THE RELATIONSHIP BETWEEN SCHOOL ENVIRONMENT AND CHILDHOOD TRAUMATIC DENTAL INJURIES

by

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ABSTRACT

Traumatic dental injuries are a major public health problem. There is a relatively little information about the epidemiology of traumatic dental injuries and in particular, their determinants. Since the school environment may be a factor contributing to trauma in general, attending a supportive school may reduce the frequency of traumatic dental injuries. The objective of this study was to assess the prevalence of traumatic dental injuries and investigate the relationships between traumatic dental injuries and the schools' social and physical environment. A cross-sectional study was carried out in 52 schools in an urban area of Thailand on a sample of 2,725 children. Cluster analyses were performed to classify the schools as supportive and non-supportive schools according to social and physical environmental characteristics. Associations between traumatic dental injuries and school environments were carried out using multilevel analyses, taking into consideration school variations and controlling for confounding factors at the children' level. The results show that 954 children (35.0%) experienced traumatic dental injuries. The associations between traumatic dental injuries and the school environments were sequentially adjusted for sex, marital status of parent, employment status of parent, family income, educational status of parent, anterior tooth protrusion and body mass index. The prevalence of traumatic dental injuries was significantly lower in the schools with a supportive social environment, Crude OR = 0.6 (95% CI = 0.4 to 0.8, p = 0.004). After controlling for the confounding factors, the adjusted OR was 0.7 (95% CI = 0.5 to 0.9, p = 0.02). This statistically significant association existed in males

but only an insignificant tendency of association was found in females. There was no statistically significant association between traumatic dental injuries and the physical environment of the schools. Nevertheless, an insignificant tendency of association appeared in females. It is concluded that traumatic dental injuries are significantly lower in male children attending schools with supportive social environments.

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Chapter 1

1.1 Introduction

1.1.1 Introductory remarks

The epidemic of injuries may be among the most neglected problems of the late 21^{st} century even though this problem together with the epidemic of non-communicable diseases is one of four major challenges confronting human health at the end of the 20th century (WHO, 1996). The burden of all injuries is expected to be equal to that of all communicable diseases world-wide by 2020, and to exceed it in China, Latin America, and Caribbean (WHO, 1996). In Other Asia and Islands (OAI), including Thailand, the burden has increased from 14.4 percent of all deaths in 1990 to 17.2 percent expected in 2020 (WHO, 1996). The death rate from accidents and poisonings in Thailand has been ranked only second to coronary diseases, and the trend has not decreased (Division of Health Statistics, 1995).

Despite being a world-wide major public health problem (Smith & Barss, 1991; Berger & Mohan, 1996), in Thailand, limited attention has been paid to injuries. This may be, in part, due to lack of interest and co-existence of other competing health problems. As can be seen from the National Health Development Plans, there has not been any special plan for the control and prevention of *traumatic dental injury* (see Appendix 1 for the definition of terms) as there is for dental caries and periodontitis (Ministry of Public Health, 1990). More importantly, the present knowledge and understanding among health professionals of treatment and prevention of traumatic dental injury, particularly in countries such as Thailand, is not adequate for health professionals to better control and prevent the problem.

A conceptual framework of the epidemiology of injury developed by Haddon (1980) was used in approaching the study of traumatic dental injuries in Chiang Mai urban area of Thailand. Haddon (1980) created a matrix that has proved useful for conceptualizing the prevention of injuries. The matrix has two dimensions. The first dimension is divided into three time phases of injury event—'pre-event', 'event', and 'post-event' factors. However, this thesis will study only 'pre-event' and 'event' factors. Human, vehicle or vector, and environmental factors are the second dimension, which are the determinants of injury.

The environmental factors in the second dimension will be the main interest of this study. This motivation has arisen firstly from a fact that the environment is the primary determinant of general health (McKeown, 1979), which is consistent with the view that a poor physical environment contributes to poor health (Towner, 1993; Marmot & Wilkinson, 1999). Boyce et al. (1989a) also suggested that preventive strategies might benefit from investigation of socio-environmental factors that alter the risk of injuries. Those perspectives were the basis for the study of how the physical and social environments surrounding children may affect their traumatic dental injuries.

1.1.2 The Social Determinants of Health

The health of populations is related to features of society and its social and economic organisation (Acheson, 1999). The major causes of morbidity and mortality in developed countries are related to the social environment. Increasingly, these are also the major health problems for the developing world (Marmot & Wilkinson, 1999). Indeed, Marmot (2001) has said that "Health and disease are socially patterned. Rates of occurrence of disease states vary according to social and economic conditions, culture and other environmental factors". In children, the influence on health and physical health status, developmental maturation, and emotional well-being, is determined by physical, social and cultural factors (WHO, 1991; Stokols et al., 1996; WHO, 1997). The social and economic determinants largely account for the well-established social class differences in health in all societies (Acheson, 1998).

Lalonde (1974), in a seminal report on the health of Canadians, divided the causes of health and disease into four components including health services, human biology, lifestyle and environment. The latter two can be considered as social determinants. Individual behaviour and lifestyle are major determinants of health (McKeown, 1979). However, more recently there has been a shift of emphasis away from individual lifestyle. Focus on lifestyle led to 'victim blaming' which in turn directed attention away from the root causes of behaviour. Lifestyle is frequently considered a consciously chosen personal behaviour. However, it is "a composite expression of the social and cultural circumstances that condition and constrain behavior in addition to the personal decisions the individual may make" (Green & Kreuter, 1990). People make choices within the options available to them (Milio, 1981). These options are determined by the environment, which in turn is determined by government and corporate policies. The environment can contain health promoting and health damaging circumstances. Health is determined by the differing exposure to these circumstances. Living conditions provide the context in which lifestyles are sustained (Blane, 1985; Graham, 1990). Indeed, Blane (1985) has argued that the causative role of individual behaviours has been exaggerated. They should be seen "... as indicators of other factors which are more straightforwardly related to the social structure, and which are the true aetiological agents" (Blane, 1985).

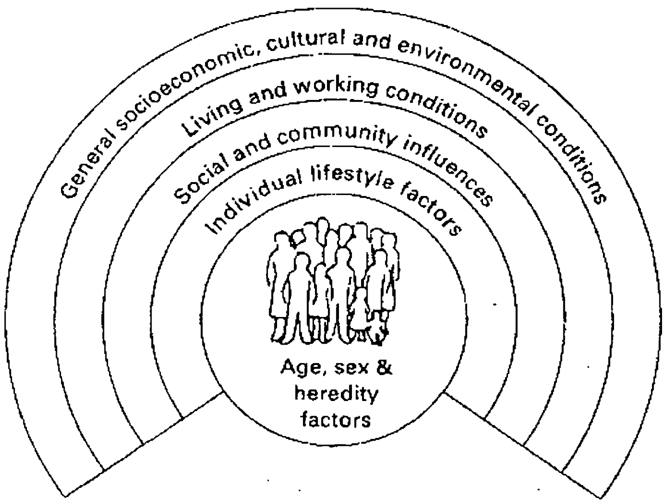
The complexity of factors determining health related behaviour is highlighted by both Milio (1981) and Hunt and McLeod (1987). Thus, lifestyles could be subdivided into freely chosen behaviours and those dependent on the socio-cultural and economic environment over which the individual has less control. The latter are more important, and therefore have become more significant determinants to investigate. This refocussing on the social determinants, sometimes called 'the new public health' (Martin & McQueen 1989), links public with public health's traditional concerns with the physical environment. 'Pure air, water and light' were the aims of the Health of the

Towns Association (Dubos, 1979). McKeown (1979) has shown conclusively that the environment and not medicine determines health. The most common causes of death in the 19th and early 20th century England were airborne, water on food borne and other types of infectious disease. McKeown (1976) concluded that the decline of these diseases was due, in chronological and numerical order of importance, to improved nutrition, better hygiene, behavioural influences (particularly control of reproduction) and lastly, the advent of effective immunisation and therapy.

1.1.3 The environment as a determinant of health

Dahlgren and Whitehead (1986) put forward a model of determinants of health, which includes the psychosocial and economic environment, personal behaviour and human biology as the main pillars of health within the spheres of person, family, community and culture. The outline of this general framework of the determinants of health is shown in Figure 1. The framework shows the interconnections of lifestyle and environmental factors. They also highlight that much research to improve health focuses on the biological factors in the innermost circle, or on individual lifestyle factors. But, as outlined earlier, living and working and learning conditions play a significant role in determining lifestyle.

Figure 1 A framework of the determinants of health (Dahlgren & Whitehead, 1986)



Milio (1981) identifies two main categories of health determinants; the environment and behaviour. Milio (1981) also cites research on the effects of single factors and the interaction of multiple factors. Individual determinants have effects which are dose-related and/or cumulative. Several factors can combine 'incrementally' to increase the risk of illness. In a 'multiplicative' increment, the combination of two risks equals more than the sum of the individual risks (Milio, 1981).

On the basis of this review indicating the great importance of social determinants of health, the social and physical environments of schools will be investigated as 'determinants' of dental injuries. As there is an interaction between the social determinants and individual biological characteristics, two biological factors which have been shown to be related to traumatic dental injuries, anterior teeth overjet and body mass index (BMI), will be used to assess the role of biological factors.

In this chapter, the next section (Section 1.2) outlines the justification for claiming that injuries are a major public health problem. General problems of injury are outlined both on a global basis and in Thailand. Following that (Section 1.3), concepts of the epidemiology of injuries are presented, particularly the epidemiological conceptual framework of injury developed by Haddon (1980). In the literature reviews (Section 1.4), general and traumatic dental injuries are defined and discussed mainly based on the second dimension of Haddon's matrix (the determinants of injury). After the literature reviews, the conceptual framework of the study of traumatic dental injuries in schoolchildren (Section 1.5), the hypothesis (Section 1.6) and the objectives (Section 1.7) of this thesis are defined.

In Chapter 2, the details of the methods used in this study are explained. Chapter 3 is the results, and Chapter 4 is the discussion and conclusion of the study.

1.2 Injury: a major public health problem

Injuries have been recognized world-wide as a major public health problem (Smith & Barss, 1991; Berger & Mohan, 1996). They are a major cause of mortality and disability. The burden of injuries world-wide measured in terms of disability-adjusted life years (DALY) are predicted to increase from 15.1 per cent of all disease burdens in 1990 to 20.1 per cent expected in 2020. In Other Asia and Islands (OAI), including Thailand, it may increase from 14.4 in 1990 to 17.2 percent in 2020 of all diseases. In addition, road traffic accidents, which are the major causes of injury, are one of the ten leading causes of death world-wide rising in the ranking from 9th in 1990 to 3rd in 2020 and from 11th to 2nd among demographically developing countries (Murray & Lopez, 1996).

In Thailand, infectious diseases were considered to be the largest health problem in the Asian region. Now, as a result of immunisation and other efforts to combat such diseases, they are less threatening to children. On the other hand, the incidence of injuries in Thailand has not decreased and they are one of the leading causes of death. The death rate from accidents and poisonings ranked only second to coronary diseases. There were 35.1 deaths per 100,000 as a result of accidents and poisonings in 1989 and the rate increased to 52.7 per 100,000 in 1993. Moreover, the death rates of suicide, homicide, and other injuries were higher than communicable diseases between 1989 to 1993 even though the rates slightly decreased from 16.3 to 14.7 per 100,000 people. These rates are more important because 75 per cent of accidental deaths are in people between 15-45 years of age which are the most productive years of life, whilst heart diseases accounted for only 25 percent of deaths in the same age category (Division of Health Statistics, 1995).

In spite of the low public health profile, the impact of injuries on communities and economies is profound. They tend to be concentrated in younger people and can result in long-term disability (Office of Population Censuses and Surveys, 1992). They affect productivity severely, particularly among the lowest income groups whose exposure to risk is greatest and whose earning capacity is most likely to rely on physical activity (Dougherty et al., 1990; Robert & Power, 1996).

In addition, physical injury leads to high rates of psychological sequelae among traumatised individuals (Helzer et al., 1987; Resnick et al., 1992; Vingilis et al., 1996). Facial injury, for example, is a common result of trauma such as accidents and particularly assaults and often results in long-term deformity and disability (Shepherd et al., 1990). Approximately one third of the patients with facial fractures had some form of neurologic injury (Haug et al., 1990; Bisson & Shepherd, 1997). Vingilis et al., (1996) indicated that the major post-trauma problems from traffic accidents were depression, anxiety, family stress, financial problems and driving fears.

Traumatic dental injury leads to psychological and social impacts on the quality of life of children (Cortes, 2001) as well as causing colour changes in teeth, pulp necrosis, pulp canal obliteration, gingival retraction, permanent displacement after luxation, pathological root resorption, and premature tooth loss (Andreasen & Andreasen, 1994; Borum & Andreasen, 1998). Moreover, the premature loss of primary dentition may affect eruption and alignment of the permanent successors (Ash, 1957; Korf, 1965).

There has been a remarkable decline in the prevalence and severity of dental caries amongst children in many counties (Burt, 1985; Petersson & Bratthall, 1996). The reduction of dental caries problem may have made traumatic dental injuries the most serious public dental health problem among youth in some countries (Andreasen & Andreasen, 1989).

Injury is an important health problem world-wide, particularly among developing countries, because most of them still lack preventive measures for injuries. This is partly due to lack of finance, manpower, and better management. If developing countries, including Thailand, ignore this problem in the future, the problem of injuries may become much larger.

1.3 Concepts in the Epidemiology of injuries

Injuries have generally been epidemic or at least endemic, and measures for their control have been exceedingly diverse and widespread. Gordon (1949) is considered as the first person that understood the medical ecology of injuries. He suggested that injuries, being characterised by point epidemics, seasonal variation, long-term trends, and geographic, socio-economic, and rural-urban distributions, behave in many respects like the classic infectious diseases and diseases (Gordon, 1949). Later, Haddon (1970) and Waller (1987) have advanced several models of injury control. Haddon's matrix has been proven to be a successful tool for analysing injury producing events and recognising factors important to their prevention (Haddon, 1968; Haddon, 1972; Haddon, 1980).

In the simplest form, the Haddon matrix has two dimensions (Table 1). The first is based on the fact that all the undesirable societal end-results of damaging interactions with environmental hazards are preceded by processes that divide into three stages; pre-event, event, and post post-event. Pre-event factors determine if a crash, fall, shooting, fire, or other event will occur. Event factors operate during the incident to reduce or completely prevent injury. Post-event factors determine the outcome once an injury has occurred. The second dimension of Haddon's matrix is divided into the three factors; 'human' (or host), 'vehicle' (or 'vector'), and 'environment'. 'Environment' is often subdivided into 'physical' and 'social'.

Table 1 Haddon's matrix (Haddon, 1980)

<table>
<tr><th rowspan="3">First dimension</th><th colspan="4">Second dimension</th></tr>
<tr><th rowspan="2">Vehicle (Vector)</th><th rowspan="2">Human (Host)</th><th colspan="2">Environment</th></tr>
<tr><th>Physical</th><th>Social</th></tr>
<tr><td>Pre-event</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Event</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Post-event</td><td></td><td></td><td></td><td></td></tr>
</table>

Factors of 'human' (or 'host'), 'vehicle' (or 'vector'), and environment were used as a basis for the review of general and traumatic dental injuries of the first dimension, this review will focus only on pre-event and event factors.

1.4 Literature review

The first section of this literature review is a review of general injuries, which are described according to the second dimension of Haddon's matrix, namely host, vehicle and environmental factors. The second section is a review of traumatic dental injuries, which presents the prevalence, incidence, severity and trends of traumatic dental injures to permanent teeth. After that, the causes of traumatic dental injuries are presented. Then, traumatic dental injuries are described according to the second dimension of Haddon's matrix. Then the related activities leading to injuries are reviewed. In particular, the role of *school environments* (see Appendix 1 for the definition of terms) as determinants of injuries is discussed.

1.4.1 General injuries

This section presents a literature review of general injuries according to the second dimension of Haddon's matrix (host, vehicle, and environmental factors).

1.4.1.1 Host factors and general injuries

1.4.1.1.1 Age and sex

Factors relating to humans, such as age and sex, are the common potential risk factors in epidemiological studies including epidemiological studies of injury, and have been demonstrated in many studies.

Injury rates vary widely across the ages and depend upon the type of injuries. A peak rate of school accidents was at about 10-13 years of age (Sheps & Evans, 1987; Stark et al., 1996). Home injury is higher in younger children particularly falls and being struck by objects (Hu et al., 1993). Pedestrian injuries are higher in young schoolchildren (Rivara & Barber, 1985). In Thailand, road traffic accidents are higher in older children and early adolescence (Junnanond, 1993).

Sex differences in injury rates are often cited but little explored even though both on the global and regional basis there are differences. The burden of injury world-wide in males (18.7%) was approximately twice that in females (11.2%) in 1990. This excess of injury burden in males appeared in every region of the world (Murray & Lopez, 1996). In children and early adolescence, at virtually all ages, boys had higher injury rates than girls for all locations and most causes (Scheidt & Jones, 1995; Gofin et al., 1989; Gallagher et al., 1984; Fife et al., 1984; Rivara et al., 1982; Danseco et al., 2000). The study of non-fatal accidents during 1995 and 1996 in England also shows the higher accident rates in males than females, particularly during the teens, for both major and minor accidents (Prescott-Clarke & Primatesta, 1998). In addition, there was a report of the incidence of childhood injuries in the United States of America during 1987 to 1994, which was analysed from National Health Interview Survey (NHIS) data (Danseco et al., 2000). For children aged 10 to 14 years, the incidence of injuries occurring at school, street and place of recreation was higher in males than females. However, there was no sex difference for injuries occurring at home, farm and industrial place.

It is impossible to change these two human factors, age and sex, to prevent injury. Nevertheless, exploring under which conditions the rates of injury change will provide more information and understanding of the nature of injury.

1.4.1.1.2 Anatomical factors

Anatomy of humans can be risk factors of injuries. Falls from heights such as beds and tables in children cause few injuries (Helfer and Slovis, 1977) but in adults the same heights often cause severe injuries (Svanstrom, 1974). In pedestrian-motor vehicle collisions, heads were the most common injured part in children probably because of the height of the body relative to the impacting parts of the cars and relatively large size of children's heads, which results in higher centres of gravity (Rivara, 1982).

Jeanneret et al. (1987) investigated the relationships between individual morphological profiles and injury patterns among children aged 12 to 15 years old. They found that slightly muscled children injured more frequently in physical training and on apparatus, generally by not performing an exercise correctly. The rather tall and light children injured more frequently during ball games. The rather tall and muscled children often injured in the course of gymnastics on the ground or on apparatus, principally by faulty performance of an exercise. However, Pretidou et al. (1994) found that height and Body

Mass Index (BMI) of children did not significantly predict occurrence of general injuries.

1.4.1.1.3 Psychological factors

Psychological factors can contribute to injury risk and have been explored in schoolchildren (Suchman, 1970; Johnson et al., 1974; Coppens & Gentry, 1991; Catado et al., 1992; Hammarström & Janlert, 1994).

Suchman (1970) carried out a study in two high schools in Pittsburgh, USA, reported that it was more likely that the injury occurrences were two or more times in the previous year in children who exhibited behavioural patterns such as fighting, disobeying teachers, being punished for misbehaviour and drinking alcohol. Children who exhibited negative attitudes and values, such as taking chances even if this meant possibly getting hurt and finding driving in a fast car thrilling, had higher risk to have injuries. Accidental injuries were also more common in children who described themselves as being wild, daring, like showing off, often losing their temper and being careless.

Johnson et al. (1974) conducted a study of student injuries in the Seattle public schools during the school year 1969-1970. They found that school injury is correlated with abnormally aggressive behaviour. In total, 13 per cent of the injuries investigated were described as due to aggressive behaviour. However, a study conducted in Sweden (Hammarström & Janlert, 1994) reported the injuries caused by aggressive behaviour was as high as 25 per cent. Aggression injuries decreased from elementary grades through junior-high grades, and pushing predominated in elementary schools, and fighting among boys in junior-high and senior-high schools (Johnson et al., 1974).

Coppens and Gentry (1991) conducted an observational study using a video camera recorder to examine injury-risk situation as occurring during playground recess periods. They found schoolyard aggressive behaviours to be more often reported among boys than girls and more frequently with non-teacher than teacher monitors. In addition, Catado et al. (1992) also reported that injured children were more disruptive, more active, and had more contacts with hazards, whereas uninjured children had more appropriate behaviour.

Alcohol and drug use are correlated with motor vehicle injuries (Soderstrom et al., 1979; Jessor et al., 1980; Mayhew et al., 1986). Among US high school students, 17 per cent of all students in a study reported drinking and driving at least once in the last month (Escobedo, 1994). The prevalence of reported alcohol use, binge drinking, and alcohol plus other drug use increased with age, and first use of alcohol at age 14 or younger also increased with declining school performance (Escobedo et al., 1995). Among people who drive after drinking, the relative risk of being involved in a crash is greater for young persons at all blood alcohol concentrations than it is for older persons (Jesser et al., 1980). Soderstrom (1979) also reported that, in Baltimore, detectable levels of blood alcohol were found in 40 per cent of teenage victims of automobile-related injuries and 25 per cent of victims of motorcycle-related injuries.

1.4.1.1.4 Socio-economic factors

Socio-economic status of human is also important in initiating the occurrence of injuries. There is extensive evidence indicating that children living in poverty have higher injury rates (Read et al., 1963; Velcek et al., 1977; Mackay et al., 1979; Dougherty et al., 1990; Towner et al., 1994; Robert & Power, 1996).

Robert and Power (1996) studied whether the decline in child death rates due to injuries between 1981 and 1991 in England and Wales varied by social class. They found that childhood injuries are closely linked with social deprivation. Children from poorer background are five times more likely to die as a result of an accident than children from better off families. The child death rates in social class IV and V (poorer) decreased by only 21 and 2 per cent respectively while those rates in social class I and II (more affluent) decreased by 32 and 37 percent.

A study conducted by Petridou et al. (1994) measured the effects of a number of family-related variables. It revealed that low level of parental education and family disruption (single parenthood) are strongly correlated to school-injury experience.

1.4.1.2 Vehicle factors and general injuries

Gibson (1961) clearly identified the necessary, specific agents of injuries as 'Man's... responses... to the flux of energy which surrounds him – gravitational and mechanical, radiant, thermal and chemical. Some limited fields and ranges of energy provide stimuli for his sense organ; others induce physiological adjustments; still others produce injury... Injuries to living organism can be produced only by some energy interchange. Consequently, a most effective way of clarifying sources of injury is according to the form of physical energy involved. Physical energy is mechanical, thermal, radiant, chemical, or electrical.'

Haddon (1980) also stated that 'Several kinds of energy are the necessary, specific causes of such injuries as lacerations, burns, electrocutions, acute radiation effects, and corrosive burns, and that other injuries involve agents such as water (as in drowning), carbon monoxide, and cyanide that specially interfere with normal body energy exchange.'

However, energy that may reach the body and substances that may interfere with its normal function are usually carried by inanimate objects or living organisms corresponding to 'vehicles' and 'vectors' of infectious diseases (Haddon, 1980). For examples, electric lines are vehicles of electricity, hot rivets are vehicles of thermal energy, poison containers are vehicles of their contents, animals are vehicles of their toxins, and moving objects are vehicles of mechanical energy.

The modification of consumer products has decreased the incidence of childhood injuries. For example, the use of child-resistant caps for medications and household poisons and limits on the number of pills in a single vial for many over-the-counter medications saved the lives of about

460 children under the age of five between 1974 and 1992 (Thomas et al., 1996).

1.4.1.3 Environmental factors and general injuries

The environment can be considered in terms of physical and social dimensions. The physical and social environment do not exist independently of each other; any environment is the result of the continuing interaction between natural and man-made components, social processes, and relationships between individual and group (Syme, 1996). In Illich's (1984) critique of modern medicine, he concluded that the environment is the primary determinant of the state of general health of any population.

1.4.1.3.1 Physical environment

The physical environment plays an important role in the occurrence of event leading to injury. For instance, Hu et al. (1993) found that injuries in children occurred more frequently during warm/hot seasons. This may be because during those seasons days are longer than nights so children have more time to take risks. However, this cannot be generalised to Thai children because in Thailand the day and the night are approximately equal in every season. On the other hand, in the rainy season children may have more indoor activities. Therefore the pattern and severity of traumatic injury may change during this season compared to other seasons.

Providing a favourable physical environment can reduce the frequency and severity of injuries. In the design of stairs, for instance, it has been shown that U-shaped two-flight stairs cause substantially fewer accidents than straight, single-flight stairs (Svanstrom, 1974). This will be useful for the new buildings, not for existing buildings unless they are to be rebuilt. 'High rise' bikes are more unstable and dangerous than standard bikes (Waller, 1971; Thorson, 1974). Playground equipment such as climbing frames and slides seem to be associated with more severe injuries than swings or other equipment (Illingworth et al., 1975). Playground surfaces or other types of floors made with soft materials such as sand, sponge, rubber matting and thick carpet are less dangerous than those made of harder materials such as concrete, asphalt, wood and metal.

Svanstrom (1974) studied fall accidents on staircases and reported that 20 per cent of all accidents were from inadequate lighting, wear and loose objects, and moistness or dirt on or nearby the staircases. Improving and regularly paying more attention to the environment such as fixing the lights or brightening with a new one, fixing the objects, and cleaning may reduce this problem.

In addition, 'Traffic calming' efforts to reduce or slow the speed of traffic in neighbourhoods have successfully reduced the risk of pedestrian injuries in Europe and in some American cities (Vis et al., 1992; Engel & Thomsen, 1992). These strategies include lowering speed limits in residential areas, installing speed bumps, and routing heavy traffic away from neighbourhoods.

Moreover, a matched case-control study in Germany reported that significant associations with injury risk were identified for some pre-specified modifiable environmental factors (Von-Kries et al., 1998). The results showed that there were significantly more streets with a speed limit of 30 km/h around the homes of controls than cases. There were also significantly more pedestrian crossings with traffic lights on streets with a speed limit 50 km/h or above around the homes of controls compared with cases. Finally, there were significantly more playgrounds around the houses of controls compared with cases.

1.4.1.3.2 Social environment

The social environment includes the group to which we belong, the neighbourhoods in which we live, the organisation of our workplaces, and the policies we create to order our lives (Yen & Syme, 1999). Haan et al. (1987) conducted an epidemiological study on environment. They examined the 9-year risk of mortality for residents of 'the poverty area' in Oakland. They found that the increased risk associated with residence in a poverty area was not affected after adjusting separately for age, sex, race, baseline physical health status, income, access to medical care, unemployment status, education, health practices, social isolation, and depression. It is suggested that residence affects health not only through an individual's socio-economic status, behaviours, or psychological factors but that something in the environment also powerfully affects the health of individuals.

The social environment was created by individuals and was also independent of them. Yen and Syme (1999) quoted Durkheim (1951) as an example of the attempt to explain social phenomenon that social environment can be explained in terms of both individual and group characteristics. Durkheim (1951) argued that people act together not only for similar purposes but also for a common purpose. He conducted statistical analyses of suicide data during the 1870s and 1880s and considered suicide as a 'group' phenomenon. He observed that suicide rates differed from locale to locale and that differences persisted over time. He suggested that the social environments played a role in creating a characteristic suicide rate for specific locations and that differences in social environments were responsible for these different rates. The common ideas, beliefs, customs, and tendencies of social group created a 'reality' that was more than the sum of individual ideas, beliefs, customs, and tendencies.

Factors of social environment also are important in initiating the occurrence of injuries. The incidence rate of injury in unsupervised areas where children are not supervised and where staff cannot reasonably be expected to have much control over children's actions, were associated with the greatest risk of injury in primary schools such as at playgrounds (Sheps & Evans, 1987; Stark et al., 1996).

A study conducted in an urban area of the USA reported that injury rate and severity tend to vary considerably from school to school (Boyce et al., 1984a). In this study, it was found that longer school hours, alternative curriculum, less experienced school nurses, and lower children-to-teacher ratio were significantly associated with higher injury rates. Both the studies conducted by Bell (1986) and that of Coppens and Gentry (1991) also revealed that lack of supervision in the playground was associated with a higher injury rate. Different type of schools (e.g. public and private schools, levels of organised supervision) might have different social environments, and this might affect the pattern, incidence and severity of injuries (Moysés, 2000).

1.4.2 Traumatic dental injuries

1.4.2.1 The prevalence, incidence, severity, and trends of traumatic dental injuries to permanent teeth

1.4.2.1.1 The prevalence of traumatic dental injuries

The prevalence of traumatic dental injuries to permanent teeth is relatively high among schoolchildren, varying across countries and ranging from 5.1 to 34.4 percent (Tables 2 to 6) (Source: based on Cortes, 2001) giving an average prevalence of 20 percent. The countries where the prevalence were reviewed were divided into 6 groups according to their regions and listed in alphabetical order, following the method adopted by WHO to report the DMFT in the Oral Health Country Profiles.

Among European countries (EURO)(Table 2), the prevalence of traumatic dental injuries to permanent teeth ranged from 8.7 per cent in Israel (Zadick et al., 1972) to 34.4 per cent in England (Hamilton et al., 1997). The majority of data were from the UK (Clarkson et al., 1973; Todd, 1975; Todd & Dodd, 1985; Hunter et al., 1990; O'Brien, 1994; Hamilton et al., 1997; Marcenes & Murray, 2000). Among Eastern Mediterranean (EMRO) countries (Table 3), the prevalence ranged from 5.1 (Baghdady et al., 1981b) to 19.2 per cent (Hamdan & Rock, 1995). Table 4 shows the prevalence in countries from the Americas (AMRO). The prevalence ranged from 5.0 (Oluwole & Leverett, 1986) to 20.4 per cent (Nicolau et al., 2001). In the African continent, the prevalence ranged from 15.4 (Hargreaves et al., 1995) to 19.1 per cent (Naqvi & Ogidan, 1990a) (Table 5). From the Western Pacific Region (WPRO), Australia and Japan had prevalence of 6.1 (Burton et al., 1985) and 21.8 (Uji, 1988) per cent (Table 6). However, there are no population-based prevalence data from 10 countries of South East Asia region (SEARO), including Thailand.

Table 2 Population-based studies on the prevalence of traumatic dental injuries to permanent teeth in countries from Europe (EURO)*

Country	Author (Year)	Age groups	Sample size	% Overall	% Highest (ages)
Denmark	Andreasen and Ravn (1972)	9-17	487	22.0	-
Finland	Järvinen (1979b)	6-16	1,614	19.8	35.1 (14)
France	Delattre et al. (1994)	6-15	2,020	13.6	19.8 (12)
Ireland	O'Mullane (1972)	6-19	2,792	13.0	23.6 (12)
Ireland	Holland et al. (1988)	8; 12; 15	7,171	-	16.4 (12 &15)
Israel	Zadick et al. (1972)	6-14	10,903	8.7	19.6 (13-14)
Italy	Petti and Tarsitani (1996)	6-11	824	20.3	33.7 (9)
Italy	Petti et al. (1997)	6-11	938	21.3	-
Sweden *(urban)*	Forsberg and Tedestam (1990)	7-15	1,635	18.0	-
Sweden *(rural)*	Joseffsson and Karlander (1994)	7-17	750	11.7	-
UK *(England)*	Clarkson et al. (1973)	11-17	756	9.8	10.7 (12)
UK *(England)* *(Wales)*	Todd (1975)	5-15	12,952	-	18.0 (12)
UK *(England)* *(Northern Ireland)* *(Scotland)* *(Wales)*	Todd and Dodd (1985)	8-15	22,375	-	26.0 (13-15)
UK *(South Wales)*	Hunter et al. (1990)	11-12	968	15.3	-
UK *(England)* *(Northern Ireland)* *(Scotland)* *(Wales)*	O'Brien (1994)	8-15	18,869	-	19.0 (13)
UK *(England)*	Hamilton et al. (1997)	11-14	2,022	34.4	-
UK *(England)*	Marcenes and Murray (2000)	14	2,242	23.7	-

* Source: based on Cortes (2001)

Table 3 Population-based studies on the prevalence of traumatic dental injuries to permanent teeth in countries from Eastern Mediterranean (EMRO)*

Country	Author	Age groups	Sample size	% Overall	% Highest (ages)
Iraq	Baghdady et al. (1981b)	6-12	6090	7.7	-
Jordan *(urban)*	Jamani and Fayyad (1991)	7-12	3041	10.5	15.0 (11-12)
Jordan *(Urban)*	Hamdan and Rock (1995)	10-12	234	19.2	-
Jordan *(rural)*	Hamdan and Rock (1995)	10-12	225	15.5	-
Syria	Marcenes et al. (1999)	9-12	1,087	8.0	11.7 (12)
Sudan	Baghdady et al. (1981b)	6-12	3057	5.1	-

* Source: based on Cortes (2001)

Table 4 Population-based studies on the prevalence of traumatic dental injuries to permanent teeth in countries from The Americas (AMRO)*

Country	Author	Age groups	Sample size	% Overall	% Highest (ages)
Brazil *(Bauru)*	Bijella (1972)	7-15	15675	6.0	23.5 (10-11)
Brazil *(Jaragua do Sul)*	Marcenes et al. (2000)	12	4760	15.3	-
Brazil *(Curitiba)*	Moyses (2000)	12	1,823	14.8	-
Brazil *(Horizonte)*	Cortes (2001)	9-14	3,702	12.1	16.1 (14)
Brazil *(Cianorte)*	Nicolau et al. (2001)	13	652	20.4	-
Dom Republic *(S.Domingo)*	Garcia-Godoy et al. (1981)	7-14	596	18.1	19.4 (14)
Dom Republic *(S.Domingo)*	Garcia-Godoy et al. (1985)	6-17	1200	12.2	13.7 (15)
Dom Republic *(S.Domingo)*	Garcia-Godoy et al. (1986)	7-16	596	18.9	-
USA	Macko et al. (1979)	12-15	1314	19.1	-
USA	Oluwole and Leverett (1986)	11-21	5000	5.0	-
USA**	Kaste et al. (1996)	6-20	3337	18.4	-
USA *(Florida)*	Kania et al. (1996)	7.0-12.6	3396	19.2	-

* Source: based on Cortes (2001)
** The National health and Nutrition Examination Surveys

Table 5 Population-based studies on the prevalence of traumatic dental injuries to permanent teeth in countries from Africa (AFRO)*

Country	Author	Age groups	Sample size	Prevalence (%)	
				Overall	Highest (age)
Kenya	Ng'Ang'et al. (1988)	13-15	250	16.8	-
Nigeria (Ibadan)	Falomo (1986)	10-17	250	16.0	-
Nigeria (Benin)	Naqvi and Ogidan (1990a)	9-16	1102	19.1	-
South Africa	Hargreaves et al. (1995)	11	1,035	15.4	-

* Source: based on Cortes (2001)

Table 6 Population-based studies reporting the prevalence of traumatic dental injuries to permanent teeth in countries from Western Pacific (WPRO)*

Country	Author (Year)	Age groups	Sample size	Prevalence (%)	
				Overall	Highest (age)
Australia *(NorthernSydney)*	Burton et al. (1985)	12-15	12,287	6.1	-
Japan	Uji (1988)	6-18	15,822	21.8	-

* Source: based on Cortes (2001)

1.4.2.1.2 The incidence of traumatic dental injuries

There were a few studies that reported the incidence of traumatic dental injuries. Stockwell (1988) studied 66,500 students aged 6 to 12 years in Perth, Australia. During a period of twelve months, 1.66 children and 2.05 teeth per 100 children received traumatic dental injuries to anterior permanent teeth.

In Sweden, Glendor et al. (1996) studied traumatic dental injuries occurring in a one-year period among children and adolescents aged 0 to 19 years (62,914 individuals). They reported that the incidence of traumatic dental injuries to both primary and permanent teeth was 13 per 1,000 per year. The age-specific rates of traumatic dental injuries of subjects aged 12 years was 13.5 per 1,000 per year.

1.4.2.1.3 The severity of traumatic dental injuries

Severity of traumatic dental injuries can be assessed by number of traumatised teeth per episode, number of traumatised teeth per person, and degree of damage to each involved tooth. Number of traumatised teeth per episode and degree of damage to each involved tooth show degrees of severity in each injury event. For example, a child falling down stairs and traumatising two teeth. The left maxillary central incisor was a fracture involving dentine without exposed pulp, and the right maxillary central incisor was luxation. Therefore, this information describes the amount of damage to the body parts of an injured subject from an injury event. Nevertheless, a number of traumatised teeth per person may be either a cumulative number of traumatised teeth from several injury events or the same number of traumatised teeth per episode if that subject experienced only a single injury event. Thus, reports on only number of traumatised teeth per person may be inadequate unless indicating that the number is from a single injury event.

Number of traumatised teeth

More than half of injured subjects in most studies had only one traumatised tooth per person to permanent incisors (Table 7) (Zadik et al., 1972;

Järvinen, 1979a; Jamani & Fayyad, 1991; Kaste et al., 1996; Cortes, 2001). Only one study reported nearly two-thirds of injured subjects having more than one traumatised tooth per person (Zerman & Cavalleri, 1993). Holland et al. (1994) reported 68 per cent of males and 79 per cent of females had a single traumatised incisor among 16-24 year-old. In contrast, the percentages of injured subjects having more than one traumatised incisors among older age groups (25-34 years) in both males (54 %) and females (54 %) were slightly higher than those having only a single traumatised incisor. The majority of subjects having only one traumatised tooth in the permanent dentition also is consistent in the studies which included canines or all teeth (Stockwell, 1988; Forsberg & Tedestam, 1990; Glendor et al., 1996), except in one study (Fleming et al., 1991).

