Barriers and Facilitators to Children Wearing a Sports Mouthguard: A Systematic Review

Mohammad Ali Alqarni

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Background: The global prevalence of traumatic dental injury (TDI) to the permanent dentition has been found to be as high as 15.2% (95 CI; 13.0%-17.4%) among children and adults (7 to 98 years old) and 25% in schoolchildren (7 to 17 years old). For young people, treatment can be complicated, costly and time consuming and the consequences of dental trauma can have a lifelong impact on their quality of life. Several studies have found a significant association between mouthguard use and prevention of dental trauma ($p<0.001$) and thus strongly recommend their use in sports activities, especially for children. However, the acceptability and compliance of wearing mouthguards varies, and the reasons why a child chooses to wear or not wear a mouthguard need to be explored.

Aim: To identify the barriers to and facilitators of wearing a sports mouthguard among children.

Method: A systematic review (Registration details: CRD42020186953, 23 September 2020) was conducted using studies published up to May 2022 identified from several electronic databases: Ovid MEDLINE, Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily, Embase, Embase Classic, Web of Science, and Scopus. Searches were based on the search strategy developed for Ovid MEDLINE (R) and revised appropriately for each corresponding database. Studies with participants aged 7 to 19 were included. Studies reporting any emotional, social, and behavioural responses to the usage of mouthguards, as well as the cost/expenses, were included.

The data was extracted using a modified data extraction form, and the barriers and facilitators identified were categorised using the Theoretical Domains Framework (TDF) domains, and further sub-categorised into five sociological levels of influence (individual, interpersonal, organisational, community, and public policy). The risk of bias in the included studies was assessed using the Newcastle-Ottawa Scale (NOS).

Results: This systematic review included 36 studies (cross-sectional: n=30; cohort: n=06) from 1470 records identified. The barriers and facilitators identified were categorized into seven TDF domains (knowledge, beliefs about consequences, intentions, memory, attention, and decision process, environmental context and resources, social influence, and emotions). The “environmental context and resources” domain was the most prevalent domain in 30 of the included studies, and also contained the greatest number of barriers. “belief about consequences” was the next most common domain and the greatest number of facilitators were identified in this domain. The most common barriers were interference with breathing (N=24) and speech (N=23), while the belief that mouthguards provide protection was noted to be the most recurrent facilitator in 13 of the included studies. Furthermore, most of identified barriers and facilitators were categorised under individual sociological level.

Conclusion: The results of this systematic review indicate that there are more barriers than facilitators in the use of mouthguards. The majority of barriers were found in the domain of environmental context and resources. Knowledge, belief about consequences, and social influence were also major categories with both barriers and facilitators identified at deferent sociological levels.

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Thesis Layout

This thesis is written in a chapter format. The first chapter contains the introduction, literature review, aim, and objectives. The following two chapters explain the methodology ***(Chapter 2)*** and results ***(Chapter 3)***. The discussion and conclusion are presented in the last two chapters.

Chapter 1

Introduction and Literature Review

1.1 Prevalence of Traumatic Dental Injuries

Traumatic dental injury (TDI) refers to injuries of the teeth, hard and soft tissues within and around the mouth and oral cavity. It is frequently sudden, accidental and unexpected, and often requires emergency assessment and treatment (Andreasen J.O, 2013). Globally the annual incidence of TDI among children and adolescents is around 4.5% (Lam, 2016). A meta-analysis found the global prevalence of TDI was 15.2% (95 CI; 13.0%-17.4%) in the permanent dentition and 22.7% (95 CI; 17.3%-28.7%) in the primary dentition (Petti et al., 2018). The prevalence of TDI in children is particularly concerning, with a review of the literature showing that TDIs involving the primary dentition occurred in approximately one third of preschool children. In addition, TDIs involving the permanent dentition occurred in approximately one quarter of all schoolchildren, with differences occurring both within and between countries (Glendor, 2008).

Studies conducted in different countries show significant variation in the prevalence of TDI among children. This variation is influenced by a number of factors, including age group, gender and socioeconomic status; and the type of study. For example, the literature indicates a higher prevalence of TDI among twelve-year-old boys relative to girls of the same age in Brazil at 12.2% and 8.8% respectively (Soriano et al., 2007) and in India at 18.7% and 11.4% respectively (Telgi Lingesh Ravishankar,

2010). A five-year cohort study showed that the prevalence of TDI of permanent teeth among children and adolescents in Sweden is 37.6% (Oldin et al., 2015), which is high compared to 11.7% reported by (Josefsson and Karlander, 1994) cross-sectional study. Even within the United Kingdom (UK) there is variation; for example, in Newham, London, the prevalence of TDI is 23.7% among 14-year-old schoolchildren (Marcenes and Murray, 2002), whereas a national cross-sectional study found the prevalence of TDI to permanent incisors was 9% among schoolchildren from England, Wales and Northern Ireland (Blokland et al., 2016). Such variation in these findings may be related to clear differences in sample size and places where these samples collected from, for example, in Blokland et al. (2016) 6707 participants collected from England, Wales and North Ireland while in Marcenes and Murray (2002) 411 child participated from one borough in London (Newham) as well as the nature of the study and the methodological approach used. Furthermore, the high prevalence in Newham, London was explained by the fact that it is a socially deprived area with high levels of unemployment, with accidents being the major cause of TDI(Marcenes and Murray, 2002) (Marcenes and Murray, 2001).

There is contradictory evidence on whether the prevalence of TDI is higher in primary or permanent dentition (Petti et al., 2018, Zaleckiene et al., 2014). In addition, the most common injury was an uncomplicated crown fracture for permanent dentition compared to luxation injuries to the primary dentition (Bastone et al., 2000). Any treatment procedure for the TDI, irrespective of the dentition type, aims to restore the tooth and aesthetics of the smile. However, for

young people, treatment can be complicated, costly and time consuming, especially when a tooth or teeth in the permanent dentition have been injured. The consequences of dental trauma can have a lifelong impact on quality of life (Zaleckiene et al., 2014).

