their significance after adjusting for confounding. This was particularly true for peers smoking tobacco and other drugs, evenings spent out with friends, ease with which others can join the group and peer participation in organised sport (Tables 23 and 24).

3.4.4. Section summary

- The risk of TDIs was significantly higher among adolescents who were smokers compared to those who had never smoked (RR 1.20; 95% CI 1.002–1.43). This relationship differed significantly by sex as girl smokers had higher risk of TDIs than those who had never smoked

(RR 2.50; 95% CI 1.42–4.41) while the respective adjusted association was not significant among boys.

- Adolescents who had been involved in more than 3 fights during the last year had higher risk of TDIs than those who had not had a fight in the same period (RR 1.33; 95% CI 1.09–1.63). This relationship differed significantly by sex as only boys in this category had a significantly higher risk of TDIs (RR 1.46; 95% CI 1.19–1.79), but not girls.
- Both boys and girls had a higher risk of TDIs when they reported carrying weapons on 1–5 days during the month preceding the study compared to those who did not carry weapons at all (Boys RR 1.30; 95% CI 1.07–1.58; girls RR 2.19; 95% CI 1.04–4.58), but this relationship was not significant among those who had carried weapons on more than 5 days.
- The risk of TDIs was higher for adolescents who had multiple risk-taking behaviours compared to those who did not (RR 1.44; 95% CI 1.20–1.72), with girls in this group having a stronger association with TDIs as opposed to boys (girls RR 2.50; 95% CI 1.46–4.28; boys RR 1.41; 95% CI 1.17–1.71).
- Adolescents who had less than three close friends had higher risk of TDIs than those who had three or more close friends (RR 1.19; 95% CI 1.00–1.42).
- The risk of TDIs was higher for boys whose peers carried weapons (RR 1.19; 95% CI 1.01–1.40) and those who spent time with their friends after school on more than 3 days a week (RR 1.25; 95% CI 1.07–1.46), compared to their counterparts.

Table 23: Relative risk for associations between TDIs and peer influence

Variable	Model A	Model B	Model C	Model D	Model E	Model F	Model G
Peers smoke tobacco (n=773)							
None	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Some or all	**1.70*****	**1.70*****	1.16	1.16	1.16	1.15	1.15
	[1.45,1.99]	**[1.45,1.99]**	[0.99,1.37]	[0.98,1.37]	[0.98,1.37]	[0.97,1.36]	[0.97,1.36]
Peers smoke other drugs (n=757)							
None	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Some or all	**1.47*****	**1.46*****	1.11	1.10	1.10	1.10	1.10
	[1.19,1.82]	**[1.18,1.81]**	[0.90,1.36]	[0.90,1.35]	[0.90,1.35]	[0.90,1.35]	[0.89,1.35]
Peers carry weapons (n=722)							
None	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Some or all	**1.86*****	**1.86*****	**1.21***	**1.21***	**1.21***	**1.21***	**1.21***
	[1.58,2.18]	**[1.58,2.18]**	**[1.03,1.43]**	**[1.03,1.42]**	**[1.03,1.43]**	**[1.03,1.43]**	**[1.03,1.43]**
Number of close friends (n=878)							
≥ 3 or more	Referent	Referent	Referent	Referent	Referent	Referent	Referent
< 3 friends	0.99	0.99	**1.19***	**1.19***	**1.19***	**1.19***	**1.19***
	[0.82,1.18]	[0.82,1.18]	**[1.00,1.42]**	**[1.00,1.42]**	**[1.00,1.42]**	**[1.00,1.42]**	**[1.00,1.42]**
Out with friends after school a week (n=875)							
< 4 days	Referent	Referent	Referent	Referent	Referent	Referent	Referent
≥ 4 days	**1.54*****	**1.54*****	**1.18***	**1.17***	**1.17***	**1.20***	**1.19***
	[1.32,1.80]	**[1.31,1.80]**	**[1.01,1.36]**	**[1.01,1.36]**	**[1.01,1.36]**	**[1.03,1.40]**	**[1.03,1.39]**
Evenings out with friends per week (n=875)							
< 4 evenings	Referent	Referent	Referent	Referent	Referent	Referent	Referent
≥ 4 evenings	**1.36*****	**1.36*****	1.09	1.09	1.09	1.11	1.10
	[1.15,1.60]	**[1.15,1.60]**	[0.93,1.28]	[0.93,1.27]	[0.93,1.28]	[0.95,1.31]	[0.94,1.29]
Easiness for others to join the group (n=876)							
Easy / very easy	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Difficult / very difficult	**1.18***	**1.18***	1.06	1.06	1.06	1.06	1.07
	[1.01,1.38]	**[1.01,1.38]**	[0.91,1.23]	[0.91,1.23]	[0.91,1.23]	[0.91,1.23]	[0.92,1.24]
Peers participate in organised sport (n=758)							
None	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Some or all	**1.34****	**1.34****	1.07	1.07	1.07	1.09	1.09
	[1.09,1.64]	**[1.09,1.64]**	[0.87,1.30]	[0.88,1.31]	[0.88,1.31]	[0.89,1.33]	[0.89,1.33]

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Model A crude; Model B adjusted for age; Model C additionally adjusted for sex; Model D additionally adjusted for father education; Model E additionally adjusted for nationality; Model F additionally adjusted for physical activity; Model G additionally adjusted for incisor overjet exceeding 3mm.

Table 24: Relative risk for associations between TDIs and peer influence, stratified by sex

Variable	Model A		Model B	
	Boys	**Girls**	**Boys**	**Girls**
Peers smoke tobacco	(n=403)	(n=370)	(n=403)	(n=370)
None	Referent	Referent	Referent	Referent
Some or all	1.18	1.02	1.16	1.02
	[1.00,1.40]	[0.52,1.99]	[0.98,1.38]	[0.52,2.03]
Peers smoke other drugs	(n=376)	(n=381)	(n=376)	(n=381)
None	Referent	Referent	Referent	Referent
Some or all	1.11	1.04	1.10	1.03
	[0.91,1.36]	[0.38,2.81]	[0.90,1.35]	[0.38,2.82]
Peers carry weapons	(n=358)	(n=364)	(n=358)	(n=364)
None	Referent	Referent	Referent	Referent
Some or all	**1.19***	1.53	**1.19***	1.59
	[1.01,1.40]	[0.73,3.22]	**[1.01,1.40]**	[0.74,3.44]
Number of close friends	(n=452)	(n=426)	(n=452)	(n=426)
≥ 3 or more	Referent	Referent	Referent	Referent
< 3 friends	1.10	1.36	1.10	1.35
	[0.91,1.33]	[0.97,1.91]	[0.91,1.33]	[0.97,1.88]
Out with friends after school a week	(n=450)	(n=425)	(n=450)	(n=425)
< 4 days	Referent	Referent	Referent	Referent
≥ 4 days	**1.24****	0.73	**1.25****	0.74
	[1.06,1.44]	[0.35,1.53]	**[1.07,1.46]**	[0.35,1.58]
Evenings out with friends per week	(n=450)	(n=425)	(n=450)	(n=425)
< 4 days	Referent	Referent	Referent	Referent
≥ 4 days	1.09	1.08	1.09	1.09
	[0.92,1.28]	[0.63,1.85]	[0.93,1.28]	[0.62,1.89]
Easiness for others to join the group	(n=451)	(n=425)	(n=451)	(n=425)
Easy / very easy	Referent	Referent	Referent	Referent
Difficult / very difficult	1.02	1.20	1.03	1.19
	[0.87,1.19]	[0.84,1.73]	[0.88,1.20]	[0.83,1.71]
Peers participate in organised sport	(n=412)	(n=346)	(n=412)	(n=346)
None	Referent	Referent	Referent	Referent
Some or all	1.07	1.06	1.10	1.09
	[0.85,1.33]	[0.72,1.55]	[0.88,1.38]	[0.74,1.61]

Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$;
Model A crude; Model B adjusted for age, father education, nationality, physical activity and incisor overjet exceeding 3mm.