Some studies stated clearly those with more than one traumatised tooth had one accident (Stockwell, 1988; Forsberg & Tedestam, 1990; Fleming et al., 1991; Zerman & Cavalleri, 1993; Glendor et al., 1996). Thus, injured subjects having more than one traumatised tooth in the other studies might be injured from either one or more than one injury event (Table 7).

Table 7 Percentage of injured persons, by number of traumatised teeth per person to the permanent dentition

Teeth included in studies	Authors (Year of publication)	Age (years)	Percentage of injured person	
			1 traumatised teeth	> 1 traumatised teeth
Incisors				
	Zadik et al. (1972)	6-14	75.0	25.0
	Järvinen (1979a)	6-16	78.4	21.6
	Jamani and Fayyad (1991)	7-12	85.2	14.8
	Zerman and Cavalleri (1993)*	6-21	36.6	63.4
	Holland et al. (1994)	16-24	Male 68.0 Female 79.0	Male 32.0 Female 21.0
		25-34	Male 46.0 Female 46.0	Male 54.0 Female 54.0
	Kaste et al. (1996)	6-50	50.0	50.0
Incisors and canines				
	Stockwell (1988)*	6-12	80.5	19.5
All teeth				
	Forsberg and Tedestam (1990)*	7-15	75.0	25.0
	Fleming et al. (1991)*	0.8-12.8	42.7	57.3
	Glendor et al. (1996)*	0-19	56.0	44.0

* The information from a single event (1 episode)

Degree of damage to each involved tooth

Enamel fracture is the most common type of the degree of damage, which were reported in many of the population-based studies (Bijella, 1972; O'Mullane, 1972; Todd, 1975; Järvinen, 1979a; Baghdady et al, 1981b; Garcia-Godoy et al., 1981; Todd & Dodd, 1985; Falomo, 1986; Garcia-Godoy et al., 1986; Holland et al., 1988; Ng'ang'a &Valderhaugh, 1988; Forsberg & Tedestam, 1990; Naqvi & Ogidan, 1990a; Sanchez & Garcia-Godoy, 1990; O'Brien, 1994; Joseffsson & Karlander, 1994; Dellatre et al., 1995; Hamden & Rock, 1995; Hargreaves et al., 1995; Kania et al., 1996; Kaste et al., 1996;

Petti et al., 1996; Petti & Tarsitani, 1996; Marcenes et al., 1999; Marcenes et al., 2000; Marcenes & Murry, 2000; Cortes, 2001).

The degree of damage to each involved tooth due to trauma may be assessed in many ways. Some diagnostic criteria include both the damage to dental hard tissue and periodontal tissue (Tables 8, 10 and 12). The diagnosis may be limited only to dental hard tissue and dental pulp (Table 15), or extended to supporting tissues such as periodontal tissues (Table 16) and supporting bone (Table 17), and gingiva or oral mucosa (Table 18). The above diagnostic criteria are reasonable to give the picture of degree of damage from injury events. However, these criteria should be appropriate to diagnose the injured individuals who attended for the dental services hours after the injury events or whose traumatised teeth were not restored after months or years after injury events.

In the epidemiological survey particularly in developed countries and in urban areas of developing countries, it is likely to find subjects who already had their traumatised teeth restored. Therefore, there are several classifications used in assessment of traumatic dental injuries for the subjects in the studies which include types of restoration in their categories (Tables 9, 11, 13 and 14). These diagnostic criteria are hard to rank by degree of damage from injury event unless the categories are carefully grouped together or analysed within a limitation. To avoid this problem, injuries have been named as 'type of traumatic dental injuries'. The problem of comparisons between studies according to the classification of traumatic dental injuries and justification of selecting the classification criteria of the study for this thesis are presented in Section 1.4.2.2.1.

Table 8 The diagnostic criteria of traumatic dental injuries classified by Ellis and Davey (1970)

Categories (Classes)	**Criteria**
Class I	Simple fracture of the crown, involving little or no dentine
Class II	Extensive fracture of the crown, involving considerable dentine, but not dental pulp
Class III	Extensive fracture of the crown, involving considerable dentine and exposing the dental pulp
Class IV	The traumatised tooth which becomes nonvital, with or without loss of crown structure
Class V	Tooth loss as a result of trauma
Class VI	Fracture of root, with or without loss of crown structure
Class VII	Displacement of the tooth, without fracture of crown or root
Class VIII	Fracture of the crown *'en masse'* and its replacement

Table 9 The diagnostic criteria of traumatic dental injuries classified by Todd (1975)

Categories (Codes)	**Criteria**	**Description**
Code 1	Discoloration	Self explanatory
Code 2	Fracture involving enamel	Self explanatory
Code 3	Fracture involving enamel and dentine	Self explanatory
Code 4	Fracture involving enamel and dentine and pulp	Self explanatory
Code 5	Missing due to trauma	Self explanatory
Code 6	Temporary crown fitted	Refer to items of immediate treatment, such as foil, steel caps, pinch bands acetate crown, etc.
Code 7	Permanent or semi-permanent restoration fitted	Include basket crowns, veneer crown, post crown, pin inlays, etc.
Code 8	Displacement	Self explanatory
Code 9	No trauma	Self explanatory

Table 10 The diagnostic criteria of traumatic dental injuries classified by Garcia-Godoy (1981)

Categories (Classes)	Criteria	Description
Class 0	Enamel crack	An incomplete fracture of enamel without loss of tooth substance
Class 1	Enamel fracture	A fracture of the enamel with loss of tooth substance not involving the dentine
Class 2	Enamel-dentine fracture	A fracture of the enamel and the dentine not involving the pulp
Class 3	Enamel-dentine fracture with pulp exposure	A fracture of the enamel and the dentine exposing the pulp
Class 4	Enamel-dentine-cementum fracture without pulp exposure	A fracture involving enamel, dentine, and cementum without pulp exposure
Class 5	Enamel-dentine-cementum fracture with pulp exposure	A fracture involving enamel, dentine, and cementum with pulp exposure
Class 6	Root fracture	A fracture involving cementum, dentine, and pulp
Class 7	Concussion	An injury to the tooth without abnormal loosening or displacement, but with marked reaction to percussion
Class 8	Luxation (loosening)	An injury to the tooth with abnormal loosening or displacement and without displacement
Class 9	Lateral displacement	A displacement of the tooth from axial position
Class 10	Intrusion	A displacement of the tooth into alveolar bone
Class 11	Extrusion	A partial displacement of the tooth out of its alveolar socket
Class 12	Avulsion	A complete displacement of the tooth out of its alveolar socket

Table 11 The diagnostic criteria of traumatic dental injuries classified by Todd and Dodd (1985)

Categories (Codes)	Criteria	Description
Code 0	No trauma	
Code 1	Discoloration	
Code 2	Fracture (enamel)	Fracture involving enamel
Code 3	Fracture (enamel and dentine)	Fracture involving enamel and dentine
Code 4	Fracture (involving pulp)	Fracture involving enamel, dentine, and pulp
Code 5	Missing due to trauma	Missing due to trauma
Code 6	Acid-etch composite restoration	Acid-etch composite restoration
Code 7	Permanent crown	Including jacket and post crowns, either porcelain or acrylic
Code 8	Other restoration	Other permanent or semi-permanent restorations (stainless steel crowns, pinch bands, cellulose acetate crowns, pinned inlays, etc.)
Code 9	Denture due to trauma	Denture provided after tooth loss due to trauma

Table 12 The diagnostic criteria of traumatic dental injuries classified by Naqvi and Ogidan (1990b)

Categories (Classes)	Criteria	Description
Class I	Enamel fracture	Loss of enamel only as a result of trauma to the affected tooth
Class II	Enamel-dentine fracture without pulp exposure	Loss of enamel and dentine tissues without obvious pulpal exposure
Class III	Enamel-dentine-pulp fracture	Loss of enamel and dentine tissues, and resulting in exposure of pulp
Class IV	Enamel-dentine-cementum-pulp fracture	Loss of the whole crown at the gingival sulcus or part of the crown and cementum in the sulcal region
Class V	Concussion	An injury to the tooth without abnormal loosening or displacement but with a marked reaction to percussion. Sometimes after injury it would be manifested by a change of tooth colour and / or fistulous tract
Class VI	Luxation	An injury to the tooth resulting in abnormal mobility but without displacement
Class VII	Displacement	Abnormal position of a tooth as a result of trauma. There may be a change in tooth colour and the presence of a fistulous tract sometimes after injury
Class VIII	Avulsion	Loss of the tooth due to traumatic injury

Table 13 The diagnostic criteria of traumatic dental injuries classified by O'Brien (1994)

Categories (Codes)	Criteria	Description
Code 0	No trauma	
Code 1	Discoloration	
Code 2	Enamel	Fracture involving enamel
Code 3	Enamel and dentine	Fracture involving enamel and dentine
Code 4	Enamel, dentine, pulp	Fracture involving enamel, dentine, and pulp
Code 5	Missing due to trauma	Missing due to trauma
Code 6	Acid-etch composite	Acid-etch composite restoration
Code 7	Permanent replacement	Permanent replacement including crown, denture, bridge pontic
Code 8	Temporary restoration	Temporary restorations
Code 9	Assessment cannot be made	Assessment cannot be made

Table 14 The diagnostic criteria of traumatic dental injuries classified by National Institute of Dental Research (NIDR) (1989) and NHANES III (1996)

Categories (Codes)	Criteria	Description
Code 0	No trauma	No evidence of traumatic injury
Code 1	Enamel	Unrestored enamel fracture without involving dentine
Code 2	Dentine	Unrestored fracture involving dentine
Code 3	Pulpal damage	Untreated damage as evidenced by one of the following: a) dark discoloration as compared to the other teeth - a discoloration of one tooth or adjacent teeth, which are otherwise healthy, is considered a sign of injury, or b) presence of a swelling and / or fistula in the labial or lingual vestibule adjacent to an otherwise healthy tooth
Code 4	Repair	Fracture restored, either with a full crown or a less extensive restoration. It may be necessary to question the subject to determine the reason for the restoration.
Code 5	Repair pulpal	Presence of a lingual restoration as a sign of endodontic therapy, and a positive history from the subject of root canal treatment following traumatic injury
Code 6	Missing	Tooth missing due to trauma
Code Y	Unable to score	Any other tooth or space that does not fall within the preceding categories

Table 15 The diagnostic criteria of traumatic dental injuries classified by Andreasen and Andreasen (1972; 1994): Injury to hard tissue and pulp

Categories (Codes)	Criteria	Description
N 502.50	Enamel infraction	An incomplete fracture (crack) of enamel without loss of tooth substance
502.50	Enamel fracture (uncomplicated crown fracture)	A fracture with loss of tooth substance confined to enamel
N 502.51	Enamel-dentine fracture (uncomplicated crown fracture)	A fracture with loss of tooth substance confined to enamel and dentine but not involving pulp
N 502.52	Complicated crown fracture	A fracture involving enamel, dentine, and pulp
N 502.54	Uncomplicated crown-root fracture	A fracture involving enamel, dentine, and cementum but not exposing pulp
N 503.54	Complicated crown-root fracture	A fracture involving enamel, dentine, cementum, and exposing pulp
N 502.53	Root fracture	A fracture involving dentine, cementum, and pulp

Table 16 The diagnostic criteria of traumatic dental injuries classified by Andreasen and Andreasen (1972; 1994): Injuries to periodontal tissues

Categories (Codes)	Criteria	Description
N 503.20	Concussion	An injury to the tooth-supporting structures without abnormal loosening or displacement of the tooth but with marked reaction to percussion
N 503.20	Subluxation (loosening)	An injury to the tooth-supporting structures with abnormal loosening but without displacement of the tooth
N 503.20	Extrusive luxation (peripheral dislocation, partial avulsion)	Partial displacement of the tooth out of its socket
N 503.20	lateral luxation	Displacement of the tooth in a direction other than axial. This injury is accompanied by comminution or fracture of the alveolar socket
N 503.21	Intrusive luxation	Displacement of the tooth into the alveolar bone. This injury is accompanied by comminution or fracture of the alveolar socket
N 503.22	Avulsion (exarticulation)	Complete displacement of the tooth out of its socket

Table 17 The diagnostic criteria of traumatic dental injuries classified by Andreasen and Andreasen (1972; 1994): Injuries to the supporting bone

Categories (Codes)	Criteria	Description
N 502.60	Comminution of the mandibular alveolar socket	Crushing and compression of the alveolar socket
N 502.40	Comminution of the maxillary alveolar socket	Crushing and compression of the alveolar socket
N 502.60	Fracture of the mandibular alveolar socket	A fracture confined to the facial or oral socket wall
N 502.40	Fracture of the maxillary alveolar socket	A fracture confined to the facial or oral socket wall
N 502.60	Fracture of the mandibular alveolar process	A fracture of the alveolar process which may or may not involve the alveolar socket
N 502.40	Fracture of the maxillary alveolar process	A fracture of the alveolar process which may or may not involve the alveolar socket
N 502.60	Fracture of the mandible	A fracture involving the base of the mandible and often the alveolar process
N 502.40	Fracture of the maxilla	A fracture involving the base of the maxilla and often the alveolar process

Table 18 The diagnostic criteria of traumatic dental injuries classified by Andreasen and Andreasen (1972; 1994): Injuries to gingiva or oral mucosa

Categories (Codes)	Criteria	Description
S 01.50	Laceration of gingiva or oral mucosa	A shallow or deep wound in the mucosa resulting from tear, and usually produced by a sharp object
S 00.50	Contusion of gingiva or oral mucosa	A bruise usually produced by impact with a blunt object and not accompanied by a break in mucosa, usually causing submucosal hemorrhage
S 00.50	Abrasion of gingica or oral mucosa	A superficial wound produced by rubbling or scraping of the mucosa leaving a raw, bleeding surface

1.4.2.1.4 Trends in traumatic dental injuries

There are two epidemiological studies showing the trends of traumatic dental injuries. One is the two last Children's National Surveys in the UK and another study carried out in Denmark (Andreasen & Ravn, 1972; Ravn, 1974; Todd & Dodd, 1985; Andreasen & Andreasen, 1989; O'Brien, 1994).

The national children dental surveys in the UK have been carried out three times; in 1973, 1983, and 1993. The prevalence of traumatic injuries to permanent teeth of children showed an increase in the prevalence between 1973 and 1983 followed by a decline between 1983 and 1993. The initial analysis showed that there were a large increase in the number of incisors with fractured enamel and a slight decrease in the more serious injuries between 1973 and 1983 (Todd & Dodd, 1985). However, O'Brien (1994) stated that these changes were likely to be due to a change in the diagnostic criteria. Therefore, only the studies in 1983 and 1993 seemed to be comparable. During this period, there was a marked decline in the proportions of children who had traumatised their permanent teeth particularly among the older age group. An explanation is that the children, particularly boys, might have spent less time on rough play and active sports than they had spent in 1983 (O'Brien, 1994).

In Copenhagen, Andreasen and Ravn (1972) examined children aged 9-17 years in municipal dental services and reported that 22 per cent of children had traumatised their permanent dentition. Later, Ravn (1974) reported that 34 per cent of boys and 23.1 per cent of girls had experience of traumatic injuries to permanent teeth before leaving school in the 9th grade. In addition, Andreasen and Andreasen (1989) also reported that every fifth Danish child traumatised their permanent dentition before reaching school-leaving age.

1.4.2.2 Problems in the previous prevalence studies of traumatic dental injuries

There are several problems with previous published studies of traumatic dental injuries, which should be considered, such as differences in method of data collection, selection bias, and measurement error.

1.4.2.2.1 Difficulties in comparison of results

An important problem of prevalence studies of traumatic dental injuries conducted world-wide is the difficulty in comparison of results between different times or places. One of the reasons is the scarcity of standardised methods for data collection (Andreasen & Andreasen, 1994; Cortes, 2001). Therefore, the prevalence of traumatic dental injuries conducted world-wide may either reflect the real local differences or be the result of the different approaches. The problem of incomparable data comes from either the differences in the classification criteria or the differences in using examination methods to identify traumatic dental injuries.

There are many different criteria of classifications used to identify traumatic dental injuries (Table 8 to 18). The results reported in epidemiological surveys underestimate the frequency of pulp-involved teeth, root resorption, pulp and root canal obliteration, and injury to the supporting structures because the diagnostic facilities such as radiographs and pulp vitality tests were not included in the examination procedures. However, some studies determined the sequelae of these injuries (DelBalso & Todd, 1975; Todd & Dodd, 1985; Bhat & Li, 1990; O'Brien, 1994; Kaste et al.; 1996).

The examination in some studies was performed in clinics under dental school service conditions, using sources of light from the dental chair. Although these studies had characteristics of the population-based study and the samples could represent the study populations (all eligible children in the study population were examined) (Hedegard & Stalhane, 1973; Järvinen, 1979b; Joseffsson & Karlander, 1994), they can hardly be compared with results of other epidemiological studies which examined children with other sources of light such as natural day light (Järvinen, 1979b; Garcia-Godoy et al., 1981; Baghdady et al., 1981a; Baghdady et al., 1981b; Garcia-Godoy, 1984; Garcia-Godoy et al., 1985; Falomo, 1986; Garcia-Godoy et al., 1986; Jamani & Fayyad, 1991; Hamdan & Rock, 1995; Hargreaves et al., 1995). The natural daylight may underestimate the prevalence of traumatic dental injuries. Andreasen and Andreasen (1994) suggested that artificial light is mandatory for the identification of enamel cracks and discolouration.

To minimise the above problems, in epidemiological studies, particularly the studies that are performed dental examination outside clinic an artificial light should be used in dental examination. Moreover, in the studies, which identify traumatic dental injuries from evidence of tooth damage, an appropriate classification criterion in identifying traumatic dental injuries should be carefully selected. The classification criteria should cover as many types of traumatic dental injuries as possible. It is not only more informative but also provide more choices for researcher or combine categories according to the purpose of study. Though it would increase the time of dental examination, they will be able to do it easily and quickly after some practice. The classification of traumatic dental injuries developed by Cortes (2001) is a classification system, which includes most possible types of traumatic dental injuries identified from evidence of tooth damage (Table 19). This classification was used in the dental examination for this thesis.

Table 19 The diagnostic criteria of traumatic dental injuries classified by Cortes (2001)

Categories (Codes)	**Criteria**	**Description**
Code 0	No trauma	No observed injury to the incisors
Code 1	Discoloration due to trauma	Discoloration ranging from yellow to dark gray when compared to the other teeth
Code 2	Enamel crack	An incomplete fracture of enamel without loss of tooth substance
Code 3	Enamel fracture	Loss of a small portion of the crown, including only enamel
Code 4	Enamel and dentine fracture	Loss of enamel and dentine without exposing pulp
Code 5	Fracture with pulp exposure	Loss of enamel and dentine and / or cementum, exposing pulp
Code 6	Missing tooth due to trauma	Absence of the tooth due to a complete exarticulation
Code 7	Composite restoration	Restoration provided due to crown fracture and / or located in the palatal surface of the crown
Code 8	Bonded fragment	Bonding of the tooth due to crown fracture
Code 9	Permanent crown provided	Jacket or post crown or any kind of restoration involving all the whole crown
Code 10	Semi-permanent crown provided	Any kind of crown or denture or bridge (Pontic) placed provisionally
Code 11	Denture or bridge provided (Pontic)	Denture or bridge (Pontic) provided
Code 12	Fistulous tract and / or presence of swelling	Presence of fistula and / or swelling in the labial or lingual vestibule without evidence of caries
Code 99	Assessment cannot be made	Signs of trauma cannot be assessed due to appliances or absence of any of the incisors

1.4.2.2.2 Selection bias

In many published prevalence studies, the methods of sample selection and/or the sample sizes were not mentioned or not clearly stated (Gauba, 1967; Baghdady et al., 1981a; Baghdady et al., 1981b; Burton et al., 1985; Falomo, 1986). It is not clear whether the samples represented their study populations.

1.4.2.2.3 Measurement error

Some studies might introduce measurement error due to lack of validity and reliability of the data. Training and calibration of the examiners were not mentioned in many studies (Clarkson et al., 1973; Todd, 1975; Stalhane & Hedegard, 1975; Todd & Dodd, 1985; O'Brien, 1994; Dellatre et al., 1994; Hamdan & Rock, 1995; Hargreaves et al., 1995). Although some studies avoided variation in examination between the examiners by using a single researcher, the training and intra-examiner calibration were not mentioned (Bijella, 1972; Falomo, 1986). Moreover, several studies did not mention the number of examiners included in the studies (Garcia-Godoy et al., 1981; Garcia-Godoy, 1984, Garcia-Godoy et al., 1985; Garcia-Godoy et al., 1986; Majewski et al., 1988; Kaba & Marechaux, 1989). In addition, in some studies even the examination procedures were not reported (Nicholas, 1980; Holland et al., 1988; Forsberg & Tedestam, 1990).

1.4.2.3 Causes of traumatic dental injuries

The causes of traumatic dental injuries can be classified in many ways, such as:

- by manner: fall, fight, assault, pushing, struck by objects, collision
- by vehicles (vectors): all types of traffic accidents
- by activities: all types of sports, cycling, riding, driving and general playing
- according to place of occurrence: work accidents
- others such as violence, child abuse.

The causes of traumatic dental injuries have been described and identified in many studies (Baghdady et al., 1981a; Garcia-Godoy et al., 1981; Garcia-Godoy, 1984; Meadow & Needleman, 1984; Burton et al., 1985; Falomo, 1986; Liew & Daly, 1986; Oikarinen & Kassila, 1987; Harrington et al., 1988; Stockwell, 1988; Uji & Teramoto, 1988; Crona-Larson & Noren, 1989; O'Neil et al., 1989; Bhat & Li, 1990; Häyrinen-Immonen et al., 1990; Fleming et al., 1991; Perez et al., 1991; Zerman & Cavalleri, 1993; Joseffsson & Karlander, 1994; Luz & Di Mase, 1994; Onetto et al., 1994; Caliskan & Tükün, 1995; Petti et al., 1996; Marcenes et al., 1999; Marcenes et al., 2000; Nicolau et al., 2001).

'Fall' is the major cause of traumatic dental injuries (Table 20) though the classification into categories of the causes vary among studies. There are some studies, in which the major cause of traumatic dental injuries is not due to 'fall'. Baghdady et al. (1981a) studied Iraqi and Sudanese primary schoolchildren. They reported 'fall' was the major cause among Iraqi sample

(Table 20). However, percentage of causes due to ‘pushing and fighting’ (70.6%) was higher than ‘fall’ (18.9%) among Sudanese sample. Joseffsson and Karlander (1994) studied 102 Swedish children, and reported that ‘collision during play’ (16.7%) was the major cause and was slightly higher than ‘fall’ (14.7%). Marcenes et al. (1999) reported that violence (42.5%) was the major cause in Syrian children, while ‘fall’ accounted for 9.1 per cent. In fact, some of the causes due to ‘pushing and fighting’ or ‘play’ can be categorised as ‘fall’ as well. Therefore it can be generally said that ‘fall’ is the main cause of traumatic dental injuries.

However, there are varieties in categorisation of the causes of traumatic dental injuries. For examples, fall, fight, assault, pushed, struck by object, contact with another child, collision, and removing bottle top with the teeth are the causes, by the manner in which traumatic dental injuries occurred. Drinking alcohol, all types of vehicle accidents, ground, wall, and furniture are vectors leading to injuries. All types of sports, cycling, riding, driving, and playing are related activities during the injury occurrences. Some of them can be classified according to place of occurrence such as work accident, traffic accident. Moreover, some of them are difficult to be classified such as violence and child abuse. Previous studies mixed the above causes in many ways, and this makes them difficult to compare. In addition, the ‘fall’ category, which is the most frequent cause of traumatic dental injuries, is not clear for identifying the aetiology of injuries. Fall may due to many specific causes either accidental and intentional, such as fall from height, fall from losing balance at the same level which needs to be explained in more detail. Only a few studies gave details of specific causes of fall. For example, Zerman and Cavalleri (1993) reported falls from building (stairs, windows, and others), falls during playing with toys, during playing with equipment (e.g. seesaw), during free play, during sports.

For the other types of causes, Burton et al. (1995) reported causes in terms of vehicle and manner in Australian children. They found that 'ground and concrete' was the major vectors (20.3%), and 'run into object' was the common manner leading to injuries (28.4%) whilst 'bit into object' accounted for only 0.6 per cent. Petti et al. (1996) reported 'play' (64.2%) was the major cause among Italian schoolchildren, and they did not include 'fall' into their categories.

Garcia-Godoy (1984) identified the causes of traumatic dental injuries for both general and specific aetiologies. Fall against object, struck by object, and contact with another child were categorised for general causes. The specific causes were categorised according to the type of vehicle or vector, which could be associated with the related activities as well, such as baseball, basketball, roller skates, bicycle/tricycle, and car accident. Burton et al. (1985) presented the causes of traumatic dental injuries according to both vehicle and the manner in which trauma occurred. The vehicles, which Burton classified, were bicycle, wall, pool, sport equipment, body contact, metal, stick, bottle, playground, car accident, bath, furniture, and others. The manner were 'ran into object', 'tripped', 'struck by object', 'pushed', and 'projected from', as well as 'bit into object'. Häyrinen-Immonen et al. (1990)

studies focusing on sport activities. The categorisation of causes were ice hockey, swimming, ball game, skating, gymnastics, and miscellaneous.

Table 20 Percentages of traumatic dental injuries according to the major cause in several studies

Countries	Authors (Year)	Age (years)	The major cause Type	%
Australia *(NorthernSydney)*	Burton et al. (1985)	12-15	Ground & concrete contact	20.3
Australia	Liew and Daly (1986)	All age	Fall	26.6
Australia	Stockwell (1988)	6-12	Fall	22.7
Brazil	Luz and Di Mase (1994)	All age	Fall	59.8
Brazil	Marcenes et al. (1999)	9-12	Violence	42.5
Brazil	Marcenes et al. (2000)	12	Fall	26.0
Brazil	Nicolau et al. (2001)	13	Fall	24.1
Chille	Onetto et al. (1994)	2-21	Fall	65.6
Dominican Republic	Garcia-Godoy et al. (1981)	7-14	Fall	50.0
Dominican Republic	Garcia-Godoy (1984)	5-14	Fall	78.0
Finland	Oikarinen and Kassila (1987)	< 20	Fall	54.6
Iraq	Baghdady et al. (1981a)	6-12	Fall	54.0
Italy	Zerman and Cavalleri (1993)	6-21	Fall	54.8
Italy	Petti et al. (1996)	6-11	Play	64.2
Japan	Uji and Teramoto (1988)	6-18	Fall	41.6*
Nigeria	Falomo (1986)	10-17	Fall	76.1
Sudan	Baghdady et al. (1981a)	6-12	Pushing& Fighting	70.6
Sweden	Crona-Larsson and Norén (1989)	6-19	Fall	31.0
Sweden	Joseffsson and Karlander (1994)	7-17	Collision during play	16.7
Turkey	Caliskan and Tükün (1995)	6-35	Fall	45.1
UK *(Northern Ireland)*	Fleming et al. (1991)	0-13	Fall	51.1
USA	Meadow and Needleman (1984)	13 m-19 yrs	Fall	61.8
USA	Harrington et al. (1988)	All age	Fall	55.0
USA	O'Neil et al. (1989)	<1 to >15	Fall	58.8
USA	Perez et al. (1991)	All age	Fall	46.0
Sweden	Crona-Larson and Noren (1989)	6-19	Fall	36.0

* During the year 1980-1983

As mentioned and explained in Section 1.3, an approach for injury prevention and control is to take account of the three determinant factors (human, vehicle or vector, and environment) in each related activity in the studies of aetiology of injuries. Then, the results of studies could be useful for health planners. Therefore in a study of aetiology of traumatic dental injuries, the vehicles leading to injury, the characteristics of subjects, the environment around or related to injury event, and the related activity during the injury occurrence should be investigated in each subject. Then, the real factors leading to traumatic dental injuries will be clearly identified and will be useful for generating strategies of prevention and control.

1.4.2.4 Traumatic dental injuries in the second dimension of Haddon's matrix

1.4.2.4.1 Host factors and traumatic dental injuries

Age

In children, the prevalence of traumatic dental injuries to permanent teeth increases with age (Zadick et al., 1972; Baghdady et al., 1981a; Baghdady et al., 1981b; Falomo,1986; Uji & Teramoto, 198; Holland et al., 1988; Jamani & Fayyad, 1991; Marcenes et al., 1999; Cortes, 2001). According to the population-based studies (Tables 2, 3 and 4), traumatic dental injuries were more common in late childhood and early teenagers (Bijella, 1972; O'Mullane, 1972; Zadik et al., 1972; Clarkson et al., 1973; Todd, 1975; Järvinen, 1979a; Garcia-Godoy et al., 1981; Todd & Dodd, 1985; Holland et al., 1988; Jamani & Fayyad, 1991; Delattre et al., 1994; O'Brien, 1994; Marcenes et al., 1999). There were many studies reporting that the highest prevalence of traumatic dental injuries to permanent teeth at age of 12 years old (O'Mullane, 1972; Clarkson et al., 1973; Todd, 1975; Holland 1988;

Jamani & Fayyad, 1991; Delattre at al. 1994) (Tables 2 and 3). However, Todd and Dodd (1985) showed that frequency of traumatic dental injuries to permanent teeth in English children increases with age up to 13, then remained constant till 15. This pattern of traumatic dental injuries according to age was consistent with other studies (Uji & Teramoto, 1988; Delattre et al., 1994; Marcenes et al., 1999).

Sex

Most population and hospital-based studies showed that males are at higher risk of traumatic dental injuries than females, with the male:female ratios of 1.2:1 to 3.2:1 (Table 21). Only two studies, from the Dominican Republic, reported that injury rates in girls were higher than those in boys (Garcia-Godoy et al., 1981; Garcia-Godoy, 1984). In addition, Kania et al. (1996), Petti et al. (1997) and Nicolau et al. (2001) also reported that the risk of traumatic dental injuries to permanent teeth (odds ratios) in males were 1.3, 1.2 and 2.2 times that of females, respectively.

Table 21 Sex differences in traumatic dental injuries world-wide; both in population and hospital-based studies

Country	Author (Year)	% (cases) M / F	Ratios M : F
Australia*	Stockwell (1988)	12.8 / 11.1	1.2 : 1
Australia*	Liew and Daly (1986)	(168 / 65)	2.6 : 1
Brazil *(São Paulo)**	Luz and Di Mase (1994)	(178 / 93)	1.9 : 1
Brazil *(Jaragua do Sul)*	Maecenes et al. (2000)	20.7 / 9.3	2.2 : 1
Brazil *(Belo Horizonte)*	Cortes (2001)	15.6 / 9.1	1.7 : 1
Brazil *(Cianorte)*	Nicalau et al. (2001)	27.5 / 13.4	2.0 : 1
Chile*	Onetto et al. (1994)	(134 / 93)	1.4 : 1
Denmark	Andreasen and Ravn (1972)	25.7 / 16.3**	1.6 : 1
Dominican repulic	Garcia-Godoy et al. (1981)	17.4 / 18.8	0.9 : 1

Table 21 (continued)

Country	Author (Year)	% (cases) M / F	Ratios M : F
Dominican republic	Garcia-Godoy (1984)	-	0.9 : 1
Dominican Republic	Garcia-Godoy et al. (1985)	18.0 /12.0	1.5 : 1
Dominican Republic	Garcia-Godoy et al.(1986)	31.7 / 15.0	2.1 : 1
Finland	Järvinen (1979b)	25.0 /14.6	1.7 : 1
Finland*	Oikarinen and Kassila (1986)	(857 / 315)	2.7 : 1
Finland*	Häyrin-Immonen et al. (1990)	(81 / 25)	3.2 : 1
France *(Rennes)*	Dellatre et al. (1995)	17.0 / 10.2	1.7 : 1
Greece *(Athens)**	Oulis and Berdouses (1996)	(147/ 95)	1.5 : 1
Iraq	Baghdady et al. (1981b)	8.8 / 6.9	1.3 : 1
Ireland	Holland et al. (1988)	21.2 / 12.2 [1]	1.7 : 1
Ireland	O'Mulane (1972)	-	1.5 : 1
Israel	Zadik et al. (1972)	9.8 / 7.6	1.3 : 1
Italy *(Rome)*	Petti and Tarsitani (1996)	-	1.6 : 1
Japan	Uji and Teramoto (1988)	27.7 / 16.2	1.7 : 1
Jordan	Jamani and Fayyad (1991)	12.1 / 8.8	1.4 : 1
Jordan *(urban)*	Hamden and Rock (1995)	23.9 / 14.9	1.6 : 1
Jordan *(rural))*	Hamden and Rock (1995)	19.1 / 12.2	1.6 : 1
Nigeria	Falomo (1986)	17.3 / 11.6	1.5 : 1
Singapore*	Sae-Lim et al. (1995)	(314 /147)	2.1 : 1
South Africa	Hargreaves et al. (1995)	18.5 / 12.3	1.5 : 1
Sudan	Baghdady et al. (1981b)	7.5 / 2.9	2.6 : 1
Sweden	Forsberg and Tedestam (1990)	-	1.6 : 1
Sweden *(rural)*	Joseffsson and Kariander (1994)	(55 / 33)	1.7 : 1
Sweden*	Robertson et al. (1997)	(121 / 77)	1.6 : 1
Turkey*	Caliskan & Tükün (1995)	(201 / 109)	1.8 : 1
UK *(England)**	Gelbier (1967)	(56 / 30)	1.9 : 1
UK *(England)*	Clarkson et al. (1973)	25.7 / 16.3	1.6 : 1
UK *(England & Wales)*	Todd (1975)	22.0 / 12.0**	1.8 : 1
UK *(England, Northern Ireland, Scotland, Wales)*	Todd and Dodd (1985)	29.0 / 16.0**	1.8 : 1
UK *(Northern Ireland)**	Fleming et al. (1991)	(252 / 155)	1.6 : 1
UK *(England, Northern Ireland, Scotland, Wales)*	O'Brien (1994)	25 / 9 [2]	2.8 : 1
UK *(England)*	Hamilton et al. (1997)	42.0 / 28.0	1.5 : 1
UK *(England)*	Marcenes and Murray (2000)	27.9 / 19.7	1.4 : 1
USA	Law (1961)	-	2.0 : 1
USA (Massachusetts)	Macko et al. (1979)	24.5 / 13.7	1.8 : 1
USA *(New York)*	Oluwole and Leverett (1986)	(124 / 71) [3]	1.7 : 1
USA *(Pittsburgh)**	Battenhouse et al. (1988)	(440 / 236)	1.9 : 1
USA *(Missouri)**	Harrington et al. (1988)	(304 / 197)	1.6 : 1
USA *(Missouri)**	O'Neil et al. (1989)	(473 / 292)	1.6 : 1
USA *(Florida)*	Kania et al. (1996)	21.2 / 16.9	1.2 : 1
USA	Kaste et al. (1996)	27.5 / 17.8	1.5 : 1

* Non-population based studies
** Age-specific of 12-year-old
[1] The prevalence of 12-year-old group
[2] Age specific at 12 year old
[3] The examined cases (195 cases out of 250 original cases)

Anatomical factors

Anterior tooth protrusion, measured in terms of *overjet-size* (see Appendix 1 for the definition of terms), is an anatomical factor related to traumatic dental injuries (dental anatomy factor). The relationship between overjet-size and traumatic dental injuries has been well studied (Järvinen, 1972; Oluwole & Leverett, 1986; Hunter et al., 1990; Kania et al., 1996; Petti & Tarsitani, 1996; Nguyen et al., 1999; Marcenes et al., 1999; Marcenes & Murray, 2000; Marcenes et al., 2000; Cortes, 2001). Järvinen (1972) reported that, children before 10 years of age, the increase of the prevalence of traumatic dental injuries was most rapid in the extreme (> 6 mm) overjet group. Oluwole and Leverett (1986) reported that, in a sample aged 11 to 21 years, there were 112 cases of traumatic dental injuries having their overjets 4 mm or more compared to 78 cases having overjets less than 4 mm.

Hunter et al. (1990) studied the prevalence of accidental damage to maxillary incisor teeth in a group of 980 children aged 11 to 12 years in South Wales. They found that the percentage of subjects suffering traumatic dental injuries increased significantly with increasing overjet; from 8.9 per cent in the overjet of less than 5 mm to 17 per cent in the overjet of 5 to 9 mm and to 50 per cent in the overjet of more than 5 mm. They noted that there was no statistical difference of mean overjets between males who had evidence of traumatic dental injuries and those who did not. In contrast, the females who experienced traumatic dental injuries had a mean overjet greater than of those who did not. They raised a postulate that it is the more boisterous nature of the boys' activities rather than of their occlusion, which is of importance in determining the prevalence of traumatic dental injuries, while in the girls, an increased overjet plays a key role.