1.2 Aetiology

Traumatic dental injuries occur as a result of direct or indirect impact with inanimate and animate objects to the dental region (Zaleckiene et al., 2014). Of all causes, sports-related TDI was the most common, being more prevalent than violence, bicycle accidents and biting on hard objects (Prabhu et al., 2013, Singh et al., 2015). Cross-sectional studies conducted in Finland and Japan showed that sports-related dental injury accounts for around 30% of all TDIs, followed by falls, collisions, traffic accidents, and fighting (Järvinen, 1980, Uji and Teramoto, 1988). These findings were somewhat different to those of a cross-sectional study conducted among 7-to-12-year-old children in India, which demonstrated that around 38% of TDIs were due to falls while playing, which was significantly higher compared to other causes such as falls while riding a bicycle and fighting (Sharma and Dua, 2012). However, a review of the literature showed that sports, violence and traffic accidents are the most common cause of TDI among schoolchildren (Glendor, 2009). Furthermore, a cross-sectional study conducted in Brazil among 12-year-olds showed that one of the main causes of dental injuries was sports activities (Marcenes et al., 2008), and a systematic review on the causes, prevalence and possible outcomes of TDI among 1-to-19-year-old children reported that about 40% of TDIs were due to sports activities (Zaleckiene et al., 2014). Other common

causes of TDI include falls (Feldens and Junior, 2016), collision (Sulieman and Awooda, 2018) and road accidents (Nagarajappa et al., 2020). See table below for more details of the aetiology of TDI:

Table 1: Aetiology of TDI

Study and Setting	Study design	Participant age range	Sample size	Causes of TDI
(Prabhu et al., 2013), India	Cross-sectional	10 – 16 years	446	**Sports (58%)**, Falls (13%), Collision (4%), Traffic accidents (2%), Fights (2%), Unknown (23%)
(Järvinen, 1980), Finland	Cross-sectional	5 – 16 years	321	**Sports (28%)**, falls (25%), Collision (9%), Traffic accidents (7%), Fights (6%), Others (18%), Unknown (7%)
(Uji & Teramoto, 1988), Japan	Cross-sectional	6 – 18 years	15822	Falls (38%), **Sports (29%)**, Fights (8%), Traffic accidents (2%)
(Singh et al., 2015), India	Cross-sectional	3 – 17 years	1112	Falls (39%), **Sports (23%)**, Bicycle accidents (13%), Biting on hard objects (8%), Violence (7%), Unknown (11%)
(Marcenes et al., 2000), Brazil	Cross-sectional	12 years	476	Falls (26%), Traffic accidents (21%), **Sports (19%)**, Violence (16 %), others (11%)
(Levin et al., 2003), Israel	Cross-sectional	18 – 19 years	943	**Sports-related dental injury (27%)**, Sustained soft tissue lacerations (18%), Sustained dental injuries (9%)
(Rambharos et al., 2014), India	Cross-sectional	12 – 14 years	2000	Falls (40%), **Sports (16%)**, Violence (14%), Biting on hard object (13%), Traffic accidents (10%), Collision (7%)

(Traebert et al., 2003), Brazil	Cross-sectional	11 – 13 years	2260	**Physical leisure activities (29%), Playing with others (18%)**, Collision (9%), Falls (8%), Eating (6%), Inappropriate usage of teeth (3%), Traffic accidents (2%), Violence (1%), Unknown (24%)
(Naidoo et al., 2009), South Africa	Cross-sectional	11 – 13 years	1665	Falls (43%), **Sports (13%)**, Collision (9%), Unknown (9%)
(Al-Jundi, 2002), Jordan	Retrospective study	15 months – 14 years	195	**Falls during paly (58%)**, Fall from high equipment (14%), Fall from bike (8%), Collision (8%), Fights (8%), **Sports (3%)**, Accidents (1%)
(Atabek et al., 2014), Turkey	Retrospective study	7 – 14 years	623	Falls (61%), Game accidents (16%), **Sports accidents (11%)**, Collision (9%), Others (3%)

1.3 Factors Related to Traumatic Dental Injury

Various studies have identified different variables that are associated with the occurrence of TDI, including age and gender of the child, overjet, socioeconomic status of the household, mothers' and fathers' education level, and ethnicity (references mentioned with each factor below) .

1.3.1 Age of the Child

Several cross-sectional studies conducted among children aged 6-17 years across the globe showed a correlation between the age of the child and the prevalence of dental injuries. As the age of the child increases, the prevalence of TDI also increases (Cortes et al., 2001, Noori and Al-Obaidi, 2009, Singh et al., 2015). Similarly, a cross-sectional study in India involving children aged 12 and 15 years old revealed that dental injury was higher in 15-year-olds than 12-year-old adolescents; however, age was not statistically significantly associated with dental injuries (Nagarajappa et al., 2020). This correlation could be related to the increase in the activity and mobility of the child with age, or due to the cumulative nature of dental injuries (Noori and Al-Obaidi, 2009).

Although the prevalence of TDI increases as children get older, this does not necessarily mean that older age groups are the most vulnerable to sustaining a dental injury (Cortes et al., 2001a). This is because untreated TDIs in younger children potentially leave the child exposed to further damage, and any further TDI incurred at an older age may complicate a pre-existing dental injury. Preventive measures, such as wearing mouthguards during sports activities, should also target younger age groups, because TDI has the potential to negatively impact a child's quality of life, especially those aspects related to their emotional and social wellbeing (El-Kalla et al., 2017).

1.3.2 Gender of the Child

Cross-sectional studies conducted among Japanese, South African and Indian schoolchildren demonstrated that sports-related dental injury was higher in boys than in girls and there was a significant association between a child's gender and

dental injuries (Govindarajan et al., 2012, Naidoo et al., 2009, Sharma and Dua, 2012, Tsuchiya et al., 2017). In contrast, an Indian cross-sectional study conducted among children aged 3 to 17 years old showed that dental injury rates were higher among boys, but that the gender of the child was not statistically significantly associated with TDI (Singh et al., 2015). However, a retrospective study by Garcia Godoy et al. (1982) reported contrasting findings from research in the Dominican Republic among 7-14-year-olds, in which rates of TDI were found to be higher among girls. This trend is most likely due to increased participation in sports activities among girls. The contrast in findings regarding the association between the gender of the child and TDI could be due to cultural and behavioural diversity among children. For example, in some cultural environments, girls are not allowed to participate in outdoor games, which may result in a lower rate of TDI among girls in those places (Kallel et al., 2015).