3.5. Assessing the effect of peer influence on the association between risk-taking behaviours and TDIs

3.5.1. Section overview

This section presents results assessing the fourth research objective, to assess whether the associations between adolescents' risk-taking behaviours and the prevalence of TDIs among adolescents were modified by negative peer influence.

3.5.2. Multivariable analysis of the effect of peer influence on the association between risk-taking behaviours and TDIs

Among the whole sample, the risk of TDIs was significantly higher among adolescents who were smokers compared to those who had never smoked (RR 1.20; 95% CI 1.002–1.43). Among the group of adolescents whose peers did not carry weapons at all, current tobacco smokers were at higher risk of TDIs (RR 1.69; 95% CI 1.31–2.18) compared to those who never smoked, while this relationship was not significant among the group of adolescents whose some or all of their peers were carrying weapons (Table 25).

When each sex was examined separately, girl smokers among the whole sample had higher risk of TIDs than those who had never smoked (RR 2.50; 95% CI 1.42–4.41) while this was not significant among boys. However, both sexes showed an effect modification when stratified by carrying weapons among peers, but with different magnitudes. Current smokers among the group of girls whose peers did not carry weapons were at higher risk of TDIs (RR 3.12; 95% CI 1.65–5.89) compared to those who never smoked. Among the group of girls who reported no difficulties in communication with their best friends, current smokers were at higher risk of TDIs (RR 2.21; 95% CI 1.16–4.22) compared to those who never smoked.

Among the group of boys whose peers did not carry weapons, current smokers were at higher risk of TDIs (RR 1.55; 95% CI 1.21–1.99) compared to those who never smoked, while this relationship was not significant among the group of boys whose some or all of their peers were carrying weapons. The significant association between TDIs and the group of boys whose peers

did not carry weapons represents a substantial change from the statistically not significant relationship when the sample of boys was examined as a whole.

Table 25: Effect modification of peer influence on the relative risk of tobacco smoking on TDIs

Peer relationship variable strata	Current tobacco smokers					
	All		Boys		Girls	
	RR[1]	[95% CI]	RR[1]	[95% CI]	RR[1]	[95% CI]
	(n=878)		(n=453)		(n=425)	
No stratification	**1.20***	**[1.00,1.43]**	1.10	[0.92,1.32]	**2.50****	**[1.42,4.41]**
Stratified for peer weapons carrying						
	(n=551)		(n=204)		(n=347)	
None of peers carry weapons	**1.69*****	**[1.31,2.18]**	**1.55*****	**[1.21,1.99]**	**3.12**$^{**}_{*}$	**[1.65,5.89]**
	(n=169)		(n=154)		(n=15)	
Some or all peers carry weapons	0.89	[0.68,1.15]	0.84	[0.65,1.09]	-†	
Stratified for the easiness to communicate with best friend						
	(n=87)		(n=46)		(n=41)	
Difficult to communicate with best friend	1.39	[0.90,2.14]	1.21	[0.82,1.78]	-†	
	(n=767)		(n=390)		(n=377)	
Easy to communicate with best friend	1.15	[0.95,1.40]	1.08	[0.89,1.31]	**2.21***	**[1.16,4.22]**

[1] Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
All models are adjusted for age, sex, father education, nationality, physical activity and incisor overjet exceeding 3mm.
† Model was not stable due to shortage of observations.

Among the whole sample, the risk of TDIs was significantly higher among adolescents who carried weapons compared to those who did not; Relative risk was 1.36 (95% CI 1.12–1.66) for those who carried weapons in one to five days during the month preceding the study and 1.24 (95% CI 1.00–1.53) for those who carried weapons in more than five days during the same period. However, these effects were modified when the sample was stratified by peer support (Table 26). Among the group of adolescents whose peers were supportive, adolescents who reported carrying weapons on one to five days in the month preceding the study were at higher risk of TDIs (RR 1.28; 95% CI 1.01–1.62) compared to those who did not carry weapons at all. However, this risk was even higher among the group of adolescents whose peers were not supportive (RR 2.18; 95% CI 1.05–4.57).

The effect of peer support was even clearer among adolescents who reported carrying weapons on more than five days in the month preceding the study. Among this group, adolescents whose

peers were not supportive, the risk of TDIs was higher (RR 3.55; 95% CI 1.40–9.03) compared to those who did not carry weapons at all. This relationship was statistically not significant among the same group of weapons carrier, compared to those who did not carry weapons at all, when peers reported to be supportive (RR 1.23; 95% CI 0.97 -1.55).

Table 26: Effect modification of peer influence on the relative risk of carrying weapons on TDIs

Peer relationship variable strata	Carried weapon in 1–5 days		Carried weapon in more than 5 days	
	RR[1]	[95% CI]	RR[1]	[95% CI]
No stratification (n=875)	**1.36****	**[1.12,1.66]**	**1.24***	**[1.00,1.53]**
Stratified by peer group support				
Peers support each other **(n=744)**	**1.28***	**[1.01,1.62]**	1.23	[0.97,1.55]
Peers do not support each other **(n=43)**	**2.18***	**[1.05,4.57]**	**3.55****	**[1.40,9.03]**

[1] Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001.
All models are adjusted for age, sex, father education, nationality, physical activity and incisor overjet exceeding 3mm.

Among the whole sample, the risk of TDIs was higher for adolescents who had multiple risk-taking behaviours compared to those who did not (RR 1.44; 95% CI 1.20–1.72), with girls in this group having a stronger association with TDIs than boys (girls RR 2.50; 95% CI 1.46–4.28; boys RR 1.41; 95% CI 1.17–1.71). Among the group of adolescents whose peers were supportive, adolescents who had multiple risk-taking behaviours were at higher risk of TDIs (RR 1.36; 95% CI 1.11–1.68) compared to those who had no risk-taking behaviours (Table 27). However, adolescents who had multiple risk-taking behaviours but their peers were not supportive were at even higher risk of TDIs (RR 1.81; 95% CI 1.02–3.19) compared to those who had no risk-taking behaviours.

When each sex was examined separately, girls whose peers were supportive and who had multiple risk-taking behaviours again showed much higher risk of TDIs, compared to those had no risk-taking behaviours and supportive peers (RR 2.63; 95% CI 1.46–4.72). Boys who had multiple risk-taking behaviours in the group whose peers were supportive also showed higher risk of TDIs (RR 1.32; 95% CI 1.06–1.64), compared to those had no risk-taking behaviours,

while showed even higher risk in the group whose peers were not supportive (RR 1.97; 95% CI 1.08–3.58).