Kania et al. (1996) studied 3,396 third and fourth grade schoolchildren in Florida and reported that there was a statistical difference in the prevalence of traumatic dental injuries between the group of children with larger overjet compared to those with a smaller one. Petti and Tarsitani (1996) conducted a study in 824 Italian children aged 6 to 11 years. The result revealed that the risk of traumatic dental injuries in children with overjet larger than 3 mm was 2.6 times greater than those with overjet of 3 mm or less.

Nguyen et al. (1999) aggregated the risk of traumatic dental injury due to overjet using several published papers and performing a meta-analysis on the results. From this study, it can be concluded that children with an overjet larger than 3 mm are approximately twice as much at risk of injury to anterior teeth than children with an overjet smaller than 3 mm. In addition, risk of injury of anterior teeth tended to increase with increasing overjet size. Increasing overjet size as a risk of traumatic dental injuries was also shown in later studies (Cortes, 2001; Marcenes & Murray, 2000) though some other studies found only borderline significant results (Marcenes et al., 1999; Marcenes et al., 2000).

A study was carried out to assess relation of body size and traumatic dental injuries in population of 938 children aged 6 to 11 years (Petti et al., 1997). When *the Body Mass Index (BMI)* (see Appendix 1 for the definition of terms) of the children was equal to or higher than the value of the 97th percentile of the age-specific reference table for the French population (Rolland-Cachera et al., 1991), the child was defined as obese. The sample included 11.4 per cent obese children. This study showed that there was no significant difference in prevalence of traumatic dental injuries between obese and non-obese children. The obese children had only enamel and enamel-dentine fractures, while the non-obese children also had more severe types of tooth damage. Obese children were more likely to have traumatic dental injuries arising from indoor play or contact sport, whilst non-obese children were more likely to be injured in outdoor play or events such as falling from a bicycle.

Nicolau et al. (2001) conducted a study in 652 Brazilian children aged 13 years. They considered children with BMI of more than 23 (BMI scores equal or above the 85th percentile) as overweight. The prevalence of traumatic dental injuries was significantly higher in overweight than non-overweight children (crude odds ratio of 1.8 and adjusted odds ratio of 1.9).

Socio-economic factors

The role of socio-economic status on traumatic dental injuries is not clear. Very few studies have included socio-economic status in their reports. Moreover, there is no agreement among those that have included it. There were three studies reporting significant associations between indicators of socio-economic status and traumatic dental injuries (Jamani & Fayyad, 1991; Hamilton et al., 1997; Cortes, 2001). On the other hand, others could not find significant associations between socio-economic status and traumatic dental injuries (Marcenes et al., 2000; Marcenes & Murray, 2000; Nicolau et al., 2001).

A study in Jordan showed that there was a significant difference between the low class group (11.3%) and the high class group (7.5%) but there was no significant difference between that of the low and the middle class group (12.6%) (Jamani & Fayyad, 1991).

In the study of Hamilton et al. (1997), which was carried out among 11-14 year-old children in Bury and Salford UK, the ACORN classification was used to study the relationship between socio-economic status and traumatic dental injuries. This study showed a prevalence of traumatic dental injuries of 38 per cent in lowest group (ACORN group III) compared with 30 per cent in the middle and upper groups (ACORN groups II and I).

Though there was no significant association between indicators of socio-economic status and traumatic dental injuries among Brazilian children in the studies of Marcenes et al. (2000) and Nicolau et al. (2001). Cortes (2001) reported that the children in high socio-economic group were 1.43 times more likely to have traumatic dental injuries than children in low socio-economic status. It was speculated that children in higher socio-economic group might be able to own expensive play equipment such as bicycle, skateboards, roller skates, and access to swimming pool.

In a study in Newham, London (Marcenes & Murray, 2000), the Jarman Index (Jarman, 1984) was used as a measure for socio-economic deprivation. They speculated that the lack of statistically significance between the Jarman Index overall scores and the occurrence of traumatic dental injuries within Newham might be due to the small variation in the levels of deprivation observed in the area. An individual component of the Jarman Index, overcrowded households, however, was statistically significantly related to the presence of traumatic dental injuries. An overcrowded household may increase the likelihood of having accidents and therefore traumatic dental injuries.

1.4.2.4.2 Vehicle factors and traumatic dental injuries

Many hard materials could directly contact teeth either intentionally or unintentionally, and cause damage. Because of unawareness of danger, particularly in young children, some types of toys might be the objects leading to traumatic injuries particularly when children play together. This could include other hard materials, which children use every day such as pencils, pens, rulers, spoons and forks. These examples indicate that vehicles or vectors may influence rates of traumatic injuries. Modifying or selecting them properly and avoiding some types of vehicle may reduce or eliminate injuries though the event itself may not be prevented.

A study carried out in 12,287 Australian children aged 12 to 15 years showed that the most frequent cause of traumatic dental injuries was ground and concrete contact (approximately 21%). The next frequent causes were body contact, bicycle and other metal objects, respectively (Burton et al., 1985). Swimming pool walls were the vehicles causing traumatic dental injuries approximately 9 per cent of all injured children.

In the USA, a study was carried out in hospital emergency rooms during the 9-year period concerning consumer product-related tooth injuries in children under 15 years of age (Bhat & Li, 1989). The study revealed that the most common categories of consumer products associated with traumatic dental injuries were sport and play (25%), followed by floors, stairs and showers (23%), and bicycle and other wheeled vehicles (18%).

1.4.2.4.3 Environmental factors and traumatic dental injuries

Physical environment

The occurrence of traumatic dental injuries varies according to time and places. Andreasen (1970) reported that traumatic dental injuries mostly occurred in winter. Oikarinen and Kassilla (1986) conducted a study in 1,152 Finnish patients under 20 year of age treated for traumatic dental injuries during 1979 and 1980. The study showed that winter was the worst time for group sport accidents, spring for home or school accidents, the summer months favoured injuries caused by traffic accidents and acts of violence and the fall months had a majority of injuries caused by individual sports. Altogether, 46% of all the traumatic dental injuries occurred at school and 54% outside school time. Stockwell (1988) also reported that approximately one-third of traumatic dental injuries occurred at school, one-third at home, and the remainder elsewhere.

Crona-Larsson and Noren (1989) reported that traumatic dental injuries in Swedish children from cycling mostly occurred during spring and early summer and during autumn. This is probably because of climate, as cycling is difficult in the winter in Sweden. Oulis and Berdouses (1995) also reported that the largest number of patients with traumatic dental injuries in Greece presented in spring. However, Luz and Di Mase (1994) reported that traumatic dental injuries in children increased in warm weather, particularly in summer, compared with cold weather. Their results were consistent with other studies (Garcia-Godoy et al., 1979; Perez et al., 1991).

In Southeast Asia, Singapore, a hospital-based study (Sae-Lim et al., 1994) showed that the time of occurrence of traumatic dental injuries was fairly well dispersed throughout the years. However, if only teenagers were considered, there were higher rates during school vacations.

Reports of the effect of physical environment in terms of crowding on traumatic dental injuries is not well established. However, Marcenes and Murray (2000) studied the association between deprivation and traumatic dental injuries. The levels of deprivation were observed by using Jarman index (Jarman, 1984), which a component of the Jarman index is overcrowding. They found that overcrowded households were significantly associated with traumatic dental injuries.

Social environment

Baghdady et al. (1981b) carried out two similar epidemiologic surveys of traumatic dental injuries in Iraqi and Sudanese schoolchildren. They reported that the Iraqi females suffered traumatic dental injuries more often than Sudanese from aggressive actions. That may imply that the Iraqi females are not restricted and may be more active than other females.

Glendor et al. (1996) carried out a study in children in Sweden. They found that the incidence of traumatic dental injuries among the late teenagers was lower for both genders compared with younger ages. They explained that this might be due to more organised sports and greater use of protective equipment, rules and referees in this age group.

Marcenes et al. (1999) considered that the differences in prevalence of traumatic dental injuries in Syrian boys and girls might be explained by behavioural and cultural diversity. They also found that traumatic dental injuries due to sporting activities were not prevalent. This may be because sports facilities are not widely available in Syria compared to Brazil, a country is well known for soccer playing. There, 13.7 per cent of traumatic dental injuries was caused by playing soccer (Marcenes et al., 2000). These two studies used the same methodology. It is suggested that the causes of traumatic dental injuries vary in different countries according to local customs.

1.4.2.4.4 Related activities leading to injuries

Related activity here means the activity which a victim of injury is doing or taking part in at the moment of the injury event. In other words, it is the cause of injuries in terms of manner (Section 1.4.2.3). But some related activities describe in much more detail the activities, particularly the activities just a moment before a manner. For example, 'fall' from tripping/slipping is a cause in terms of manner but the related activities causing tripping/slipping may be due to running or walking. The manner of collision may be from running or playing.

Despite understanding the determinants of injuries in terms of host, vehicle and environmental factors, the activities leading to injuries also need to be explored. The controlling and preventive measures for some related activities might be similar and some of them might be different. Therefore, traumatic dental injuries occurring in each related activity should be studied.

1.4.3 The role of school environments as determinants of injuries

The role of school environments as determinants of injuries has been relatively well established (Feldman et al., 1983; Boyce et al., 1984a; Boyce et al. 1984b; Bell, 1986; Bremberg & Gerber, 1988; Boyce et al., 1989; Bergström & Björnstig, 1991; Coppens & Krehel-Gentry, 1991; Lenaway et al., 1992; Rudd & Walsh, 1993; Sosin et al., 1993; Petridou et al., 1994; Stark et al., 1996; Maitra, 1997; Moysés, 2000). According to Rudd and Walsh (1993), school that are small, safe, engaging, and intimate communities are the most healthful environments. Although the roles of teachers on health promotion and safety at school, as well as the advantages of school-parent links, have been explored, there was little evidence of impact on children (Young, 1992; Carter et al., 1994; Denman, 1998; Leger, 1998). Gains appear to be associated with the level of teacher's commitment and parental and community participation.

School may provide an environment, which could either improve or harm the health of children. Some characteristics of school in terms of their environments were reported to be related to general and traumatic dental injuries as follows.

1.4.3.1 The role of social environment

School policies, in terms of social environment, were reported to be associated with traumatic dental injuries (Moysés, 2000). The commitment towards health and safety, which is a component of school's health promotion, was associated with traumatic dental injuries. 9.7% fewer children had traumatic dental injuries in schools with demonstrated commitment towards health and safety (Moysés, 2000).

According to supervision in school, higher injury rates were found in schools with lower student-to-staff ratios (Boyce et al., 1984a). The presence of teachers in playgrounds was associated with a lower injury rate (Feldman et al., 1983; Bell, 1986; Coppens & Krehel-Gentry, 1991). This finding appears to be consistent with the study conducted by Stark et al. (1996), who observed that injury rate in 'uncontrolled areas' (without supervision) of elementary schools increased compared with 'controlled areas'.

There is no study reporting the importance of children receiving safety information on the occurrence of injuries. However, a study showed that schools with a comprehensive curriculum were more likely to have a fewer children with traumatic dental injuries (Moysés, 2000).

According to social relationships of school, schools with an intimate community are the most healthful environments (Rudd & Walsh, 1993). At the individual level, a study by Bremberg and Gerber (1988) revealed that injured children were significantly more likely to have unsatisfactory relationships with schoolmates than non-injured children. However, social relationships at school in terms of a school characteristic such as school-home and school-community relationships need to be explored.

A child's educational performance is related to risk of injury. A poor performance at school is strongly correlated with school-injury experience (Petridou et al., 1994). However, performance of a group of children (e.g. a school) may vary across groups. It is interesting to assess if other group-performances, such as violence and dropout rates, absenteeism and punishment rates, are associated with the occurrence of traumatic dental injuries.

1.4.3.2 The role of physical environment

Generally, poor physical environment contributes to poor health (Towner et al., 1993; Wilkinson & Marmot, 1999). The school buildings and surrounding areas can have an impact on children's academic achievement and learning (Moore & Lackney, 1993). Moreover, injuries sustained by children in school accidents are reported to be related with a lack of safe grounds/playgrounds, sport facilities, and stairways (Lenaway et al., 1992; Stark et al., 1996; Maitra, 1997). There is some evidence of the relationships between physical environment at school and injuries (Boyce et al. 1984b; Boyce et al., 1989; Coppens & Krehel-Gentry, 1991; Lenaway et al., 1992; Rudd & Walsh, 1993; Sosin et al., 1993; Stark et al., 1996; Maitra, 1997). Schools that are small in size, safe and engaging are the most healthful environments (Rudd & Walsh, 1993). On the other hand, lack of safe grounds/playgrounds, sport facilities, and stairways was related with a high injury rate (Lenaway et al., 1992; Stark et al., 1996; Maitra, 1997).

In fall related injuries, ground-surface on playground is an injury determinant, particularly on severity of injuries (Boyce et al. 1984b; Coppens & Krehel-Gentry, 1991; Sosin et al., 1993). The laying of impact-absorbing surface was regarded as an important measure to reduce the consequences of fall-injury (Boyce et al., 1984b; Sosin et al., 1993). Moreover, the incidence of fall injuries was lowest in the case on sand surfaces, and slightly higher for grass, gravel and matting but the rate in the case of asphalt was six times that of sand despite considerably lower equipment heights (Sosin et al., 1993).

Overall, since there was evidence that the rate and severity of injuries tended to vary considerably from school to school (Boyce et al, 1984a; Bergström & Björnstig, 1991), it could be speculated that school environment might be associated with occurrence of general and traumatic dental injuries. This speculation is supported by the study of Boyce et al. (1989). They suggested that preventive strategies might benefit from investigation of physical environmental factors that altered risk of injuries.

1.4.4 Summary

Since there is a little information about traumatic injuries (Kashemsant, 1978), especially no published information about traumatic dental injuries in Thailand, the first part of the study should attempt to get basic information on prevalence of traumatic dental injuries and information regarding human, vehicles or vectors, environments, and related activities leading to traumatic dental injury. Syme (1996) has noted that '... epidemiologists tend to study individuals in order to find causes of diseases even though it is clear that this will not be helpful in understanding the distribution of disease in the population'. Syme continues: ... almost all epidemiologists study large numbers of individuals in communities. This is not epidemiology. It is clinical medicine in large groups'.

Moreover, according to Rivara (1982), the prevention of accidents based on attitudes focusing on the concept of fault and negligence has been unsuccessful in decreasing the problems. He quoted Wigglesworth (1978) that an approach for prevention of the problem in adults had been attempted through deterrence and punishment of those who are 'guilty'. He also raised an example of this approach from a study conducted by Ross (1975) that the DUI (Driving Under Influence) of alcohol laws in Sweden had been unsuccessful in decreasing traumatic death. The net result has been to blame the victim rather than searching for appropriate ways to prevent the problem (Rivara, 1982). Therefore, the main focus of this thesis is on the physical and social environment factors relating to the occurrence of injury. In addition, this thesis sets out not only to collect epidemiological information about traumatic dental injuries in Chiang Mai urban area, but also to obtain information which may be useful for planning and making decisions on control and prevention in the future.

1.5 The conceptual framework of the study of traumatic dental injuries in schools

Human, vehicle or vector, and environment factors are the risk factors of traumatic dental injuries (Figure 2). The human factors, in this study, comprise demographic factors, socio-economic factors, dental anatomy factor and Body Mass Index (BMI) (Figure 2). The demographic factors are age and sex, and the dental anatomy factor is anterior protrusion of teeth (incisal overjet).

The vehicle or vector factors may be either biological or physical vehicles (Figure 2). The biological can be either human or animal. The physical vehicles mainly are mechanical vehicles.

The environmental factors are the main interest for the study, namely the social and physical environments in schools (Figure 2). Social environment includes school policies, supervision, safety information, social relationships, and children's performance. Physical environment is classified as conditions of buildings, cleanliness, floor conditions, light conditions of school, and crowding as well as amount of playground in school.

Figure 3 shows the details of components of social and physical environment at school. For social environment, school policies consist of safety plans, strategies to prevent accident and violence, and implemented policies. Supervision is ratio of supervisor and children. Safety information comprises receiving of safety information of children, and safety related subjects passing through school curriculum. Social relationships are the relationships between school and home, and school and community. Children's performance includes examination result of health education subject, violence, dropout, absentee, and punishment rates of school. For physical environment, conditions of roofs and windows represent conditions of school buildings. Cleanliness and floor conditions of school are assessed on areas in school such as classrooms, corridors, canteen, toilets, and playgrounds. Light conditions of school are assessed in the areas of classrooms, canteen, and toilets. Crowding of children is ratio of all children in school and school area. Amount of playground is ratios of whole playground area or hard surface area on playground and all children in school.

Figure 2 Human, Vehicle or Vector and Environment in the risk factors of traumatic dental injuries

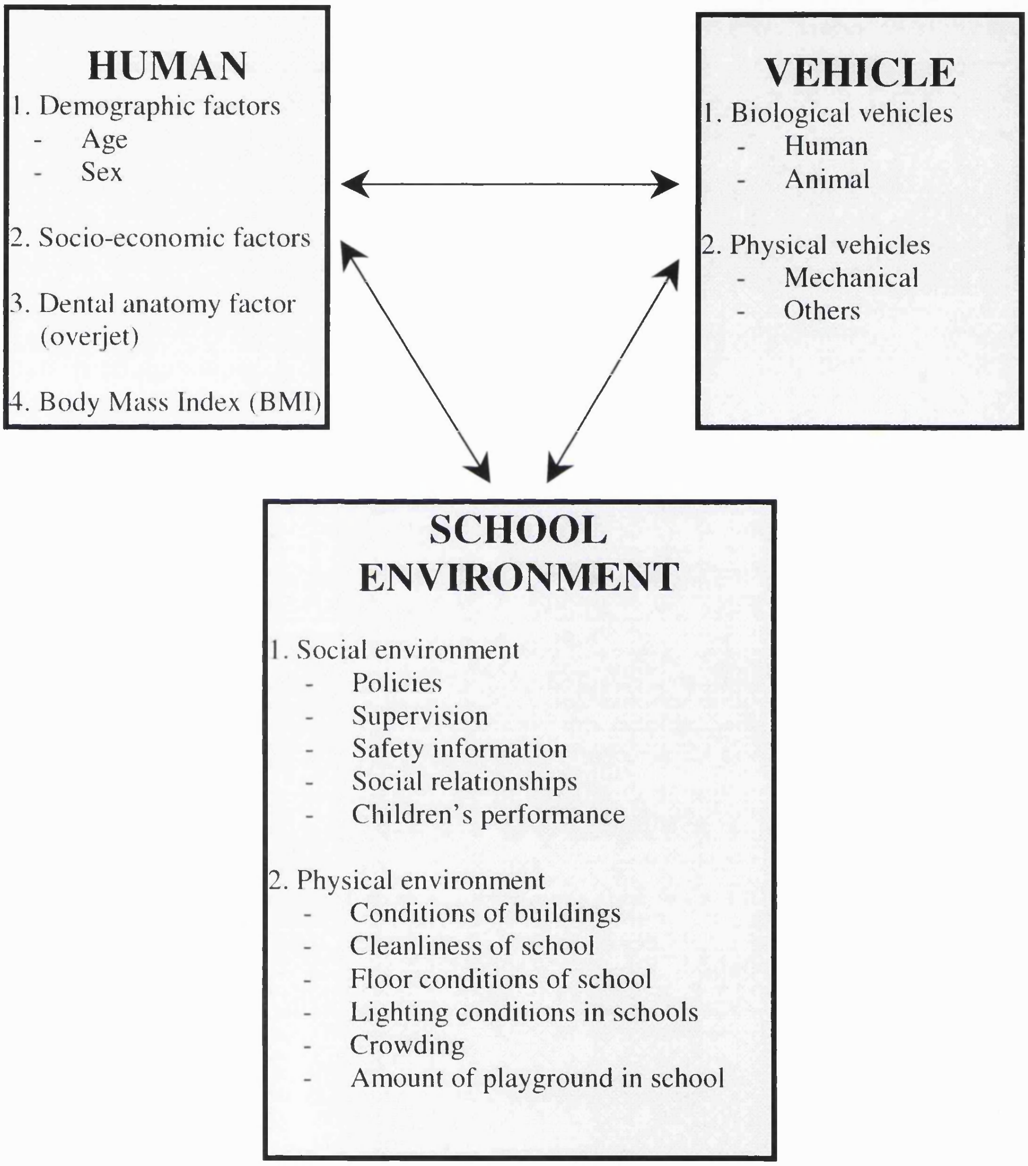
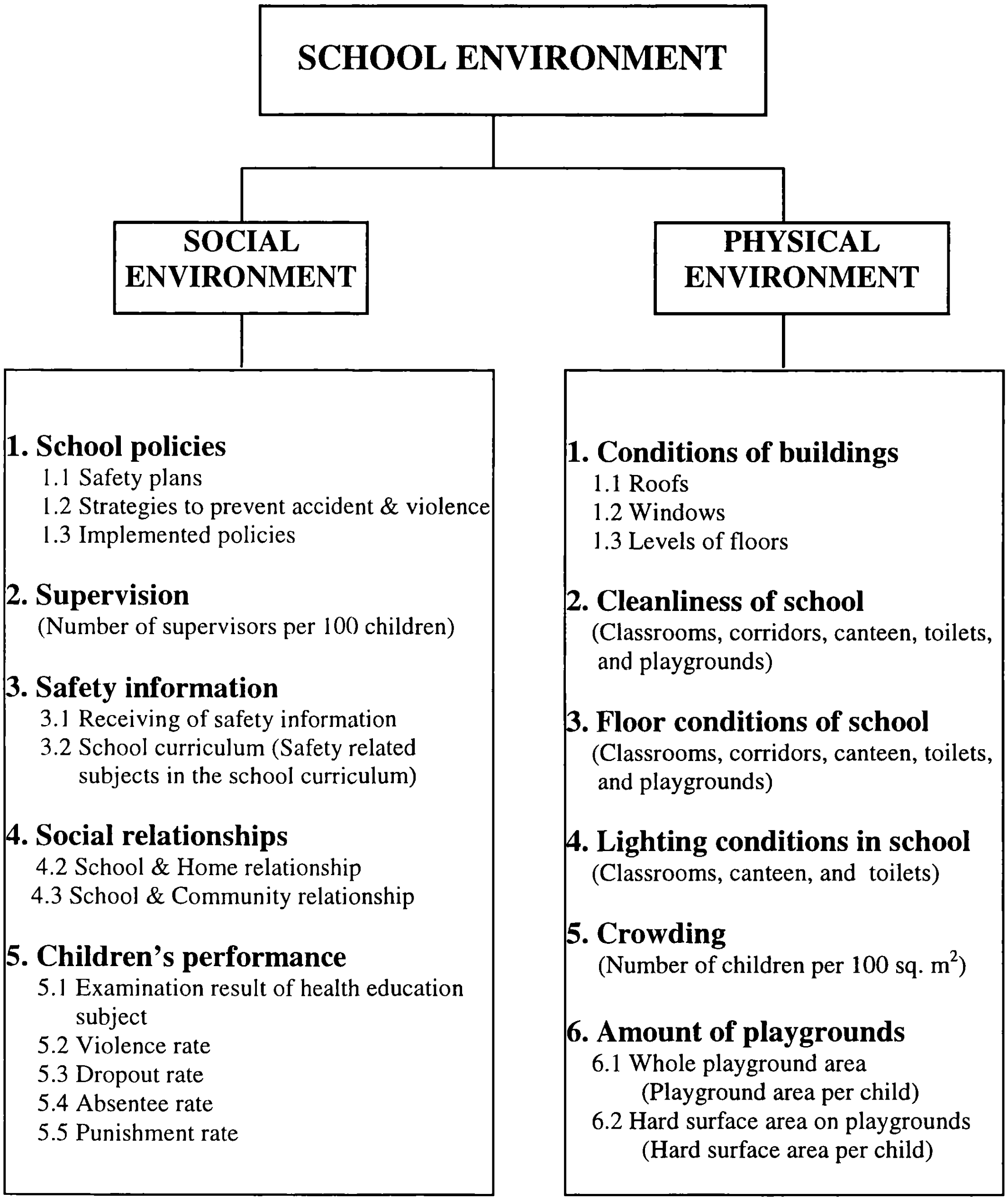


Figure 3 The component of social and physical environment at school



1.6 Hypothesis

The prevalence of traumatic dental injuries in children attending schools with more socially supportive and physically favourable environments is significantly lower than in those attending schools with less socially supportive and physically favourable environments.

1.7 Objectives

1.7.1 To assess the prevalence of traumatic dental injuries to permanent teeth in Class Level 6 schoolchildren in Chiang Mai urban area by sex, age, physical and social environments of schools, socio-economic and anatomical factors of children

1.7.2 To assess the type of traumatic dental injuries to permanent teeth and tooth positions of damaged teeth in Class Level 6 schoolchildren in Chiang Mai urban area

1.7.3 To assess the event relating to traumatic dental injuries to permanent teeth: time and place of injury occurrence; causes of traumatic dental injuries; type of vehicles or vectors; type of activities leading to injuries

1.7.4 To assess the association between social environments of school and traumatic dental injuries in Class Level 6 school children

1.7.5 To assess the association between physical environments of school and traumatic dental injuries in Class Level 6 schoolchildren

1.7.6 To assess the relative importance of school environments and human factors of children (demographic, socio-economic and dental anatomy factors as well as BMI of children) in relation to traumatic dental injuries in Class Level 6 schoolchildren

Chapter 2

2. Methodology

This section consists of the description of the study area, the study population, the age group selected for the study, type of studies, data requirements, the pilot studies, and sample size estimation and sample selections and response rates, local contacts, data collection and procedures, controlling for bias, as well as data processing, data analyses, ethical considerations.

2.1 The study area

This study was carried out in the urban area of ‘Chiang Mai’ province, which is located at 696 kilometres north to Bangkok, the capital of Thailand. Chiang Mai is the centre of commercial and governmental offices in the northern part of Thailand. This province is divided into 21 districts within 20,107 square kilometres (Office of the Prime Minister, 1992). ‘Muang’ district is the centre of Chiang Mai province, and it was referred to as the urban area of this study. The central part of Muang district is highly concentrated with business activities and vehicular traffic. This central part is under the responsibility of the Chiang Mai Municipality, and is called ‘the municipal area’. The remaining part of Muang district, which surrounds the municipal area, is less densily populated. The Chiang Mai Provincial Governmental Office is responsible for this peripheral part of Muang district, and this area is called ‘the peri-municipal area’.

2.2 The study population

The study population was all primary schools in Muang district, Chiang Mai province. There were 58 primary schools in this district; 32 public schools, 11 municipal schools, and 15 private schools. The schools are under control of the Office of Chiang Mai Provincial primary school, the Chiang Mai Municipality and the Educational Office of Chiang Mai Province, respectively.

3 public schools and 2 private schools were excluded from the study population. The reason was that the location of the excluded public schools is on a mountain (the Doi Suthep Mountain) though they are also located in Muang district. The route to this area is a single road and ended at a village on this mountain. Not only the geographic condition is different from the other schools but also all children in these excluded public schools were hill-tribe people (called Mong or Meaw). Their religion, culture, life style and beliefs are different from the people on lower plateau of Maung district. The exclusion of 2 private schools was that they were new schools and had no children in class level 6 during the study period.

There were 4,720 children Class Level 6 in the 53 primary schools included as a defined study population; 1,259 children from 29 public schools, 427 children from 11 municipal schools and 3,034 children from 13 private schools (Table 22).

Table 22 The numbers and percentages of children in primary school level 6 defined as the study population, by school types

School types	Number of schools	Number of children	%
Public school	29	1,259	26.7
Municipal school	11	427	9.0
Private school	13	3,034	64.3
Total	53	4,720	100.0

2.3 The age groups of the study

Since traumatic dental injuries were more common in late childhood and early adolescence (Section 1.4.2.4.1), the study of traumatic dental injuries should be focused on these age groups. However, in Thailand it is compulsory to study to at least primary school Class Level 6. To ensure that a representative sample of children would be included, school children in this level aged about 12 years were assessed for traumatic dental injuries. Children in higher educational levels were not included in the study though they would have more traumatic dental injuries. The reason for not including them is that many of them leave schools for work.

2.4 The study type

A cross-sectional study was the method for this study. The exposures and disease status were assessed simultaneously. Each school included in the study was studied for characteristics of exposures in schools, and children were assessed for disease outcome. The frequency of traumatic dental injuries was the disease status in this study. The main exposures were social and physical environment of schools. The other exposures were demographic factors, socio-economic factors, Body Mass Index (BMI), and anterior tooth protrusion (incisal overjet) of children. Moreover, the children who had experienced traumatic dental injuries were studied in detail for the events relating to injuries such as location and time of injury occurrence, types of vehicle or vector which directly contacted the teeth and caused tooth damage, and types of activities leading to injuries.

The other types of study designs, such as hospital based case-control study and prospective cohort study, could also have been used to test the hypothesis of this study. Their advantages and limitations are discussed in this section.

A prospective cohort study would be an option for testing the effect of school environment on traumatic dental injuries in children. An advantage of this study design is that the exposures can be recorded before the occurrence of outcome. However, it is not appropriate to use this study design to test the effect of many exposures at the same time. Moreover, this study type needs a period of time to follow cohorts until the outcome occurs.

Though a case-control study can assess effect of many exposures of traumatic dental injuries at the same time, the main problem is that exposures must precede outcome. However, we would not be able to find this information from the study area to confirm the temporal relationship between school environment and traumatic dental injuries.

2.5 Data requirements

There were four main types of required data, the outcome, the outcome-related information, the main exposures and the other exposures. Below is a table of all variables included in this study, which are sequentially presented (Table 23). Following this table, the detail of data requirements are described.

Table 23 Data requirements; the variables in the study of traumatic dental injuries in schools

Type of variables	Data required	Descriptions
2.5.1 Outcome	**Traumatic dental injuries**	0 = No 1 = Yes
2.5.2 Outcome related	**2.5.2.1 Types of traumatic dental injuries and tooth positions of damaged teeth**	The classification of the types of traumatic dental injuries used in this study shown in Table 19 **(Section 1.4.2.2.1)**
	2.5.2.2 The event relating to traumatic dental injuries	Event relating to traumatic dental injuries are time of injury occurrence, causes, types of vehicle or vector which directly contacted or injured children, place where injuries occurred, and type of activity leading to injury.
2.5.3 Main exposures	**2.5.3.1 Social environment** **2.5.3.1.1 School policies** - Safety plans & strategies to prevent accident & violence *Does the school have clear guidelines and procedures on the following topics: alcohol policy, drug ban, first aid, safety plan, and dissemination of safety information?*	0 = No 1 = Yes

Table 23 (continued)

Type of variables	Data required	Descriptions
	- Implemented policies *Which policies have been implemented and how long are they placed?*	
	2.5.3.1.2 Supervision	Ratio between number of supervisors and number of children in school (Number of teachers per 100 children per day), then, code the ratio for each child of that school.
	2.5.3.1.3 Safety information from outside school *Frequency of children receiving safety information given inside school by non-school sources*	0 = Fewer than once a year or never 1 = Once a year or more but fewer than once a term 2 = Once a term or more but fewer than once a month 3 = Once a month or more
	2.5.3.1.4 School curriculum ***Topics:*** *drug & solvent abuse, alcohol & violence, feeling/emotional development, responsibility relationships, family life, coping with stress, safety education, first aid, environmental aspect of health education, child protection, bullying, self esteem*	0 = Once a week 1 = Twice a week 2 = Three times a week 3 = Four times a week 4 = More than four times a week (These scores were chosen for each item)

Table 23 (continued)

Type of variables	Data required	Descriptions
	2.5.3.1.5 Social relationships	
	- School and home relationships *Participation of parents in each meeting*	0 = Less than 25 % 1 = 25 to 49 % 2 = 50 to 74 % 3 = 75 to 100 %
	- School and community relationships *Frequency that school has been used for the community activities during evening or weekend.*	0 = Fewer than once a year 1 = Once a year or more but fewer than once a term 2 = Once a term or more but fewer than once a month 3 = Once a month or more but fewer than once a week 4 = Once a week or more
	2.5.3.1.6 Indicators of children's performance	
	- The result of health education examination *(Children of class level 6) (Total = 40 marks)*	Mean score for each school
	- Violence rate reported last year *(All children)*	Cases per 100 children per year
	- Dropout rate recorded last year *(Children of class level 6)*	Cases per 100 children per year
	- Absentee rate *(Children of class level 6)*	Days per child per year
	- Punishment rate *(Children of class level 6)*	Cases per 100 children per week

Table 23 (continued)

Type of variables	Data required	Descriptions
	2.5.3.2 Physical environment	
	2.5.3.2.1 Condition of school buildings	
	- Roofs	0 = Poor 1 = Average 2 = Good
	- Windows	0 = Poor 1 = Average 2 = Good
	- Number of floor levels	Count number of floor levels
	2.5.3.2.2 Cleanliness of school *Assessed in five areas; classrooms, corridors, canteen, toilets, and playground*	0 = Poor 1 = Average 2 = Good (Scored for each area)
	2.5.3.2.3 Condition of floors *Assessed in five areas; classrooms, corridors, canteen, toilets, and playground*	0 = Poor 1 = Average 2 = Good (Scored for each area)
	2.5.3.2.4 Lighting conditions *Assessed in three areas; classroom, canteen, and toilets*	0 = Poor 1 = Average 2 = Good (Scored for each area)
	2.5.3.2.5 Crowding in schools	Number of children per 100 square metres (All children in school * 100 / whole school area)
	2.5.3.2.6 Amount of playground area in school	
	- Whole playground area	Playground area per child (Square metres / child)
	- Hard surface area on playground	Hard surface area per child (square metres / child)

Table 23 (continued)

Type of variables	Data required	Descriptions
2.5.4 Other exposures	**2.5.4.1 Demographic factors**	
	- Sex	0 = Male 1 = Female
	- Age	Years
	2.5.4.2 Socio-economic factors	
	- Marital status of parents	0 = No or a single parent 1 = Both parents
	- Employment status of parent	0 = Unemployment 1 = Employment
	- Educational status of parent	0 = Compulsory level or lower 1 = Above compulsory level
	- Family income	0 = 5,000 Baht or less per month 1 = Above 5,000 Baht per month
	2.5.4.3 Dental anatomy factor and Body Mass Index	
	- Anterior tooth protrusion (Overjet)	measured in milimetres
	- Body Mass Index (BMI)	weight / square height

2.5.1 Data requirement for the outcome measure

The outcome of this study is whether a child had traumatic dental injuries or not. Traumatic dental injuries occurring at any place were included.

2.5.2 Data requirements for outcome related information

2.5.2.1 Types of traumatic dental injuries and tooth positions of damage teeth

When a child had evidence of traumatic dental injuries, types of tooth damage were recorded in the corresponding tooth positions in the clinical examination record form (Appendix 2). Thus, the proportions of damaged teeth were calculated and stratified by types of tooth damage and tooth positions. Among the injured children, the proportions of children according to number of traumatised teeth were also calculated from this record form.

2.5.2.2 The event relating to traumatic dental injuries

Injured children were studied in detail for the events relating to traumatic dental injuries. The data requirements were time the injury occurred, causes, types of vehicle or vector (directly contacted to teeth of children), place where injuries occurred, and types of activities leading to injury.

2.5.3 Data requirement for the main exposures

The main exposures were school environment, which is the school-level information presenting the characteristics of schools in terms of social environment and physical environment.

2.5.3.1 Social environment of school

The social environment of school comprises school policies, supervisions, and safety information from non-school sources, school curriculum, social relationships as well as children's performance. The required information of each item of social environment is as follows:

2.5.3.1.1 School policies on safety

This requirement was to see if school had safety plans and strategies on the following topics: alcohol policy, drug ban, first aid, safety plan, and dissemination of safety information. The other required data were which safety policies have been implemented and how long they were in place.

2.5.3.1.2 Supervisions

The required data was the number of teachers who were responsible to supervise children in a school per day.

2.5.3.1.3 Safety information from non-school sources

This required information was how often that children of each school received safety information from the community.

2.5.3.1.4 School curriculum

Another requirement for safety information was to what degree the school had emphasised safety issues and related topics in the school curriculum. The topics in school curriculum which are possibly related to safety consisted of drugs and solvent abuse, alcohol and violence, feeling/emotional development, responsibility relationships, family life, coping with stress, and safety education, first aid, environmental aspect of health education, child protection, self esteem, as well as bullying.

2.5.3.1.5 Social relationships

There were two requirements for social relationships.

School and home relationship

The data requirement was how many parents participated in each meeting between teachers and parents.

School and community relationship

Frequency that people in community used school for activities, such as meetings, sport activities, campaigns, or parties, represented relationship between school and community.

2.5.3.1.6 Indicators of children's performance

This performance consists of the results of health education examination, violence rate in school reported last year, dropout rate recorded last year, absentee rate of Class Level 6 children within a year (when the children were in Class Level 5, last year), and punishment rate of Class Level 6 children within a week. In Thailand, there are examinations of all taught subjects in school to test the quality of primary school children. All children in Class Level 6 in Thailand participated in this standard examination. The subject of health education was a part of this examination and reported separately from the other subjects as a mean score for each school (Office of Chiang Mai Provincial Primary School, 1999; Educational Office of Chiang Mai Province, 1999).

2.5.3.2 Physical environment of school

The physical environment of school comprises conditions of buildings, cleanliness of schools, floor conditions of schools, lighting in schools, crowding of children in schools and amount of playground area in schools.