1.3.3 Overjet

"An overjet is characterised by the horizontal distance between the buccal surface of the mandibular central incisor and the incisal tips of the maxillary central incisor" (Baydaş et al., 2004, p. 351). Two Jordanian cross-sectional studies among 12-year-olds and 13-15-year-olds showed that children who have an overjet greater than 3 millimetres were more likely to suffer TDIs than children with an overjet less than 3 millimetres (Al-Bajjali and Rajab, 2014, Al-Khateeb et al., 2005). A more recent study has shown an increased risk of TDI due to overjet and inadequate lip sealing in both the primary and permanent dentition (Soares et al., 2018). Cross-sectional studies conducted in the Dominican Republic and India reported that, among

schoolchildren (6-14-year-olds), increased overjet was associated with TDI (Garcia Godoy et al., 1982, Garg et al., 2017). In contrast, a cross-sectional study conducted in Northern Ireland among children aged 11 to 12 years concluded that overjet was not associated with TDI (Burden, 1995). Such conflicting findings regarding the association between overjet and TDI may be related to differences in environmental and behavioural susceptibilities, as well as the methodological approach used between the studies (Feldens et al., 2010).

A systematic review of literature that included randomised control trials for comparing the early phase of treatment (two stages) versus late treatment (one stage) for Class 2 Division 1 overjets showed that the incidence of front teeth trauma was 30% in the late treatment group versus only 19% in the early treatment group. It is evident from this study that early treatment for overjet was important in reducing traumatic dental injuries (Veitz-Keenan and Liu, 2019).

1.3.4 Socioeconomic Status

Two Brazilian studies reported that children from low-income households had higher rates of dental injuries than children from high-income households (Jorge et al., 2009, Moysés et al., 2006). In contrast, a cross-sectional study conducted to assess the risk factors of TDI among 10–16-year-old Canadian and Indian schoolchildren indicated that there was no statistically significant relationship between the socioeconomic status (SES) of the participants and TDI. This could be due the majority of children participating in this study being from high socioeconomic groups (Fakhruddin et al., 2008a, Prabhu et al., 2013). However, another cross-sectional study conducted among 12-year-old children in Brazil

reported that those from a high socioeconomic background had more dental injuries than children from a low socioeconomic background (Marcenes and Murray, 2001). The high risk of developing TDI among children from a high socioeconomic background may be related to access to bicycles, water sports, horse riding, skateboarding and roller skating. Contrasting results from different countries may also be due to different indicators used for describing socioeconomic status and the variable access to dental care in each country.

1.3.4.1 Parents' Education Level

Cross-sectional studies conducted in Brazil and Poland among children aged 12 and 15, respectively, demonstrated that there was a higher risk of TDI among children of mothers with a lower educational level (Kaczmarek et al., 2019, Marcenes et al., 2001). In general, it is assumed that the higher an individual's educational level is, the stronger their earning potential and standard of living is, which could include having a safer living environment. Jorge et al. (2009) cite this as being a potential reason for such differences in TDI risk in children, noting also that mothers with higher levels of education were found to be more likely to take action to prevent accidents.

The relation between father's education level and TDI has been shown in three studies conducted in Israel and Brazil, which concluded that father's educational attainment was not significantly associated with TDI (Berti et al., 2015, Marcenes et al., 2001, Zadik, 1976). Whereas the studies discussed previously used income as an indicator of SES, father's education was used as the indicator in these three studies.

1.3.5 Ethnicity

A survey conducted in the United States showed that the prevalence of dental trauma was similar across different ethnic groups (Kaste et al., 1996). In contrast, a cross-sectional study also conducted in the United States reported that the prevalence of dental trauma was higher in African-American and Hispanic populations than in Caucasian populations, but there was no significant association between ethnic groups and dental trauma (Alonge et al., 2001). A Brazilian study among pre-school children showed that the race/ethnicity of the child does not have a positive relation with TDI (Feldens et al., 2010).

1.4 Effect of Traumatic Dental Injury on Quality of Life

Several studies on TDI have shown a negative impact on the quality of life of children. A cross-sectional study conducted among Egyptian schoolchildren aged 11 to 14 years old showed that TDI has a negative impact on oral health quality of life in terms of pain and the functional, emotional and social aspects of children's lives (El-Kalla et al., 2017). A Brazilian study showed a statistically significant and independent association between TDI and the quality of life of children aged 11 to 14 years old (Traebert et al., 2012). A case-control study conducted among public schoolchildren and adolescents in Rio de Janeiro, Brazil, showed that TDI has a negative impact on their emotional and functional status (Antunes et al., 2013).

Some studies have reported that a fracture to a single tooth has an impact on children's quality of life and functional activities. A study conducted among 12-14-year-old Brazilian schoolchildren found that children with a fractured tooth are

more likely to report an impact on daily living, such as “eating and enjoying food” and “smiling, laughing, showing teeth without embarrassment” than do children who do not have TDI (De Souza Cortes et al., 2002). A study comparing adolescents who were treated for enamel-dentine fracture and those who do not have a history of trauma found that, in about 40% of cases, patients with TDI were impaired in at least one of their daily activities. Among this group, the activities reported by the adolescent group to have been most severely impacted were showing teeth while smiling, eating, and speaking in public. However, only 17% of the control sample, who had no history of trauma, reported experiencing some restrictions on their daily activities (Ramos-Jorge et al., 2007).