In the group of adolescents whose some or all of their peers were participating in organised activities and compared to those who had no risk-taking behaviours, adolescents who had only one risk behaviour were at higher risk of TDIs (RR 1.39; 95% CI 1.04–1.88), while those who had multiple risk behaviours were at even higher (RR 1.80; 95% CI 1.32–2.44). These relationships were not significant among the groups of adolescents whose peers were not participating in organised activities, whatever the number of risk behaviours they had. When each sex was examined separately, both boys and girls had the highest risk of TDIs when they had multiple risk-taking behaviours and peers were participating in organised activities compared to those who had no risk-taking behaviours among the same group (boys RR 1.98; 95% CI 1.26–2.55; girls RR 2.97; 95% CI 1.30–6.79).

Table 27: Effect modification of peer influence on the relative risk of multiple risk-taking behaviours on TDIs

Peer relationship variable strata	All		Boys		Girls	
	RR[1]	**[95% CI]**	**RR[1]**	**[95% CI]**	**RR[1]**	**[95% CI]**
No stratification	(n=873)		(n=450)		(n=423)	
1 risk behaviour	1.12	[0.94,1.34]	**1.22***	**[1.00,1.48]**	0.95	[0.66,1.36]
Multiple risk behaviours	**1.44*****	**[1.20,1.72]**	**1.41*****	**[1.17,1.71]**	**2.50*****	**[1.46,4.28]**
Stratified by peer support						
Peers support each other	(n=742)		(n=360)		(n=382)	
1 risk behaviour	1.11	[0.92,1.35]	1.19	[0.96,1.47]	0.97	[0.66,1.42]
Multiple risk behaviours	**1.36****	**[1.11,1.68]**	**1.32***	**[1.06,1.64]**	**2.63****	**[1.46,4.72]**
Peers do not support each other	(n=43)		(n=30)		(n=13)	
1 risk behaviour	1.18	[0.62,2.25]	1.16	[0.63,2.13]	-[†]	
Multiple risk behaviours	**1.81***	**[1.02,3.19]**	**1.97***	**[1.08,3.58]**		
Stratified by peer participation in organised activities						
Peers do not participate in organised activities	(n=347)		(n=169)		(n=178)	
1 risk behaviour	1.04	[0.80,1.36]	1.11	[0.83,1.48]	0.90	[0.52,1.57]
Multiple risk behaviours	1.20	[0.91,1.59]	1.12	[0.83,1.50]	**2.60****	**[1.44,4.71]**
Some or all peers participate in organised activities	(n=354)		(n=181)		(n=173)	
1 risk behaviour	**1.39***	**[1.04,1.88]**	**1.79****	**[1.26,2.55]**	0.91	[0.51,1.60]
Multiple risk behaviours	**1.80*****	**[1.32,2.44]**	**1.98*****	**[1.39,2.83]**	**2.97****	**[1.30,6.79]**

[1] Relative risk using Poisson model with robust error variances; 95% confidence intervals in brackets.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Each category is compared to adolescents with no risk behaviours.
All models are adjusted for age, sex, father education, nationality, physical activity and incisor overjet exceeding 3mm.
[†] Model was not stable due to shortage of observations.

3.5.3. Section summary

- The risk of TDIs among smokers compared to those who never smoked was higher when adolescents had peers who never carried weapons (RR 1.69; 95% CI 1.31–2.18) and among girls with no difficulties in communication to their best friends (RR 2.21; 95% CI 1.16–4.22), while these relationships was not significant in the opposed strata.

- The risk of TDIs was higher among the group of adolescents who reported carrying weapons in 1–5 days for the month preceding the study and their peers were not supportive (RR 2.18; 95% CI 1.05–4.57) than the same category of weapon users but with supportive peers (1.28; 95% CI 1.01–1.62).

- The effect of peer support was even clearer among adolescents who reported carrying weapons on more than five days in the month preceding the study. Among this group, adolescents whose peers were not supportive, the risk of TDIs was higher (RR 3.55; 95% CI 1.40–9.03) compared to those who did not carry weapons at all. This relationship was statistically not significant among the same group of weapons carrier but with supportive peers.

- The risk of TDIs among adolescents with multiple risk-taking behaviours compared to those who had no risk-taking behaviours was higher when adolescent had supportive peers (RR 1.36; 95% CI 1.11–1.68) but even higher when they lack peer support (RR 1.81; 95% CI 1.02–3.19).

- Adolescents with multiple risk-taking behaviours had a higher risk of TDIs than those who had no risk-taking behaviours (RR 1.80; 95% CI 1.32–2.44) and those with only one risk-taking behaviour (RR 1.39; 95% CI 1.04–1.88) when their peers were participating in organised activities, while this was statistically not significant among the same category among those with peers not participating in such activities.

Chapter 4
Discussion

4.1. Overview of key findings

The overall aim of this project was to examine whether certain behavioural and psychosocial determinants were associated with the prevalence of TDIs among adolescents, with a particular focus on the role of their risk-taking behaviours and peer influence. Due to the lack of valid and up-to-date data on the prevalence of TDIs among the adolescents in Saudi Arabia, the study initially assessed the prevalence of TDIs among adolescents in Riyadh. The results confirmed the first hypothesis of the study, which was that the prevalence of TDIs among this population would be high, and found a very high prevalence of TDIs (42.6%; 95% CI 39.4% to 45.8%). There were considerable variations in the prevalence between both sexes with a much higher prevalence of TDIs among boys (59.4%; 95% CI 54.9% to 63.8%) compared to girls (24.9%; 95% CI 21.1% to 29.2%) (Table 10).

The study also confirmed the second hypothesis, that high risk-taking adolescents would have significantly higher prevalence of TDIs than their low risk-taking counterparts, even after adjusting for age, sex, father's education, nationality, physical activity and incisor overjet exceeding 3mm. First, the risk of TDIs was significantly higher among adolescents who were smokers compared to those who had never smoked (RR 1.20; 95% CI 1.002–1.43; Table 15), among those who had been involved in more than 3 fights during the year preceding the study compared to those who had not had a fight in the same period (RR 1.33; 95% CI 1.09–1.63; Table 17), and among those that reported carrying weapons on 1–5 days during the month preceding the study compared to those who did not carry weapons in the same period (RR 1.36; 95% CI 1.12–1.66; Table 19). The results also showed that adolescents who had multiple risk-taking behaviours had higher risk of TDIs compared to those who had only one or were not

showing any of the studied risk-taking behaviours (RR 1.44; 95% CI 1.20–1.72; Table 21). The relationship between risk-taking behaviours and TDIs differed significantly between boys and girls depending on the type of risk behaviour under examination. This association kept significant among girls only for the smoking behaviour and among boys only for the fights indicator, while the associations between TDIs and both weapon use and multiple risk behaviours were significant in both sexes.

The results also confirmed the third hypothesis that the prevalence of TDIs in this population would be significantly higher in adolescents with higher negative peer influence. The risk of TDIs was higher among adolescents who had less than three close friends compared to those who had three or more close friends (RR 1.19; 95% CI 1.00–1.42), those whose peers carried weapons compared to their counterparts (RR 1.21; 95% CI 1.03–1.43), and those who spent time with their friends after school on more than 3 days a week, compared to those who spent less time with them (RR 1.25; 95% CI 1.07–1.46; Table 23).