2.5.3.2.1 Conditions of buiidings

Roofs and windows conditions of school as well as number of floor levels of building were assessed.

2.5.3.2.2 Cieanliness of schools

Cleanliness of school was separately assessed for five different areas; classrooms, corridors, canteen, toilets, and playground.

2.5.3.2.3 Floor condition of schools

Floor condition of school was separately assessed for five different areas including classrooms, corridors, canteen, toilets, and playground.

2.5.3.2.4 Lighting in schools

Light condition was assessed to see whether there was enough light in three different areas; classrooms, canteen, and toilets.

2.5.3.2.5 Crowding of children in school

Ratio between total child population of school and school area (children per 100 square metres) was used to determine crowding.

2.5.3.2.6 Amount of playground area in school

Whole playground area

The ratio of the amount of playground area and total number of children in school (square metres per child) was calculated.

Surfaces of playgrounds

Hard surfaces on playground are defined as surface, which is covered with concrete, asphalt, stone, wood, gravel, brick, ceramic, marble, metal, and hard plastic material. Soft surfaces are defined as sand, soil, and grass. The ratio of amount of hard playground surface and total number of children in school (square metres per child) was calculated.

2.5.4 Data requirements for the other exposures

The data requirement for the other exposures in this study were the student-level information consisting of the *characteristics of children* (see Appendix 1 for the definition of terms) such as demographic and socio-economic factors, dental anatomy factor and Body Mass Index.

2.5.4.1 Demographic factors

This required data were age and sex of the subjects.

2.5.4.2 Socio-economic status of children

The socio-economic factors include marital, employment, educational status of parents and family income.

2.5.4.3 Dental anatomy factor and Body Mass Index

Anterior tooth protrusion (Overjet)

The relation between maxilla and mandible was assessed by measuring anterior tooth protrusion (overjet). This measurement is a horizontal distance between incisal edge of upper central incisor and anterior surface of lower central incisor at centric occlusion. Both right and left central incisors were measured for overjets. Then, the average overjet was calculated for each subject (Appendix 2). If the overjet of any child could be measured only one side because of missing teeth or unable for examination, that side of overjet was directly used.

Body Mass Index (BMI)

Body Mass Index (BMI) is a standard measure of overall nutrition. It is a ratio that requires measurement of height and weight. BMI is defined as body weight in kilograms (kg) divided by the square of height in metres (m); BMI = kg/m^2.

2.6 Pilot studies

2.6.1 Pilot study I

The first pilot study was conducted in December 1998. The purposes of this pilot study were to get information on the prevalence of traumatic dental injuries in Chiang Mai Province and train the examiners to examine traumatic dental injuries according to the classification used in this study (Appendix 2). The study was carried out at Mae-Sa Primary School, a public primary school in Mae-Rim District of Chiang Mai Province. This school is approximately 12 kilometres from Maung District.

There were 139 children from primary school Class Level 3 to 6 and secondary school Class Level 1 to 3 in this school. All of them were examined for traumatic dental injuries. The result showed that 43 children, approximately 30 % of all examined children, had experienced traumatic dental injuries. The traumatic dental injuries in boys was 1.6 times those in girls with crude odds ratio of 2.1 (95%CI = 1.0, 4.5).

2.6.2 Pilot Study II

The Ban Rim Tai primary school, which is located in Mae Rim district, was used for the second pilot study. This pilot study was in August 1999. The children of this school had similar characteristics to the children in Maung district. Therefore, it can be assumed that they could have their life styles and backgrounds similar to those children in Maung district.

The aims of this pilot study were to train the interviewers and observers and questionnaire validation. Five children in primary school Class Level 6 who experienced traumatic dental injuries were found. The interviewer interviewed these five children by using the questionnaire for children (Appendix 3). Any problem in understanding of questions in the questionnaire was discussed between the interviewer and the author. After the training session, corrections were made to improve the questionnaire.

To improve the questionnaire for head teachers (Appendix 4), the author interviewed the head teacher of this school. Then, corrections were made to improve questionnaire. The head teacher could not immediately answer some parts of the information in the questionnaire and these were altered.

On the same day, two observers observed the physical conditions of the school and completed the physical environment checklist (Appendix 5). The author was one of the observers. During coding the scores for physical environment, these two observers discussed the content and standardised the method of assessment. In addition, these children took the questionnaire for parent/guardian (Appendix 6) to their parents or guardians. The parents were informed by a message on the first page of the questionnaire to complete questionnaire and return it with their children, once completed. After that, improvements and corrections were made to the questionnaire for parents/guardian.

2.7 Sample size estimations, sample selections and response rates

2.7.1 The sample size estimations

Sample size of a study depends on the purposes, scope and type of study. In this study, the most important objective was to test the hypothesis that children attending in more supportive and favourable school environments will have lower prevalence of traumatic dental injuries than children attending in less supportive and favourable school environments. Meanwhile, this study was intended to study the prevalence of traumatic dental injuries in the study population. Therefore, the sample size in this study should have enough power to test the hypothesis and find out the prevalence of traumatic dental injuries.

According to the hypothesis of this study, the proportion of traumatic dental injuries in children living in adverse school environment was P_1 and that in children living in more favourable school environment was P_2. Then, the null hypothesis that the proportions of two populations are equal ($P_1 = P_2$ or $P_1 - P_2 = 0$) is appropriate to use as the statistical method to estimate the sample size for testing this type of hypothesis (Casagrande et al., 1978; Haseman, 1978; Aleong & Bartlett, 1979; Lwanga & Lemeshow, 1991; Julious et al., 1995; Altman, 1996). The significance level (α) was considered at 5 % and the power of the test (1-β) was at 90%. The formula for sample size estimation (for two-sided test) is as follows:

$$\eta = \left\{Z_1 - \alpha/2\sqrt{\left[2\overline{P}\left(1-\overline{P}\right)\right]} + Z_1 - \beta\sqrt{\left[P_1(1-P_1)+P_2(1-P_2)\right]}\right\}^2 / (P_1 - P_2)^2$$

where

$$\overline{P} = (P_1 + P_2)/2$$

According to the previous studies, the average prevalence of traumatic dental injuries was approximately 20 per cent (Section 1.4.2.1.1). Therefore, it could be assumed that the prevalence among children living in more supportive and favourable school environment was 20 per cent (P_2). The anticipated prevalence of traumatic dental injuries among children living in less supportive and favourable school environment was 30 per cent. Then, the required minimal sample size for testing the hypothesis of this study in schools was 412 children from less supportive and favourable school environment and 412 children from more supportive and favourable school environment (overall = 824 children).

However, the sample size estimation for the prevalence study of traumatic dental injuries was calculated by using the following formula.

$$n = Z^2 P(1-P)/(p-P)^2$$

The size of population from which the sample was selected was 4,720 children. The expected prevalence of traumatic dental injuries in the study population (P) was 20 percent and the worst acceptable prevalence found in the sample was 22 percent (p). Then, at the confidence level of 99 per cent (1-α), the required minimal sample size was 1,699 children.

2.7.2 The sample selection

There were 53 primary schools with 4,720 children in Maung district, Chiang Mai province included as the study population. All of these primary schools were expected to be included in this study. According to the classification of school size in Thailand (Ministry of Education, 1996), small, medium, and large sized schools are the school having 120 children or less, 121 to 1,000 children, and more than 1,000 children, respectively. The sample selection of this study was based on the proportional stratified sampling according to the school-sized categories.

There were 13 small sized schools, 27 medium sized schools, and 13 large sized schools. Of 4,720 children in primary school Class Level 6, 143, 881, and 3,696 children were from the small, medium, and large sized schools, respectively. Therefore, by the proportional stratified sampling technique, the required sample sizes were 51, 323, and 1,325 for the small, medium, and large sized schools, respectively (Table 24).

Table 24 Number of primary schools, number of children in Class Level 6 and the required sample sizes by school sizes

School sizes	Number of primary schools	Number of children class level 6 (11-12 years)	Proportion	Required sample size (children)
Small (≤ 120 children)	13	143	0.03	51
Medium (121-1,000 children)	27	881	0.19	323
Large (> 1,000 children)	13	3,696	0.78	1,325
Total	**53**	**4,720**	**1.00**	**1,699**

2.7.3 The response rates

Of 53 primary schools in the study population, one private school did not respond. However, 2,725 children were examined for evidence of traumatic dental injuries though the calculated minimal sample size for the study in schools was 1,699 children. The reason for over sampling was that the examiners examined not only for traumatic dental injuries but also for dental caries, dental calculus and gingivitis. Then, the examined children were given reports of the result and the suggestions to their parents. Therefore, almost all of the parents, particularly of the small and medium sized schools, allowed their children to participate in the study by signing the consent forms. The final samples included for the clinical examination and classified by school sizes compared to the required minimal sample sizes are shown in Table 25.

The parents of the 2,725 children were asked to complete the questionnaire about their socio-economic status (Appendix 6). The response rate of this questionnaire was 100 per cent (Table 25).

Table 25 The required minimal sample sizes the included sample sizes for clinical examination, and response rates of the questionnaire for parents classified by the school sizes

School sizes	**Required minimal sample sizes** (children)	**Included sample sizes for clinical examination** (children)	**Response rates of the questionnaire for parents** (children) (%)
Small (≤ 120 children)	51	128	128 (100.0)
Medium (121-1,000 children)	323	786	786 (100.0)
Large (> 1,000 children)	1,325	1,811	1,811 (100.0)
Total	1,699	2,725	2,725 (100.0)

2.8 Local contacts

The local contacts of the selected schools were performed in August 1999. To get the permission and ethical clearance and co-operation for this study, the official letters under the name of Chiang Mai University requested co-operation from the persons who had authority in the selected schools: the director of the Office of Chiang Mai Provincial Primary School, the director of the Educational Office of Chiang Mai Province, the Chiang Mai Municipal Governor, and the directors or head teachers of the selected schools.

2.9 Data collection

2.9.1 General and demographic information

In each school, teachers were asked to fill in the general information of the school and the demographic information such as age and sex of every subject for the clinical examination before the examination started (Appendix 2).

2.9.1.1 Body Mass Index of subjects

Each subject with a clinical examination record form was weighed and had height measured by using the same portable weighing machine and the same height scale throughout the study (Appendix 2).

2.9.1.2 Traumatic dental injury and anterior tooth protrusion

Three trained examiners (dentists) examined children for traumatic dental injuries to anterior teeth (12 teeth) according to the classification developed by Cortes (2001) (Table 19, Section 1.4.2.2.1). The children were seated on portable dental chairs, and examined with plane mouth mirror and explorer under light from portable lamps. Subjects were asked for a history of any questionable lesion to confirm diagnosis. This dental examination was performed without tooth vitality test and radiographic examination. In addition, the anterior tooth protrusions (overjet) were measured in milimetres for both right and left side of central incisors of all subjects by using the standardised rulers (Appendix 2).

2.9.1.3 Event relating to traumatic dental injuries

After the clinical examinations, subjects who had evidence of traumatic dental injuries were interviewed for details of injury event. A trained interviewer interviewed the 'traumatised' children using a questionnaire (Appendix 3). The 'traumatised' children were reminded about the detail of injury events by relating to persons (e.g. friends, parents, brother or sister), activities, time (e.g. vacation, weekend, after class), and places (e.g. school, home, playground).

2.9.1.4 Socio-economic status of children

The parents or guardians of the examined children received the self-administered questionnaire, parent and guardian questionnaire (Appendix 6), by passing them via the children. After they had completed them, they returned the questionnaires with their children to the schools. These returned questionnaires were firstly collected from teachers after the distribution for two weeks. Some of subjects returned the questionnaire late. In another two weeks, the remaining questionnaires were collected.

2.9.1.5 Social environment of schools

This data collection and procedure was done on a different day from that of the clinical examination. The directors or head teachers of the schools were interviewed using the questionnaire for head teachers (Appendix 4). The author was the person who interviewed the directors or head teachers of the schools. There were some questions that the directors or head teachers could not give the answers on the day of interview. Some questions needed answers from other teachers who were responsible for special subjects. For example, the statistical information of children, such as number of children in classes and school, and number of dropout children, was answered by the teachers who were responsible for administrative work. The teachers who were responsible for health in schools gave the information of accident cases, which were sent to hospital.

2.9.1.6 Physical environment of schools

The numbers of children in schools were collected from the administrative offices of schools and recorded into the physical environment record form (Appendix 5).

Crowding of children in a school is the average area of school that a child can occupy (school area per child). The information of school area was collected from the school map at the administrative office of each school. Then, this data was recorded in the physical environment record form (Appendix 5).

The whole playground area was calculated from the school map. A school map generally shows the whole size of school area and the area where the buildings cover. Then, the remaining area from the building covered area is the whole playground area for that school.

Hard surface area in a school was directly measured by two observers using a rolling measurement tape (200 metre-length).

The physical conditions of school were conditions of buildings, classrooms, corridors, canteens, and toilets, as well as conditions of playgrounds. This part of data was collected by direct observation on any day after the survey. To prevent school making changes to the school, particularly the information about cleanliness, each school was informed not more than two hours before the visitation. Two trained observers conducted the observations at the same time and agreed on the final scores.

2.10 Controlling for bias

Since this study was focused on primary school children Class Level 6, children in all levels of socio-economic status should be included in the study In addition, almost all of the primary schools in the study area were included in this study, 52 schools out of 53 schools. The sample size was also much greater than required.

2.11 Validation of traumatic dental injury examination, interview, observation, and content of questionnaires

Three examiners (dentists) practised with an expert in examination of traumatic dental injuries from slides. They were trained to diagnose types of traumatic dental injury according to the classification used in this study. After that, a training session was set for the examiners in the pilot study I (Section 2.6.1).

An interviewer read through the questionnaire for children, and the author explained the meaning of each question. Two observers also read through the physical environment checklist of school. Because the author was one of the observers, he explained the meaning of each item in the checklist to the other observer. The questionnaire and checklist were checked for the valid contents with experts on this study subject. After that, both interviewers and observers practised using the improved questionnaire and checklist in the pilot study II (Section 2.6.2). The validation of the questionnaire for head teacher was mentioned in Section 2.6.2.

2.12 Reliability of interviews, observations, and clinical examinations

Clinical examinations and observations for physical environment of schools were assessed for the consistency of measurements. In general, there is no approved method of measuring examiner or observer variability. However, Cohen's Kappa coefficient of agreement (Cohen, 1960) is probably the most reliable method of assessing reliability (Landis & Koch, 1977, Nuttal & Paul, 1985; Hunt, 1986; Bulman & Osborn, 1989). The Kappa statistic relates the actual measure of overall agreement with the degree of agreement which would have been attained had the diagnoses been made at random, or in other words, the extent to which the actual degree of agreement recorded improves upon chance. The general formula is:

$$K = (P_0 - P_e) / 1 - P_e$$

where, P_0 is the proportion of observed agreement and P_e is the proportion of agreement which could be expected by chance.

The following six-point scale (Landis & Koch, 1997) has been proposed for interpreting the kappa values:

Below 0.00	- Poor agreement
0.00 – 0.20	- Slight agreement
0.21 – 0.40	- Fair agreement
0.41 – 0.60	- Moderate agreement
0.61 – 0.80	- Substantial agreement
0.81 and above	- Almost perfect agreement.

2.12.1 Reliability of the examiners

The examiners were tested for both inter- and intra- examiner agreements.

Inter-examiner calibration

For the evidence of traumatic dental injuries (yes or no), 410 children (15.0% of the sample) was re-examined by three examiners. The Kappa scores ranged from 0.83 to 0.87 indicating almost perfect agreement between the examiners (Table 26).

Table 26 The inter-examiner reliabilities for the evidences of traumatic dental injuries in 410 children

Examiners	Kappa scores	Z	P-value
Between examiner 1 & 2	0.83	29.73	< 0.001
Between examiner 1 & 3	0.85	17.14	< 0.001
Between examiner 2 & 3	0.87	17.54	< 0.001
Between examiner 1 & 2 & 3	0.85	29.73	< 0.001

Intra-examiner calibration

Each examiner examined approximately 900 children in this study (Table 27). 444 children were included for the intra-examiner calibration, and the re-examination of each subject was carried out after the first examination for one week. Approximately 16.7% of the examined children were re-examined by each examiner, and the Kappa scores ranged from 0.85 to 0.96 indicating almost perfect agreement between both examinations of each examiner (Table 27).

Table 27 The intra-examiner reliabilities for the evidences of traumatic dental injuries in 444 children

Examiners	Number of children		Kappa scores	Z	P-value
	Overall	Repeated (%)			
Examiner 1	902	146 (16.2)	0.96	11.57	< 0.001
Examiner 2	914	150 (16.4)	0.88	10.82	< 0.001
Examiner 3	909	148 (16.3)	0.85	10.37	< 0.001

2.12.2 Reliability of the observers

Two observers observed the physical environment of each school at the same time and discussed and agreed on the final scores. The observed areas or locations were also photographed during the observations. A measurement of inter-observer agreement was also carried out on two other observers who observed physical environment from the photographs. They observed, on a randomly selected ten schools, the condition of buildings, cleanliness of schools and condition of floors (Appendix 5). The results of the scores between these two observers and the original scores recorded directly from the schools were compared using Cohen's Kappa Coefficient of Agreement (Cohen, 1960). The Kappa scores ranged from 0.34 to 0.83 indicating fair agreement to almost perfect agreement (Table 28). The agreements between three observers shown by the combined Kappa scores for each item (e.g. roof, window) ranged from 0.44 to 0.83 indicating moderate to almost perfect agreement. More importantly, between two observers who observed the same photographs, there were substantial to perfect agreement with combined Kappa scores of 0.61 to 1.00.

Table 28 The inter-observer agreements on the observation of physical environments of schools. Comparison between direct observation at schools and photographic observations by two other observers; 10 schools

Physical environment		**Agreements between observations (Kappa scores)**			
		Direct & Observer 1	**Direct & Observer 2**	**Observer1 & Observer 2**	**Direct & Observer 1 & Observer 2**
Condition of buildings					
Roof	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	0.52	0.34^{NS}	0.61	0.44
	Good	0.52	0.34^{NS}	0.61	0.44
	Combined	**0.52**	**0.34**^{NS}	**0.61**	**0.44**
Windows	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	0.60	0.60	1.00	0.73
	Good	0.60	0.60	1.00	0.73
	Combined	**0.60**	**0.60**	**1.00**	**0.73**
Cleanliness of schools					
Classrooms	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	0.78	0.52	0.78	0.71
	Good	0.78	0.52	0.78	0.71
	Combined	**0.78**	**0.52**	**0.78**	**0.71**
Corridors	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	0.73	0.73	1.00	0.83
	Good	0.73	0.73	1.00	0.83
	Combined	**0.73**	**0.73**	**1.00**	**0.83**
Canteens	Poor	1.00	0.61	0.61	0.76
	Fair	0.80	0.60	0.80	0.73
	Good	0.80	0.78	1.00	0.86
	Combined	**0.83**	**0.67**	**0.84**	**0.78**
Toilets	Poor	1.00	1.00	1.00	1.00
	Fair	0.58	0.78	0.78	0.71
	Good	0.38^{NS}	0.61	0.61	0.52
	Combined	**0.64**	**0.81**	**0.81**	**0.75**
Playground	Poor	0.61	0.61	1.00	0.71
	Fair	0.39^{NS}	0.39^{NS}	0.60	0.46
	Good	0.52	0.52	0.58	0.55
	Combined	**0.49**	**0.49**	**0.66**	**0.54**

Table 28 (continued)

Physical environment		**Agreements between observations (Kappa scores)**			
		Direct & Observer 1	**Direct & Observer 2**	**Observer1 & Observer 2**	**Direct & Observer 1 & Observer 2**
Condition of floors					
Classrooms	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	0.52	0.73	0.73	0.68
	Good	0.52	0.73	0.73	0.68
	Combined	**0.52**	**0.73**	**0.73**	**0.68**
Corridors	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	0.37^{NS}	0.73	0.78	0.58
	Good	0.37^{NS}	0.73	0.78	0.58
	Combined	**0.37**^{NS}	**0.73**	**0.78**	**0.58**
Canteens	Poor	N.O.	N.O.	N.O.	N.O.
	Fair	1.00	0.38^{NS}	0.61	0.71
	Good	1.00	0.38^{NS}	0.61	0.71
	Combined	**1.00**	**0.38**^{NS}	**0.61**	**0.71**
Toilets	Poor	0.73	0.73	1.00	0.83
	Fair	0.34^{NS}	0.52	0.80	0.57
	Good	-0.11^{NS}	-0.05^{NS}	0.61	0.26^{NS}
	Combined	**0.41**^{NS}	**0.55**	**0.83**	**0.61**
Playground	Poor	0.52	0.78	0.73	0.68
	Fair	0.34^{NS}	0.58	0.78	0.57
	Good	-0.05^{NS}	-0.05^{NS}	1.00	0.46
	Combined	**0.38**^{NS}	**0.61**	**0.80**	**0.60**

N.O. = No observation
^{NS} = Non significance (considered at $p < 0.05$)

2.12.3 Reliability of the interviewers

The interviewer, who interviewed 'traumatised' children, was tested for intra-interviewer reproducibility by interviewing the same subjects (for every ten subjects}. The duplicate interviews were conducted on 100 'traumatised' children one week after the first interview. There were 11 questions for the interview; Question 2.1 to 2.11 (Appendix 3). The agreement between the first and second interviews on the same subjects using Spearman's correlations ranged from 0.89 to 1.00 with $p < 0.001$ indicating very good agreement.

2.13 Data processing

The procedures of data processing include data entry, verification, cleaning, and consistency check. The data of this study were entered and processed by using the Epi Info version 6.04a programme (Dean et al., 1996). Every created file on the computer was copied for backup file in both hard and floppy disks.

The data were entered into two similar files but different file names on two computers at the Department of Community Dentistry, Faculty of Dentistry, Chiang Mai University. While each typist were entering the data, the interactive data checking such as range checks, must-enter variables, conditional jumps, and legal values were processed according the setting during the questionnaire preparation in this programme before the data collection. After completing the data entry on both computers, the validation of the data was performed between these two files. Any discrepancy showing the different values in each file was corrected. Then, the final file was checked for consistency and missing values. The data cleaning and verification also took place daily after the data collection from interview, observation, and examination. The examiners, observers, and interviewer sorted out unclear or missing data with the author.

Before data analysis, the data in the Epi Info version 6.04a (Dean et al., 1996) was converted to the Stata statistical package programme version 6.0 (Stata Corporation, 2000). After that, the transferred data set was checked for internal consistency and edited for possible errors.

2.14 Data analyses

All statistical analyses in this study were carried out using statistical software such as the Stata Statistical Package Programme Version 6.0 (Stata Corporation, 2000), the Statistical Package for Social Science for windows version 10 (SPSS/PC, 1999) and the MLwiN version 1.02.0002 (Rasbash et al., 1998). There were three stages of the data analyses. The first stage was the description of all information in the study. The second stage was an analysis classifying the schools according to social and physical environments of schools. The last stage was the analyses assessing the relationships between school environments and traumatic dental injuries.

2.14.1 Descriptive analyses

There were two data sets at the beginning of data analyses, the school level and student level data sets. The descriptive data were analysed according to the original level of information. The main exposures, physical and social environment of schools, were described at the school level. The outcome, outcome related information, and the other exposures were described at the student level. The results of descriptive analyses were presented in terms of frequencies, percentages, medians, minimum, maximum, percentiles, and modes.

2.14.2 The classlfication of schools

The purpose in classifying the schools in this study was to group them into four groups according to school environments. The first two groups were classified by the extent to which schools have been socially supported. The second two groups were classified according to how much that schools had a physically favourable environment.

2.14.2.1 Principle of classification of schools

2.14.2.1.1 The choice of variables included in the cluster analysis of schools

The initial choice of the particular set of measurements used to characterise each school to be clustered constitutes a frame of reference within which to establish the clusters; the choice reflects the investigator's judgement of relevance for the purpose of classification. The purpose of classifying the schools in this study was to identify whether they were more or less socially supportive environment and more or less physically favourable environment in terms of safety or safety-related characteristics. The chosen characteristics should be relevant to the type of classification being sought.

In general, there is no sound theoretical basis for determining the number of variables to use. Therefore the problem must be approached empirically (Everitt, 1993). In most applications it is probable that the researcher will err on the side of taking more rather than fewer measurements, which can give rise to computational problems with some cluster techniques. More importantly, the presence of additional variables on which clusters are not distinguished may obscure the cluster structure (De Sarbo et al., 1984).

2.14.2.1.2 Standardisation of variables

In general, the variables describing the objects to be clustered were not measured in the same units. Some of the variables may be nominal, ordinal, interval or ratio scales. For interval and ratio scaled variables, the solution suggested most often is to simply standardise each variable to unit variance before any analysis, using standard deviations calculated from the complete set of objects to be clustered. However, this may have the serious disadvantage of diluting differences between groups on the variables, which are the best discriminators (Fleiss & Zubin, 1969; Duda & Hart, 1973). Moreover, on using the within-group standard deviations for standardisation the possible correlation between the variables is unknown (Everitt, 1993). Therefore, when the variables measured are of different types, the simplest approach is to convert all variables into the lowest scale of the included variables. For example, in case of mixing up with four types of scales (nominal, ordinal, interval and ratio scales), the ordinal, interval and ratio scaled variables should be converted into binary form. This has the advantage of being very straightforward, but the disadvantage of sacrificing potential useful information.

Since the lowest of the school characteristics collected in this study was ordinal scale, the higher scales were converted into ordinal forms before performing cluster analysis.

2.14.2.1.3 Weighting of variables

To weight a variable means to give it greater or lesser importance than other variables when using these variables to produce a classification. Although it is possible to arrange for certain variables to be weighted, various authors question the validity of such a procedure. Sneath and Sokal (1973) considered that the weights can only be based on intuitive judgements of what is important, and that these may simply reflect existing classifications. However, in general, this is not what is required in a clustering application. The methods of cluster analysis are applied to a data set in the hope that previously unnoticed and potentially useful groups will emerge. In addition, accepted groupings may perhaps not turn up because they are not supported by the present data. Then the investigator may be forced to revise hypotheses or propose a better measurement (Everitt, 1993).

Gordon (1980) argued that if no information at all is available about the relevance of different variables, equal weighting would seem appropriate. After a detailed study on a data set has been carried out, certain variables are likely to be considered of greater importance in discriminating between groups of cases. However, Dunn and Everitt (1982) pointed out that the real problem with a priori weighting is not that it is logically invalid, but that it is often very difficult to decide how to weight the variable in practice.

Since there is not clear information about the relevance of different variables of school characteristics, the equal weighting method was applied in this study. However, there were some variables possibly describing the same context. Therefore, Principal Component Analyses (PCA) (Appendix 7) were performed to reduce the number of variables into a smaller number. Then, the best representative for each obtained context was selected for the final variables in cluster analysis.

2.14.2.2 The technique of cluster analysis used in this study

The optimisation cluster analysis or *k*-means cluster analysis is the selected method for classifying the schools in this study. The reasons are that this method is not hierarchical or nested, and an appropriate choice of the final number is made at the end to satisfy the purpose of school classification of this study.

Optimisation cluster analysis or *k*-means cluster analysis is a type of methods for cluster analysis, which divides data into a particular number of groups to optimise some criterion, often based on the within-group covariance matrix (MacQueen, 1967). The statistical method is presented in Appendix 8.

Everitt (1993) has explained that the standard procedure is to start with a partition into *k* groups (initial groups or clusters), and then scan through the data set transferring each point to a different group if that would reduce the criterion. This scan continues until no further transfers take place. The criterion has converged to an optimal value (cluster centre or mean score), although typically a local rather than global optimum.

When an analysis was performed using a Statistical Package for Social Science for windows version 10 (SPSS/PC, 1999), the computer randomly specified the initial cluster centres. The possible cluster centres of the given number of groups were repeatedly calculated until satisfying the clustering criterion. Finally, the final cluster centres of the chosen number of groups were obtained. The essential steps in the algorithms of cluster analysis in this study are:

(a) Find some initial partition of the schools into two groups (clusters).

(b) Calculate the change in the clustering criterion produced by moving each school from its own to another cluster.

(c) Make the change which leads to the greatest improvement in the value of the clustering criterion.

(d) Repeat steps (b) and (c) until no move of a single school causes the clustering criterion to improve.

2.14.3 The relationships between school environments and traumatic dental injuries

2.14.3.1 Rationale for the use of multilevel analysis in the study

The school environment in this study is a context of particular characteristics of school obtained from a classification of schools, which was explained in Section 2.14.2. Therefore, social and physical environments are school-level information. On the other hand, the traumatic dental injuries were measured at student-level. To assess the relationship between school environments and traumatic dental injuries, it means that the effects of school-level (group-level) variables on the student-level (individual-level) outcome were examined.

In analysing data corresponding to individuals (students) nested within groups (schools), there are several options (Diez-Roux, 2000). The first is to ignore group membership and focus exclusively on inter-individual variation and on individual-level attributes. This approach ignores the potential importance of group-level attributes influencing individual-level outcome (traumatic dental injuries). The second option is to focus exclusively on inter-group variation and on data aggregated to the group level. This approach is ignores the role of individual-level variables in shaping the outcome. The summarised data from individual-level to group-level also loss information. Both the first and the second approaches essentially collapse all variables in the same level and ignore the multilevel structure. The third approach is to define separate regressions for each group. This approach allows regression coefficients to differ from group to group, but does not examine how specific group-level properties may affect individual-level outcome or interact with individual-level variables. In addition, it is not practical when dealing with large number of groups or smaller number of observations per group. The fourth approach is to include group membership in individual-level equations in the form of dummy variables (as well as the interactions of group dummy variables with individual-level predictors). This approach is analogous to fitting separate regressions for each group and does not allow examination of exactly what group characteristics may be important in explaining the outcome. In addition, this approach treats the groups as unrelated and ignores the fact that groups may be draw from a larger population of groups with things in common.

The multilevel analysis (or hierarchical modelling) is a suitable method in assessing the relationships between school environments and traumatic dental injuries in this study. Because this approach differs from the approaches outlined above in that:

(a) it allows the simultaneous examination of the effects of group-level and individual-level predictors,
(b) the non-independence of observations within groups is accounted for,
(c) groups or contexts are not treated as unrelated, but are seen as coming from a larger population of groups (Duncan et al., 1998),
(d) both inter-individual and inter-group variations can be examined (as well as the contributions of individual-level and group-level variables to these variations) (Snijders & Bosker, 1997).

2.14.3.2 The statistical model of multilevel analysis

For multilevel analysis involving two levels, students nested within schools (as in this study), the model can be conceptualised as a two-stage system of equations in which the student variation within each school is explained by a student-level equation, and the variation across schools in the school-specific regression coefficients is explained by a school-level equation. The description of multilevel modelling both for linear and binary response described by Goldstein et al. (1998) is illustrated in Appendix 9.

2.14.3.3 The process of performing multilevel analysis in this study

Multilevel analyses were performed to investigate the associations between traumatic dental injuries and the explanatory variables in the study by accounting for variations between schools. The sequence of the process is as follows:

a) The unadjusted associations between traumatic dental injuries and both the social and physical environments and the characteristics of children, such as demographic, socio-economic, and dental anatomy factors and the Body Mass Index were explored.
b) The associations between traumatic dental injuries and school environment adjusted for each confounding factor were performed to show how the strength of the association was affected by each confounding factor compared to the unadjusted association.
c) Then, the association between traumatic dental injuries and school environment sequentially adjusted for confounding factors.
d) After that, the interactions between explanatory variables on traumatic dental injuries were investigated. When any significant interaction had been found, further analysis was performed.

In addition, the statistical significance was considered at 95% confidence interval for associations between variables and at 90% confidence interval for interactions between variables.

2.15 Ethical considerations

This study was approved in October 1999 by the Human Experimentation Committee, Faculty of Dentistry, Chiang Mai University, Chiang Mai, Thailand (Appendix 10). More importantly, this study was not harmful to the subjects because the dental examination was mainly based on clinical observation. The instruments such as plane mouth mirrors and explorers were prepared for each child in a sterile sealed plastic bag and sterilised by the autoclave at the Faculty of Dentistry, Chiang Mai University. The informed consent was sent to the parents or guardians of every subject for a permission to participate in the study. They were informed of the purposes of the study, and that information was confidential. Moreover, the children who had traumatised teeth requiring dental treatment were told about treatments and their parents were informed. In addition, every subject was examined for dental caries, gingivitis, and calculus, and this information was also reported to their parents or guardians.

Chapter 3

3. Results

The results in this chapter are presented in four main sections. The first section is the results of descriptive analysis (3.1). The second section (3.2) shows a classification of schools in terms of their social and physical environments. The included schools were classified using characteristics of schools (school level information on social and physical characteristics). The third section (3.3) is the results of the analyses for the relationships between traumatic dental injuries and school environments using multilevel analysis. Both unadjusted and adjusted relationships for confounding factors were performed in this section. Finally, the fourth section is a summary of the results of the study (3.4).

3.1 Descriptive analyses

The presentation of the results of the descriptive analyses is divided into seven sections. The first section describes the characteristics of children included in the study, in terms of demography, dental anatomy and body mass index (BMI) and socio-economic factors. The second section presents the outcome and the outcome-related information such as type of traumatic dental injuries with their location and the distribution of children according to number of damaged teeth. Section three shows the time and places the injuries occurred. The fourth and fifth sections present the causes and vehicles (vectors) which directly contacted or injured the children. Section six presents the activities leading to traumatic dental injuries. The last section is the description of school characteristics in terms of social and physical environment.

3.1.1 The characteristics of children included in the study

Table 29 shows the characteristics of children included in this study. According to the demographic factors, 1,394 children (51.2%) were females and 1,331 children (48.8%) were males. Their ages ranged from 9 to 18 years (Mean $\pm$ SD = 11.8 $\pm$ 0.7), and most of them (64.3%) were 12 years old. The younger than 12 years old was 29.1percent, and the older than 12 years old was 6.6 per cent.

In terms of socio-economic factors, 20.8% of the children had none or a single parent and 79.2% had both parents. The parents of 134 children (4.9%) and 1,153 children (42.3%) were unemployed and educated at the compulsory level or lower, respectively. The family income of 61.5% of children was above 5,000 Baht.

Eight per cent of children had anterior tooth protrusion (overjet) of more than 5 mm. The body mass indices of children ranged from 11.3 to 41.0 kg/m^2 (Mean $\pm$ SD = 19.0 $\pm$ 3.8), and this variable was categorised by tertile.

Table 29 Distribution of 2,725 children according to demographic, dental anatomy and Body Mass Index and socio-economic factors

Children' characteristics	Number of children	%
Demographic factors		
Sex		
- Males	1,331	48.8
- Females	1,394	51.2
Age		
- Older than 12 years old	181	6.6
- 12 years old	1,751	64.3
- Younger than 12 years old	793	29.1
Socio-economic factors		
Marital status of parents		
- No or a single parent	567	20.8
- Both parents	2,158	79.2
Employment status of parent		
- Unemployment	134	4.9
- Employment	2,591	95.1
Educational status of parents		
- Compulsory level or lower	1,153	42.3
- Above compulsory level	1,572	57.7
Family income		
- 5,000 Baht or less per month	1,049	38.5
- Above 5,000 Baht per month	1,676	61.5
Dental anatomy factor and Body Mass Index		
Anterior tooth protrusion (Overjet)		
- > 5 mm	231	8.5
- ≤ 5 mm	2,494	91.5
Body Mass Index (BMI, kg/m²)		
- Underweight (< 16.92)	909	33.4
- Normal weight (16.92 to 19.62)	907	33.3
- Overweight (>19.62)	909	33.4

3.1.2 The outcome and outcome related information

3.1.2.1 The prevalence of traumatic dental injuries to permanent anterior teeth (The outcome)

Table 30 shows that, of 2,725 children examined, 954 children (35.0%) had evidence of traumatic dental injuries. According to demographic factors, males (45.3%) had traumatic dental injuries approximately twice as much as females (25.2%), and the prevalence of traumatic dental injuries increased with ages. At the age of 12 years, which was the majority of the sample, the prevalence of traumatic dental injuries was 35 percent. According socio-economic status, the children having no or a single parent (42.3%), unemployed parents (61.9%), parents with educational status at compulsory level or lower (38.7%) and family income of 5,000 Baht or less (40.4%) had higher prevalence of traumatic dental injuries. When considering the dental anatomy factor, the children with overjet of more than 5 mm (42.9%) had higher prevalence of traumatic dental injuries than those with overjet of 5 mm or less (34.3%). Moreover, the children in the 2nd tertile of BMI (37.3%) experienced traumatic dental injuries more than those in the 1st and 3rd tertiles.