Untreated TDIs have been found to lead to increased negative consequences compared to children who have had treatment for their injured tooth/teeth, as well as children who have not experienced any TDI. A Canadian school-based case-control study among children aged 12 to 14 years old showed that those with untreated TDI were three times more likely to report chewing difficulties and to avoid smiling or laughing than children without any dental injuries. In addition to functional impacts, children with TDI were four times more likely to report “not wanting to talk with other children” than children without any dental injuries. This study highlights that untreated TDIs can lead to children having poor social interaction (Fakhruddin et al., 2008b). Similarly, a study conducted with Egyptian schoolchildren showed that untreated dental injuries have a negative impact on quality of life, whereas children who received treatment for dental injuries show improvement in social and emotional aspects of oral health-related quality of life,

but not in functional aspects of quality of life (El-Kalla et al., 2017). Berger et al. (2009) conducted a study to investigate perceptions of quality of life and pain following dental trauma in children using the Child Oral Health Quality of Life survey. They found that TDIs were given scores which were very similar to those of children suffering from cleft lip and palate.

A study conducted in a dental hospital in the UK on the quality of life of children after TDIs showed that children report a high impact on functional aspects of oral health-related quality of life, such as getting food stuck between the teeth and difficulty in chewing (Porritt et al., 2011). Interestingly, girls with TDI were more likely to report a negative impact on their quality of life than boys with TDI, possibly because girls are more likely to report health-related outcomes or emotional problems than their male counterparts (Peres et al., 2008, Porritt et al., 2011).

1.5 Healthcare Economics

Studies conducted across Europe have shown that the costs of treating dental trauma have increased over the years. A prospective study over two years conducted in Sweden found that the healthcare service costs associated with TDI of the primary and permanent dentition were £73 and £256 respectively. In addition, the indirect costs of TDI of primary and permanent dentition were £61 and £112 respectively that accounted for the loss of production, for instance, the companions time lost from other productive activities such as work (Glendor et al., 2001). Traumatic dental injuries in Denmark cost between US $2 and $5 million per million people every year to treat (acute trauma service, follow-up, and later restoration) (Borum and Andreasen, 2001). In the UK, the total cost (both direct and indirect

costs) of treating one permanent incisor following a TDI was £856, of which the indirect costs (working days lost by caretakers) accounted for 39%, a significant amount (Wong and Kolokotsa, 2004). The mean total cost of permanent dentition injuries with pulp tissue exposure and/or dislocation was €1687.90, and the cost of injuries without pulp tissue exposure and/or dislocation was €1350.80, according to a prospective study conducted over the course of a year at Dublin Dental University Hospital (Bani-Hani et al., 2020).

Several studies have shown that the number of visits for treatment and follow-up plays an important role in determining the cost of the treatment. A study conducted in Sweden showed that the mean number of visits for every TDI of primary and permanent dentition was 2.2 and 3.4, respectively. It was also found that 79% of those having a TDI of primary dentition had to return for a follow-up visit, as compared to 90% of those having a TDI of permanent dentition, further increasing the cost and impact on the child and family (Borssén et al., 2002). A prospective study conducted in Dublin found that travelling longer distances (more than 50 kilometers) to hospital increased the cost of treatment of TDI (Bani-Hani et al., 2020), while a study conducted in the Leeds Dental Institute found that, for every injured tooth, the median number visits was five including two treatment visits and three review visits, respectively (Keasberry et al., 2013).

Several studies in the literature have shown that early dental attendance has reduced the dental-related costs by increasing the use of preventative services which help in preventing/reducing the effect of dental injury (Lee et al., 2006, Savage et al., 2004). These preventative services include age-appropriate oral

health education, risk assessment and screening of both children and their parents (Savage et al., 2004). It also includes specific anticipatory guidance, such as the role of fluoride in the prevention of caries and the role of wearing a mouthguard in the prevention of dental trauma (Savage et al., 2004). This is a very important step to reduce the costs associated with TDIs.

1.6 Prevention of Traumatic Dental Injuries in Sports

According to the Fédération Dentaire International (FDI), sports are divided into two categories with regard to TDIs: high risk and medium risk (Merglova, 2018). High-risk sports include field hockey, ice hockey, American football, lacrosse, rugby, inline skating, mountain bike riding, martial arts and skateboarding. Medium-risk sports include squash, soccer, handball, basketball, water polo, parachuting and gymnastics (Merglova, 2018). Moreover, injuries from contact sports can be prevented by identifying modifiable risk factors (Stracciolini et al., 2017).

Various injury prevention measures have been undertaken in a variety of contact sports. For example, the morbidity rate in American football has declined by 74% since 1976 following the implementation of the National Operating Committee on Standards for Athletic Equipment (NOCSAE) on helmet standards. In addition, a decline in complicated head injuries was observed from 4.25 to 0.68/100000 population (Levy et al., 2004). Furthermore, the incidence of concussion due to the use of helmets decreased by 15% between 1983 and 1999 among high school football players (Levy et al., 2004).

A prospective study in the United States found that the use of face protection, such as a full cage or shield, reduced the risk of head, facial and neck injuries. It was reported that, among junior ice hockey players, those with no facial protection had twice the rate of injury relative to players with partial protection, and seven times the rate of injury experienced by players with full face protection (Stuart et al., 2002). Concussion rates were also reduced among players with full face protection compared to players with partial or no face protection (Stuart et al., 2002). Although these studies did not report on TDIs, it is reasonable to assume that, as the injuries were to the head, dental injuries are also likely to have declined as a result of wearing head protection, especially when face protection was involved.

1.7 Mouthguards

1.7.1 Effectiveness in Preventing Dental Trauma

Mouthguards are elastic devices to be worn by athletes to protect the oral structures from traumatic injuries (Broad, 2011). Mouthguards are of three different types: stock, mouth-formed, and custom-made (Patrick et al., 2005). The stock ready-made mouthguards are the least effective type as they offer minimum protection, come in a limited range of sizes, are not adapted to the user's mouth; and they may even be dangerous through causing breathing difficulties (Patrick et al., 2005, Parker et al., 2017). Mouth-formed ("boil and bite") mouthguards are softened by placing them in hot water and can be adapted to the user's mouth manually using the tongue and fingers (Patrick et al., 2005). Custom-made mouthguards are made from an impression of the client's upper teeth and are the

most effective as they offer the best fit, efficacy and adaptability. They are also the most available expensive type, and require at least one dental visit (Patrick et al., 2005; Parker et al., 2017).