Finally, the results showed that the associations of carrying weapons as well as having multiple risk-taking behaviours with TDIs were stronger among adolescents that reported lack of peer support, a form of negative peer influences (RR 2.18; 95% CI 1.05–4.57 and RR 1.36; 95% CI 1.11–1.68, respectively; Tables 26 and 27). In other words, negative peer influences seem to amplify the aforementioned associations between risk-taking behaviours and TDIs. Also, smoking seems increasing the risk of TDIs among adolescents whose none of their peers carrying weapons (RR 1.69; 95% CI 1.31–2.18), while these relationships were not significant in the group of adolescents whose some or all of their peers were carrying weapons (Table 25).

4.2. Comparisons of the study findings with previous studies

4.2.1. Prevalence of Traumatic Dental Injuries

This study showed that the prevalence of TDIs among adolescents in Riyadh, Saudi Arabia, was very high compared to the previous studies from the same city (Al-Majed 2011; Al-Majed et al. 2001). This was the first study to assess the prevalence of TDIs among both boys and girls in Saudi Arabia. Compared with the limited available evidence, the prevalence of boys' TDIs in the current study (59.4%) was higher than the 34% prevalence among 12 to 14 year-old Riyadh boys (Al-Majed et al. 2001). However, the prevalence among girls in the current study (24.9%) was lower than in Al-Majed's study in the same city. He reported a prevalence of 34.4% (Al-Majed 2011).

The higher prevalence of TDIs in this study compared to the previous study among the younger boys in Riyadh could be partially explained by an increasing trend in TDIs among this population from the late nineties up to date. However, the cumulative effect of TDIs is also a plausible explanation as the mean age of the adolescents in this study was older. The lower prevalence among girls in this study compared to the prevalence among girls in the previous study in Riyadh could be explained by a decreasing trend in TDIs among this population during the last couple of years. Although the different classifications of the measurements of TDIs in both of these previous studies (Al-Majed 2011; Al-Majed et al. 2001) were different from the one used in this study, the overall results were similar as they combined all the injuries categories into one category for the analysis. Nevertheless, variations in samples and methods used to assess TDIs could have influenced these findings. For example, only the upper incisors were the teeth assessed for TDIs in both previous studies while this study assessed both upper and lower anterior teeth including canines.

The high prevalence of TDIs in this study is similar to most other studies that have reported a high prevalence of TDIs among adolescents. The closest prevalence of TDIs reported among

similar age group was the 37.1% among 12 and 15 year-old adolescents in Curitiba, Brazil (Carvalho et al. 2010), 35% among schoolchildren aged 11 to 13 years in Chiang Mai, Thailand (Malikaew et al. 2006), 34.8% among adolescents aged 12 years from Porto Alegre, Brazil (Damé‐Teixeira et al. 2013), 34.4% among 11 to 14 year-old schoolchildren from Salford and Bury, UK (Hamilton et al. 1997) and 33.8% from adolescent aged 10 to 12 years from East Jerusalem Sgan-Cohen et al. (2008).

However, the overall prevalence of TDIs in the current study was considerably higher than all the known published studies from Middle East. They reported prevalence ranging from of 5.5% to 29.6% (Al-Bajjali and Rajab 2014; Årtun et al. 2005; Hamdan and Rajab 2003; Livny et al. 2010; Marcenes et al. 1999; Noori and Al-Obaidi 2009; Rajab et al. 2013; Sgan-Cohen et al. 2005).

The wide variations in reported prevalence of TDIs in the current study compared to other studies could be partly explained by methodological differences, including sampling approaches and diagnosis criteria for TDIs. For example, although this study used a modified version of the WHO classifications that is designed for epidemiological field screening (Glendor et al. 2007) and recommended as the best option for epidemiological studies of TDIs (Andersson and Andreasen 2011), many of the aforementioned studies used other classifications, such as O'Brien's (O'Brien 1994) and Andreasen's (Andreasen et al. 2007) as well as their variations. Studies by Toprak et al. (2014), Rodrigues Campos Soares et al. (2014), Paiva et al. (2014), Oliveira Filho et al. (2014), Castro et al. (2011), Bendo et al. (2010) and Soriano et al. (2007) used the Andreasen's classification (Andreasen et al. 2007), which resembles a lot the one used in this study but with slight differences in categorisations (e.g. having special category for intrusion and luxation). These differences should not affect comparability with this study because we grouped together all cases of TDIs. However, differences in the measurement of TDIs in the other classifications could have a considerable influence on the prevalence. This is supported by findings of a meta-analysis performed on 24 prevalence studies of TDIs in Latin

America and Caribbean region which found that the pooled prevalence increased to 20.8% when only studies that used O'Brien's or similar systems were considered, compared to 14.4% when studies using Andreasen's or similar indices were also included (Aldrigui et al. 2014).

It should also be noted that no participants were re-examined in the main study to look for repeatability of the measured outcomes. This was not feasible to do within the school setting and it would risk the willingness of schools to participate in the study. The emphasis on the main study was on achieving a large sample. However, re-examinations were carried out in the pilot study stage (during the calibration stage) in which participants were seen in two intervals within a couple of weeks. The results demonstrated the repeatability of the examinations and showed good to excellent intra-examiner agreements for both examiners, with a Kappa of 0.75 for one examiner and a Kappa of 0.91 for the other examiner (Section 1.6).

4.2.2. Distribution of TDIs by sociodemographic and clinical factors

The current study showed that boys had significantly higher prevalence of TDIs than girls. These results agree with the findings of many other studies worldwide that reported higher risk of TDIs among boys (Al-Bajjali and Rajab 2014; Aldrigui et al. 2014; Ankola et al. 2013; Årtun and Al-Azemi 2009; Bastone et al. 2000; Borzabadi-Farahani and Borzabadi-Farahani 2011; Bücher et al. 2013; Glendor 2008, 2009; Huang et al. 2009; Kovács et al. 2012; Murthy et al. 2014; Naidoo et al. 2009; Noori and Al-Obaidi 2009; Rambharos et al. 2014; Taiwo and Jalo 2011; Thelen and Bårdsen 2010; Yassen et al. 2013). It is also reported in relation to many other types of injuries during the different stages of youth and among many different contexts (Centers for Disease Control and Prevention 2011a; Chen et al. 2005; Kozik et al. 1999; Mytton et al. 2009; Soubhi et al. 2004).

This difference in the prevalence of TDIs toward higher rates among boys could be explained by the increased engagement of boys in risk-taking behaviours compared to girls (Byrnes et al. 1999; Ginsburg and Miller 1982; Rosen and Peterson 1990). This is supported by evidence

indicating that boys differ from girls in cognitive appraisal of risk (Morrongiello 1997; Morrongiello and Rennie 1998), emotional reactions to risk (Morrongiello and Lasenby-Lessard 2007; Morrongiello and Matheis 2004), and socialisation patterns (Block 1983). Boys also involved in more sports and rigorous activities (Rosen and Peterson 1990) and have fewer restraints from parents to get involved risk activities compared to girls (Morrongiello and Dawber 1999; Morrongiello and Hogg 2004).

In the current study, there were no significant differences in the prevalence of TDIs between the age groups. This can be related to the narrow range of age group that were recruited for this study. This age range was used in an attempt to provide a sample reflecting the adolescence developmental stage, which should facilitate inferring from the findings on adolescents and comparing with other studies. This stage of development was selected as it has unique features differentiating it from early childhood and adulthood stages as adolescents in this stage start seeking more risky behaviours (Jessor 1991; Wiefferink et al. 2006) and more independence from their parents towards their peers (Morrongiello et al. 2008; Schwebel and Brezausek 2010). In addition, adolescents in this sensitive age could be more prone to psychosocial stress while still not having enough capability to cope with it (Smith et al. 1992; Smith et al. 1990). In relation to TDIs, this stage has the peak of TDIs incidence, with estimation that 71 to 92% of all TDIs sustained in a lifetime occur before the age of 19 years (Bastone et al. 2000; Glendor 2009), and a tendency to have more TDIs compared to younger childhood stages (Bücher et al. 2013; Cortes et al. 2001; Goettems et al. 2014b; Rodrigues Campos Soares et al. 2014; Schatz et al. 2013; Yassen et al. 2013).