Table 30 The prevalence of traumatic dental injuries, by the characteristics of children

Characteristics of children	**Traumatic dental injuries (%)**		**Total (%)**
	No	**Yes**	
Sex			
- Males	728 (54.7)	603 (45.3)	1,131 (100.0)
- Female	1,043 (74.8)	351 (25.2)	1,394 (100.0)
Age			
- < 12 years old	531 (67.0)	262 (33.0)	793 (100.0)
- 12 years old	1,138 (65.0)	613 (35.0)	1,751 (100.0)
- > 12 years old	102 (56.4)	79 (43.6)	181 (100.0)
Marital status of parent			
- No or a single parent	327 (57.7)	240 (42.3)	567 (100.0)
- Both parents	1,444 (66.9)	714 (33.1)	2,518 (100.0)
Employment status of parent			
- Unemployed	51 (38.1)	83 (61.9)	134 (100.0)
- Employed	1,720 (66.4)	871 (33.6)	2,591 (100.0)
Educational status of parent			
- Compulsory level or lower	707 (61.3)	446 (38.7)	1,153 (100.0)
- Above compulsory level	1,064 (67.7)	508 (32.3)	1,572 (100.0)
Family income			
- 5,000 Baht or less per month	625 (59.6)	424 (40.4)	1,049 (100.0)
- Above 5,000 Baht per month	1,146 (68.4)	530 (31.6)	1,676 (100.0)
Anterior tooth protrusion (Overjet)			
- > 5 mm	132 (57.1)	99 (42.9)	231 (100.0)
- $\leq$ 5 mm	1,639 (65.7)	855 (34.3)	2,494 (100.0)
Body Mass Index (BMI, kg/m^2)			
- 1st tertile (< 16.92)	615 (67.7)	294 (32.3)	909 (100.0)
- 2nd tertile (16.92 to 19.62)	569 (62.7)	338 (37.3)	907 (100.0)
- 3rd tertile (>19.62)	587 (64.6)	322 (35.4)	909 (100.0)
Total	**1,771 (65.0)**	**954 (35.0)**	**2,725 (100.0)**

3.1.2.2 Types of traumatic dental injuries and positions of damaged teeth

Each subject was examined for traumatic dental injuries to the 12 upper and lower anterior teeth. The expected number of teeth to be examined in the 2,725 children was 32,700 teeth. However, 31,458 teeth were available for the examination; 1,242 teeth were missing not due to trauma. 15,468 upper anterior teeth and 15,990 lower anterior teeth were examined for traumatic dental injuries.

The proportion of damaged teeth, calculated here, was based on the teeth already erupted. There was evidence of traumatic dental injuries to 1,517 teeth (4.8%), 1,112 teeth (7.2%) of upper anterior teeth and 405 (2.5%) of lower anterior teeth (Table 31).

Tables 32 and 33 show that enamel fracture was the main type of traumatic dental injury, both in upper (905 teeth) and lower (294 teeth) anterior teeth. The damage type appearing only enamel crack in lower anterior teeth (72 teeth; 17.8% of the affected lower anterior teeth) was approximately three times of that in upper anterior teeth (54 teeth; 4.9% of the affected upper anterior teeth). Overall, there were only 26 children (2.7% of injury cases) affected only with evidence of enamel crack. Among the combinations of types of tooth damage, enamel fracture with enamel crack was the most common, 46 and 20 teeth in upper and lower anterior teeth, respectively.

Central incisors were the most common teeth with traumatic dental injuries, both in the upper and lower jaws. There were 518 (34.1%), 461 (30.4%), 156 (10.3%) and 154 teeth (10.2%) of all 1,517 damaged teeth from the upper right, upper left, lower left, and lower right central incisors, respectively (Figure 4). Only 11 canines were affected, which accounted for 9 children. However, eight children with affected canines also had evidences of damage on other teeth.

Table 31 Numbers and percentages of damaged upper and lower anterior teeth

Evidence of teeth damaged	Number of teeth (%) Upper anterior	Lower anterior	Total
No	14,356 (92.8)	15,585 (97.5)	29,941 (95.2)
Yes	1,112 (7.2)	405 (2.5)	1,517 (4.8)
Total	15,468 (100.0)	15,990 (100.0)	31,458 (100.0)

Figure 4 The distribution of damaged teeth according to tooth positions

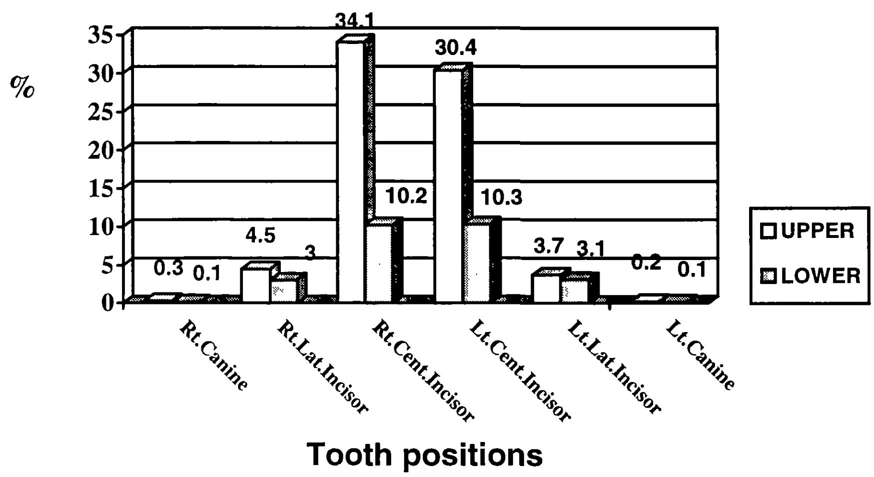


Table 32 The numbers of teeth according to types of tooth damage and tooth positions for upper anterior teeth

Types of tooth damage	Codes	Tooth positions						Total
		13	12	11	21	22	23	
Discolouration due to trauma	1	0	0	0	1	0	0	1
Enamel crack	2	3	0	23	27	0	1	54
Enamel fracture	3	1	63	427	361	52	1	905
Enamel and dentine fracture	4	1	4	26	28	1	1	61
Fracture with pulp exposed	5	0	0	5	8	1	0	14
Missing tooth due to trauma	6	0	0	3	2	0	0	5
Composite restoration	7	0	0	3	6	0	0	9
Bonded fragment	8	0	0	0	0	0	0	0
Permanent crown provided	9	0	1	0	0	1	0	2
Semi-permanent crown provided	10	0	0	0	1	0	0	1
Denture or bridge provided (pontic)	11	0	0	1	1	0	0	2
Fistulous tract and / or presence of swelling	12	0	0	0	2	0	0	2
	1 & 3	0	0	0	0	0	0	0
	1 & 4	0	0	0	2	0	0	2
	1 & 5	0	0	0	1	0	0	1
	2 & 3	0	1	24	20	1	0	46
	2 & 4	0	0	6	1	0	0	7
	2 & 5	0	0	0	0	0	0	0
Subtotal		**5**	**69**	**518**	**461**	**56**	**3**	**1,112**
No trauma	**0**	2,289	2,644	2,206	2,264	2,652	2,301	14,356
Total		**2,294**	**2,713**	**2,724**	**2,725**	**2,708**	**2,304**	**15,468**

Table 33 The numbers of teeth according to types of tooth damage and tooth positions for lower anterior teeth

Types of tooth damage	Codes	Tooth positions						Total
		43	42	41	31	32	33	
Discolouration due to trauma	1	0	0	1	1	0	0	2
Enamel crack	2	1	7	31	27	6	0	72
Enamel fracture	3	1	35	112	105	40	1	294
Enamel and dentine fracture	4	0	1	6	4	1	0	12
Fracture with pulp exposed	5	0	1	0	2	0	0	3
Missing tooth due to trauma	6	0	0	0	0	0	0	0
Composite restoration	7	0	0	0	0	0	0	0
Bonded fragment	8	0	0	0	0	0	0	0
Permanent crown provided	9	0	0	0	0	0	0	0
Semi-permanent crown provided	10	0	0	0	0	0	0	0
Denture or bridge provided (pontic)	11	0	0	0	0	0	0	0
Fistulous tract and / or presence of swelling	12	0	0	0	0	0	0	0
	1 & 3	0	0	0	1	0	0	1
	1 & 4	0	0	0	0	0	0	0
	1 & 5	0	0	0	1	0	0	1
	2 & 3	0	1	4	15	0	0	20
	2 & 4	0	0	0	0	0	0	0
	2 & 5	0	0	0	0	0	0	0
Subtotal		**2**	**45**	**154**	**156**	**47**	**1**	**405**
No trauma	0	2,574	2,652	2,569	2,562	2,645	2,583	15,585
Total		**2,576**	**2,697**	**2,723**	**2,718**	**2,692**	**2,584**	**15,990**

3.1.2.3 Distribution of children according to number of damaged teeth

Most of the children with trauma had one damaged tooth (Table 34). Among the children with traumatised teeth, the number of children decreased as the number of damaged teeth increased.

Table 34 Numbers and percentages of children, by number of damaged teeth

Number of damaged teeth per child (teeth)	Number of children	%
0	1,771	64.99
1	562	20.62
2	281	10.31
3	71	2.61
4	26	0.95
5	10	0.37
6	3	0.11
7	0	0.00
8	1	0.04
Total	2,725	100.00

3.1.3 Time and place of injury

3.1.3.1 Traumatic dental injuries according to time the injury occurred

Among the children with traumatic dental injuries, 31.3% had traumatic dental injuries within 1 year before the date of interviews, 24.2% reported that the traumatic dental injury occurred over 1 to 2 years ago (Table 35).

Table 35 Years since traumatic dental injuries occurred

Years ago	Number of children	%
≤ 1	298	31.3
> 1 to 2	231	24.2
> 2 to 3	109	11.4
< 3 to 4	104	10.9
> 4	5	0.5
Do not know	207	21.7
Total	954	100.0

Most of traumatic dental injuries in this study occurred during the school terms (Table 36). Most of injury cases (48.8%) occurred during the first term and 15.7% occurred in the second term. Only 3.7% of cases occurred during vacations. The majority (44.0%) of injuries occurred on weekdays (Table 37) and between 12.00 to 18.00 p.m. (49.8%) (Table 38).

Table 36 School term (semester) when traumatic dental injuries occurred

School term	Number of children	%
First term	466	48.8
Second term	150	15.7
Vacation	35	3.7
Do not know	303	31.8
Total	954	100.0

Table 37 Day of week traumatic dental injuries occurred

Day	Number of children	%
Weekday	420	44.0
Weekend	225	23.6
Do not know	309	32.4
Total	954	100.0

Table 38 Time of day when traumatic dental injuries occurred

Time of day	Number of children	(%)
06.00 - 11.59	86	9.0
12.00 - 17.59	475	49.8
18.00 - 05.59	86	9.0
Do not know	307	32.2
Total	954	100.0

3.1.3.2 Traumatic dental injuries according to place where injuries occurred

Homes and schools were the common places where traumatic dental injuries occurred; 31.7% at home and 28.0% at schools (Table 39). 4.7% and 1.2% of traumatised cases occurred in the street/road and swimming pool, respectively. 10.7% occurred at other places such as supermarkets, shops, waterfalls, hot water spring, public playground, and other public places.

Table 39 Traumatic dental injuries according to place where injuries occurred

Places	Number of children	(%)
Homes	303	31.7
School	267	28.0
Street / Road	45	4.7
Swimming pool	11	1.2
Others	121	12.7
Do not know	207	21.7
Total	**954**	**100.0**

3.1.4 Traumatic dental injuries according to causes

Table 40 shows that 75.4% of the traumatic dental injuries were from unintentional causes. 3% were intentional traumatic dental injuries from pushing and struck by objects (Table 41).

Falls were the main cause of traumatic dental injuries (24.8%); falls from tripping / slipping (14.9%) was the major type among the causes from falling (Table 41). The next most frequent cause of falls was from unintentional pushing (6.7%). The remaining causes from falls were from intentional pushing and falls from a height (Table 41).

Misuse of teeth was the second most common cause of traumatic dental injuries according to the manner of causes (18.7%). The third most common cause was collision or obstructed by objects (10.7%). The fourth cause was from accidentally biting hard material (9.8%). The other causes were the unintentionally struck by objects (9.1%), cycling (2.9%), intentionally struck by objects (1.3%), and traffic accidents (1.0%).

Table 40 Numbers and percentages of traumatic dental injuries classified according to intentional or unintentional causes

Type of traumatic dental injuries	Number of children	%
Intentional	28	2.9
Unintentional	719	75.4
Do not know	207	21.7
Total	1,131	100.0

Table 41 Numbers and percentages of traumatic dental injuries classified according to manner of the injury events

Manner of injury events	Number of children	(%)
Fall, unintentional pushing	64	6.7
Fall, intentional pushing	16	1.7
Fall, tripping / slipping	142	14.9
Fall, from height	14	1.5
Subtotal	**236**	**24.8**
Collision, obstructed by objects	102	10.7
Struck by objects, unintentionally	87	9.1
Struck by objects, intentionally	12	1.3
Traffic accident	10	1.0
Cycling	28	2.9
Misuse of teeth*	178	18.7
Accidentally bit hard material	94	9.8
Do not know	207	21.7
Total	**954**	**100.0**

* opening bottle caps, biting metal wire / rope / pen / pencil / necklace / parts of toy / finger nail, etc.

3.1.5 Traumatic dental Injuries according to types of vehicle or vector which directly contacted or injured children

The most common vehicle or vector causing tooth damage was the ground (22.4%). Among types of ground surface, concrete surface was the major vector (14.6%) (Table 42).

The second most common vector was object causing tooth damage due to misuse of teeth (18.6%) (Table 42). Ice (3.2%), bottle caps (2.7%) and pen and pencil (2.4%) were the common vectors that traumatised children in those who misused their teeth. Tamarind seed caused 1.8% of cases. Interestingly, plastic milk containers, which contain milk provided to children every day at school, caused 10 cases (1.0%).

The other common types of vector were objects, which children unintentionally bit (9.9%) (Table 42). Among this type of vector, animal bones were the major objects that caused tooth damage (6.1%). Stone in rice and snacks accounted for 1.6% and 0.4%, respectively. Human body caused 7.6% of cases and head of other child was the main part of body that caused tooth damage (6.0%). Other obstructing or hitting objects caused 6.7% of traumatised cases and the most common object was metal/wooden barrier (2.6%). Parts of buildings caused 5.1% of cases. Concrete wall, wooden door, and concrete post were common vectors of this vector type. The vectors by sport equipment caused 3.8% of cases. The number of traumatised children caused by football was equal to that caused by swimming pool walls (1.3%). Furniture/home equipment caused 3.2% of cases. The major furniture/home equipment causing tooth damage was table/cabinet (1.8%). Playground equipment caused the least number of traumatised cases, only 0.6% of cases and the causes were from high frames, swings and slides.

Table 42 Types of vectors which directly contacted or injured children

Vectors	Number of children	%
1. Ground surfaces		
concrete	139	14.6
asphalt	19	2.0
gravel	17	1.8
soil	16	1.7
ceramic	10	1.0
stone	8	0.8
wood	4	0.4
grass	1	0.1
Subtotal	**214**	**22.4**
2. Objects causing tooth damage due to misuse of teeth		
ice	30	3.2
bottle cap	26	2.7
pen/pencil	23	2.4
tamarind seed	17	1.8
toy	14	1.5
metal wire	13	1.4
metal screw	13	1.4
candy	11	1.2
Milk plastic container	10	1.0
necklace	6	0.6
a piece of wood	6	0.6
rope	5	0.5
metal nail	2	0.2
fingernail	1	0.1
coin	1	0.1
Subtotal	**178**	**18.7**
3. Objects causing tooth damage due to accidentally biting		
animal bone	58	6.0
stone in rice	15	1.6
snack	4	0.4
other hard material	17	1.8
Subtotal	**94**	**9.8**

Table 42 (continued)

Vectors	Number of children	%
4. Human bodies		
head	57	6.0
hand	10	1.0
elbow	2	0.2
knee	2	0.2
foot	1	0.1
shoulder	1	0.1
Subtotal	**73**	**7.6**
5. Other obstructing or hitting objects		
metal/wooden barrier	25	2.6
car/bus	11	1.1
glass/bottle	10	1.0
spoon	9	0.9
dish	3	0.3
tree	2	0.2
scissors	1	0.1
water tab	1	0.1
plastic bowl	1	0.1
plastic gun bullet	1	0.1
umbrella	1	0.1
trumpet	1	0.1
Subtotal	**66**	**6.7**
6. Objects which are parts of buildings		
concrete wall	17	1.8
wooden door	12	1.3
concrete post	11	1.1
wooden post	4	0.4
wooden window	3	0.3
elevator's door	1	0.1
handrail of stairs	1	0.1
Subtotal	**49**	**5.1**
7. Sport equipment		
football	12	1.3
swimming pool's wall	12	1.3
soccer goal post	4	0.4
takrorball*	3	0.3
basketball	2	0.2
badminton racket	2	0.2
boxing glove	1	0.1
Subtotal	**36**	**3.8**
8. Furniture/home equipment		
table/cabinet	17	1.8
chair	5	0.5
refrigerator	3	0.3
bed	3	0.3
clay jar	2	0.2
lamp	1	0.1
Subtotal	**31**	**3.2**
9. Playground equipment		
high frame	2	0.2
swing	1	0.1
slider	1	0.1
others	2	0.2
Subtotal	**6**	**0.6**

Table 42 (continued)

Vectors	Number of children	%
10.Unknown	207	21.7
Total	**954**	**100.00**

* Takor is a sport, which is popular in South East Asia, plays with takorball. Takorball is woven from bamboo or plastic material. The size is one fourth of a football.

3.1.6 Activitles leading to traumatic dental injuries

According to the types of activities that children were doing when the injury occurred, biting hard material was the most common activity (18.7%) (Table 43). The other activities leading to traumatic dental injuries were running (12.8%), eating (9.9%) and playing sports (6.9%). Football (soccer) and swimming were the major sports leading to injuries, 36 and 18 cases, respectively. Playing games caused 5.6% of cases. Chasing games were the main game type causing the highest number of injury cases (41 cases). General playing accounted for 4.2% of cases. It is noticeable that opening bottle cap caused 2.7% whereas boxing which is a popular sport in Thailand caused only 1.3%.

Table 43 Activities leading to traumatic dental injuries

Type of activities		Number of children	(%)
Biting hard material		178	18.7
Running		122	12.8
Eating		94	9.9
Playing sports		66	6.9
- Football (soccer)	36		
- Swimming	18		
- Basketball	6		
- Takor	3		
- Exercise	3		
Playing games		53	5.6
- Chasing game	41		
- Finding game	7		
- Jumping over straight elastic line	3		
- Horse attacking*	2		
General playing		40	4.2
- Playground equipment	6		
- Other general playing	34		
Walking		31	3.2
Cycling		28	2.9
Opening bottle cap		26	2.7
Pushing or pulling something		17	1.8
Sitting		13	1.4
Boxing		12	1.3
Drinking from glass or bottle or tap water		12	1.3
Standing		11	1.2
Somersault		9	0.9
Climbing		8	0.8
General jumping		7	0.7
Riding on motorcycle		7	0.7
Sleeping		6	0.6
Picking up something		3	0.3
Travelling on bus / car		3	0.3
Taking a bath		1	0.1
Do not know		207	21.7
Total		**954**	**100.0**

* A game where a child rides on the back of another child who is supposed to be a horse.

3.1.7 Characteristics of the schools

The school characteristics in this study were measured in terms of school environment, both social and physical environment. The information presented here is the school level information from 52 schools.

3.1.7.1 Social environment of schools

3.1.7.1.1 School policies on safety

All schools gave the same answer, namely that there was no formal policy on safety. There was no national policy on safety by the Education Department in Thailand (Ministry of Education, 1998). There was a policy on improving the environment of schools. However, this policy entailed improving the beauty and greenery of the school, and generally making it more attractive.

3.1.7.1.2 Supervision

The supervision in school was assessed by number of supervisors per 100 children. Since this data was skewed (skewness = 4.2), the central tendency was presented in terms of median. The median of supervision among the schools was 0.98 teachers per 100 children (percentile 25 & 75 = 0.75 & 1.46; minimum / maximum = 0.2 / 8.8).

3.1.7.1.3 Safety information from school by outside sources

Children in 46.1% of the schools received safety information once a month or more from sources outside school and all children received safety information at least once a year (Table 44).

Table 44 Numbers and proportions of schools, by the frequencies that children received safety information from outside school

Safety information	Number of schools	%
- Fewer than once a year or never	0	0.0
- Once a year or more but fewer than once a term	16	30.8
- Once a term or more but fewer than once a month	12	23.1
- Once a month or more	24	46.1

3.1.7.1.4 School curriculum

Table 45 shows the frequencies that children were taught safety topics through the school curriculum.

Table 45 Numbers and proportions of schools, by the frequencies that school provided safety topics in the school curriculum

Topics	Number of schools	%
Safety education		
- Once a week	0	0.0
- Twice a week	1	1.9
- Three times a week	22	42.3
- Four times a week	17	32.7
- More than four time a week	12	23.1
Environmental aspect of health education		
- Once a week	0	0.0
- Twice a week	6	11.5
- Three times a week	7	13.5
- Four times a week	28	53.8
- More than four time a week	11	21.2
Bullying		
- Once a week	0	0.0
- Twice a week	3	5.8
- Three times a week	19	36.5
- Four times a week	17	32.7
- More than four time a week	13	25.0

3.1.7.1.5 Social relationships

In terms of social relationships within the school and between school and community, there were two types of information gathered from the schools; school and home relationships and school and community relationships (Table 46). Most of the schools reported that there were parents participating at each meeting 50% or more times; 50 to 74% for 24 schools (46.2%) and 75 to 100% for 23 schools (44.2%). More than half of the schools (63.5%) were used for community activities at least once a week.

Table 46 Numbers and proportions of schools according to types of social relationships between parents and teachers, and schools and community

Social relationships	Number of schools	%
School and home relationships (Participation of parents in each meeting)		
- Less than 25%	1	1.9
- 25 to 49%	4	7.7
- 50 to 74%	24	46.2
- 75 to 100%	23	44.2
School and community relationships (Frequency that school has been used for community activities)		
- Fewer than once a year	6	11.5
- Once a year or more but fewer than once a term	3	5.8
- Once a term or more but fewer than once a month	6	11.5
- Once a month or more but fewer than once a week	4	7.7
- Once a week or more	33	63.5

3.1.7.1.6 Indicators of Children's performance

Five measures of performance by children were used as indicators; marks in health education examination, violence rate, and dropout rate, absentee rate as well as punishment rate (Table 47).

Table 47 Indicators of Children' performance among 52 schools

Children' performance	Median	Percentile 25 & 75	Min / Max
The result of health education examination (Children of class level 6) (Total = 40 marks)	20.5	19.1 & 22.6	15.4 / 31.1
Violence rate (All children) (cases per 100 children per year)	1.0	0 & 5.0	0 / 35.0
Dropout rate (All children) (cases per 100 children per year)	2.6	0.4 & 4.7	0 / 20.9
Absentee rate (Children of class level 6) (days per child per year)	2.6	0.4 & 3.8	0.1 / 17.3
Punishment rate (Children of class level 6) (cases per 100 children per week)	11.1	5.0 & 19.3	0 / 62.5

3.1.7.2 Physical environment of schools

3.1.7.2.1 Condition of school buildings

According to the criteria for ranking the quality of school building (Appendix 4), roofs, windows, and number of floor levels were the indicators in this study. Most schools (85.6%) had good condition of roofs, and no school was ranked as in poor condition (Table 48). For the condition windows, most schools (75.0%) had average conditions. Similar to the roof, there was no school ranked as poor condition for windows. The buildings of 4 schools (7.7%) had only a ground floor whereas 28 (53.8%) and 20 (38.5%) schools respectively had 2 levels and more than 2 levels.

Table 48 Numbers and proportions of schools according to condition of school buildings

Condition of school buildings		Number of schools	%
Roofs			
	- Poor	0	0.0
	- Average	7	13.5
	- Good	45	86.5
Windows			
	- Poor	0	0.0
	- Average	39	75.0
	- Good	13	25.0
Number of floor levels (including ground floor)			
	- 1 level	4	7.7
	- 2 levels	28	53.8
	- > 2 levels	20	38.5

3.1.7.2.2 Cleanliness of schools

Classrooms, corridors, canteens, toilets and playground were the areas assessed for the cleanliness of the schools. Cleanliness of every area was mostly graded as average; such as classrooms (63.5%), corridors (57.7%), canteen (57.7%), toilets (71.2%) and playground (61.5%) (Table 49).

Table 49 Numbers and proportions of schools according to cleanliness of various areas in schools

Cleanliness of schools		Number of schools	%
Classrooms			
	- Poor	2	3.8
	- Average	33	63.5
	- Good	17	32.7
Corridors			
	- Poor	0	0.0
	- Average	30	57.7
	- Good	22	42.3

Table 49 (continued)

Cleanliness of schools		Number of schools	%
Canteen			
	- Poor	3	5.8
	- Average	30	57.7
	- Good	19	36.5
Toilets			
	- Poor	9	17.3
	- Average	37	71.2
	- Good	6	11.5
Playground			
	- Poor	2	3.9
	- Average	32	61.5
	- Good	18	34.6

3.1.7.2.3 Condition of floors

There were five areas assessed for the floor conditions of the schools, which was similar to the cleanliness. All floor areas were mostly assessed as average (Table 50).

Table 50 Numbers and proportions of schools according to floor conditions of various areas in schools

Floor conditions of schools		Number of schools	%
Classrooms			
	- Poor	1	1.9
	- Average	28	53.9
	- Good	23	44.2
Corridors			
	- Poor	3	5.8
	- Average	38	75.1
	- Good	11	21.1
Canteen			
	- Poor	0	0.0
	- Average	42	80.8
	- Good	10	19.2

Table 50 (continued)

Floor conditions of schools		Number of schools	%
Toilets			
	- Poor	17	32.7
	- Average	35	67.3
	- Good	0	0.0
Playground			
	- Poor	19	36.5
	- Average	30	57.7
	- Good	3	5.8

3.1.7.2.4 Lighting conditions

Classrooms, canteen and toilets were assessed for the lighting conditions in the schools. Most schools had good lighting (Table 51).

Table 51 Numbers and proportions of schools according to lighting conditions in various areas of schools

Lighting conditions of schools		Number of schools	%
Classrooms			
	- Poor	0	0.0
	- Average	3	5.8
	- Good	49	94.2
Canteen			
	- Poor	1	1.9
	- Average	5	9.6
	- Good	46	88.5
Toilets			
	- Poor	2	3.9
	- Average	22	42.3
	- Good	28	53.8

3.1.7.2.5 Crowding in schools

The crowding in a school was measured in terms of the proportion of children and the school area. The median crowding was 5.4 children per 100 square metres (percentile 25 &75 = 2.6 & 14.8; minimum / maximum = 0.7 / 3.87).

3.1.7.2.6 Amount of playground area

Table 52 shows that, at the median, a child in this study occupied 7.8 square metres of playground area. When only hard playground surface area is considered, a child occupied 3.9 square metres.

Table 52 Amount of playground area among 52 schools

Playground area	Amount of area (Square metres per child)		
	Median	Percentile 25 & 75	Min / Max
Whole playground area	7.8	2.6 & 21.1	0.9 / 115.4
Hard surface area on playground	3.9	1.8 & 8.2	0 / 50.1

3.2 The classification of schools

This part of the results includes two main sections. The first section presents the selected variables for the environment of schools, both social and physical environments. Some initial selected variables were checked whether they were correlated and could be reduced to smaller numbers of factors. The second section is the cluster analyses of the schools according to social and physical environments.

Before performing the cluster analyses and the other analyses related to cluster analyses in this study, the possible selected variables in the analyses were standardised and converted into the same scale. Therefore, all possible selected variables were converted into ordinal scales with three order categories. Since the aim of this analysis is to classify whether the schools are more or less socially supportive and more or less physically favourable schools in relation to safety aspects, each variable was categorised by giving the score 1 as 'poor', score 2 as 'fair', and score 3 as 'good' support or favourable.

3.2.1 The selected variables for the environment of schools

Two types of school environments, social and physical, were assessed in this study.

3.2.1.1 Social environment

3.2.1.1.1 The initial selected variables for social environment

The initial selected variables for social environment of schools, which are relevant to the school characteristics in terms of safety aspects, are as follows:

- Supervision
- Children received safety information
- Safety topics provided through school curriculum
- School and home relationships
- School and community relationships
- Health education
- Violence rate
- Dropout rate
- Absentee rate
- Punishment rate.

Each of the above items was represented by a measured variable except the safety topics provided through school curriculum. They contained 11 variables and consisted of drug and solvent abuse, alcohol and violence, emotional development, responsibility relationships, family life, coping with stress, safety education, environmental health, child protection, bullying, and self esteem. These variables were considered to be related to characteristics of schools in terms of safety aspects. Thus, a principal component analysis was performed to check whether these variables explain the same thing or can be reduced to a smaller number of factors (Appendix 7). There were statistically significant correlations between them, from +0.3 to +0.6 ($p<0.05$). This indicated that it was worth performing a principal component analysis among these variables.

3.2.1.1.2 Principal component analysis of the 'safety' topics in the school curriculum

The final results of the principal component are shown in Table 53. It displays the rotated component matrix with the component score coefficient obtained by carrying out a Varimax rotation. There were four dimensions of the provided topics through the school curriculum (Table 53). Five variables were loaded on Component 1, corresponding to the psychological related topics. Component 2 consists of two variables, named as addicting substance topics. Three variables were loaded on Component 3, expressing the responsibility-related topics. The last group of variables, Component 4, is directly associated with the safety aspect. The last component, including safety education and bullying, has been called 'safety topics'. Only the variables in this component were used to express the safety topic provided by school, and included in the cluster analysis for social environment.

Table 53 The rotated component matrix with score coefficients of the provided 'safety' topics through school curriculum

Provided topics	**Components (coefficients)**			
	1	**2**	**3**	**4**
	Psychological related topics	**Addiction**	**Responsibility**	**Safety topics**
Emotional development	0.71			
Family life	0.52			
Coping with stress	0.65			
Child protection	0.75			
Self esteem	0.52			
Drug and solvent abuse		0.91		
Alcohol and violence		0.81		
Responsibility			0.61	
Environmental health			0.83	
Safety education				0.73
Bullying				0.88

There was a highly significant correlation between safety education and bullying topics (Spearman's correlation coefficient of 0.6, $p<0.001$). The component score coefficients obtained from the Principal Component Analysis for the safety education and bullying were 0.4 and 0.6, respectively. Therefore, the higher component score coefficient, the bullying score, was selected to represent the score of the provided safety topic.

3.2.1.1.3 The final selected variables in the cluster analysis of social environment

The variables included in the cluster analysis of social environment are shown in Table 54.

Table 54 The final variables included in the cluster analyses of social environment and their distributions

Variables	Number of schools	%
Supervision (Number of supervisors per 100 children) (Tertile)		
- Few (< 0.83)	18	34.6
- Average (0.83 – 1.14)	17	32.7
- More (> 1.14)	17	32.7
Children received safety information (outside sources)		
- Fewer than once a term	16	30.8
- Once a term or more but fewer than once a month	12	23.1
- Once a month or more	24	46.1
Provided safety topic through school curriculum (Bullying)		
- Fewer than three times a week	3	5.8
- Three times a week	19	36.5
- More than three time a week	30	57.7
School and home relationships (Participation of parents in each meeting)		
- Less than 50%	5	9.6
- 50 to 74%	24	46.2
- 75 to 100%	23	44.2
School and community relationships (School has been used for community activities)		
- Fewer than once a term	9	17.3
- Once a term or more but fewer than once a week	10	19.2
- Once a week or more	33	63.5
The result of health education examination (Total 40 marks) (Tertile)		
- Low (< 19.8)	18	34.6
- Average (19.8 – 21.5)	17	32.7
- High (> 21.5)	17	32.7
Violence rate (cases per 100 children per year) (Tertile)		
- High (> 1.20)	17*	32.7
- Average (0.04 – 1.20)	12*	23.1
- Low (< 0.04)	23*	44.2
Dropout rate (cases per 100 children per year) (Tertile)		
- High (> 3.80)	17	32.7
- Average (0.96 – 3.80)	17	32.7
- Low (< 0.96)	18	34.6
Absentee rate (days per child per year) (children of class level 6) (Tertile)		
- High (> 3.0)	17	32.7
- Average (1.5 – 3.0)	17	32.7
- Low (< 1.5)	18	34.6
Punished rate (cases per 100 children per week) (Children of class level 6) (Tertile)		
- High (> 16.7)	15*	28.8
- Average (7.8 – 16.7)	19*	36.5
- Low (< 7.8)	18*	34.6

* Despite using tertile to categorise the variables, the numbers of schools were not equal or nearly equal because the same values at the cut points were grouped into the same categories.

3.2.1.2 Physical environment

3.2.1.2.1 The initial selected variables for physical environment

The initial selected variables for physical environment of schools are as follows:

- Condition of school buildings
- Cleanliness
- Floor condition
- Lighting condition
- Crowding in schools
- Amount of playground area.

Each aspect of physical environment contains more than one variable, except crowding in schools. The condition of windows was selected to represent the condition of school buildings though, in fact, the roof conditions and the number of floor levels of the building had also been measured. The condition of roof was not included in the assessment because it was difficult to assess reliably. Neither was the number of floor levels because an increased number could imply either the better economic status of schools or the worse physical environment in terms of a risk of accidents.

Each school was assessed in five areas for the cleanliness and the floor conditions; classrooms, corridors, canteen, toilets and playgrounds. The variables of cleanliness were significantly correlated ($r = 0.3$ to 0.4, $p<0.05$). Thus, a principal component analysis was performed to check whether they explained the cleanliness of school. There was no significant correlation between the variables of floor conditions. Similarly, there was no significant correlation between the variables of lighting in schools, which were measured at three areas; classrooms, canteen, and toilets. Therefore, all variables of floor conditions and lighting conditions were included in the cluster analysis of physical environment.

The playground area of school was measured as square metres per child for the whole area and hard surface area. Crowding in school could be correlated to the amount of playground area because its measurement is school area per child. When the correlation was performed, there was a high positive correlation between crowding and amount of whole playground area in school ($r = +0.9$, $p<0.001$). However, the amount of hard surface area on playground was negatively correlated to both crowding and amount of whole playground area ($r = -0.6$, $p<0.001$). Therefore, a principal component analysis was performed for these variables.

3.2.1.2.2 Principle component analyses for variables of physical environment

Cleanliness of schools

Table 55 shows the final results of the principal component analysis. There was only one component extracted. The solution could not be rotated, therefore we display the non-rotated component matrix with the component score coefficients of 0.57 to 0.79. The cleanliness of classes, the highest component score coefficient of 0.79, represented school cleanliness.

Table 55 The non-rotated component matrix with score coefficients of school cleanliness

Area measured for school cleanliness	Component (coefficients)
	1
Classrooms	0.79
Corridors	0.67
Canteen	0.56
Toilets	0.57
Playground	0.69

Crowding and amount of playground area

The final results of the principal component analysis are shown in Table 56. There was only one component extracted. The component coefficient scores of crowding and amount of whole playground area are the same value and direction at 0.96. In contrast, amount of hard surface area on playground shows a negative component coefficient score of -0.81 though it tapped into the same component of the other two variables. Therefore, crowding in school was selected for further analysis but amount of whole playground area was dropped because it explained the same as crowding. Hard surface area on playground was selected to represent the amount of playground area in school.

Table 56 The non-rotated component matrix with score coefficients of crowding and amount of playground area in schools

Variables	Component (coefficients)
	1
Crowding in schools	0.96
Amount of whole playground area	0.96
Amount of hard surface area on playground	-0.81

3.2.1.2.3 The final selected variables in the cluster analysis of physical environment

All variables included in the cluster analysis of physical environment are shown in Table 57.

Table 57 The final variables included in the cluster analysis of physical environment and their distributions

Variables	Number of schools	%
Condition of buildings (windows)		
- Poor	0	0
- Fair	39	75.0
- Good	13	25.0
Cleanliness of schools (Classrooms)		
- Poor	2	3.8
- Fair	33	63.5
- Good	17	32.7
Condition of floors		
Classrooms		
- Poor	1	1.9
- Fair	28	53.8
- Good	23	44.2
Corridors		
- Poor	3	5.8
- Fair	38	73.1
- Good	11	21.2
Canteen		
- Poor	0	0
- Fair	42	80.8
- Good	10	19.2
Toilets		
- Poor	17	32.7
- Fair	35	67.3
- Good	0	0
Playground		
- Poor	19	36.5
- Fair	30	57.7
- Good	3	5.8

Table 57 (Continued)

Variables	**Number of schools**	**%**
Condition of lighting		
Classrooms		
- Poor	0	0
- Fair	3	5.8
- Good	49	94.2
Canteen		
- Poor	1	1.9
- fair	5	9.6
- Good	46	88.5
Toilets		
- Poor	2	3.8
- Fair	22	42.3
- Good	28	53.8
Crowding in schools (Tertile)		
- High	18	34.6
- Average	17	32.7
- Low	17	32.7
Hard surface area on playground (Tertile)		
- More	17	32.7
- Average	17	32.7
- Less	18	34.6

3.2.2 Cluster analyses of the schools

3.2.2.1 Cluster analysis of social environment

The schools were clustered into two groups according to the characteristics of social environment of schools. There were 30 schools in Cluster 1 and 22 schools in Cluster 2 (Table 58). The distance between these two cluster centres was 1.4.