Studies across multiple countries have shown that mouthguards play an important role in the prevention of TDIs during sports by various mechanisms. A review of the literature showed that mouthguards have the ability to reduce the number of fractured teeth on impact, increase the force required to fracture teeth, reduce the forces transmitted to the teeth, decrease head acceleration and thus help in the prevention of TDIs (Knapik et al., 2007).

Nevertheless, a meta-analysis found that the risk of orofacial injury increased by 1.6 –1.9 times in players who did not use a mouthguard of any type as compared to those who did (Knapik et al., 2007). A meta-analysis of athletes of contact sports found the prevalence of dental trauma among mouthguard users to be 7.5% to 7.75% as compared to 48.31% to 59.48% in non-users (Fernandes et al., 2019). This meta-analysis also found a significant association between mouthguard use and prevention of dental trauma ($p<0.001$) and thus strongly recommended its use in sports activities (Fernandes et al., 2019).

In addition, some studies have found that mouthguards are likely to prevent concussion in three main ways. Firstly, they absorb the impact forces to the mandible and prevent them from being transmitted to the base of the skull and brain (Takeda et al., 2005). Secondly, they increase skull stabilisation by decreased acceleration of the head and increased neck muscle activity due to a clenched position (Takeda et al., 2005). Thirdly, they create an alert mandibular position

which prevents temporomandibular joint dislocation (Takeda et al., 2005, Winters Sr, 2001). However, several prospective cohort studies have shown that mouthguards do not significantly lessen the risk of concussion (Labella et al., 2002, Marshall et al., 2005), and reviews have shown inconsistent results related to the effectiveness of mouthguards in preventing concussion; hence, no definite conclusion can be drawn based on the existing literature regarding whether or not mouthguards are effective in mitigating the likelihood of concussion (Knapik et al., 2007, Mascarenhas, 2012).

1.7.2 Children's Acceptance of and Compliance with Mouthguards

Several factors influence the acceptability of and compliance with mouthguard use among children during sports at various socio-ecological levels (individual, interpersonal, organisational, community, and public policy). In several studies across countries, the literature shows that children are happier and more enthusiastic about using custom-made and mouth-formed mouthguards than the ready-made type, thus showing that type of mouthguard is an important factor for acceptability (Chakravarthy, 2006, Walker et al., 2002). Various other factors have also been found to affect the acceptability of wearing mouthguards among children, including the belief that one is not required during a particular sporting activity, difficulty in breathing and talking, discomfort, and appearance (Sethi et al., 2016, Fakhruddin et al., 2007b). Furthermore, it seems that stakeholder's attitudes affect the acceptability of using mouthguards. For example, one reason children gave for not wearing a mouthguard during sports activities was that their parents and coaches had never talked about doing so (Collins et al., 2015, Gardiner and Ranalli,

2000). The results of a questionnaire administered to parents in a study conducted in Ireland also showed that mouthguard policy in schools, cost, and knowledge of mouthguards determined whether or not their children used one (O'Malley et al., 2012b).

An Israeli study that examined compliance after mouthguards were issued at no cost showed that only 23.2% of study participants used mouthguards whenever necessary and nearly 45% of participants did not use it at all, as they forgot that the mouthguard was available. This poor rate of compliance could be due to the lack of reinforcement about the importance of wearing the mouthguard during the study (Matalon et al., 2008). Perceptions about the effectiveness of mouthguard use and comfort while playing were found to have an important role in compliance among Australian junior rugby players in a cross-sectional survey (Kroon et al., 2016).

As outlined above, acceptability and compliance are interlinked and, thus, the above factors related to acceptability should be addressed to ensure compliance (Kroon et al., 2016).

1.8 Voice of the Child

Before 1990, children were involved in research but they were given less time and seen as a developmentally immature adults (James et al., 1998). Social scientists have embraced this shift and switched into research methodology that sees the children as '' active participants'' from the methodology that sees the children as an object of concern'' (Christensen and James, 2017). The children act of 2004 in England law consider not only the best interest of children, but also their

preferences and aspirations (Zelizer, 2000). The national service framework for children, young people and maternity services stated that children and their parents must given more access to information, control of their care and more choices regard how they are treated. Also stated that, they must also be included in the planning of their care including dental care (Health, 2004).

A systematic review of dental literature from 2000 to 2005 which identified dental research conducted on children found that children were active participants in only 0.3% of the research and children were involved to some extent in only 7% of the research papers identified (Marshman et al., 2007). In addition, another systematic review of dental literature from 2006 to 2014 found that only 17.4% involved the child's opinion in the study. From these reports, it is evident that the focus of research has increasingly been on the perspective of children, yet, despite this, children's direct participation in such research remains low (Marshman et al., 2015).

However, several studies that assess children's willingness to use a mouthguard did involve child participants (Collins et al., 2015, Walker et al., 2002). This approach is important as it allows barriers to and facilitators of mouthguard use to be identified from the perspective of the children.

1.9 Potential Frameworks for Categorizing Barriers and Facilitators

Frameworks are a broad organizing structure that are used to describe information and the relationships between concepts (Moullin et al., 2020). Theoretical frameworks provide a foundation from which generalisable knowledge can be derived for intervention strategies (Moullin et al., 2020). There are many potential

frameworks available for categorising facilitators and barriers include the Fisher-Owens model (2007) and the Theoretical Domains Framework (TDF) (Atkins et al., 2017, Riggs et al., 2015). A qualitative study by Riggs et al. (2015) sought to identify the sociocultural influences of children's oral health using the Fisher-Owens model. This model looks at the influence of oral health at three levels – child, family and community – over time, along with the wider environment (Riggs et al., 2015). The TDF, in contrast, is an integrated theoretical framework of the key determinants of behaviour synthesized from 33 theories of behaviour change into 14 domains (Atkins et al., 2017). The TDF was developed by health psychologists, health psychology theorists and implementation researchers for the use in implementation research, and is designed to identify four types of influences on behaviour – cognitive, affective, social and environmental – to inform specific evidence-based recommendations (Atkins et al., 2017). Furthermore, in order to be relevant to other areas such as changing patient behaviour when behaviour changing is crucial, TDF was extended. For instance, physical activity increasing in minors with motor impairments (Kolehmainen et al., 2011).