The current study found significant differences in the prevalence of TDIs among boys in public and private schools. However, the difference was not statistically significant among girls and the sample as a whole when both sexes were combined. The present findings seem to be consistent with other research that did not show conclusive findings. Previous studies ranged from showing no statistical significance (Goettems et al. 2014b; Oliveira Filho et al. 2013; Soriano et al. 2007),

to reporting contradictory findings; higher TDIs in public schools in some studies (Garcia-Godoy et al. 1986; Murthy et al. 2014) and in private schools in others (Garcí-Godoy 1984; Jamani and Fayyad 1991; Jorge et al. 2012).

In the current study, TDIs were higher among adolescents with lower parental education but the opposite was true when parents had postgraduate degrees as compared to undergraduate degrees. These figures corroborate the findings of a great deal of the previous work in this field that showed inconsistence in this relationship. The higher prevalence of TDIs among adolescents with lower parents education is consistent with those of Malikaew et al. (2006) among 11 to 13 year-old Thai schoolchildren, Jamani and Fayyad (1991) among 7 to 12 year-olds in Jordan, Hamilton et al. (1997) among 11 to 14 year-old British schoolchildren, Díaz et al. (2010) among 1–15 year-old children in Chile and Ramos-Jorge et al. (2011) among 12 to 15 year-olds in Brazil.

However, this result differs from other published studies that reported higher prevalence of TDIs among children with higher educated parents, such as the study by Ramos-Jorge et al. (2008) among 11 to 13 year-old schoolchildren in Brazil and Huang et al. (2009) among 15 to 18 year-old adolescents in Taiwan. Yet, the latter figures are consistent with the finding in the current study showing adolescents who have parents with postgraduate degrees had higher TDIs than those with undergraduate degree. These figures reflect the inconsistent in finding in relation to this indicator with TDIs as other studies also showed no significant relationship, including those by Livny et al. (2010) among Palestinian schoolchildren and Fakhruddin et al. (2008a) among Canadian adolescents and multiple others among Brazilian (Bendo et al. 2010; Nicolau et al. 2003; Soriano et al. 2007).

One unanticipated finding was that TDIs were less prevalent among adolescents with incisor overjet exceeding 3mm than those with less overjet. This finding adds to the inconclusive findings from previous studies that showed mixed results between higher rates of TDIs among adolescents with bigger overjet (Al-Majed 2011; Ankola et al. 2013; Årtun et al. 2005; De

Frujeri et al. 2014; Francisco et al. 2013; Glendor 2008; Nguyen et al. 1999; Paiva et al. 2014; Petti 2014; Taiwo and Jalo 2011) and no significant differences (Çetinbaş et al. 2008; Kania et al. 1996; Marcenes et al. 2000; Murthy et al. 2014; Reisen et al. 2013; Stokes et al. 1995). These conflicting results indicate an interaction of other factors, including behavioural, social or environmental factors that could be modifying this relationship. As this study showed, adolescent had higher risk of TDIs independent of their incisor overjet measures when they had more risk-taking behaviours (Tables 15 to 22) and negative peer influence (Table 23 and 24). Therefore, adolescents' risk-taking behaviours and negative peer influence, in addition to other plausible behavioural and psychosocial factors, should be accounted for simultaneously when increased overjet is to be assessed.

This study found no significant differences in prevalence of TDIs between adequate and inadequate lip coverage. This finding is consistent with many previous studies (Çetinbaş et al. 2008; Jorge et al. 2012; Kania et al. 1996; Kovács et al. 2012; Marcenes et al. 2000; Murthy et al. 2014; Reisen et al. 2013; Stokes et al. 1995; Traebert et al. 2003a; Traebert et al. 2006) but differ from others that reported significantly higher TDIs among adolescents with inadequate lip coverage (Al-Majed 2011; Al-Majed et al. 2001; Aldrigui et al. 2014; Ankola et al. 2013; Chopra et al. 2014; Goettems et al. 2014b; Petti 2014; Prabhu et al. 2013; Rambharos et al. 2014; Soriano et al. 2007; Traebert et al. 2006). However, crude significant association with this biological factor should be interpreted with caution as it lacks the consideration of behavioural and social factors that showed important modification to the relationship between this kind of factors and TDIs (Tables 15 to 24).

4.2.3. Location, activities and time of occurrence of TDIs

The current study showed that homes were the most common location of TDIs. This finding is consistent with many other previous studies (Damé‐Teixeira et al. 2013; Francisco et al. 2013; Gupta et al. 2002; Marcenes et al. 1999; Patel and Sujan 2012; Rajab 2003; Rajab et al. 2013;

Schuch et al. 2013). However, other places such as schools and street were also reported as the most common location of TDIs (Gábris et al. 2001; Onetto et al. 1994; Rodrigues Campos Soares et al. 2014; Skaare and Jacobsen 2003b; Toprak et al. 2014). The high proportions of TDIs occurring in homes, especially among girls, could be explained by the more time spent at home compared to schools or street. But these findings should be interpreted with caution. This is because proportion of adolescents who could not remember the location of their TDIs was high (Table 17), which make generalisation problematic as the locations of TDIs among those who could not remember might be different.

This study showed that sports were the most common activity conducted at the time of the occurrence of TDIs. This finding is consistent with previous studies (Wright et al. 2007; Ziegler 2014) and not surprising as adolescents at this age spend a considerable time participating in sport activities (Dhillon et al. 2014; Kumamoto and Maeda 2003; Rodd and Chesham 1997; Saini 2011; Tuna and Ozel 2014). Yet, other studies reported sports as less common compared to other events, such as parties (Skaare and Jacobsen 2003b) and assaults (Canakci et al. 2003). Girls in this sample also showed higher proportions of their TDIs related to the habit of eating raw nuts and hard food, which is a common issue among adolescents in Saudi Arabia. As previously mentioned, this could explain the high proportion of simple enamel fractures in this sample compared to the more complicated types of TDIs.

However, these data should be interpreted with caution for several reasons. First, the question about the reason or the activity related to the TDIs tends to have a high rate of non-response as well being subject to bias due to adolescents not remembering exactly the reason for their TDI, and this was also the case in the current study (Table 11). This issue limit the generalizability, as the proportion of injury-related activity among adolescents who did not respond or remember could be different from those who responded. For example, TDIs resulted from violent behaviours, such as fighting, can be substantially underestimated (Glendor 2008; Traebert et al. 2003b). In addition, many of the previous studies considered falls as a category. This could have

obscured the real activity as falls is only indicating for the process but not the activity related to TDIs. For example, TDIs from sports and leisure activities, walking and violence can all have falls as the process that preceded the injury.