Table 58 Cluster membership of schools according to social environment of schools

School code	Cluster	School code	Cluster
1	1	27	1
2	2	28	1
3	1	29	1
4	2	30	2
5	1	31	2
6	2	32	1
7	1	33	2
8	1	34	1
9	1	35	1
10	2	36	2
11	2	37	2
12	2	38	1
13	1	39	2
14	2	40	2
15	1	41	1
16	1	42	1
17	1	43	1
18	1	44	2
19	1	45	2
20	2	46	2
21	1	47	2
22	2	48	1
23	1	49	1
24	2	50	1
25	1	51	2
26	1	52	2

Table 59 shows the final cluster centres, mean scores, of each variable used in the analysis. Since the selected variables had already been given the scores 'poor' to 'good' aspects of social environment, the higher total mean scores indicated the better social environment. Therefore, the social environment of cluster 2 (23.1) was better than that of cluster 1 (20.6).

Table 59 Final cluster centres of social environment of schools

Social environment	**Mean scores**	
	Cluster 1	**Cluster2**
1. Supervision	1.8	2.2
2. Children received safety information	2.1	2.3
3. Provided safety topics through school curriculum	2.4	2.7
4. School and home relationships (Participation of parents in each meeting)	2.2	2.6
5. School and community relationships (Community activities in school)	2.6	2.3
6. The result of health education examination	1.6	2.4
7. Violence rate	1.9	2.4
8. Dropout rate	2.0	2.0
9. Absentee rate	2.2	1.8
10. Punished rate	1.8	2.4
Total	**20.6**	**23.1**

3.2.2.2 Cluster analysis of physical environment

The schools were clustered into two groups according to the characteristics of physical environment of schools. There were 24 schools in Cluster 1 and 28 schools in Cluster 2 (Table 60). The distance between these two cluster centres was 1.5.

Table 60 Cluster membership of schools according to physical environment of schools

School code	Cluster	School code	Cluster
1	2	27	2
2	2	28	2
3	1	29	2
4	1	30	2
5	2	31	1
6	1	32	1
7	2	33	1
8	1	34	1
9	2	35	2
10	2	36	1
11	2	37	1
12	2	38	2
13	2	39	1
14	2	40	1
15	1	41	2
16	2	42	1
17	2	43	2
18	2	44	2
19	1	45	2
20	2	46	1
21	2	47	1
22	2	48	1
23	2	49	1
24	2	50	1
25	1	51	1
26	1	52	1

Table 61 shows the final cluster centres, mean scores, of each variable included in the analysis. Since the selected variables had already been given the scores ‘poor’ to ‘good’ aspects of physical environment, the higher total mean scores indicated the better physical environment. Therefore, the physical environment of cluster 2 (27.3) was better than that of cluster 1 (26.5).

Table 61 Final cluster centres of physical environment of schools

Physical environment	**Mean scores**	
	Cluster 1	**Cluster2**
1. Conditions of buildings	2.4	2.1
2. Cleanliness of school	2.0	2.5
3. Floor conditions		
3.1 Classrooms	2.5	2.4
3.2 Corridors	2.1	2.2
3.3 Canteen	2.3	2.1
3.4 Toilets	1.7	1.6
3.5 Playground	1.3	2.0
4. Lighting conditions		
4.1 Classrooms	3.0	2.9
4.2 Canteen	2.8	2.9
4.3 Toilets	2.5	2.5
5. Crowding in school	1.5	2.4
6. Hard surface area on playground	2.4	1.7
Total	**26.5**	**27.3**

3.3 The relationships between traumatic dental injuries and school environments

Multilevel analyses were performed to investigate the associations between traumatic dental injuries and the explanatory variables in the study by accounting for variations between schools. The first section reports the unadjusted associations between traumatic dental injuries and the social and physical environments. The second section presents the unadjusted associations between traumatic dental injuries and the characteristics of children, such as demographic, socio-economic, and dental anatomy factors and the Body Mass Index. All these variables were possible confounding factors of the association between traumatic dental injuries and the school environment. The third section shows the associations between traumatic dental injuries and school environment controlling for each confounding factor. The results of these analyses show how the strength of the association was affected by each confounding factor compared to the unadjusted association. The last section presents the association between traumatic dental injuries and school environment sequentially adjusted for confounding factors. After that, the effect modifications for possible confounders on the associations between traumatic dental injuries were investigated. If any significant effect modification was found, further analyses were performed.

3.3.1 The unadjusted associations between traumatic dental injuries and school environments

After accounting for variations in schools there was a highly significant association between traumatic dental injuries and social environment of schools (Table 62). The estimated crude odds ratio of the social environment was 0.59 for the schools with a more supportive social environment compared to those with a less supportive social environment (p = 0.04). On the other hand, the physical environment of schools was not significantly associated with traumatic dental injuries.

Table 62 Multilevel analyses for the unadjusted associations between traumatic dental injuries and school environment, accounting for school variations

School environment	Numbers of schools / children	Crude OR (95% CI)	p-values (Wald's)
Social environment			
- More supportive	30 / 1,399	1	
- Less supportive	22 / 1,326	0.59 (0.41, 0.84)	0.004
Physical environment			
- More favourable	24 / 1,733	1	
- Less favourable	28 / 992	0.88 (0.61, 1.28)	0.52

The school variations shown in terms of logit variances were 0.24 (SE = 0.08) for the association between traumatic dental injuries and social environment and 0.29 (SE = 0.09) for the association between traumatic dental injuries and physical environment.

3.3.2 The unadjusted associations between traumatic dental injuries and chlidren's characteristics

The characteristics of children such as demographic factors, dental anatomy factor and Body Mass Index, and socio-economic factors were significantly associated with traumatic dental injuries (Table 63).

In Table 63, the estimated crude odds ratio of sex was 0.44 for females compared to males. The children aged older than 12 years had a significantly higher risk of traumatic dental injuries than those aged younger than 12 years, with an estimated crude odds ratio of 1.64 ($p = 0.01$). However, the traumatic dental injuries of the 12 year-old children was not significantly higher than the under 12 year-old children (crude OR = 1.11 $p = 0.25$).

The socio-economic factors such as marital status of parent, employment status of parent, educational status of parent and family income were highly significantly associated with traumatic dental injuries with estimated crude odds ratios 0.72, 0.32, 0.72 and 0.70 ($p \leq 0.001$), respectively (Table 63).

The risk of the children with overjet $\leq$ 5 mm on traumatic dental injuries was, significantly, 0.75 times that of the children with overjet more than 5 mm (Table 63). The association between traumatic dental injuries and Body Mass Index shows that the children in the 2nd tertile and 3rd tertile were more likely to experience traumatic dental injuries than those in the 1st tertile. However, that was a significantly higher only in the 2nd tertile children compared to the 1st tertile children (crude OR = 1.28) (Table 63).

Table 63 Multilevel analyses for the unadjusted associations between traumatic dental injuries and children's characteristics, accounting for school variations

Explanatory variables	Numbers of children	Crude OR (95% CI)	p-values (Wald's)
Sex			
- Males	1,331	1	
- Female	1,394	0.44 (0.37, 0.52)	< 0.001
Age			
- < 12 years old	181	1	
- 12 years old	1,751	1.11 (0.93, 1.34)	0.25
- > 12 years old	793	1.64 (1.16, 2.32)	0.01
Marital status of parent			
- No or a single parent	567	1	
- Both parents	2,158	0.72 (0.59, 0.88)	0.001
Employment status of parent			
- Unemployed	134	1	
- Employed	2,591	0.32 (0.22, 0.47)	< 0.001
Educational status of parent			
- Compulsory level or lower	1,153	1	
- Above compulsory level	1,572	0.72 (0.61, 0.86)	< 0.001
Family income			
- 5,000 Baht or less per month	1,049	1	
- Above 5,000 Baht per month	1,676	0.70 (0.59, 0.85)	< 0.001
Anterior tooth protrusion (Overjet)			
- > 5 mm	231	1	
- ≤ 5 mm	2,494	0.75 (0.56, 0.99)	0.04
Body Mass Index (BMI, kg/m²)			
- 1st tertile (< 16.92)	909	1	
- 2nd tertile (16.92 to 19.62)	907	1.28 (1.05, 1.56)	0.016
- 3rd tertile (>19.62)	909	1.16 (0.95, 1.42)	0.13

3.3.3 The associations between traumatic dental injuries and school environments adjusted for each characteristic of children

3.3.3.1 Social environment

When analysing the association between traumatic dental injuries and social environment for each possible confounding factor, sex was the strongest confounder that reduced the strength of association, from 0.59 to 0.65 (Table 64). Most of the other confounding factors only slightly changed the strength of associations. Adjusting for physical environment and educational status of parent did not change the strength of association. Anterior tooth protrusion and Body Mass Index also did not distort the strength of associations.

3.3.3.2 Physical environment

When the association between traumatic dental injuries and physical environment of schools was adjusted for each possible confounding factor, the strength of the association was not or only slightly distorted (Table 65). Sex was the strongest confounder. The strength of the association decreased from 0.88 to 0.95 after adjusting for sex.

Table 64 Multilevel analyses for the associations between traumatic dental injuries and social environment of schools, adjusted for each potential confounding factor; accounting for school variations

Variables	**OR (95% CI)**
	Crude OR (95% CI)
Social environment	0.59 (0.41, 0.84)
Adjusted for	**Adjusted OR (95% CI)**
+ Physical environment	0.57 (0.40, 0.82)
+ Sex	0.65 (0.47, 0.90)
+ Age	0.60 (0.42, 0.85)
+ Employment status of parent	0.61 (0.43, 0.85)
+ Family income	0.60 (0.43, 0.84)
+ Educational status of parent	0.58 (0.41, 0.83)
+ Marital status of parent	0.61 (0.43, 0.86)
+ Anterior tooth protrusion (Overjet)	0.59 (0.41, 0.84)
+ Body Mass Index (BMI)	0.59 (0.41, 0.84)

Table 65 Multilevel analyses for the associations between traumatic dental injuries and physical environment of schools, adjusted for each potential confounding factor; accounting for school variations

Variables	**OR (95% CI)**
	Crude OR (95% CI)
Physical environment	0.88 (0.61, 1.28)
Adjusted for	**Adjusted OR (95% CI)**
+ Social environment	0.83 (0.58, 1.18)
+ Sex	0.95 (0.68, 1.33)
+ Age	0.89 (0.61, 1.28)
+ Employment status of parent	0.88 (0.62, 1.26)
+ Family income	0.87 (0.61, 1.25)
+ Educational status of parent	0.87 (0.60, 1.26)
+ Marital status of parent	0.89 (0.62, 1.28)
+ Anterior tooth protrusion (Overjet)	0.88 (0.61, 1.28)
+ Body Mass Index (BMI)	0.88 (0.61, 1.28)

3.3.4 The associations between traumatic dental injuries and school environments sequentiaiiy adjusted for confounding factors

This section presents the associations between traumatic dental injuries and school environment sequentially adjusted for confounding factors. However, the associations between traumatic dental injuries and other explanatory variables in the fully adjusted model are presented in Table A11.1 (Appendix 11).

3.3.4.1 Social environment

In the multivariate analysis of the association between traumatic dental injuries and social environment, the model was adjusted firstly for physical environment (Table 66). After that, the model was adjusted for demographic factors, since the sex variable was the strongest confounder (Section 3.3.3.1). The next group of variables fitted in the model were socio-economic factors starting from marital status of parent, employment status of parent, family income, and educational status of parent. Anterior tooth protrusion and Body Mass Index were sequentially fitted in the model as the last group.

The strength of the association between traumatic dental injuries and social environment was very similar (0.59 to 0.57) when controlling for physical environment (Table 66). The strength of the association slightly decreased to 0.64 after adding and controlling for demographic factors, particularly for sex. There was a slight decrease of the strength of the association to 0.68 when controlling for the socio-economic factors of the children. There was no change in the strength of the association after adding and controlling for dental anatomy factor (overjet) and Body Mass Index. Most significantly, in the final and full model, the association between traumatic dental injuries and the social environment of schools were both significant (p = 0.016) (Table 66).

3.3.4.2 Physical environment

Since all potential confounding factors slightly distorted the strength of association between traumatic dental injuries (Section 3.3.3.2), they were sequentially fitted into the multivariate model in the same order as the model of the association between traumatic dental injuries and social environment.

The strength of association between traumatic dental injuries and physical environment was similar (0.88 to 0.83) when controlling for social environment (Table 67). However, it was diluted by the other confounding factors such as demographic factors, socio-economic factors, and dental anatomy factor (overjet) and Body Mass Index. The adjusted odds ratio of the full model was 0.89, virtually the same as the crude odds ratio of 0.88. Overall, the physical environment was not significantly associated with traumatic dental injuries (p = 0.44).

Table 66 Multilevel analyses for the associations between traumatic dental injuries and social environment of schools sequentially adjusted for demographic factors, socio-economic factors, and dental anatomy factor and Body Mass Index; accounting for school variations

Variables	**OR (95% CI)**
	Crude OR (95% CI)
Social environment	0.59 (0.41, 0.84)
Adjusted for	**Adj. OR (95% CI)**
Physical environment	0.57 (0.40, 0.82)
Physical environment & Demographic factors	
+Physical environment+Sex	0.64 (0.46, 0.89)
+Physical environment+Sex+Age	0.64 (0.46, 0.90)
Physical environment & Demographic factors & Socio-economic factors	
+Physical environment+Sex+Age+Marital status of parent	**0.67 (0.48, 0.93) †**
+Physical environment+Sex+Age+Marital status of parent+Employment status of parent	0.68 (0.50, 0.93)
+Physical environment+Sex+ Age+Marital status of parent+Employment status of parent+Family income	0.69 (0.50, 0.94)
+Physical environment+Sex+Age+Marital status of parent+Employment status of parent+Family income+Educational status of parent	0.68 (0.49, 0.93)
Physical environment & Demographic factors & Socio-economic factors & Dental anatomy factor and Body Mass Index	
+Physical environment+Sex+Age+Marital status of parent+Employment status of parent+Family income+Educational status of parent+Overjet	0.68 (0.49, 0.93)
+Physical environment+Sex+ Age+Marital status of parent+Employment status of parent+Family income+Educational status of parent+Overjet+BMI	0.68 (0.49, 0.93) ‡

† The final model: Wald's Z = -2.417, p = 0.016
‡ Wald's Z = -2.407, p = 0.016

Table 67 Multilevel analyses for the associations between traumatic dental injuries and physical environment of schools sequentially adjusted for demographic factors, socio-economic factors, and dental anatomy factor and Body Mass Index; accounting for school variations

Variables	OR (95% CI)
	Crude OR (95% CI)
Physical environment	0.88 (0.61, 1.28)
Adjusted for	**Adj. OR (95% CI)**
Social environment	0.83 (0.58, 1.18)
Social environment & Demographic factors	
+Social environment+Sex	0.89 (0.64, 1.24)
+Social environment+Sex+Age	0.90 (0.64, 1.24)
Social environment & Demographic factors & Socio-economic factors	
+Social environment+Sex+Age+Marital status of parent	0.91 (0.66, 1.25) †
+Social environment+Sex+Age+Marital status of parent+Employment status of parent	0.90 (0.66, 1.23)
+Social environment+Sex+Age+Marital status of parent+Employment status of parent+Family income	0.89 (0.66, 1.21)
+Social environment+Sex+Age+Marital status of parent+Employment status of parent+Family income+Educational status of parent	0.89 (0.65, 1.21)
Social environment & Demographic factors & Socio-economic factors & Dental anatomy factor and Body Mass Index	
+Social environment+Sex+Age+Marital status of parent+Employment status of parent+Family income+Educational status of parent+Overjet	0.89 (0.65, 1.21)
+Social environment+Sex+Age+Marital status of parent+Employment status of parent+Family income+Educational status of parent+Overjet+BMI	0.89 (0.65, 1.21) ‡

† The final model: Wald's Z = -0.604, p = 0.55
‡ Wald's Z = -0.772, p = 0.44

3.3.4.3 The interactions between variables

The interactions between the explanatory variables and the school environments and between the explanatory variables themselves were examined using the Wald's test with significance level less than 0.10. There were significant interactions between the sex variable and the social environment of schools (p = 0.08) (Table A11.2, Appendix 11) and the physical environment of schools (p = 0.07) (Table A11.3, Appendix 11). However, there was no significant interaction between the social and physical environments (p = 0.20) (Table A11.4, Appendix 11).

3.3.4.4 The associations between traumatic dental injuries and school environment, by sex

Since there were significant interactions for the sex variable, the multilevel analyses of the associations between traumatic dental injuries and the school environments were performed separately for males and females (Table 68).

In males, there was a significant association between traumatic dental injuries and social environment of schools after adjusting for physical environment of schools, age, marital status of parent and educational status of parent (Table 67). A more supportive social environment was significantly more protective (adjusted OR = 0.65 p = 0.022) than a less supportive social environment. However, there was no significant association between the physical environment of schools and traumatic dental injuries in males (Table 68).

In females, though the school environments were not statistically significantly associated with traumatic dental injuries, there was a tendency for a more supportive social environment to be more protective (adjusted OR=0.82) than a less supportive social environment after adjusting for physical environment of schools, age and marital status of parent. In contrast to the males, there was a tendency for the females attending schools with a more favourable physical environment to have a lower risk of traumatic dental injuries than those attending schools with a less favourable physical environment after adjusting for social environment of schools, age, marital and employment status of parent (OR=0.80) (Table 68).

Despite no statistically significantly interaction between the social and physical environments (Table A11.4, Appendix 11) and instead of adjusting the social environment for the physical environment and vice versa, it was considered worthwhile to investigate the associations between traumatic dental injuries and the combination of sex, social and physical environments. The results of the further analyses show that there was a significantly lower risk of traumatic dental injuries in the females attending a school with either type of social and physical environment compared to males attending a school which was both less socially supportive and physically favourable environments (Table 69). In males, there was a tendency for a more supportive social environment with either type of physical environment to be more protective than less socially supportive and physically favourable environments (Table 69).

When performing a subgroup analysis for sex, there was no significantly association between traumatic dental injuries and the combination of social and physical environments of schools. In males, it was confirmed that there was a tendency for a more socially supportive environment with any type of physical environment to be more protective. However, in females, this protective tendency was only apparent when school environments were both more socially supportive and physically favourable (Table 70).

Table 68 Multilevel analyses for the associations between traumatic dental injuries and school environments, by sex

Sex	School environment	Number of children (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Males	**Social environment**			
	Less supportive schools	769 (57.8)	1	1
	More supportive schools	562 (42.2)	0.62 (0.43, 0.89)	**0.65 (0.45, 0.94)** [1*]
	Physical environment			
	Less favourable schools	894 (67.2)	1	1
	More favourable schools	437 (32.8)	1.18 (0.82, 1.69)	1.06 (0.74, 1.52) [2]
Females	**Social environment**			
	Less supportive schools	630 (45.2)	1	1
	More supportive schools	764 (54.8)	0.85 (0.57, 1.26)	0.82 (0.55, 1.23) [3]
	Physical environment			
	Less favourable schools	839 (60.2)	1	1
	More favourable schools	555 (39.8)	0.86 (0.58, 1.27)	0.80 (0.54, 1.20) [4]

* Wald's Z = -2.290, p = 0.022

[1] The final model; adjusted for physical environment, age, marital status of parent, employment status of parent, and educational status of parent
[2] The final model; adjusted for social environment, age, and marital status of parent
[3] The final model; adjusted for physical environment, age, and marital status of parent
[4] The final model; adjusted for social environment, age, marital status of parent, and employment status of parent

Table 69 Multilevel analyses for the associations between traumatic dental injuries and the combination of sex and social and physical environment of schools

Sex and social and physical environment	Number of children	Crude OR (95% CI)	Adjusted OR (95% CI) †
Males in schools with a **less** supportive social and **less** favourable physical environment	388	1	1
Males in schools with a **less** supportive social but **more** favourable physical environment	381	1.05 (0.66, 1.68)	1.10 (0.70, 1.72)
Males in schools with a **more** supportive social but **less** favourable physical environment	506	0.63 (0.39, 1.02)	0.69 (0.44, 1.09)
Males in schools with a **more** supportive social and **more** favourable physical environment	56	0.61 (0.30, 1.23)	0.62 (0.31, 1.25)
Females in schools with a **less** supportive social and **less** favourable physical environment	358	0.40 (0.29, 0.55)	**0.41 (0.30, 0.56)**
Females in schools with a **less** supportive social but **more** favourable physical environment	272	0.38 (0.23, 0.62)	**0.38 (0.24, 0.62)**
Females in schools with a **more** supportive social but **less** favourable physical environment	481	0.36 (0.22, 0.58)	**0.38 (0.24, 0.61)**
Females in schools with a **more** supportive social and **more** favourable physical environment	283	0.21 (0.11, 0.38)	**0.22 (0.13, 0.40)**

† The final model; adjusted for age, employment status of parent, educational status of parent, and marital status of parent

Table 70 Multilevel analyses for the associations between traumatic dental injuries and the combination of the social and physical environment of schools, by sex

Sex	Social and physical environments of schools	Number of children	Crude OR (95% CI)	Adjusted OR (95% CI)
Males	**Less** supportive social and **less** favourable physical environment	388	1	1
	Less supportive social but **more** favourable physical environment	381	1.03 (0.65, 1.64)	1.09 (0.71, 1.67) [1]
	More supportive social but **less** favourable physical environment	506	0.62 (0.38, 0.99)	0.70 (0.45, 1.08) [1]
	More supportive social and **more** favourable physical environment	56	0.64 (0.32, 1.29)	0.59 (0.29, 1.17) [1]
Females	**Less** supportive social and **less** favourable physical environment	358	1	1
	Less supportive social but **more** favourable physical environment	272	1.08 (0.64, 1.82)	1.02 (0.60, 1.72) [2]
	More supportive social but **less** favourable physical environment	481	1.06 (0.64, 1.78)	1.06 (0.64, 1.78) [2]
	More supportive social and **more** favourable physical environment	283	0.63 (0.34, 1.17)	0.61 (0.33, 1.13) [2]

[1] The final model; adjusted for age, marital status of parent, employment status of parent, educational status of parent, and family income
[2] The final model; adjusted for age, employment status of parent, family income, and educational status of parent

3.4 Summary of findings

The results presented in this chapter can be summarised as follows:

1. The prevalence of traumatic dental injuries to permanent teeth in Class Level 6 schoolchildren in Muang district, Chiang Mai province, was 35.0 per cent (Section 3.1.2.1).
2. The unadjusted associations between traumatic dental injuries and the characteristics of children show that, according to the demographic factors of children, females were much less likely to have traumatic dental injuries than males (Table 30 and 63) and the risk of traumatic dental injuries increases with ages (Tables 30 and 63).
3. Marital, employment and educational status of parents, and family income were the important indicators in terms of socio-economic factors to predict the risk of traumatic dental injuries. The children having both parents, employed parents, educational status of parents above compulsory level and family income above 5,000 Baht were significantly less likely to have traumatic dental injuries (Tables 30 and 63).
4. In addition, the risk of traumatic dental injuries in children having incisal overjet 5mm or less was significantly lower than those with overjets of more than 5 mm (Tables 30 and 63).
5. Lastly, the children in the 2nd tertile of BMI had a significantly higher risk of traumatic dental injuries than of those in the 1st tertile (Tables 30 and 63).

6. The schools were classified into two groups according to social and physical environments using cluster analyses. The context of social environment of schools includes supervision, safety information, social relationships and children's performance. The context of physical environment of schools included condition of buildings, cleanliness of schools, condition of floors, condition of lighting, crowding in schools and hard surface area on playground. There were 30 and 22 schools considered being more socially supportive and less socially supportive, respectively (Table 58). For physical environment, there were 24 and 28 schools considered being more and less favourable, respectively (Table 60).
7. After adjusting for physical environment, sex, age and marital status of parents, the risk of traumatic dental injuries in children attending schools with a more supportive social environment was significantly lower than that with a less supportive social environment. This significant relationship was consistent in males. In females, there was only a tendency of a protective relationship. However, there was no significantly association between traumatic dental injuries and physical environment of schools. A similar result was apparent in males. In the other hand, there was a tendency for females attending schools with a more favourable physical environment to have a lower risk of traumatic dental injuries than those attending schools with a less favourable physical environment.

Chapter 4

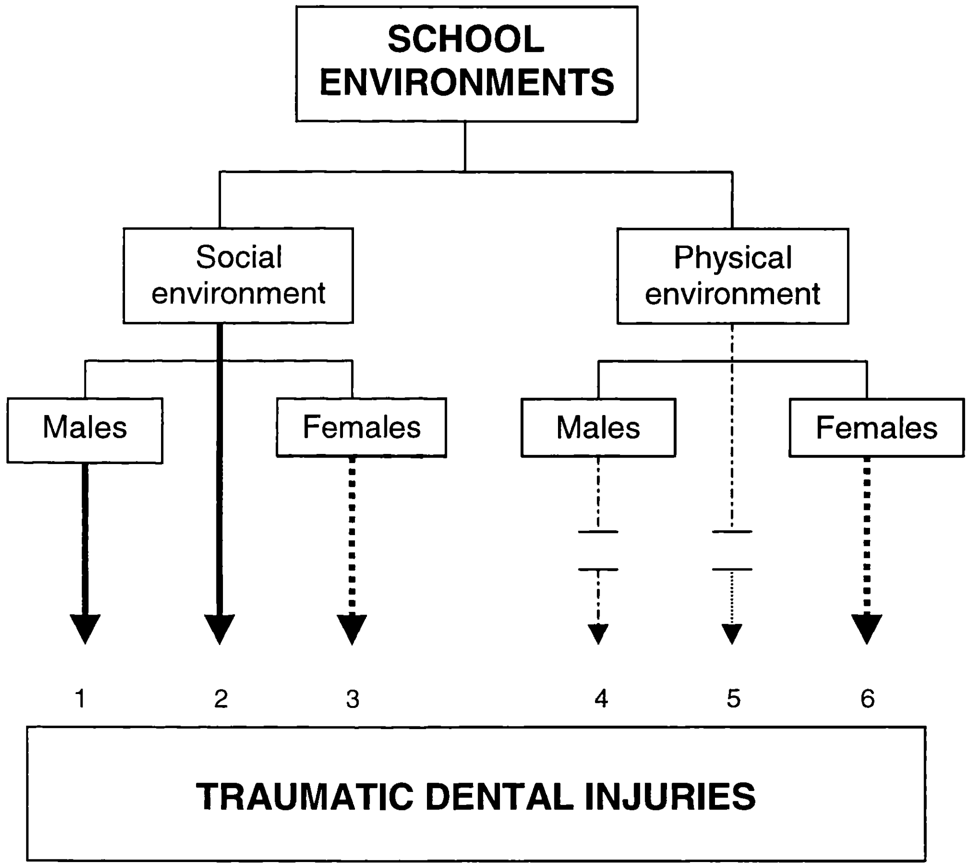
4. Discussion and conclusions

4.1 Discussion of the relationships between school environments and traumatic dental injuries

This study is the first to investigate how social determinants affect the prevalence of traumatic dental injuries. Most of the studies on traumatic dental injuries concentrated on the actual causes as distinct from determinants. Determinants are the causes of the causes.

The hypothesis that this thesis set out to test was that the prevalence of traumatic dental injuries in children attending schools with more socially supportive and physically favourable environments was significantly lower than in those attending in schools with less socially supportive and physically favourable environments. This hypothesis was partially substantiated by the results of the study. There were significant differences in levels of traumatic dental injuries by whether schools were socially supportive. The social environment of the schools was more important to males than females. Overall, children attending schools with better social environments had a protective effect on the occurrence of traumatic dental injuries, as demonstrated by the odds ratio of 0.67 (Table 66). The summary of the main findings in this study is shown in Figure 5.

Figure 5 The relationships between school environments and traumatic dental injuries, by sex, after adjusting for confounding factors



Significant protective effect for children in more socially supportive environment:
Tendency to protective effect for children in more socially supportive or physically favourable environment
Non-significant association

1 Adjusted for physical environment, age, marital status of parents, employment status of parents, and educational status of parents
2 Adjusted for physical environment, sex, age, and marital status of parents
3 Adjusted for physical environment, age, and marital status of parents
4 Adjusted for social environment, age, and marital status of parents
5 Adjusted for social environment, sex, age, and marital status of parents
6 Adjusted for social environment, age, marital status of parents, and employment status of parents

The chances of having traumatic dental injuries were affected by the sex of the child and the socio-economic status of their parents as well as their dental occlusal relationship and their BMI. These latter effects are expected as there are well-established relationships between traumatic dental injuries and sex (O'Brien, 1994; Kania et al., 1996; Kaste et al., 1996; Petti et al., 1997; Marcenes & Murray, 2000; Marcenes et al., 2000; Cortes, 2001; Nicolau et al., 2001), age (O'Brien, 1994; Kaste et al., 1996; Marcenes et al., 1999; Cortes, 2001), socio-economic factors (Jamani & Fayyad, 1991; Hamilton et al., 1997; Cortes, 2001), degree of anterior tooth overjet (Järvinen, 1972; Oluwole & Leverett, 1986; Hunter et al., 1990; Kania et al., 1996; Petti & Tarsitani, 1996; Nguyen et al., 1999; Marcenes et al., 1999; Marcenes & Murray, 2000; Marcenes et al., 2000; Cortes, 2001) and body mass index (Petti et al., 1997; Nicolau et al., 2001).

The main finding was that the social environment had a greater effect than the physical environment on the level of traumatic dental injuries. This may be explained by the relatively good level of the physical environments of the schools in Muang district, Chiang Mai province. Although the schools were dichotomised by physical environment, as can be seen from the photographs of the buildings, canteens, toilets and playgrounds (Appendix 12), those schools classified as having a 'poor' physical environment were of a reasonable standard. The differences in physical environment were nevertheless great enough to have some protective effect on the chances of females having traumatic dental injuries (Table 68 and Figure 5). Females attending schools with both more supportive social and favourable physical environments were less likely to have traumatic dental injuries than females attending schools with more supportive social but less favourable physical environments (Tables 69 and 70). The fact that females are more sensitive to the same physical environments than males, in terms of risk of traumatic dental injuries, may be explained by the widespread finding of differences by sex, in the prevalence of traumatic dental injuries (O'Brien, 1994; Kania et al., 1996; Kaste et al., 1996; Petti et al., 1997; Marcenes & Murray, 2000; Marcenes et al., 2000; Cortes, 2001; Nicolau et al., 2001) and accidents in general (Scheidt & Jones, 1995; Gofin et al., 1989; Gallagher et al., 1984; Fife et al., 1984; Rivara et al.; 1982, Danseco et al., 2000). Indeed, the analyses of the prevalence of traumatic dental injuries by sex in the study showed that females had a lower prevalence than males to suffer a traumatic dental injury (Tables 30, 63 and A11.1).

The finding that schools with a more supportive environments had a lower 'risk' of traumatic dental injuries corroborates the findings from the studies of Health-Promoting-School initiation that showed that such schools enhance the health of schoolchildren (Moysés, 2000). More importantly, the findings by Moysés (2000) that Health Promoting Schools in Curitiba, Brazil, had lower rates of traumatic dental injuries lends support to the findings from the present study. Moysés (2000) conducted a cross-sectional study among 1,823 children aged of 12 years in 33 schools in deprived areas of Curitiba, Brazil. The aim of how study was to focus on the influence of schools on oral health and self-concepts in terms of self-esteem and life style of children.

Since some schools in the study area had developed health-promoting policies, it was hypothesised that children in supportive schools where health-promoting policies had been developed had better oral health and more positive self-concepts. The results showed that children in supportive schools had better oral health than in non-supportive schools. More homogeneous results were found in supportive schools. In terms of traumatic dental injuries, schools with a comprehensive curriculum were less likely to have traumatic dental injuries. The chances of having traumatic dental injuries were 5 per cent less in schools with a comprehensive curriculum, and were 9.7 per cent less in schools which demonstrated commitment towards health and safety. Some of the criteria used in the study were similar to those used in the present study (for more details of this study see Section 1.4.3, and Moysés, 2000).

In addition to the sex variable, another important alternative explanation for the associations between school environments and traumatic dental injuries was socio-economic status and marital status of the parents. Marital status of parents was dichotomised into whether a child had 'both parents' or 'no or a single parent'. Children with 'both parents' were independently significantly more likely to be protective than those with 'no or a single parent' (Table 63). Without controlling for the 'marital status of parents' variable, the protective effects of the both social and physical environments on traumatic dental injuries were overestimated (Tables 66 and 67).

Employment and educational status of parents were also independently significantly associated with traumatic dental injuries (Table 63). Though children with employed parents were statistically independently highly protected compared to those with unemployed parents (Table 63), the 'employment status of parents' variable appeared to be important in influencing the association between social environment on traumatic dental injuries in males, and the association between physical environment and traumatic dental injuries in females (Table 68 and Figure 2). However, the 'educational status of parents' variable affected only the relationship between social environment and traumatic dental injuries in males (Table 68 and Figure 2).

In fact, the 'family income' variable in the present study was also independently associated with traumatic dental injuries. Children from higher-income families were less likely to have traumatic dental injuries than those from lower-income families (Table 63). This result is contrary to the studies of Moysés (2000) conducted among Brazilian children. In the study of Moysés (2000), the overall family income at *individual-level* was not associated with traumatic dental injuries. This may be related to two factors. Firstly, the pattern of family income of the sample in the study of Moysés (2000) was very similar because most families (approximately 90%) included in the study were in the children were in the low-income group. In the present study, approximately 40 per cent for the low-income group (Tables 29 and 63). There was more variation in the pattern of family income among the Thai children sample. Secondly, the relationship between socio-economic factors and traumatic dental injuries in the present study was taken into account in the multilevel structure of information (analysed at individual-level data accounting for school variations) but the finding *at individual-level* in the study of Moysés (2000) did not. Despite a non-significant association *at individual-level*, however, Moysés reported that there was an independent significant association between family income *at school-level* and traumatic dental injuries, suggesting that more traumatic dental injuries were expected at the school when families were more affluent.

Overall, marital status, employment, and educational status of parents and family income were included in the socio-economic background of children in this study. All of these variables were independently significantly associated with traumatic dental injuries. The most sensitive indicator of socio-economic background in explaining the associations between school environments and traumatic dental injuries was the 'marital status of parents' variable. The next most sensitive indicators were the 'employment status of parents' and 'educational status of parents' variables, respectively.

Although there are different indicators in socio-economic background of children between studies, the finding that children from lower socio-economic backgrounds are more likely to have traumatic dental injuries is consistent with a study on British children (Hamilton et al., 1997) but differs from studies in Brazilian children (Moysés, 2000; Cortes, 2001). In the study of Cortes (2001), it was speculated that the children form higher socio-economic profiles could afford play and sport equipment such as bicycles, skate boards, and roller skates, which contribute to traumatic dental injuries. However, such equipment is not so popular in Thailand and Thai children may have different physical activities from Brazilian children.

The other alternative explanations for the risk of traumatic dental injuries were overjet-size and body-size of children. Though the results from previous studies are not consistent, the present study shows that children with overjet-size more than 5 mm were independently significantly more likely to experience traumatic dental injuries than those with overjet-size 5 mm or less. According to the body-size, in terms of body mass index (BMI), children in the second tertile experienced more traumatic dental injuries than children in the first tertile (the lowest BMI group) whilst the prevalence of traumatic dental injuries of children in the third tertile (the highest BMI group) was not different from the first tertile. In other words, it could be that normal weight children are more likely to have traumatic dental injuries than under or over-weight children. Nevertheless, both 'overjet' and 'BMI' variables did not affect the relationships between social and physical environments of schools and traumatic dental injuries.

4.2 Discussion of the prevalence of traumatic dental injuries

4.2.1 The prevalence of traumatic dental injuries to permanent anterior teeth

The prevalence of traumatic dental injuries to permanent anterior teeth reported in this study (35%) was higher than in other studies including studies using the same criteria for traumatic dental injuries (Cortes, 2001). The proportion of damaged teeth in this study (4.6 per 100 anterior teeth) was also higher than that reported in the study conducted by Cortes (2001) (approximately 2 per 100 incisors). Though the present study included canines in the examination they were seldom involved, only 0.3 per 100 anterior teeth. The reasons for a higher prevalence are discussed below.

It may be speculated that the differences of the prevalence might be due to the different criteria in classifying traumatic dental injuries. The criteria used in this study include most possible types of traumatic dental injuries identified from evidence of tooth damage (Table 19), particularly enamel cracks when compared to the criteria used in the population-based studies in the UK (O'Brien, 1994) and USA (Kaste et al., 1996). However, the prevalence of children aged 12 years old in the present study (35%) (Table 30) was more than twice that of the study in Brazil (13.6%) (Cortes, 2001), which used the same criteria for traumatic dental injuries. This indicates that the higher prevalence in the Thai children needs further explanation.

The very high prevalence of traumatic dental injuries in this Thai population is probably due to four factors. The first is the inclusion of enamel cracks in the classification. That accounted for 2.7 per cent of cases. The three other factors which may differ in the Thai population compared to others are 'misuse of teeth' (18.6%), 'accidentally bit hard material' (9.9%) and 'do not know' (21.7%) (Table 41). They accounted for half of the manner of injury events. Burton et al. (1985) reported that 'bit into object' accounted for only 0.6 per cent of all causes according to manner of injuries but the 'bit into object' in their study could be either 'misuse of teeth' or 'accidentally bit hard material'. Although it is difficult to compare the 'misuse of teeth' with other populations because data are not available, the practices of using teeth for a wide variety of non-eating functions in Thai children are frequently commented upon by visitors. Another practice which is relatively common in Thailand is 'biting ice' and 'animal bones'. The former is intentional but the latter is unintentional. Animal bones are frequently chopped up in the preparation of foods in Thailand. Small fragments of bone therefore remain in foods and are unexpectedly bitten. Biting on 'animal bones', 'stones in rice' and 'other hard materials' accounted for 9.9 per cent of all vectors for traumatic dental injuries.