Understanding the influences on behaviour helps guide identification of appropriate behaviour change techniques and thus designing broader intervention strategies (Atkins et al., 2017). Furthermore, the target population needs to include not just the target adopters of the desired behaviours, which in this study are children, but also other relevant stakeholders, which in this study are parents, coaches, and school authorities (Atkins et al., 2017). The organisational levels at which change is proposed could be several, e.g., individual, team, organisation or

population levels (Atkins et al., 2017). In order to be effective, the sociological model takes into account the individual as well as their ties to other people, organizations, and their community at large. This approach has five stages: the personal, interpersonal, organizational, community, and public policy stages. An individual's knowledge and skills are addressed at the individual level. The interpersonal level concerns a person's relationships with others, such as those with family and friends. The organizational level has the opportunity to reach more people in different sectors of the community. In this paradigm, a community is the confluence of many organizations in a given area. The governing bodies are in charge of the prevention effort at the final level - Public Policy.

In this study TDF was used to categorise the barriers to and facilitators of wearing a mouthguard at the five sociological levels. This was done in order to gain a better understanding of the barriers and facilitators at the different sociological levels.

1.10 Aim

To identify the barriers to and facilitators of wearing a sports mouthguard among children.

1.11 Objectives

- Determine the barriers to children wearing a sports mouthguard during sports activities using the Theoretical Domains Framework.
- Determine the facilitators of children wearing a sports mouthguard during sports activities using the Theoretical Domains Framework.
- Categorise the socio-ecological level barriers to and facilitators of wearing a sports mouthguard during sports activities among children.

Chapter 2

Methodology

At the start, the research protocol of this systematic review was registered and published on PROSPERO, Centre for Reviews and Dissemination (CRD) at the University of York, UK (Registration details: CRD42020186953, 23 September 2020).

2.1 Inclusion Criteria for Considering Studies for This Review

In formulating the research question, the PICOS (population, intervention, comparison, and outcome) methodology was applied as follows:

2.1.1 Types of Studies

Only published primary research articles were included. Studies including systematic reviews were excluded, as the outcomes/results of the systematic reviews are secondary results with the original results reported in the original study. All study settings were considered, and sampling methods could include randomised, convenience, stratified, and cluster samples. For studies involving responses to a questionnaire, a minimum response rate of 60% was required (Fincham, 2008, Petti et al., 2018). Studies had to be published before May 2020

2.1.2 Types of Participants

Children and adolescents aged up to 19 years old (including children/adolescents with specific medical or behavioural difficulties) who participated in any sport were eligible to be included in the study.

2.1.3 Type of Outcome Measures

Barriers to and facilitators of wearing sports mouthguards among children during sports activities.

2.1.4 Type of Interventions

All studies that examined the use of mouthguards by children during sports activities were considered, whether the activity was for practice or in competitive matches.

2.1.5 Search Methods for Identification of Studies

An initial broad electronic database search was conducted in June 2020 to identify studies, with precise search strategies devised for each database. The following electronic databases were searched:

- Ovid MEDLINE (R) (1946 to May 2022)
- Epub Ahead of print, In-Process & other Non-Indexed Citations and Daily (in May 2022).
- Embase (1996 to May 2022)
- Embase Classic (1947 to May 2022)
- Web of Science (in May 2022)
- Scopus (in May 2022)

Only articles published in English were included. Searches were conducted using the search method created for Ovid MEDLINE (R). The medical subject headings (MeSH) / keywords and the search strategy were employed using a combination of controlled vocabulary and free text terms for identifying studies in Ovid MEDLINE (R). The search strategy was formulated in consultation with the supervision of a specialist librarian from Leeds University Library. This search strategy was revised and adapted for each database. Details of the search strategy are described in Appendix 1. References management and deduplication were carried out using EndNote (X 9.0 Thomson Reuters). At the end of the review (1 May 2022), the electronic search was repeated.

2.2 Data Collection and Analysis

2.2.1 Selection of Studies

The electronic database search was conducted by one reviewer, Mohammad Alqarni (MQ), while a minimum of two reviewers independently performed study selection, data extraction, and quality assessment. The titles and abstracts of the selected papers were separately examined by three reviewers (MQ, KG-B[1] and KK[2]). For those studies that matched the inclusion criteria, full texts were retrieved and independently reviewed by three reviewers (MQ, KG-B and SB[3]), and quality assessments were undertaken by two researchers (MQ and SB). Any disagreements

[1] **Kara Gray-Burrows,** Faculty of Medicine and Health, School of Dentistry, University of Leeds, Leeds, UK.
[2] **Kate Kenny,** Faculty of Medicine and Health, School of Dentistry, University of Leeds, Leeds, UK.
[3] **Sarah Barrow,** Leeds Dental Institute (LDI), Leeds, UK.

at any stage were settled through discussion and consensus between the above-mentioned reviewers; and if at any point consensus could not be reached, a fourth reviewer's (PD)[4] opinion was sought.

All studies that met the inclusion criteria were included regardless of their quality. For several articles, it was noted that some of the relevant data was missing or inconsistent, and the authors of these articles were contacted via email for clarification. Each of these authors were contacted three times.

2.2.2 Data Extraction, Management and Coding

A data extraction form (Appendix 2) was used as a framework to capture all relevant information about the study characteristics and outcomes of the included studies. The form was based on the Centre for Reviews and Dissemination (CRD) guidelines for conducting reviews in health care (CRD, 2009). The form was piloted by two researchers (MQ, KG-B) independently on five of the included studies. Data extraction was carried out independently by three reviewers (MQ, KG-B and SB).

The first part of the data extraction sheet included information about the study, such as author's name, date/year of publication, article title, type of publication, country of origin, and any additional notes. Next, information about the aim/objectives of the study, study design, inclusion and exclusion criteria, and recruitment procedures used was recorded on the data extraction form. The number of participants involved in the study and participant characteristics also

[4] **Peter Day,** Faculty of Medicine and Health, School of Dentistry, University of Leeds, Leeds, UK.

were noted, including age, gender, type of sport played, history of TDI, and history of sports-related mouthguard use.