4.2.4. Associations between risk taking behaviours and TDIs

The current study found that the risk of TDIs was significantly higher among risk-taking adolescents compared to their counterpart peers. Adolescents who were smoking tobacco, involved in fights, and those who were carrying weapons had higher risks of TDIs than those who were not involved in those activities. This is the first study to comprehensively assess the role of risk-taking behaviour in TDIs among adolescents in a population-based study and therefore there are very few studies to compare these results with. However, the current findings are consistent with the limited available evidence, including the association between TDIs and illicit drug, alcohol use and violence (Jorge et al. 2012; Murphy et al. 2009; Odoi et al. 2002; Oliveira Filho et al. 2013; Oliveira Filho et al. 2014).

The current study found that the risk of TDIs was significantly higher among adolescents who were smokers compared to those who had never smoked. The only study on this subject found no significant association with smoking (Jorge et al. 2012). However, this study assessed smoking collectively as a part of a measure assessing psychoactive substances including alcohol, stimulants, sedatives, hallucinogens, and others. The current study assessed this behaviour more comprehensively, considering both current and previous smoking and controlling for multiple factors that could confound this relationship.

In comparison to the study by Murphy et al. (2009), the current study agrees with the finding showing that health risk-behaviour are associated with TDIs, although the indicators and methods are different. Murphy and his colleagues studied a small sample (67 adolescents) consisting mostly of boys (86%) who visited trauma centres for treatment of facial injuries. In addition, the authors did not control for well-known confounders, such as age, sex,

socioeconomic status and physical activity level. Therefore, the larger sample and the random population-based design of the current study make the results more generalizable. Also, this study benefited from accounting for the known potential confounding variables in the analysis. Moreover, this design of this study allowed covering other injuries that have less chances to be treated in a trauma centre for many possible reasons, such as the lack of access to this centre or perceiving TDIs as a less critical case for a visit to such centres.

The increased risk of TDIs found among adolescents in the current study who were involved in physical fights is consistent with other studies that reported links between violent behaviour and TDIs (Odoi et al. 2002). However, the current study looked at this relationship using a population-based sample compared to the small, hospital-based sample used by Odoi and his colleagues. In addition, the current study used adolescents' self-report to assess this behaviour unlike that study which used parents' reports. This should overcome some of the well-known limitations of the parents' reports in regards to this kind of behaviours, including the chances of introducing components of socially desirable responding that could influence the validity of the repose (McCrory and Layte 2012) and the weak correlations between parent and self-reports scores (Muris et al. 2003).

Nevertheless, the current findings on the association between physical fights and TDIs are consistent with the substantial body of work in the scientific literature showing that this type of behaviour is associated with increased risk of many types of body injuries (de Looze et al. 2012; Pickett et al. 2006; Pickett et al. 2002a; Turner et al. 2004). It can also be argued that the findings of the current study are supporting the idea that fighting is a marker for a lifestyle that has intrinsic TDIs risks for adolescents. This makes fighting behaviour an early and reliable marker of risk-taking behaviours that could lead to TDIs as it is highly visible and often results in visiting health care units (Sosin et al. 1995). The differences between boys and girls can be explained by the evidence suggesting that boys have much more chances to become involved in

physical fights, while girls are found more likely to engage in undercover forms of emotional aggression (Crick and Bigbee 1998; Crick and Grotpeter 1995; Rose and Rudolph 2006).

The current study is the first to assess the relationship between TDIs and weapon use among adolescents. The risk of TDIs was higher among adolescents who reported carrying weapons. This finding match those observed in earlier studies related to other types of injuries (Senterre et al. 2014). The attenuation of significance of this relationship observed among adolescents who had carried weapons on more than 5 days could be a result of the few observations for this category (49 boys and 8 girls). Another explanations of this observation could be that adolescents who are excessively involved with weapons are more skilful or adaptable to the increased risks of injuries compare to other adolescents, or seen by their peers as powerful and fearless which could decreased their chances of being bullied or involved in fights with violent peers compared to the other adolescents. The observed differences in weapon carrying between boys and girls may reflect the number and type of aggressive activities and situations that boys and girls experience as boys might often carry weapons as a proactive aggression while girls might do so for defensive purposes (Pickett et al. 2005a).

The current study showed that the prevalence of TDIs was higher among adolescents who had multiple risk-taking behaviours compared to those who did not. This finding is consistent with previous research showing that clustering of risk behaviours is an important determinant for injury (de Looze et al. 2012; Pickett et al. 2006; Pickett et al. 2002a). This clustering among adolescents could indicate an underlying propensity of higher risk-taking and confirms the importance of the relationship between risk-taking behaviours and TDIs. Risk-taking in this context has negative consequences and can be considered as a lifestyle risk that is contributing significantly to the risk of TDIs among this population.

These risk-taking behaviours are considered as a direct cause of injury (Pickett et al., 2005). However, the cross-sectional design of this study does not allow for assessing the causal relationship. Another plausible theory is that these behaviours are related to injuries in an

indirect manner, as whether or not adolescents have propensity to be high risk-takers depends on various factors, including their individual traits and the social environment they live in (Jessor and Jessor 1977). The findings of the current study support this hypothesis as peer influence found to be modifying the effect of some risk-taking behaviours on TDIs (Table 32 to 35). Beside the factors assessed in this study, other risk and protective factors related to parents (e.g. parenting style and supervision quality), schools (e.g. social support in school) and neighbourhood (e.g. residential environments and social vulnerability) can influence risk behaviours. Therefore, these factors need to be considered in future research in order to be able to predict injuries from risk behaviours (Jessor 1991).

Yet, eating raw nuts and dried melon seeds is a common behavioural trait among Saudi adolescents, unlike many other countries, and this could have an influence on the high rates of TDIs experienced in this population. It is not yet clear how much damage can this habit exactly cause to the teeth, but it may lead to tooth fractures following to an impulsive and strong bite. In this study, 10.7% of those with TDIs (6.9% among the boys and 20.0% among girls) reported eating or peeling hard food and nuts as the reason for their TDIs. These figures could even be underestimated as they only reflect the proportions out of only 48.7% of adolescents with TDIs who could remember the "cause" for this (Table 11). This behavioural characteristic among adolescents in Saudi Arabia could also explain the high proportion of the simple enamel fractures in this sample (33.1%; 46.2% among boys and 19.5% among girls) compared to the more complicated type of TDIs (Table 10). Previous studies among adolescents in the same city did not assess this factor, despite mentioning it as one of the plausible explanations for the high prevalence of TDIs (Al-Majed et al. 2001). However, a study among adolescents in Thailand acknowledged this kind of behaviour and found that a high proportion of TDIs was related to chewing bones and dissecting crab shells, which are common habits among that population (Huang et al. 2009).

4.2.5. Associations between peer influence and TDIs

Peer relationships influenced the risk of TDIs among adolescents. Higher risk of TDIs was found among adolescents who had less than three close friends, spent more than 3 days a week with friends after school and whose peers carried weapons, compared to their counterparts. The significant role of peers on TDIs found in this study support the very limited literature available to date, from a single hospital-based study that showed a link between peer relationship problems and higher levels of TDIs (Odoi et al. 2002). The current study covered a wide range of peer relationship characteristics compared to the study by Odoi and his colleague which only covered peer relationship role briefly within a broad measure covering multiple behavioural and emotional constructs among children (Goodman 1997). In addition, the current study used adolescents' self-reports whereas parents' reports were used by Odoi et al. (2002) which showed less validity in judging children peer relationships (Stone et al. 2010). In addition, the population-based sample used in the current study allowed for more defined population from which the TDIs cases arose compared to the hospital-based sample design employed in Odoi et al. (2002).