In addition, since social inequalities can affect health (Department of Health and Social Security, 1980; Marmot & Wilkinson, 1999), it could be speculated that there might be a *more* inequality in health among Thai children. As can be seen from the result of the main finding that there was a protective effect in children attending schools with better social environment, which suggested that there might be social inequalities in health among the schools. These inequalities also correspond to the findings that the children with a single, unemployed, low education and low income parent had higher rates of traumatic dental injuries (Tables 62 and A11.1), and these children might have less chance to study in schools with better social environments.

4.2.2 Type, number and location of damaged teeth

Enamel fracture was the major type of traumatic dental injuries. That is consistent with other population-based studies (Bijella, 1972; O'Mullane, 1972; Todd, 1975; Järvinen, 1979; Baghdady et al, 1981b; Garcia-Godoy et al., 1981; Todd & Dodd, 1985; Falomo, 1986; Garcia-Godoy et al., 1986; Holland et al., 1988; Ng'ang'a &Valderhaugh, 1988; Forsberg & Tedestam, 1990; Naqvi & Ogidan, 1990a; Sanchez & Garcia-Godoy, 1990; O'Brien, 1994; Joseffsson & Karlander, 1994; Dellatre et al., 1995; Hamden & Rock, 1995; Hargreaves et al., 1995; Kania et al., 1996; Kaste et al., 1996; Petti et al., 1996; Petti & Tarsitani, 1996; Marcenes et al., 1999; Marcenes et al., 2000; Marcenes & Murry, 2000; Cortes, 2001).

The damage type showing only enamel cracks in lower jaw (17% of the affected lower anterior teeth) was approximately three-third of that in upper jaw (4.9%of the affected upper anterior teeth) (Tables 32 and 33).

More than half of the injury cases had only one damaged tooth (Table 34). This is similar to most of other population-based studies (Table 7). In addition, as observed in previous studies, the upper central incisors were the most commonly affected teeth.

4.2.3 Discussion of the ecology of traumatic dental injuries

This study also explored the ecology of traumatic dental injuries; where, when, how and to whom the injuries occurred.

4.2.2.1 Discussion of time and place of injury

Most of the traumatic dental injuries occurred at home and school. The levels of traumatic dental injuries occurring in these two locations was nearly equal (Table 39). Most of traumatic dental injuries occurred on weekdays and between midday and 6 p.m. (Tables 37 and 38). The higher incidence in the afternoon may be related to levels of supervision. Parents were more likely to be at work and afternoons are when children had lunch breaks and playtime. Running was the major activity leading to traumatic dental injuries. Though it is natural for children to run around freely most of the time, better warning signs on risky areas such as steps, uneven ground surfaces, slippery surfaces, may reduce the injury events. Moreover, better supervision on risky areas should be provided.

An interesting finding was that traumatic dental injuries occurred more frequently in the first than in the second school term and during vacations (there are two school terms in Thailand). This may be because at the beginning of school term some children were exposed to school environment and were not familiar with the physical problems in the school. With a new or recently changed environment, the risk of accident may increase. However, as time passes, children might adapt themselves better to new environments. Then accident rates decrease.

4.2.2.2 Discussion of causes, vectors and activities leading to injuries

Since the classifications of causes of traumatic dental injuries varied between studies, it is difficult to compare causes between the present study and previous studies. However, some of them can be compared.

The most common cause of traumatic dental injuries was unintentional injuries (75.4%) (Table 40). 'Fall' was the most common manner causing traumatic dental injuries (24.8%) (Table 41). This finding is similar to that reported by previous studies (Table 20). The present study also shows that the most common specific manner of 'fall' was tripping/slipping (Table 41), which is consistent with a study among 12 year-old Brazilian children (Marcenes et al., 2000). A relatively common cause according to manner (18.7%) of traumatic dental injuries was misuse of teeth (opening bottles, etc.) (Tables 41 and 42). No previous study reported the cause according to misuse of teeth. However, this cause is suggested to be important among Thai children (see Section 4.2.1). The next most common causes according to manner was 'collision/obstructed by objects' (10.7%) and 'accidentally bit hard material' (9.8%), respectively (Tables 41 and 42). In the study of Burton et al. (1995), they studied causes of traumatic dental injuries among 12,287

Australian high-school children and reported 'ran into objects' as the major cause according to manner. In fact, 'ran into objects' is the manner defined in the present study as 'collision, obstructed by objects'. However, they reported that 'bit into object' caused traumatic dental injuries only 6 per cent of all causes according to manners.

Ground surfaces (22.4% of all cases), particularly concrete surface (14.6% of all cases), were the most common vectors which directly contacted or injured children (Table 42). This finding is consistent with the study reported by Burton et al. (1995).

Biting hard material was the most common activity leading to traumatic dental injuries (Table 43). This cause is actually the same as 'misuse of teeth'. It is an intentional activity of children but they may not realise the danger of this habit. Unlike 'eating', the third cause according to activity leading to injury, which is unintentional.

It is noticeable that intentional injuries were only 2.9 per cent (Table 40). They include 'fall, intentional pushing' and 'struck by objects, intentionally' (Table 41). Other recent studies reported a higher prevalence of traumatic dental injuries caused by violence. Marcenes et al. (2000), in a study of 12 year-old Brazilian children, reported that 16.4 per cent of traumatic dental injury cases were caused by violence, such as fall from pushing, collision due to pushing and other types of violence. Moreover, in the study in 9 to 12 year-old Syrian children, the causes from violence were over 40 per cent.

However, the study in 13 year-old Brazilian children conducted by Nicolau et al. (2001) found that the causes from violence was only 1.5 per cent of cases whilst the unknown causes were 40.6 per cent. The present study also shows a relatively high percentage of unknown causes (21.7%). This high per cent of unknown causes together with low report of intentional cases may be related to the reason that when the damage is due to violence, the victim tends to report 'do not know' (Marcenes et al., 2000; Moysés, 2000; Nicolau et al., 2001).

4.3 Methodological considerations

4.3.1 Response rates

There were 53 primary schools in the study population. One school did not agree to participate. Overall, there were 4,720 children attending Class Level 6, of whom 143, 881 and 3,696 children were from small, medium and large-sizes schools, respectively. The study sample was 60 per cent over-sampled above the minimal required sample size. Overall, 2,725 children of 52 schools had clinical examinations. Compared to the study population, 128 (89.5%), 786 (96.9%) and 1,811 (49.0%) were from small, medium and large-size schools, respectively. The reason was the over sampling explained in Section 2.7.3.

4.3.2 The study design

The study was designed for two main purposes; a prevalence survey for traumatic dental injuries and assessment of the associations between school environments and traumatic dental injuries. The study design was a cross-sectional survey, in which exposure and disease status are assessed simultaneously among individuals in a well-defined population. Since it was a population-based approach, it allowed inferring the findings to the population. However, the cross-sectional nature of the study design leads to difficulty in differentiating temporal effects. Thus, this study could only examine the association between the school environments and traumatic dental injuries. Whether school environments change before traumatic dental injuries or vice versa cannot be ascertained. In addition, this type of study suffered from the limitation that the report of trauma related information was to a certain extent dependent on information from the child.

4.3.3 The method used to classify the schools

The classification of schools into more or less supportive schools is critical in a study such as this one. There are a variety of ways in which this could have been done.

The optimisation method of cluster analysis was used in this study. There are both advantages and disadvantages in using this technique. The main advantage of cluster analysis is that it provides a natural categorisation of schools because all relevant variables or all variables we believe that could explain school environment were included in the analyses. Although some variables were dropped, this was because of using Principal Component Analysis (PCA) in weighting of variables. Since some of them explained the same context, only the representative variable of a context was selected for the final variables in the cluster analysis. It is suggested that this method does not ignore any initial relevant variables. Besides, the optimisation method of cluster analysis is a standard technique, easy to understand and interpret compared to other methods of cluster analysis. However, a disadvantage of the optimisation method in this study was the sacrifice of losing information because the included variables for the cluster analyses were standardised by converting them into the same scale, from continuous to ordinal variables. Moreover, caution should be exercised when using the optimisation method since this method needs equal weighting of variables before performing the cluster analysis. In this study, a PCA (Principal Component Analysis) was used for equalising the weight of variables. For this purpose, the PCA was used to reduce the number of variables used in the cluster analysis so that only one variable was used to represent each context. In other words, the variables explaining the same context were grouped by PCA as a component, and then a representative variable was selected from the component as the indicator of that context. If there had been many variables representing one context and few representing another one in the cluster analysis, the context with many variables could have dominated the cluster centres.

An alternative to cluster analysis is allocating a score to each school. We may use our own scoring system but it may be criticised for being subjective.

Nevertheless, an alternative approach to classifying the schools according to particular contexts or variables is to use the PCA (Moysés, 2000). By using the PCA approach, the initial relevant variables for school environment will firstly be grouped as components, which can be explained in terms of the contexts. Then, each school will obtain a score for each context by multiplying the original score of that variable (say score 2 of score 1 to 3) by the coefficient score of that variable in the component in the PCA. A higher total score indicates a better school environment if the original variables were always ranked from poor to good. However, a limitation of this approach is that some initial relevant variables might not be included in any component. Then, a decision has to be made if these variables will have to be dropped out or included as separate components. Therefore, PCA does not provide a natural categorisation of schools, whereas cluster analysis does.

4.3.4 Multilevel modelling approach

An illustration of the variations of traumatic dental injuries across the schools was in the unadjusted models (Section 3.3.2). There were significant variations with the variance of 0.24 and 0.29 at $p < 0.001$ for the association between social environment and traumatic dental injuries and physical environment and traumatic dental injuries, respectively. These school variations indicate that multilevel modelling was required. If the multilevel structure had not been taken into account, for purposes of simplicity, then the results would have been biased. Other advantages of using multilevel modelling approach were explained in the rationale for the use of multilevel analysis in the study (Section 2.14.3.1).

4.4 Conclusions

1. The prevalence of traumatic dental injuries to permanent teeth was high in the Thai schoolchildren;
2. The prevalence of traumatic dental injuries in children attending schools with more supportive social environments was significantly lower than in those attending schools with less supportive social environments. This finding was statistically significant in males but not in females. In females, there was an insignificant tendency;
3. There was no significant association between traumatic dental injuries and physical environments of schools. Nevertheless, there was a tendency for the prevalence of traumatic dental injuries in females attending schools with more physically favourable environments to be lower than in those attending schools with less physically favourable environments.

4.5 Implications and recommendations for future research

4.5.1 Implications

This study is the first study on the prevalence of traumatic dental injuries in Thailand. Since the prevalence was very high, it indicates that the major dental public health problems to be concerned in Thailand are not only dental caries, periodontal diseases and dental fluorosis but also traumatic dental injuries.

The finding of significant relationships between school environments in Chiang Mai urban area and traumatic dental injuries of children in this area indicates that there were inequalities in dental health between the schools. Efforts should be made to address the factors relating to traumatic dental injuries in the schools with a high prevalence of traumatic dental injuries.

Although anterior tooth overjet was independently associated with traumatic dental injuries, this relation did not exist after controlling for school environments. This highlights the importance of health promotion for the control of traumatic dental injuries rather than the current emphasis on orthodontic treatment for overjet.

4.5.2 Recommendations for future research

1. As the prevalence of traumatic dental injuries was high in this study, the study should be replicated in other provinces using the same protocol.

2. Social and physical factors were significant determinants of traumatic dental injuries. An alteration in these factors may play an important role in reducing traumatic dental injuries. A controlled field trial should be carried out to assess whether changing important social and physical factors in schools has an effect on traumatic dental injuries.

3. In this study, traumatic dental injuries were used as a marker of injury based on the suggested association between traumatic dental injuries and general accidents. The high prevalence of traumatic dental injuries reported in this study suggests that general injuries may be common in the schools of Chiang Mai province. Further research is required to assess the relationship between dental and general injuries.

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APPENDIX 1

Definitions of terms

1. Traumatic dental injury

The term 'injury' comes from the Latin, *injuria*, and means harm or insult. Haddon et al. (1981) defined injury as damage resulting from acute exposure to physical and chemical agent. The use of this term allows separation of event from its consequences and fosters the application of a scientific approach to the injury epidemic.

Traumatic dental injury in this thesis is defined as 'damage of teeth resulting from acute exposure to physical agent'.

2. School environments

School environments are concepts or contexts explained by characteristics of schools. School environments in this study were divided into social and physical environments. The concept of social environment was expected to comprise various items such as school policies, supervision in school, safety information and social relationships as well as children's performance (e.g. the result of health education examination, violence rate, dropout rate, and absentee rate, as well as punishment rate in school). Similarly, the concept of physical environment was expected to comprise various items such as crowding, amount of playgrounds, conditions of buildings, and cleanliness, floor conditions, lighting conditions in school.

3. Characteristics of children

Characteristics of children in this study consist of socio-economic status of the parents, demographic factors and dental anatomy factor as well as body mass index of children.

4. Overjet-size

Overjet-size or incisal overjet or overjet is a measurement of dental anatomy in terms of anterior tooth protrusion. This measurement is a horizontal distance between incisal edge of upper central incisor and anterior surface of lower central incisor at centric occlusion.

5. Body Mass Index (BMI)

Body Mass Index (BMI) is a standard measure of overall nutrition. It is a ratio that requires measurement of height and weight. BMI is defined as body weight in kilograms (kg) divided by the square of height in metres (m); BMI = kg/m^2.

APPENDIX 2

CLINICAL EXAMINATION FORM

Date of dental examination: ..../........./................

Examiner code............................ Duplicate number ....

Subject name... I.D.No. ....

Class.........../...........

School name...

Sex: Male [ ] Female [ ]

Date of birth: Month............................ Year.........................

1. Damage to the tooth/teeth:

13	12	11	21	22	23	
						Episode
						Damage type
						Damage type
						Episode
43	42	41	31	32	33	

Other damaged tooth/teeth (Specify the damage):
....
....
....

2. Incisal overjet [ ] [ ]

(mm.) (Right) (Left)

3. Body Mass Index (BMI, Kg/m^2)

Weight: [ ] Kilograms

Height: [ ] Metres

The classification of traumatic dental injuries classified by Cortes (2001)

Categories (Codes)	Criteria	Description
Code 0	No trauma	No observed injury to the incisors
Code 1	Discoloration due to trauma	Discoloration ranging from yellow to dark gray when compared to the other teeth
Code 2	Enamel crack	An incomplete fracture of enamel without loss of tooth substance
Code 3	Enamel fracture	Loss of a small portion of the crown, including only enamel
Code 4	Enamel and dentine fracture	Loss of enamel and dentine without exposing pulp
Code 5	Fracture with pulp exposure	Loss of enamel and dentine and / or cementum, exposing pulp
Code 6	Missing tooth due to trauma	Absence of the tooth due to a complete exarticulation
Code 7	Composite restoration	Restoration provided due to crown fracture and / or located in the palatal surface of the crown
Code 8	Bonded fragment	Bonding of the tooth due to crown fracture
Code 9	Permanent crown provided	Jacket or post crown or any kind of restoration involving all the whole crown
Code 10	Semi-permanent crown provided	Any kind of crown or denture or bridge (Pontic) placed provisionally
Code 11	Denture or bridge provided (Pontic)	Denture or bridge (Pontic) provided
Code 12	Fistulous tract and / or presence of swelling	Presence of fistula and / or swelling in the labial or lingual vestibule without evidence of caries
Code 99	Assessment cannot be made	Signs of trauma cannot be assessed due to appliances or absence of any of the incisors

The episode of traumatic dental injuries

Episode of traumatic dental injuries	Code
The first event	A
The second event	B
The third event	C
.	.
.	.
.	.

APPENDIX 3

Questionnaire for children

Do not mark in this space

Part 1. General and demographic information

1.1 Date of interview: ..../................./...................

1.2 School name..

1.3 I.D.No. of subject.........................
Name of subject...
Class............/..................

1.4 Sex ☐ 1. Male ☐ 2. Female

1.5 Age in years at last birthday. ....years
Date of birth............/.................../................

Part 2. Traumatic dental injury information

2.1 Did you have any experience of dental trauma?

☐ 1. No

☐ 2. Yes

☐ 3. Don't know

*If **'No'** or **'Don't know'** finish the interview, and if **'Yes'** continue interviewing the subject.

2.2 When did traumatic dental injury occur? (Month/Year)
................../..................

2.3 The injury event occurred during

☐ 1. School terms

☐ 2. Vacation

☐ 3. Don't know

Continue

Do not mark in this space

2.4 What time of the day did the injury occur?
(approximately) ....

2.5 Location of the event of traumatic dental injury

☐ 1. School (Go to Q. 2.6 then Q. 2.10 and so on)

☐ 2. Home (Go to Q. 2.7 then 2.10 and so on)

☐ 3. Public road/street (Go to Q. 2.8 then 2.10 and so on)

☐ 4. Public footpath (Go to Q. 2.8 then 2.10 and so on)

☐ 5. Others specify..
(Go to Q. 2.9 and so on)

☐ 6. Don't know (Go to Q. 2.10 and so on)

2.6 If the injury event occurred **in school**, where is the exact area?

☐ 1. Classroom

☐ 2. Corridors

☐ 3. Stairs

☐ 4. Other areas in the building (specify)..........................

☐ 5. Playground (specify)..

☐ 6. Canteen

☐ 7. Toilet

☐ 8. Others (specify)..

☐ 9. Don't know

Continue

Do not mark in this space

2.7 If the injury event occurred **at home** where did it occur? ☐

☐ 1. Bedroom ☐ 2. Kitchen

☐ 3. Dining room ☐ 4. Stair

☐ 5. Inside the building at other areas (specify)................

☐ 6. Outside building / pavement (specify ground type)....

☐ 7. Outside building / courtyard

☐ 8. Outside building at other areas (specify)...................

☐ 9. Don't know

2.8 Where exactly did the injury event occur on public road/street/footpath? ☐

Road/street/lane...
Subdistrict.......................................
District..
Province..
The well-known or noticeable place nearby
(e.g. next to, opposite to, at road junction, cross road)
....

2.9 Where exactly did the injury occur at other places than at public road/street/footpath? ☐
Name or type of place..
Location...

2.10 Type of object which directly contacted and injured the subject's teeth ☐

☐ 1. Ground surface (specify type e.g. wood, concrete, asphalt, soil, sand, ceramic, stone)....................................

☐ 2. Toy (specify)...

☐ 3. Playground equipment (specify)...............................

☐ 4. Sports equipment (specify)......................................

☐ 5. Other objects (specify)..

☐ 6. Don't know

Continue

Do not mark in this space

2.11 The activity which the subject was doing when the event occurred

☐ 1. Walking ☐ 2. Running

☐ 3. Cycling ☐ 4. Riding motorcycle

☐ 5. Traveling on bicycle with another person who was cycling

☐ 6. Traveling on motorcycle with another person who was riding

☐ 7. Traveling by bus or car

☐ 8. Supervised playing (specify)....................................

☐ 9. Unsupervised playing (specify).................................

☐ 10. Other activities (specify)...

☐ 11. Don't know

2.12 How did the traumatic dental injury occur? (Explanation by subject)

....

....

....

....

....

....

....

....

....

****

APPENDIX 4

QUESTIONNAIRE FOR HEAD TEACHERS

1. Name of school:...

Address:...

Telephone number:.................................. Fax number:............................

3. Name of respondent: 3.1 ....

Position in school:...

3.2 ....

Position in school: ....

3. The size of school area .... Square metres

4. The number of all children in the year 1999 (last year) .... children.

The number of Class Level 5 children in 1999 (last year ....Children.

5. The number of children dropping out before completing Class Level 6 in the year 1999 (last year) .... children.

6. The number of days that the Class Level 5 children in 1999 (last year) missed classes ....days.

7. During the last school year, how many cases of violence among children at your school were reported to the school administrators / head teacher? (Violence: e.g. fighting, bullying and assault) .... cases.

8. During the last school year, how many cases of accidents occurred in children at your school that needed hospital treatments? .... cases.

9. Were there any violent cases where police intervention was necessary at the school?

☐1.Yes ☐2. No

10. What is the average number of the Class level 6 children (this year) who were punished each week? (Punishment: e.g. detention at school in the evening, given something to do and others) .... children.

11. Please indicate the frequencies (per week) when the following topics are taught in your school?

Topics	**Frequency per week**				
	0 - 1	**2**	**3**	**4**	**> 4**
drugs and solvents abuse	☐	☐	☐	☐	☐
alcohol and violence	☐	☐	☐	☐	☐
feeling / emotional development	☐	☐	☐	☐	☐
responsibility relationships	☐	☐	☐	☐	☐
family life	☐	☐	☐	☐	☐
coping with stress	☐	☐	☐	☐	☐
safety education	☐	☐	☐	☐	☐
first aid	☐	☐	☐	☐	☐
environmental aspects of health education	☐	☐	☐	☐	☐
child protection	☐	☐	☐	☐	☐
bullying	☐	☐	☐	☐	☐
Self esteem	☐	☐	☐	☐	☐

12. How often do the children have the opportunity to gain practical information about safety issues from school by outside sources?

☐1. Once a month or more

☐2. Once a term or more but fewer than once a month

☐3. Once a year or more but fewer than once a term

☐4. Fewer than once a year or never

13. During the last school year did any person (e.g. police, fire brigade staff, health professionals and parents of children), discuss safety issues with teachers, staff members or children in school?

☐1. Yes ☐2. No

If answer to Question 13 is **'yes'**, who were these people? *(You can give more than one answer)*

☐1. Health professionals ☐2. Police / Fire staff

☐3. Parents ☐4. Other (please specify) ....

14. How many times per year does the school arrange meetings between teachers and parents? .... times.

On average, what percentage of parents attend these meetings?

☐1. 75 to 100% ☐2. 50 to 74%

☐3. 25 to 49% ☐4. Less than 25%

15. How often is the school used for community activities during in the evening and weekends?

☐1. Fewer than once a year or never

☐2. Once a year or more but fewer than once a term

☐3. Once a term or more but fewer than once a month

☐4. Once a month or more but fewer than once a week

☐5. Once a week or more

****

Thank you for your cooperation.

Questinnaire for head teacher (Thai version)
แบบสอบถามสำหรับผู้อำนวยการโรงเรียนหรือครูใหญ่

สำหรับเจ้าหน้าที่

๑. ชื่อโรงเรียน .... □□

ตำบล .... อำเภอเมือง จังหวัดเชียงใหม่

โทรศัพท์ .... โทรสาร ....

๒. ชื่อผู้ให้ข้อมูล ๒.๑ .... □

ตำแหน่งในโรงเรียน ....

๒.๒ ....

ตำแหน่งในโรงเรียน ....

๓. ขนาดพื้นที่ของโรงเรียน .... ไร่ ....งาน .... ตารางวา □□□□

๔. จำนวนนักเรียนในปีการศึกษา <u>๒๕๔๑</u> (ปีการศึกษาที่แล้ว).................. คน □□□□

จำนวนนักเรียนระดับประถมศึกษาปีที่ ๕ (๒๕๔๑) .... คน

๕.จำนวนเด็กนักเรียนประถมศึกษาที่ลาออกหรือย้ายออก<u>ก่อน</u>จบชั้นประถมศึกษาปีที่ ๖ ในปีการศึกษา ๒๕๔๑ : .... คน □□□

๖. <u>จำนวนวันขาดเรียน</u>ของเด็กนักเรียนชั้นประถมศึกษาปีที่ ๕ ในปีการศึกษา ๒๕๔๑ (ปัจจุบันนักเรียนนี้อยู่ชั้น ป.๖) : .... วัน ต่อ ๑ ปีการศึกษา □□□□

๗. ในปีการศึกษา ๒๕๔๑ มีเหตุการณ์กี่รายที่ผู้บริหารของโรงเรียนได้รับรายงานเกี่ยวกับเด็กนักเรียนประถมศึกษาทะเลาะกันหรือรังแกกัน : .... ราย □□

๘. ในปีการศึกษา ๒๕๔๑ มีเด็กนักเรียนประถมศึกษากี่คนที่ได้รับ<u>อุบัติเหตุภายในโรงเรียน</u>และต้องนำส่งโรงพยาบาล : .... คน □□

๙.เคยมีเหตุการณ์<u>ความรุนแรง</u> ที่เกิดขึ้นภายในโรงเรียนและต้องอาศัยเจ้าหน้าที่ตำรวจเข้ามาจัดการหรือไม่ □

□ ๑. เคยมี □ ๒. ไม่เคยมี

๑๐.จำนวนเฉลี่ยของเด็กนักเรียนชั้นประถมศึกษาปีที่ ๖ ที่ถูกทำโทษในแต่ละอาทิตย์ (การทำโทษ เช่น การถูกลงโทษให้อยู่ที่โรงเรียนในช่วงตอนเย็น, การมอบหมายให้กระทำสิ่งบางอย่าง, หรือ อื่นๆ): .... คน □□

๑๑. หัวข้อใดต่อไปนี้ ทางโรงเรียนได้จัดสอนให้แก่นักเรียนมากน้อยเพียงใด

หัวข้อที่จัดสอน	จำนวนครั้งต่ออาทิตย์				
	๐ - ๑	๒	๓	๔	> ๔
ยาเสพติดและสารเสพติด	☐	☐	☐	☐	☐
เครื่องดื่มแอลกอฮอล์และความรุนแรง	☐	☐	☐	☐	☐
พัฒนาการของความรู้สึกและอารมณ์	☐	☐	☐	☐	☐
ความรับผิดชอบ	☐	☐	☐	☐	☐
ชีวิตครอบครัว	☐	☐	☐	☐	☐
การรับมือกับความเครียด	☐	☐	☐	☐	☐
การศึกษาความปลอดภัย	☐	☐	☐	☐	☐
การปฐมพยาบาล	☐	☐	☐	☐	☐
สุขศึกษาด้านสิ่งแวดล้อม	☐	☐	☐	☐	☐
การคุ้มครองผู้เยาว์	☐	☐	☐	☐	☐
การรังแก	☐	☐	☐	☐	☐
ความมั่นใจและภูมิใจในตัวเอง, การชื่นชมผู้อื่น	☐	☐	☐	☐	☐

๑๒.นักเรียนมีโอกาสบ่อยแค่ไหนที่ได้รับข้อมูลเกี่ยวกับความปลอดภัยด้านอุบัติภัยที่ทางโรงเรียนจัดให้ (นอกเหนือจากการได้รับความรู้ผ่านหลักสูตร) หรือบุคคลภายนอกนำมาเผยแพร่ให้แก่นักเรียนที่โรงเรียน

☐ ๑. มากกว่าหนึ่งครั้งต่อเดือน

☐ ๒. มากกว่าหนึ่งครั้งต่อเทอม แต่น้อยกว่าหนึ่งครั้งต่อเดือน

☐ ๓. มากกว่าหนึ่งครั้งต่อปี

☐ ๔. น้อยกว่าหนึ่งครั้งต่อปี หรือไม่เคยได้รับ

๑๓.ในปีการศึกษาที่แล้ว เจ้าหน้าที่ตำรวจ เจ้าหน้าที่ดับเพลิง เจ้าหน้าที่สาธารณสุขหรือบุคลากรทางการแพทย์ และผู้ปกครองของนักเรียน หรือ บุคลากรด้านอื่นๆ ได้มาเยี่ยมโรงเรียนและพูดคุย แนะนำเกี่ยวกับเรื่องความปลอดภัยให้แก่ครู เจ้าหน้าที่ของโรงเรียน หรือนักเรียน ใช่หรือไม่ ☐

☐ ๑. ใช่ ☐ ๒. ไม่ใช่

ถ้า "ใช่" บุคคลหรือกลุ่มบุคคลนั้นคือใคร (ท่านสามารถเลือกคำตอบได้มากกว่า ๑ ข้อ) ☐

☐ ๑. บุคลากรทางการแพทย์หรือเจ้าหน้าที่สาธารณสุข

☐ ๒. เจ้าหน้าที่ตำรวจหรือเจ้าหน้าที่ดับเพลิง ☐ ๓. ผู้ปกครองของนักเรียน

☐ ๔. อื่นๆ (ระบุ) ....

๑๔.ทางโรงเรียนมีการประชุมพบปะผู้ปกครองนักเรียนเฉลี่ยประมาณปีละ ... ครั้ง ☐

๑๕.ในการประชุมฯแต่ละครั้งผู้ปกครองเข้าร่วมประชุมคิดเป็นประมาณร้อยละเท่าใด ☐

☐ ๑. ๗๕ ถึง ๑๐๐% ☐ ๒. ๕๐ ถึง ๗๔ %

☐ ๓. ๒๕ ถึง ๔๙% ☐ ๔. น้อยกว่า ๒๕ %

๑๖.โรงเรียนถูกใช้เป็นสถานที่ในการจัดกิจกรรมของชุมชนในช่วงตอนเย็นหรือวันหยุดเสาร์ - อาทิตย์ หรือวันหยุดอื่นๆ บ่อยหรือไม่ ☐

☐ ๑. อย่างน้อย ๑ ครั้ง/อาทิตย์ ☐ ๒. อย่างน้อย ๑ ครั้ง/เดือน

☐ ๓. อย่างน้อย ๑ ครั้ง/เทอม ☐ ๔. อย่างน้อย ๑ ครั้ง/ปี

☐ ๕. น้อยกว่าปีละครั้ง หรือไม่เคยถูกใช้เลย

ขอขอบคุณสำหรับเวลาอันมีค่าของท่าน

APPENDIX 5

PHYSICAL ENVIRONMENT CHECKLIST IN SCHOOL

Name of school:..
Subdistrict:...
Observer:...
Date of observation:................/.................../.........................

1. Crowding

1.1 The crowding of children in school

The area of school...........................square metres
All children in school.......................children
(crowding = number of children in 100 square metres)

1.2 The amount of playgrounds

The size of provided playgrounds in school ....square metres
The size of hard surface area on playground..............square metres

2. Physical conditions of school

2.1 Conditions of the building

Items	Outside conditions			Description
	Good	*Average*	*Poor*	
Number of floor levels	.... levels			including ground floor
Roof				**Good** = no open cracks or holes and eaves or the roof itself can protect rain; **Average** = no open cracks or holes but no eaves and rain could make some part of the house wet; **Poor** = open cracks or holes need repairing and no eaves, rain can make inside the house wet
Windows				**Good** = safety caches or frame with good condition (not broken), and the lower border of windows is high from floor at least 1 metre; **Average** = no safety caches or frame but the lower border of windows is high from floor at least 1 metre (or safety catches or frame but broken, but the lower border of windows is high from floor at least 1 metre); **Poor** = no safety catches or frame and the lower border of windows is high from floor less than 1 metre

Items	Classroom conditions			Description
	Good	*Average*	*Poor*	
Cleanliness				**Good** = no rubbish and tidy; **Average** = no rubbish but untidy or vice versa; **Poor** = rubbish and untidy
Floor				**Good** = not slippery without risky steps or projections; **Average** = slippery but without risky steps or projections (or risky steps or projections without slippery); **Poor** = slippery with risky steps or projections
Light (During day time)				**Good** = bright from natural light without using artificial light but having artificial light for in case of the natural light is not enough and without any broken; **Average** = bright only from artificial light, and without any broken; **Poor** = dim and the source of artificial light is broken

Items	Corridor conditions			Description
	Good	*Average*	*Poor*	
Cleanliness				**Good** = no rubbish and tidy; **Average** = no rubbish but untidy; **Poor** = dirty with rubbish and untidy
Floor				**Good** = not slippery without risky steps or projections; **Average** = slippery but without risky steps or projections (or risky steps or projections without slippery); **Poor** = slippery with risky steps or projections

Items	Canteen conditions			Description
	Good	*Average*	*Poor*	
Cleanliness				**Good** = no rubbish or garbage and tidy; **Average** = no rubbish or garbage but untidy; **Poor** = dirty with rubbish or garbage and untidy
Floor				**Good** = not slippery without risky steps or projections; **Average** = slippery but without risky steps or projections (or risky steps or projection without slippery); **Poor** = slippery with risky steps or projections
Light				**Good** = bright from natural light without using artificial light but having artificial light for in case of the natural light is not enough, and without any broken; **Average** = bright only from artificial light and without any broken; **Poor** = dim and source of artificial light is broken

Items	Toilet conditions			Description
	Good	*Average*	*Poor*	
Cleanliness				**Good** = no rubbish or sand and not wet: **Average** = no rubbish or sand but wet (or rubbish or sand but not wet); **Poor** = rubbish or sand and wet area
Floor				**Good** = not slippery without risky steps or projections; **Average** = slippery but without risky steps or projections (or not slippery with risky steps or projections); **Poor** = slippery with risky steps or projections
Light				**Good** = bright from natural light without using artificial light but having artificial light for in case of the natural light is not enough, and without any broken; **Average** = bright only from artificial light and without any broken; **Poor** = dim and source of artificial light is broken

2.2 Conditions of playgrounds

Items	conditions			Description
	Good	*Average*	*Poor*	
Cleanliness				**Good** = tidy, no rubbish; **Average** = no rubbish but untidy; **Poor** = untidy with rubbish
Floor				**Good** = Soft surface without risky areas (e.g. uneven levels, risky steps, projections and obstructions); **Average** = Soft surface but with some risky areas (or hard surface without risky areas); **Poor** = Hard surface with risky area

APPENDIX 6

Parent and guardian questionnaire

Name of child.. I.D.No. ☐☐☐☐
School... Class.........................

Dear Parent or Guardian,

We at the University of Chiang Mai are doing a study on traumatic dental injuries in children who are studying in the schools in Maung district, Chiang Mai province. We would appreciate your co-operation. The correct information from you is very important for planning preventive measures to reduce traumatic dental injuries in future. Your answers will be treated confidentially.

Please fill in your answers by ticking off the appropriate choice or writing your answers in the space provided. Once completed, please return it to the school by your child.

Thank you for your time

General and socio-economic information

Do not mark in this space

1. Please give the address where the child lives. ☐

Road/street/lane..
Subdistrict ....
District...
Province..

2. What is your relationship to the child? ☐

☐ 1. Father ☐ 2. Mother

☐ 3. Other
(Please specify: e.g. step parent, uncle, aunt, brother, sister)..

Do not mark in this space

3. What is the marital status of the child's parent?

☐ 1. Single ☐ 2. Married or couple

☐ 3. Divorced ☐ 4. Widow

☐ 5. Both died

4. What is the educational status of the child's parent?

Father

☐ 1. Primary school level 4 or less

☐ 2. Primary school level 5 to 7

☐ 3. Junior high school level 1 to 3

☐ 4. High school or vocational school

☐ 5. Bachelor degree level or higher

Mother

☐ 1. Primary school level 4 or less

☐ 2. Primary school level 5 to 7

☐ 3. Junior high school level 1 to 3

☐ 4. High school or vocational school

☐ 5. Bachelor degree level or higher

Guardian

☐ 1. Primary school level 4 or less

☐ 2. Primary school level 5 to 7

☐ 3. Junior high school level 1 to 3

☐ 4. High school or vocational school

☐ 5. Bachelor degree level or higher

Do not mark in this space

5. What work do you do?

Type of work

Father.. ☐

Mother... ☐

Guardian.. ☐

6. How many members are there in the house where the child lives? ☐☐

.... persons

7. How many brothers and sisters does the child have? ☐☐

.... persons

8. What is the birth order of the child among his/her brothers and sisters? ☐☐

.... order

9. How many members in your family earn money? ☐☐

.... persons

10. What is the average income of your family per month? ☐

☐ 1. Less than 3,000 baht ☐ 2. 3,000 - 5,000 baht

☐ 3. 5,001 - 10,000 baht ☐ 4. 10,001 - 20,000 baht

☐ 5. 20,001 - 30,000 baht ☐ 6. 30,001 - 50,000 baht

☐ 7. Above 50,000 baht

14. The child lives with ☐

☐ 1. Both father and mother ☐ 2. Father

☐ 3. Mother

☐ 4. Others (Please specify)..

****

แบบสอบถามสำหรับผู้ปกครอง

เลขที่ ☐☐☐☐

เพศ ☐ ชาย ☐ หญิง

โรงเรียน .... ☐☐ ชั้นประถมศึกษาปีที่ ๖ / ....

เรียนท่านผู้ปกครอง

คณะผู้ทำวิจัยจากภาควิชาทันตกรรมชุมชน คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ กำลังศึกษาวิจัยเกี่ยวกับการบาดเจ็บของฟันในเด็กนักเรียนชั้นประถมศึกษาปีที่ ๖ ที่ศึกษาในโรงเรียนเขตอำเภอเมือง จังหวัดเชียงใหม่ คณะผู้ทำวิจัยใคร่ขอความร่วมมือจากท่านในการตอบแบบสอบถาม ข้อมูลที่ถูกต้องที่ได้จากท่านจะมีความสำคัญในการหามาตรการป้องกันเพื่อลดการบาดเจ็บของฟันของบุตรหลานของท่านในอนาคตและข้อมูลของท่านจะถูกปกปิดเป็นความลับ

กรุณาตอบคำถามโดยกาเครื่องหมายถูก(✓) ลงในช่องสี่เหลี่ยมข้างหน้าคำตอบที่ท่านเลือก หรือเขียนคำตอบลงในช่องว่างที่เตรียมไว้ให้เมื่อท่านตอบแบบสอบถามเสร็จแล้วกรุณามอบแบบสอบถามให้เด็กของท่านนำกลับมามอบให้ครูประจำชั้น

ขอบคุณสำหรับเวลาของท่าน

สำหรับเจ้าหน้าที่

๑. กรุณากรอก ย่านที่อยู่ปัจจุบันของเด็กนักเรียนนี้ ☐

หมู่ที่ .... ถนน ....