In the next part of the form, the intervention characteristics, setting in which the intervention was delivered, type of mouthguards, and duration of intervention were recorded. Finally, the outcome data/results were noted, including barriers to and facilitators of wearing mouthguards, the statistical techniques used, and any subgroup analysis.

In the same data extraction sheet, by the same three reviewers, the emerged barriers to and facilitators of wearing mouthguards were matched to the 14 TDF domains (Atkins et al., 2017). Each of these domains was further sub-divided into five sociological influences categories: individual, interpersonal, organisational, community, and public policy. After data coding independently, the three coders came together to determine a level of agreement on how this data fits with the TDF domains. When discrepancies arise, for example, coding the same barrier or facilitator to different domains, reviewers aim to reach consensus providing a justification weather assigning barriers and facilitators or not to a specific domain. In case of failing to reach a consensus, a fourth researcher (PD) was consulted (Debono et al., 2017).

At the same time, the same three reviewers, had further categorized the barriers and facilitators into the sociological model using the same coding strategy for TDF. The consensus between researchers regarding linking the data to the appropriate sociological level should be achieved. The same fourth researcher was consulted in case of failure to reach a consensus.

2.3 Quality Assessment of Included Studies

To evaluate the external validity and risk of bias in the selected studies, Newcastle-Ottawa Scale (NOS) checklists for cross-sectional and cohort studies were used (Appendices 3 and 4).

The NOS is a tool used for assessing the quality of non-randomised studies. The University of Newcastle in Australia and the University of Ottawa in Canada worked together to develop the NOS tool. In order to specify the variables that would be used for data extraction, they used Delphi process. The cross-sectional studies were assessed based on the NOS designed for cross-sectional studies, while the quality of cohort studies was analysed using the NOS specified for cohort studies. Using this tool, each study was evaluated on a total of three items: selection, comparability, and outcome. These three items were further categorised into seven sub-items for cross-sectional studies, eight sub-items for cohort studies. Stars were awarded for each quality item achieved and served as a quick visual assessment. High-quality cohort and cross-sectional studies could be awarded up to nine or ten stars, respectively. Grading of the quality of the articles will be according to the final scores as the following, good (Score ≥7) fair (4-6) poor (Score ≤3).

Chapter 3

Results

3.1 Search Results

A total of 1470 research articles were identified from the database search. Following removal of duplicates, 447 studies were subjected to further screening; of these, 375 were excluded after screening the titles and abstracts. The remaining 72 studies were then subjected to full-text screening. Overall, 36 studies were excluded, leaving 36 studies to be included in this review (Figure 3-1). The reason for the exclusion of 36 articles after full-text screening is presented in Table 2.

In addition, for transparency and accuracy, the detailed PRISMA checklist is provided in Appendix 6.

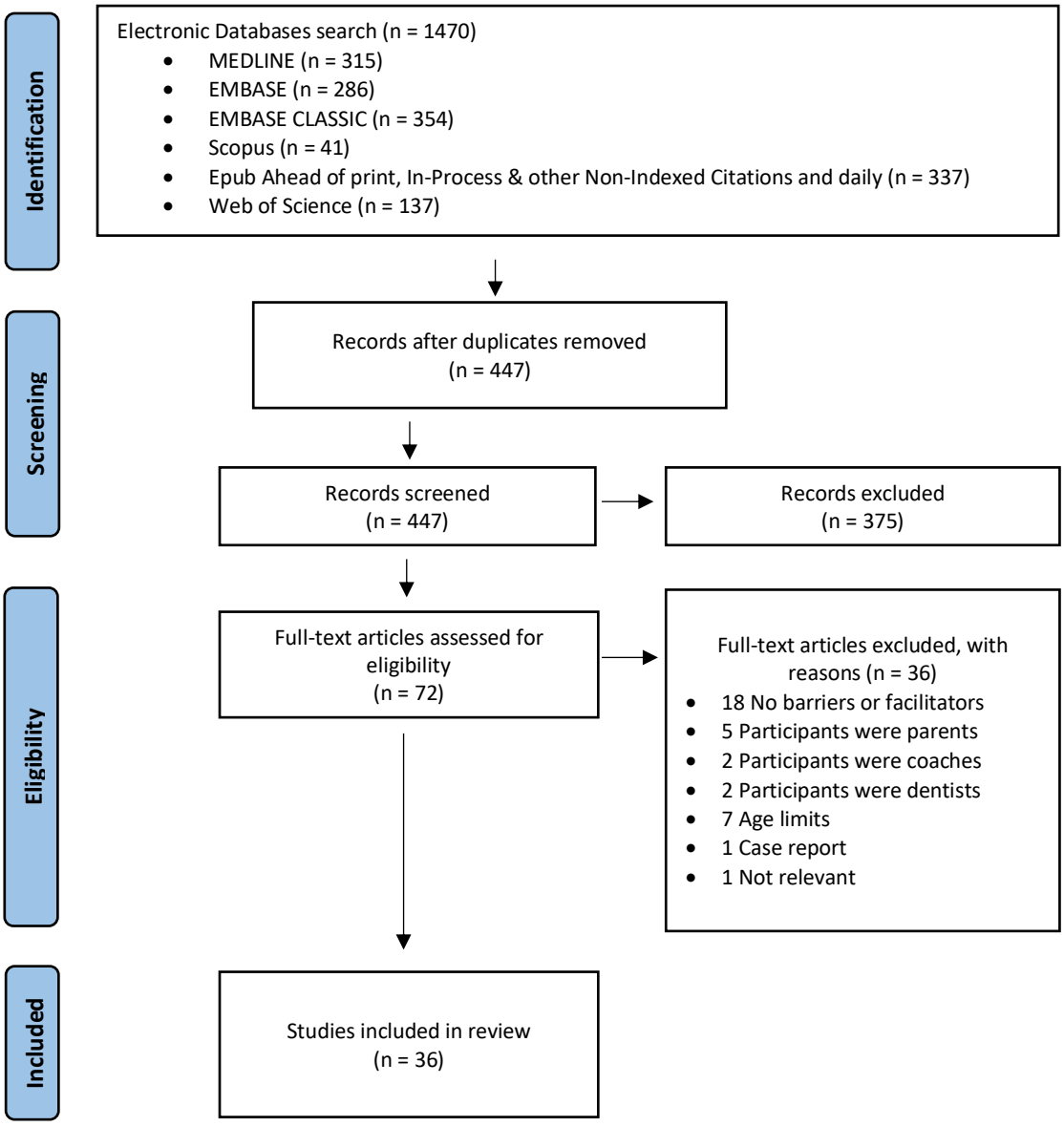

Figure 3-1: PRISMA Flowchart Summarising the Systematic Review Process.