The current findings that indicate peer influence components are linked to TDIs could be explained by the socialisation process between adolescents and their peers (Brechwald and Prinstein 2011; Christensen and Morrongiello 1997; Dishion and Owen 2002; Giletta et al. 2012; Hall and Valente 2007; Plumert and Schwebel 1997; Prinstein et al. 2010; Simons-Morton and Chen 2006). The increased influence of peers during adolescence as they begin to explore and emphasise their independence can impact their behaviours and decision-making while striving to conform to their peers' norms. Socialising with peers can influence adolescents to engage in certain behaviours or an indirectly influence through the perceptions of the adolescents themselves about their groups' beliefs, norms and anticipations (Simons-Morton and Chen 2006). However, other research indicates that this influence could also be a selection process in which adolescents with similar behaviours and personalities tend to select like-minded peers

(Allen et al. 2006; Brechwald and Prinstein 2011; Duncan et al. 2000). Nevertheless, these interactions are important feature during adolescents' developmental stage as they are ways of satisfying the need to feel loved and accepted by a group (Baumeister and Leary 1995; Osterman 2000). In addition, it showed a vital role toward developing autonomy, identity and social competence (Currie et al. 2008a; Currie et al. 2012).

The higher risk of TDIs found among adolescents who had less than three close friends in the current study highlights the importance of establishing peer relationships during this age group. This is critical for adolescents as it has a long-term effect on their social adjustment (Poulin and Chan 2010) and development of social competencies (Hartup 1996). Adolescents with few friends were more prone to become victims of bullying and fights (Larson and Richards 1991).

The higher risk of TDIs among adolescents whose peers carried weapons highlights the importance of adolescents' perception of their peers' engagement in risk behaviours. The importance of this indicator comes from the evidence supporting social comparison and behaviour approximation effects which showed a strong link to peer influence (Brechwald and Prinstein 2011). It seems that the perceptions of adolescents that their peers are engaging in risk-behaviours, carrying weapons in this case, might increase the chances of engagement in the same or similar behaviours, which ultimately increase their chances of having TDIs.

The higher risk of TDIs found among adolescents who spent more than 3 days a week with friends after school might relate to the evidence from many previous research showing that the chances of adolescents reporting risk behaviours is linked to the number of times they get out with their friends (Brown et al. 2001; Kuntsche et al. 2009). This increased in the risk behaviours among adolescents showed significant associations with increased risk of TDIs (Tables 15 to 22) as well as many other types of injuries (de Looze et al. 2012; Pickett et al. 2006; Pickett et al. 2002a; Turner et al. 2004). Therefore, it seems that the increase in adolescents' time spent with their friends outside their homes affect their risk of TDIs indirectly

through the influence of their peers that increase their chances of engaging in more risk behaviours.

4.2.6. The effect of peer influence on the association between risk-taking and TDIs

In addition to its direct link to TDIs, peer influence modified the relationship between risk-taking behaviours and these injuries. Among the high-risk TDIs group who reported carrying weapons, the sub-group with non-supporting peers had a significantly higher risk of TDIs compared to those with supportive peers. The same was with adolescents with multiple risk-taking behaviours as they showed higher risk of TDIs among the sub-group with non-supporting peers compared to the supportive peers sub-group. These findings indicate that beside its direct effect on TDIs, peer support can modify the effect of risk-taking behaviours on TDIs. This finding is supported by research indicating that supportive social environments are a protecting factor for adolescents from engaging in these risk-taking behaviours and the occurrence of some forms of injury (Freeman et al. 2011; Pickett et al. 2006). This support from peers could be crucial among adolescents as they seek to replace their parental support. Peers play an important role in helping adolescents to solve problems and control situations that could lead to an injury (Smith et al. 1990).

The study also showed another effect modification mechanism among girl smokers. Within this group, girls who had no difficulties in communication with their best friends had a high risk of TDIs while this was not significant among the other sub-group. This suggests that the increase in exposure to peer influence among high risk-taking girls increases their risk of TDIs. One explanation is that many girls in Saudi Arabia are faced with cultural and social restrictions in relation to going out with friends, unlike boys for whom this is much more common. Therefore, the fact that those already high risk-takers are more capable of communicating with their peers could expose them to more negative peer influence which in turn increased their risk of TDIs.

Another interesting effect modification found among the girl smokers is that the risk of TDIs within this high-risk group was higher among the sub-group with peers who never carried weapons compared to the sub-group with peers perceived of carrying weapons. In addition, within adolescents with multiple risk-taking behaviours who were a high-risk group in relation to TDIs, the sub-group with peers participating in organised activities had a high risk of TDIs, while this was statistically not significant in the other sub-group of peers not participating in such activities.

The current findings indicating that peers influence could modify the risk of TDIs among risk-taking adolescents further support the idea that social contacts can significantly affect attitudes and behaviours during this critical developmental stage (Crosnoe et al. 2003; Fishbein and Ajzen 1975; Glaser et al. 2010; Ladd 2005; Maisto et al. 1999; Oetting and Beauvais 1987; Simons-Morton and Farhat 2010; Urberg 1992). This might be because adolescents at this age are trying to satisfy their need to feel loved and accepted by their peers and to establish their own autonomy and identity (Baumeister and Leary 1995; Osterman 2000), which in turn influences their behaviours (Currie et al. 2008a; Currie et al. 2012). This influence was seen in this study in forms of both directly on an adolescent to engage in risk-taking behaviour, such smoking and carrying weapons, or as an indirect influence through the perceptions of the adolescent himself/herself about their groups' norms and behaviours, such as peers carrying weapons and involved in physical activities, which support wide range of previous research (Borsari and Carey 2001; Brechwald and Prinstein 2011; Kobus 2003; Simons-Morton and Chen 2006; Tyas and Pederson 1998).

4.3. Strengths and limitations of the study

4.3.1. Strengths of the study

The present study has several strengths. First, it is the first study that assessed the prevalence of TDIs among both male and female adolescents in Saudi Arabia in the same study and using

standardised methods. Another strength is the use of stratified cluster random sampling to ensure better representativeness of the study population in Riyadh city. Therefore, the results can better reflect the prevalence of TDIs of male and female adolescents in this city.

In addition, the study is the first to assess the relationship between TDIs and risk-taking behaviours comprehensively among both male and female adolescents in Saudi Arabia while controlling for the potential confounding factors of age, sex, socioeconomic status, physical activity and overjet. The use of multiple indicators of risk-taking behaviours and the consistent findings across most of them increase the credibility of the evidence. Also, this is the first study to assess the relationship between TDIs and peer influence comprehensively among both male and female adolescents in Saudi Arabia while controlling for the potential confounding factors of age, sex, socioeconomic status, physical activity and overjet. The wide range of peer influence indicators used in the study provided a better picture of the role of those influences on TDIs and allowed for several aspects of the relationship to be evaluated.

Moreover, the current study is the first to assess the effect modification of peer influence on the relationship between risk-taking behaviours and TDIs among both male and female adolescents while controlling for the potential confounding factors of age, sex, socioeconomic status, physical activity and overjet. The consideration of this effect modification in the analysis of this study increases the robustness of the evidence of associations between TDIs, risk-taking behaviour and peer influence.