ซอย .... ตำบล .... อำเภอ ....

จังหวัด ....

๒. ความสัมพันธ์ของท่านผู้ตอบแบบสอบถามกับเด็กนักเรียนนี้ ☐

☐๑. บิดา ☐๒. มารดา

☐๓. อื่นๆ (โปรดระบุ เช่น บิดาหรือมารดาบุญธรรม ลุง ป้า น้าชาย น้าสาว อาผู้ชาย อาผู้หญิง ปู่ ย่า ตา ยาย พี่ชาย พี่สาว เป็นต้น) .... ☐

๑. สถานภาพสมรสของผู้ปกครองของนักเรียนคนนี้ ☐

☐๑. โสด ☐๒. แต่งงานหรือคู่ ☐๓. หย่า

☐๔. หม้าย ☐๕. เสียชีวิตแล้วทั้งคู่

สำหรับเจ้าหน้าที่ ☐

๔.ระดับการศึกษาของบิดาและมารดาของนักเรียนนี้หรือท่านผู้ปกครองของนักเรียนนี้แต่ไม่ใช่บิดาหรือมารดา

ระดับการศึกษา	บิดา	มารดา	ท่านผู้ปกครอง (แต่ไม่ใช่บิดาหรือมารดา)	
			ชาย	หญิง
๑. ชั้นป. ๔ หรือต่ำกว่า (ประถมศึกษาตอนต้น หรือต่ำกว่า)	☐	☐	☐	☐
๒. ชั้นป. ๕ ถึง ป. ๖ (ประถมศึกษาตอนปลาย)	☐	☐	☐	☐
๓. ชั้นม. ๑ ถึง ม. ๓ (มัธยมศึกษาตอนต้น)	☐	☐	☐	☐
๔. ชั้นม. ๔ ถึง ม. ๖ หรือ ปวช. (มัธยมศึกษาตอนปลายหรือเทียบเท่า)	☐	☐	☐	☐
๕. ปวส. หรือปริญญาตรี หรือสูงกว่า	☐	☐	☐	☐

๕. อาชีพขอบิดา / มารดา หรือ ผู้ปกครองของนักเรียนคนนี้ ☐

ชนิดของงาน

บิดา .... ☐

มารดา .... ☐

ผู้ปกครอง .... ☐

๖. จำนวนสมาชิกในบ้านที่เด็กนักเรียนอาศัยอยู่ .... คน ☐

๗. จำนวนพี่น้องของเด็กนักเรียน .... คน (รวมตัวเด็กนักเรียนด้วย) ☐

๘. เด็กนักเรียนเป็นบุตรลำดับที่ .... ในกลุ่มของพี่น้อง ☐

๙. จำนวนผู้ที่มีรายได้ที่เลี้ยงดูเด็กนักเรียนหรือจุนเจือครอบครัวของเด็กนักเรียน : .... คน ☐

สำหรับเจ้าหน้าที่

๑๐. รายได้รวมของบุคคลผู้ที่มีรายได้ จากข้อ ๑๐.

□๑. น้อยกว่า ๓,๐๐๐ บาท ต่อ เดือน

□๒. ๓,๐๐๐ ถึง ๕,๐๐๐ บาท ต่อ เดือน

□๓. ๕,๐๐๑ ถึง ๑๐,๐๐๐ บาท ต่อ เดือน

□๔. ๑๐,๐๐๑ ถึง ๒๐,๐๐๐ บาท ต่อ เดือน

□๕. ๒๐,๐๐๑ ถึง ๓๐,๐๐๐ บาท ต่อ เดือน

□๖. ๓๐,๐๐๑ ถึง ๕๐,๐๐๐ บาท ต่อ เดือน

□๗. มากกว่า ๕๐,๐๐๐ บาท ต่อ เดือน

□

๑๑. เด็กนักเรียนอาศัยอยู่กับ

□๑. บิดาและมารดา

□๒. บิดา

□๓. มารดา

□๔. บุคคลอื่น (โปรดระบุ) ....

□

ขอขอบคุณสำหรับเวลาของท่าน

APPENDIX 7

Principal component and factor analysis

The description of Principal component and factor analysis presented in this appendix is mainly from the SPSS/PC manual (Bryman & Cramer, 1999).

Principles of principal component and factor Analysis

Principal component analysis (PCA) and factor analysis (FA) are statistical techniques applied to a set of variables where the researcher is interested in reducing the dimensionality of a data set by obtaining subsets of variables combined into factors or components. A component expresses a general concept or dimension on the basis of the empirical links within a set of indicators (Tabchnick &Fidell, 1966).

Many of the concepts used to describe human behaviour seem to consist of a number of different aspects. Take, for example, the concept of job satisfaction. When we say we are satisfied with our job, this statement may refer to various feelings we have about work, such as being keen to go to it every day, not looking for other kinds of jobs, being prepared to spend time and effort on it, and having a sense of achievement about it. If these different components contribute to our judgement of how satisfied we are with our job, we would expect them to be interrelated. In other words, how eager we are to go to work should be correlated with the feeling of accomplishment we gain from it, and so on. Similarly, the concept of job routine may refer to a number of interdependent characteristics such as how repetitive the work is, how much it makes us think about what we are doing, the number of different kinds of tasks we have to carry out each day, and so on. Some people may enjoy repetitive work while others may prefer a job, which is more varied. To determine this, we could ask people to describe their feelings about their jobs in terms of these characteristics and see to what extent those aspects, which reflect satisfaction, are correlated with one another and unrelated to those which represent routine. Characteristics that go together constitute a factor, and factor analysis refers to a number of related statistical techniques, which help us to determine them.

Two uses of factor analysis can be distinguished. The one most commonly reported is the *exploratory* kind in which the relationships between various variables are examined without determining the extent to which the results fit a particular model. *Confirmatory* factor analysis, on the other hand, compares the solution found against a hypothetical one.

For the purpose of this thesis, the exploratory kind was used to check if various variables explaining the same concepts. For examples, if some of the various topics provided in school curriculum could explain a concept related to 'safety' topic (Section 3.2.1.1.2), and if the cleanliness of different areas in schools could explain the cleanliness of schools (Section 3.2.1.2.2).

The method of PCA and FA

The first step: The initial step is to compute a correlation matrix for included items. Here we shall use the cleanliness of different areas in schools as an example of the included items. If there are no significant correlations between these items, then this means that they are unrelated and that we would not expect them to form one or more factors. In other words, it would not be worthwhile to go on to conduct a factor analysis. Consequently, this should be the first stage in deciding whether to carry one out. However, the correlation matrix for the cleanliness of different areas, together with their significance levels, is present in Table A7.1. All but one of the items are significantly correlated at less than the 0.05 level, either positively or negatively with one another, which suggests that they may constitute one or more factors.

Table A 7.1 Correlation and significance-level matrices for the cleanliness of different areas in schools

		Classes	Corridors	Canteens	Toilets	Playground
Correlation	**Classes**	1.000	.414	.403	.330	.362
	Corridors	.414	1.000	.219	.238	.306
	Canteens	.403	.219	1.000	.058	.254
	Toilets	.330	.238	.058	1.000	.329
	Playground	.362	.306	.254	.329	1.000
Sig. (1-tailed)	**Classes**		.001	.002	.008	.004
	Corridors	.001		.059	.044	.014
	Canteens	.002	.059		.341	.035
	Toilets	.008	.044	.341		.009
	Playground	.004	.014	.035	.009	

The second step: The reliability of the factors emerging from a PCA and FA depends on the size of the sample, although there is no consensus on what the size should be. There is agreement, however, that there should be more participants than variables. Gorsuch (1983) has proposed an absolute minimum of five participants per variable and not less than 100 individuals per analysis. Since each variable included in the present study was from 52 schools and the number of variables included in the analyses was at least three variables per an analysis (Section 3.2.1.2.3), therefore it is suggested that the sample sizes of this study were satisfied the agreement.

The difference between PCA and FA

The two most widely used forms of factor analysis are *principal components* and *factor* analysis (called *principal-axis factoring* in SPSS).

PCA and FA are primarily concerned with describing the variation or variance, which is shared by the scores of people on three or more variables. This variance is referred to as *common variance* and needs to be distinguished from two other kinds of variance. *Specific variance* describes the variation, which is specific or unique to a variable and which is not shared with any other variable. *Error variance,* on the other hand, is the variation due to the fluctuations, which inevitably result from measuring something. For example, you weigh yourself a number of times in quick succession, you will find that the readings will vary somewhat, despite the fact that your weight could not have changed in so short time. These fluctuations in measurement are known as *error variance.* So the total variation that we find in the scores of an instrument (such as an item or tests) to assess a particular variable can be divided or partitioned into *common, specific and error variance.*

Total variance = Common variance + Specific variance + Error variance

Since factor analysis cannot distinguish *specific* from *error variance*, they are combined to form *unique variance*. In other words, the total variance of a test consists of its *common* and its *unique variance*.

The difference between PCA and FA (Principal-axis factoring) lies essentially in how they handle unique variance. In PCA, all the variance of a score or variable is analysed, including its unique variance. In other words, it is assumed that the test used to assess the variable is perfectly reliable and without error. In FA only the variance, which is common to or shared by the tests is analysed – that is, an attempt is made to exclude the unique variance from analysis. Since PCA examined the total variance of a test, this is set at 1, while for FA it varies between 0 and 1. The variance of a test to be explained is known as its *communality*.

The third step: In both PCA and FA, the first component or axis that is extracted accounts for the largest amount of variance shared by the test. The second component consists of the next largest amount of variance, which is not related to or explained by the first one. In other words, these two factors are unrelated or *orthogonal* to another one. The third factor extracted the next largest amount of variance, and so on. However, the first few components are the most important ones.

By using SPSS, Table A7.2 shows the initial factors (components) produced by a PCA of the cleanliness of different areas in schools, and the amount of the variance they account for (their *eigenvalue*). The variance accounted for by the first component was 2.193 or 43.8 per cent of the total variance. The total variance explained by five items was simply the sum of their eigenvalues; approximately 5.

Table A 7.2 Initial principal components and their variance of the cleanliness of different areas in school

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	2.193	43.854	43.854	2.193	43.854	43.854
2	.960	19.192	63.045			
3	.725	14.498	77.543			
4	.644	12.874	90.418			
5	.479	9.582	100.000			

Extraction Method: Principal Component Analysis.

The fourth step: Since the object of PCA and FA is to reduce the number of variables we have to handle, this step is to decide the number of components to be retained. There are two main criteria used for deciding which components to be excluded. The first, known as *Kaiser's criterion*, is to select those components having an eigenvalue of greater than one. The second method is the graphical *scree test* proposed by Cattell (1966). Using the first method, therefore, according the example of the cleanliness of different area in schools, only the first component was retained (Table A7.2).

The fifth step: After extraction, rotation is used to improve the interpretability and scientific utility of the solution. Varimax was the rotation of choice used in this study. It is an orthogonal rotation (so that the components are uncorrelated with each other), which makes the interpretation of the component easier because they are considered as independent from one another. The researcher then decides on a criterion for meaningful correlation (usually 0.32 or larger), collects together the variables with loadings (the relationship between each item or test and a component is expressed as a correlation or *loading*) in excess of the criterion, and search for a concept that unifies them (Norman & Streiner, 1998). However, the cut-off point selected here was 0.45. As can be seen in Table 55 (Chapter 3), the loadings of all items (cleanliness in five areas of schools) were higher than the cut-off point. Thus, all of these items explained a concept named the 'cleanliness of schools'.

APPENDIX 8

Optimisation Methods for Cluster Analysis

This clustering technique is sometimes called k-mean clustering technique, which produce a partition of the individuals for a number of groups, by either minimising or maximising some numerical criterion. This technique is not necessary in forming hierarchical classifications of the data. The description of statistical method in this appendix was explained by Everitt (1993).

Clustering criteria

idea
The basic behind the methods is that associated with each partition of the *n* individuals into the required number of groups, *g*, is an index, *f* (*n, g*), the value of which is indicative of the 'quality' of this particular clustering. For some indices, high values are sought, for others low values. Associating a number with each partition allows them to be compared. Many clustering criteria have been suggested, but the most commonly used arise from considering the following three matrices which can be calculated from a partition of the data.

$$\mathrm{T} = \frac{1}{\mathrm{n}}\sum_{i=1}^{g}\sum_{j=1}^{n_i}(x_{ij} - \bar{x})(x_{ij} - \bar{x})'$$

$$\mathrm{W} = \frac{1}{\mathrm{n-g}}\sum_{i=1}^{g}\sum_{j=1}^{n_i}(x_{ij} - \bar{x}_j)(x_{ij} - \bar{x}_i)' \qquad \text{.......................} (1)$$

$$\mathrm{B} = \sum_{\mathrm{i=1}}^{\mathrm{g}} n_i(\bar{x}_i - \bar{x})(\bar{x}_i - \bar{x})'$$

These $p \times p$ matrices (p is the number of variables) represent respectively, total dispersion (T), within-group dispersion (W) and between-group dispersion (B), and satisfy the following equation.

$$\mathrm{T} = \mathrm{W} + \mathrm{B} \qquad \text{......................... (2)}$$

For $p = 1$, this equation represents a relationship between scalars; simply the division of total sum-of-squares for a variable, into within and between groups sum-of-square, familiar from a one-way analysis of variance. In this case a natural criterion for grouping would be to choose the partition corresponding to the minimum value of the within group sum-of-squares, or, equivalently, the maximum value of the between group term.

For $p > 1$, the derivation of clustering criteria from equation (1) is not so clear cut, and several alternatives have been suggested. However, only the technique used in this study is described here.

Minimisation of trace (W)

An obvious extension of the minimisation of the within group sum-of-squares criterion suggested above for the case $p = 1$, when the data are not univariate, is to minimise the sum of the within groups sum-of-squares, over *all* the variables, that is to minimise trace (W). This can be equivalent to minimising the sum of squared Euclidean distances between individuals and their cluster mean, that is

$$E = \sum_{i=1}^{n} d_{i,c(i)}^{2} \qquad \text{..................................... (3)}$$

where $d_{I,c(I)}$ is the Euclidean distance from individual i, to the mean of the cluster to which it is assigned. [Minimising trace (W) is also equivalent to maximising trace (B)].

APPENDIX 9

Introducing multilevel models

The multilevel models presented in this appendix were mainly from the explanation of Goldstein et al. (1998).

Multilevel data structure

It is a norm that a population may contain hierarchical structures. For example, school education provides a clear case of a system in which individuals are subject to the influences of grouping. Students or students learn in classes; classes are taught within schools; schools may be administered within local authorities or school boards. The *units* in such a system lie at four levels of a hierarchy. A typical multilevel model of this system would assign students to level-1, classes to level-2, schools to level-3 and authorities or boards to level-4. Units at one level are recognised as being grouped, or nested, within units at the next higher level. In trials of medical procedures, several centres may be chosen and individual patients studies within one. Here the centres become the level-2 units and the patients the level-1 units.

Levels of a data structure

A tutorial example in Goldstein et al. (1998) will be used to llustrate the fundamental principle of multilevel modelling.

In this example we look at the relationship between an outcome or response variable which is the score achieved by 16 year old students in an examination and a predictor or explanatory variable which is a reading test score obtained by the same students just before they entered secondary school at the age of 11 years. The first variable is referred to as 'exam score' and the second as 'LRT score' which is short for 'London Reading Test'.

To illustrate the existence of different levels of variation, schools will be the groups of interest and students will be the individuals of interest.

Firstly, we restrict attention to a single response variable and one predictor at the student-level. We begin by looking at the data from a single school. In Figure A8.1, the exam scores of 73 children sampled from one of the schools are plotted against the LRT scores for the same children. The relationship is summarised by the prediction or regression line.

Figure A 8.1 Level-1 variation

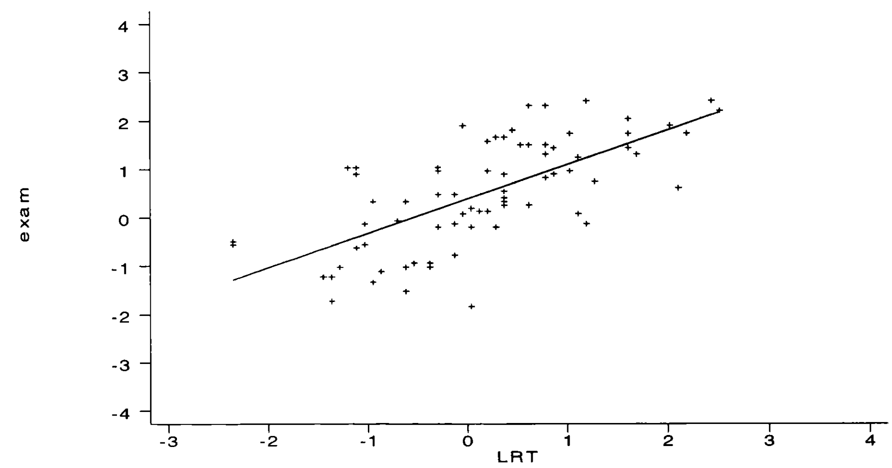
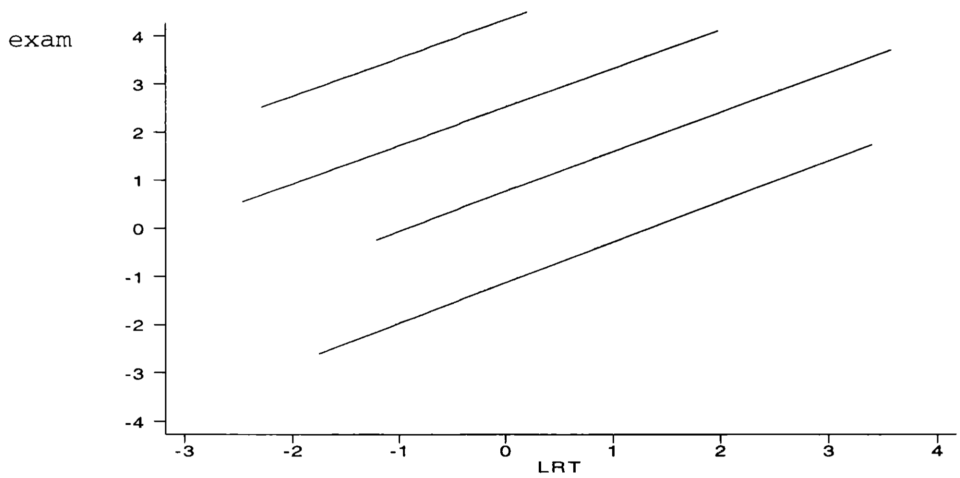


Figure A 8.1 shows that each of the graph points represents a pair of values for an individual student. The degree of scatter about the regression line represents random variation at the student-level about average relationship between 'exam' and 'LRT' scores at this school. This is the level-1 variation because it concerns the variation between level-1 unit, that is students.

We can think of the regression line as a school-level summary of this relationship which may itself vary from school to school. In Figure A 8.2, we have drawn the regression lines for four typical schools, constraining the lines to be parallel.

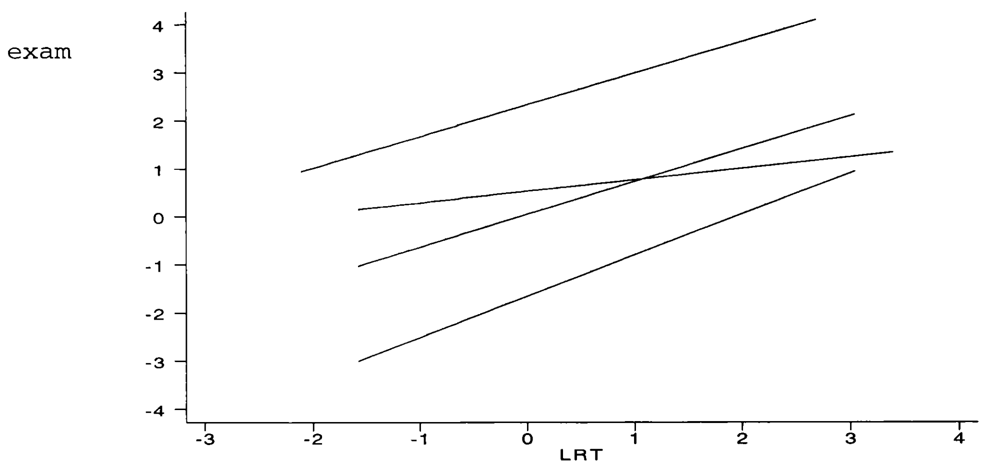
Figure A 8.2 Level-2 variation in school summary lines



The lines in Figure A 8.2 have different intercepts. The variation between these intercepts is called level-2 variation because in this example the schools are level-2 units. The schools are thought of as a random sample from a large underlying population of schools, and 'school' is referred to as a random classification. The individual schools, like the individual students, are not of primary interest. Our interest is rather to make inferences about the variation among all schools in the population, using the sampled schools as a means to that end.

If we regard the lines in Figure A 8.2 as giving the prediction of the exam score for a given LRT scores. This kind of variation is known as simple level-2 variation. If we allow the slopes of the lines to vary as in Figure A 8.3, then the differences between the schools depend on the students' LRT scores. This is an example of complex level-2 variation.

Figure A 8.3 Complex level-2 variation



Description of multilevel modelling

Figure A 8.1 provided an illustration of level-1 variation for a single school, together with a regression line representing a summary relationship between the exam and LRT scores for the students in this school. The technique of 'ordinary least squares' (OLS) is used to produce this relationship. However, our interest is to use the variation between all the schools of the sample in order to make inferences about the variation in the underlying population.

The ordinary regression relationship for a single school may be expressed as:

$$y_i = a + bx_i + e_i \tag{1}$$

where subscript i takes values from 1 to the number of students in the school. In our example y_i and x_i are respectively the exam and LRT scores for the i-th student. The regression relation can also be expressed as:

$$\hat{y} = a + bx_i \tag{2}$$

where $\hat{y}$ is the exam score predicted for the i-th student by this particular summary relationship for the school. The intercept, a, is where the regression line meets the vertical axis and b is its slope. The expression $a + bx_i$ is known as the *fixed* part of the model.

In equation (1), e_i is the departure of the i-th student's actual score from the predicted score. It is commonly referred to either as an *error* or *residual.* This residual is that part of the score, which is not predicted by the fixed part regression relationship in equation (2). With only one school, the level-1 variation is just the variance of these e_i.

Since the multilevel case of several schools which regards as a random sample of schools from a population of schools, the regression relation for each school are as follows:

$$\hat{y}_{i1} = a + bx_{i1}$$

$$\hat{y}_{i2} = a + bx_{i2}$$

....

....

$$\hat{y}_{ij} = a + bx_{ij} \tag{3}$$

where the slopes are parallel. The subscript j takes values from 1 to the number of schools in the sample. Therefore, the full model can be expressed as:

$$y_{ij} = a + bx_{ij} + e_{ij} \tag{4}$$

In general, wherever an item has two subscripts ij, it varies from student to student within a school. Where an item has a j subscript only it varies across schools but has the same value for all the students within a school. And where an item has neither subscript it is constant across all students and schools.

In a multilevel analysis, the level-2 groups are treated as a random sample from a population of schools. Then, the equation (3) is re-expressed as:

$$a_j = a + u_j \tag{5}$$

$$\hat{y}_{ij} = a + bx_{ij} + u_j$$

Where a, with no scripts, is a constant and u_j, the departure of the j-th school's intercept from the overall value, is a level-2 residual which is the same for all students in school j. The model for actual scores can now be expressed as:

$$y_{ij} = a + bx_{ij} + u_j + e_{ij} \tag{6}$$

In this equation, both u_j and e_{ij} are random quantities, whose means are equal to zero; they form the *random part* of the model (6). We assume that, being at different levels, these variables are uncorrelated and we further make the standard assumption that they follow a Normal Distribution so that it is sufficient to estimate their variances, σ_u^2 and σ_e^2 are referred to as *random parameters* of the model. The quantities a and b are known as *fixed parameters.* A multilevel model of this simple type, where the only random parameters are the intercept variance at each level, is known as a variance component model.

In order to specify more general models, we need to adapt the notation of (6). First, we introduce a special explanatory variable x_0, which takes the value 1 for all students. This allows every term on the right hand side of (6) to be associated with an explanatory variable. Secondly, we use β_0, β_1 etc. for the fixed parameters, the subscript 0, 1 etc. matching the subscripts of the explanatory variables to which they are attached. Similarly, we incorporate a subscript 0 into the random variable and write

$$y_{ij} = \beta_0 x_0 + \beta_1 x_{1ij} + u_{0j} x_0 + e_{0ij} x_0 \tag{7}$$

Finally, we collect the coefficients together and write

$$y_{ij} = \beta_{0ij}x_0 + \beta_1 x_{1ij} \quad (8)$$

$$\beta_{0ij} = \beta_0 + u_{0j} + e_{0ij} \quad (9)$$

Thus, we have specified the random variation in y in terms of random coefficients of explanatory variables. In the present case, the coefficient of x_0 is random at both level-1 and level-2. The zero subscripts on the level-1 and level-2 random variables indicate that these are attached to x_0.

Modelling binary response

For this case, the response variable is measured as a simple yes/no for each individual. The same modelling procedures can be applied to data where the response is a proportion.

According to the data of the present study, the responses were grouped into whether or not children experienced traumatic dental injuries. The sample consisted of 2,725 children from 52 schools. The main explanatory variables were derived from the characteristics of schools, named as social and physical environments (Section 3.2). These variables were the school-level information. The other variables were the characteristics of children, the student-level information (Section 3.1.1). The main interest lies in seeing how the combination of these explanatory variables influences the probability of children having traumatic dental injuries and the extent of between-school variation.

Specify the binary response model

We have a basic binary response (whether or not a child experienced traumatic dental injury) and the predictor explanatory variables are the intercepts and the ten covariates (social environment, physical environment, sex, age, and marital, employment, educational status of parents and family income as well as incisal overjet and BMI).

Let π_{ij} be the probability that *i*th child in the *j*th school experienced traumatic dental injury. We defined this probability as a function of the intercepts and the eight explanatory variables as follows:

$$\text{logit}\ (\pi_{ij}) = \beta_{1j}x_1 + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{4ij} + \beta_5 x_{5ij} + \beta_6 x_{6ij} + \beta_7 x_{7ij} +$$

$$\beta_8 x_{8ij} + \beta_9 x_{9ij} + \beta_{10} x_{10ij} + \beta_{11} x_{11ij},$$

where $\beta_{1j} = \beta_1 + u_{1j}$.

In the above equation, x_1 (with no further subscript) takes the value 1 for all children. Its coefficient β_{1j} indicates that we are modelling the intercept in this relationship as random at the level of the schools. We have used x_1 for this purpose since we shall need to use x_0 to specify the variation at level-1. The variable x_{2ij} to x_{11ij} are our ten explanatory variables, and their coefficients are modelled as fixed.

NO . 1/1999.

CERTIFICATE OF ETHICAL CLEARANCE

Human Experimentation Committee
Faculty of dentistry
Chiang Mai University
Chiang Mai, Thailand

Title of project or study: **Traumatic Dental / Oral injuries in an urban area of Thailand**

Principal Investigator : **Peerasak Malikaew**

Participating Institution (S) : **Faculty of dentistry**
Chiang Mai University
Chiang Mai, Thailand

Approved by the Faculty of Dentistry Human Experimentation Committee (date) : October 22,1999

Signature of the Chairman of the Committee :

....

(Anak Iamaroon ,D.D.S.,M.S.,Ph.D.)

Countersigned : ....

(Virush Patanaporn , D.D.S.,M.S.)
Dean ; Faculty of Dentistry

APPENDIX 11

The full adjusted model of the associations between traumatic dental injuries and all explanatory variables, and the interactions between explanatory variables

Table A11.1 A multilevel analysis the associations between traumatic dental injuries and all explanatory variables in the fully adjusted model; accounting for school variations

Variables	Crude OR (95% CI)	Adjusted OR (95% CI)
Social environment of schools		
Non-supportive	1	1
Supportive	0.59 (0.41, 0.84)	0.68 (0.49, 0.93)
Physical environment of schools		
Non-supportive	1	1
Supportive	0.88 (0.61, 1.28)	0.89 (0.65, 1.21)
Sex		
Male	1	1
Female	0.44 (0.37, 0.52)	0.43 (0.36, 0.52)
Age		
Younger than 12 years old	1	1
12 years old	1.11 (0.93, 1.34)	1.04 (0.86, 1.25)
Older than 12 years old	1.64 (1.16, 2.32)	1.11 (0.77, 1.60)
Marital status of parent		
None or a single parent	1	1
Both parents	0.72 (0.59, 0.88)	0.71 (0.58, 0.88)
Employment status of parent		
Unemployment	1	1
Employment	0.32 (0.22, 0.47)	0.35 (0.24, 0.51)
Family income		
5,000 Baht or less per month	1	1
Above 5,000 Baht per month	0.70 (0.59, 0.85)	0.82 (0.67, 0.99)
Educational status of parent		
Compulsory level or lower	1	1
Above compulsory level	0.72 (0.61, 0.86)	0.72 (0.60, 0.87)

Table A11.1 (continued)

Variables	Crude OR (95% CI)	Adjusted OR (95% CI)
Anterior tooth protrusion (overjet)		
> 5 mm	1	1
$\leq$ 5 mm	0.75 (0.56, 0.99)	0.76 (0.57, 1.02)
Body Mass Index		
1st tertile (< 16.92)	1	1
2nd tertile (16.92 to 19.62)	1.28 (1.05, 1.56)	1.41 (1.15, 1.74)
3rd tertile (>19.62)	1.16 (0.95, 1.42)	1.30 (1.05, 1.60)

Table A11.2 The interaction between social environment of schools and sex, on traumatic dental injuries

Explanatory variables	β (SE)
Social environment	-0.573 (0.185)
Sex	-0.951 (0.121)
Social environment and sex	0.309 (0.178) *

* Wald's Z = 1.74, p = 0.08
The school variation in terms of logit variance and its S.E. of this model was 0.170 (0.061).

Table A11.3 The interaction between physical environment of schools and sex, on traumatic dental injuries

Explanatory variables	β (SE)
Physical environment	-0.121 (0.188)
Sex	-1.075 (0.166)
Physical environment and sex	0.359 (0.194) *

* Wald's Z = 1.83, p = 0.067
The school variation in terms of logit variance and its S.E. of this model was 0.179 (0.064).

Table A11.4 The interaction between social and physical environments of schools, on traumatic dental injuries

Explanatory variables	**β (SE)**
Social environment	-0.796 (0.262)
Physical environment	0.014 (0.216)
Social and physical environments	0.447 (0.350) *

* Wald's Z = 1.28, p = 0.20
The school variation in terms of logit variance and its S.E. of this model was 0.195 (0.067).

APPENDIX 12

Illustrations of the conditions of physical environment of schools in the study

Figure A12.1 Condition of windows; **good windows** (no broken frames, the lower border of windows is high above floor [at least 1 metre])

Figure A12.2 Condition of windows; **fair windows** (no safety catches or frame, but the lower border of windows is high above floor [at least 1 metre])

Figure A12.3 Condition of classroom; **good cleanliness of classroom** (no rubbish and tidy)

Figure A12.4 Conditions of windows and cleanliness of classroom; **fair windows** (no safety catches or frame but the lower border of windows is high above floor [at least 1 metre]) and **fair cleanliness of classroom** (no rubbish but untidy)

Figure A12.5 Conditions of windows and classroom; **fair windows** (no safety catches or frame but the lower border of windows is high above floor [at least 1 metre]) and **poor cleanliness of classroom** (rubbish and untidy)

Figure A12.6 Condition of classroom; **good floor surface of classroom** (not slippery and without risky steps)

Figure A12.7 Condition of classroom; **fair floor surface of classroom** (not slippery, but with risky step)

Figure A12.8 Condition of classroom; **poor floor surface of classroom** (slippery and with risky step)

Figure A12.9 Condition of corridor; **good cleanliness of corridor** (no rubbish and tidy) and **good floor of corridor** (not slippery and without risky steps or projections)

Figure A12.10 Condition of corridor; **good cleanliness of corridor** (no rubbish and tidy) and **fair floor of corridor** (not slippery but, with projections)

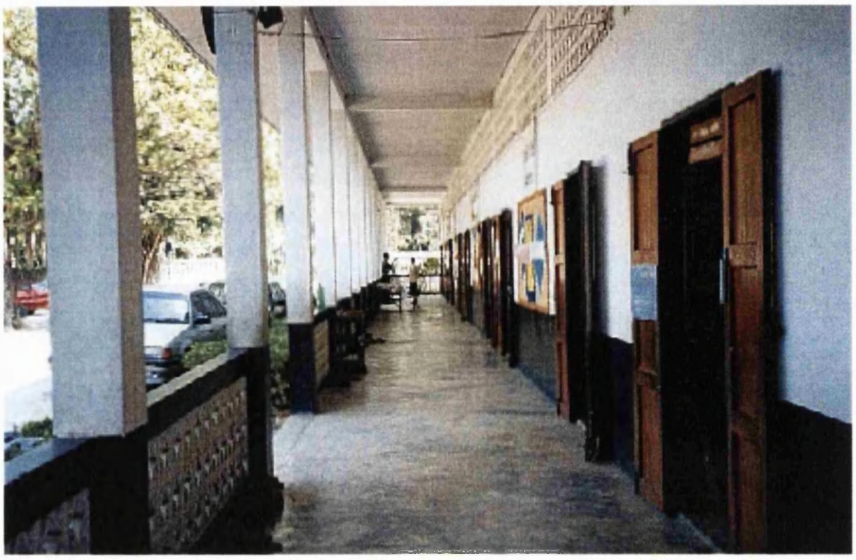


Figure A12.11 Condition of corridor; **fair cleanliness of corridor** (no rubbish, but untidy) **and fair floor of corridor** (not slippery, but some projections)

Figure A12.12 Condition of canteen; **good cleanliness of canteen** (no rubbish or garbage and tidy)

Figure A12.13 Conditions of canteen; **good cleanliness of canteen** (no rubbish or garbage and tidy) and **fair floor surface of canteen** (not slippery, but with risky step)

Figure A12.14

Conditions of toilet; **good cleanliness of toilet** (no rubbish or sand and not wet) and **good floor surface of toilet** (not slippery and without risky steps or projections)

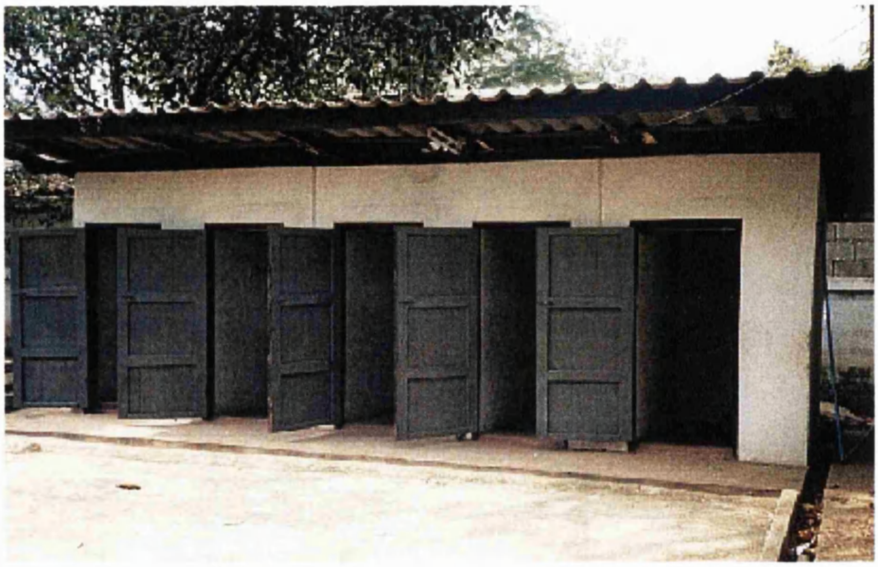


Figure A12.15 Conditions of toilets; **good cleanliness of toilets** (no rubbish or sand and not wet) and **fair floor of toilets** (not slippery, but with risky steps)

Figure A12.16 Conditions of toilets; **poor cleanliness of toilets** (sand and wet) and **poor floor surface of toilets** (slippery and with risky steps)

Figure A12.17

Conditions of toilet; **poor cleanliness of toilet** (sand and wet) and **poor floor surface of toilet** (slippery and with risky steps)

Figure A12.18 Conditions of playground; **good cleanliness of playground** (no rubbish and tidy) **and good floor of playground** (soft surface and without risky steps)

Figure A12.19 Conditions of playground; **good cleanliness of playground** (no rubbish and tidy) **and fair floor surface of playground** (soft surface but uneven and with some risky steps)