An additional strength of this study is the adoption of the highly standardised WHO HBSC and CDC YRBSS questionnaires which have been developed over several years and supported by comprehensive validation work (Brener et al. 2013; Centers for Disease Control and Prevention 2011b, 2013; Currie et al. 2010; Currie et al. 2008b; Currie et al. 2001). This improved the quality of the data collected on this survey. Also, the study benefited from the wide coverage of important indicators of adolescent risk-taking behaviours and peer influence constructs

(Brechwald and Prinstein 2011; Burk et al. 2012; Currie 2000; Currie et al. 2008a; Currie et al. 2004; Ladd 2005).

In addition, the present study used advanced statistical technique to assess the associations between TDIs, risk-taking behaviours and peer influence and went beyond previous dental studies on this aspect.

4.3.2. Limitations of the study

It is acknowledged that there are some limitations to this study. First, the cross-sectional nature of this survey does not allow associations between TDIs, risk-taking behaviours and peer influence to be interpreted in the context of cause and effect. Also, although the questionnaire items have been subjected to extensive piloting and validation (Brener et al. 2013; Centers for Disease Control and Prevention 2011b, 2013; Currie et al. 2010; Currie et al. 2008b; Currie et al. 2001), adolescents' self-reports to risk-taking behaviours and peer influence questions as well as some of the confounding variables, such as parent education and physical activity, might be influenced by recall and social desirability biases. This may lead to overestimation or underreporting of the real prevalence (Brener et al. 2003; Podsakoff et al. 2003; Schwarz 1999; Schwarz and Oyserman 2001). For example, the use of tobacco and drugs are prone to social and religious disapproval in Saudi Arabia and the laws prohibit the use of these products among adolescents. Therefore, there is an increased probability of underreporting these behaviours. On the other hand, adolescents might tend to over report their physical activities and parent education levels.

These concerns are generally applicable for self-reported measures. However, self-reports are important and a common in most surveys and different design elements were used in this study to minimise these biases. The use of anonymous questionnaires was one such example. Also, wording of the study questions and protocol towards reassuring respondents and encouraging them to answer truthfully should have further minimised any concerns among adolescents about being judged for what they report. For example, the questionnaires included instructions like "do

not write your name on this survey", "the answer you give will be kept private", "Answer the questions based on what you really do", "you may find some of the questions unusual, please take your time to read each questions carefully and answer it honestly" and "Remember, we are only interested in your opinion. It is not a test and there are no right or wrong answers."

Moreover, the use of self-administered, rather than interview-based, questionnaires also helps minimise the effects of social desirability as it reduces the salience of social cues by isolating the subject (Nederhof 1985; Podsakoff et al. 2003). Observational methods are an alternative to self-reported data for some of these variables, such as those related to risk-taking behaviours. However, they are time consuming, costly, and not free from bias either, therefore were not a real option for this study. On the other hand, previous research showed that confidentiality, anonymity of self-report reduces biases and provide accurate, reliable and valid data (Brener et al. 2003; Brener et al. 1995).

An additional potential source of bias relates to the non-respondent selection bias, which might occur as a result of the refusal of some children to participate (Grimes and Schulz 2002). However, the non-response rate was very small in this study, as none of the approached schools and only 8.7% of the recruited schoolchildren refused to participate.

Another potential limitation relates to the dichotomisation of some of the exposures and covariates that were employed in the analyses of this study. This approach might lead to loss of some information and reduction of statistical power (Altman and Royston 2006; MacCallum et al. 2002). However, the dichotomisation of these variables was based on public health recommendations and in that sense it was considered appropriate in order to assess their associations with TDIs while differentiating between health enhancing and health compromising behaviours in populations.

In regard to the clinical examinations, the prevalence of TDIs could be underestimated because some types of TDIs, such as concussions and subluxations can heal without leaving any clinical signs.

4.4. Conclusions

It can be concluded that:

1. Adolescents in Riyadh, Saudi Arabia had a very high prevalence of TDIs, with considerable variations in the prevalence in both sexes with a much higher prevalence among the boys than girls.
2. The risk of TDIs was significantly higher among adolescents who were higher risk-takers independent of their age, socioeconomic status, physical activity and incisor overjet level. However, this association varied between boys and girls. It was significant in girl smokers, boys who were involved in physical fights and both boys and girls who reported carrying weapons.
3. Both male and female adolescents who had multiple risk-taking behaviours had higher risk of TDIs compared to those who had only one or were not showing any of the studied risk-taking behaviours.
4. The risk of TDIs was higher among boys who had negative peer influence from multiple aspects related to the quality and quantity of peer relationships independent of their age, socioeconomic status, physical activity and incisor overjet level.
5. The associations of carrying weapons as well as having multiple risk-taking behaviours with TDIs were intensified among adolescents that reported lack of peer support, a form of negative peer influences.

4.5. Implications for public health research and practice

The study findings should inform the research agenda in adolescent health. There is a fundamental need for aetiological studies on TDIs to be theoretically based. These kinds of studies should consider the underlying behavioural and psychosocial mechanisms linked to TDIs. Also, future research should address the determinants of risk-taking behaviours related to TDIs among adolescents, such as smoking, physical fighting and weapon carrying, and assess how they vary between adolescents. The research agenda should also consider further assessing the peer group characteristics that could protect adolescents from TDIs, or conversely put them at increased risk. In addition, future studies should also explore and analyse other relevant behavioural and psychosocial factors in relation to TDIs and its relationship to key socioeconomic factors, such as educational level of parents, to further explore the role of broader social determinants in the occurrence of TDIs.

The current study findings also provide objective data to inform preventive initiatives. For example, fighting and weapon carrying might be early indicators for engaging in other forms of violent behaviour. In addition, the results suggest that prevention programmes should begin early to prevent the potential escalation from fighting and weapon carrying to TDIs. These initiatives could be directed to adolescents and their social contexts by integrating different strategies and incorporating a wide range of interventions channels, such as the media and schools curriculums. In addition, programs that emphasize the development of social skills and conflict resolution can also help in decreasing aggression and injuries (Bonell et al. 2013; Durlak et al. 2011; Hahn et al. 2007; Howard et al. 1999).

TDIs should be recognised as a major dental public health issue among adolescents, especially in countries with a high prevalence of these injuries. Health policy on the prevention of adolescents' TDIs requires a solid evidence base, and the current study findings identified groups of modifiable risk behaviours and social contexts associated with TIDs among adolescents that can be targeted. The occurrence of TDIs could therefore be decreased if these

behavioural patterns were included as part of a comprehensive prevention strategy that focus upon the aetiologies of TDIs as well as the risk oriented social contexts. Longitudinal studies and a panel of cross-sectional studies over time are needed to assess the role of these determinants on TDIs over time. The use of longitudinal studies could predict casual pathways with some determinants of TDIs while the use of panel of cross-sectional studies can help providing data on trends of TDIs, especially in countries that lack this kind of research like Saudi Arabia. This should be followed by studies assessing the effectiveness of TDIs prevention interventions directed to adolescents at higher risk of TDIs as well as the psychosocial contexts aggregating these injuries.

Last, the findings of the present study highlight the need for implementing a Saudi national surveillance system similar to the WHO HBSC survey in European countries (Currie 2000; Currie et al. 2008a; Currie et al. 2004; Currie et al. 2012; King 1996) and the CDC YRBSS survey in the US (Centers for Disease Control and Prevention 2011b). This should provide comparable data to monitor health-related behaviours in Saudi Arabia and enable better planning for research and interventions.

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