Table 2: List of studies excluded following full-article assessment, showing reasons for exclusion.

Study Authors	**Reason for Exclusion**
(Seals Jr et al., 1985, Singh et al., 2014, Lahti et al., 2002, Spinas et al., 2018, Schildknecht et al., 2012, Caglar et al., 2005, Cetin et al., 2009, Garon et al., 1986, Banky and McCrory, 1999, Chisholm et al., 2020, Lesic et al., 2011, Farhadian et al., 2020, Vidovic et al., 2015, Finch et al., 2005, Brown et al., 2015, Cetinbas et al., 2008, Sgan-Cohen et al., 2005, Johnson, 2015)	Does not report any barriers to or facilitators of the usage of mouthguard among children.
(Chatterjee and Hilton, 2007b, O'Malley et al., 2012a, Pribble et al., 2004b, Nowjack-Raymer and Gift, 1996a, Mojarad et al., 2020a)	Focus is on the perspective of parents
(Berg et al., 1998a, McNutt et al., 1989a)	Focus is on the perspective of coaches
(Bialy et al., 2014, Soporowski et al., 1994)	Focus is on the perspective of dentists
(Liew et al., 2014, Zamora-Olave et al., 2018, Tiwari et al., 2014, Gass et al., 2016, Jalleh et al., 2001, Onyeaso and Adegbesan, 2003, Cetinbas and Sonmez, 2006)	Outside age limits.
(Croll and Castaldi, 2004)	Case report.
(Sgan-Cohen et al., 2005)	Not relevant.

3.2 Study Characteristics

A detailed description of the characteristics of all included studies is shown in Table 3. All the selected studies were written in the English language (100%), and around 66.6% were published after 2000. The studies involved participants from 17 different countries. The majority of studies included participants from the USA (n=9, 25%), followed by India (n=5, 13.8%). Thirty studies (83.3%) used a cross-sectional study design, while the remaining six studies (16.6%) used a cohort study design.

Table 3: Characteristics of the included studies (n=34).

Characteristics	**N (%)**
Language	
English	36 (100)
Year of Publication	
Before 2000	12 (33.3)
2000-2005	3 (8.3)
2006-2010	6 (16.6)
2011-2015	7 (19.4)
2016-2020	6 (16.6)
2021-2022	2 (5.5)
Location	
USA	9 (25)
India	5 (13.8)
Poland	1 (2.7)
Turkey	2 (5.5)
New Zealand	2 (5.5)
Israel	1 (2.7)
Switzerland	2 (5.5)
Japan	2 (5.5)
UK	2 (5.5)
South Africa	1 (2.7)
Australia	2 (5.5)
Italy	2 (5.5)
Canada	1 (2.7)
Croatia	1 (2.7)
Nigeria	1 (2.7)
Spain	1 (2.7)
Saudi Arabia	1 (2.7)
Study Design	
Cross-sectional	30 (83.3)
Cohort	6 (16.6)
Type of Sport*	
Collision or contact sports	25 (69.4)
Limited contact sports	5 (13.8)
Non-contact sports	2 (5.5)
Others/Not mentioned	10 (27.7)
History of Dentoalveolar Sports Trauma	
Yes	19 (52.7)
Not mentioned	17 (47.2)
History of Mouthguard Usage	
Yes	21 (58.3)
Not mentioned	15 (41.6)
Type of Mouthguard Used**	

Boil-and-bite	12 (35.2)
Custom-made	22 (64.68)
Stock type	10 (29.4)
Not mentioned	11 (32.34)
Type of Participant	
School	19 (52.7)
Club/ professional	9 (5)
Others	8 (22.2)
More than one type of sport was reported in some studies.* * More than one type of mouthguard was used in some studies.*	

3.3 Participants/Sample

As shown in Table 3, most studies were undertaken with schoolchildren (n=19, 52.7%). The remaining studies involved participants from clubs/professional organisations (n=9, 25%) or other types of participant, for example, youngsters and youths (n=8, 22.2%).

The sample size ranged from 22 to 2670 participants, with eight studies having a sample size of more than 1000 children. In the 17 studies in which further details about the gender of the sample were provided, there were more male participants than female participants. In two studies (Persic et al., 2006; Bhadana et al., 2015), the sample included both the children and their coaches. (Persic et al., 2006) was the only study to recruit participants from three countries. Further details of participants' characteristics are described in Table 4.

Table 4: Characteristics of the participants in the included studies.

Study	**Participant Type** *(as reported in studies)*	**Sample Size**	**Age**	**Sample Details**
(Rosenberg, 1963)	Schoolchildren	406	Not mentioned	
(Sethi et al., 2016)	Schoolchildren	2,000	8-11 years	Male: 1147 Female: 853
(Emerich and Nadolska-Gazda, 2013)	Amateur boxers	338	Schoolboys and adepts (13–14 years) Juniors (15–16 years)	Male: 338 Schoolboys: 38 Adepts: 11 Juniors :106 Youths: 66 Seniors: 117
(Ramagoni et al., 2007)	Schoolchildren	719	11-14 years	Boys: 67.6% Girls: 32.4%
(Nachman et al., 1965)	High School players	1200	Not mentioned	
(Ozbay et al., 2013)	Handball players	212	6-14 years	Boys: 138 Girls: 74
(Goswami et al., 2017)	Children attending a sports camp	450	6-16 years	
(Eroglu et al., 2006)	Members of the Turkish national youth team	22	15-17 years	Boys: 11 Girls: 11
(Morton and Burton, 1979)	High school players	272	Not mentioned	
(Matalon et al., 2008)	Youngsters	69	9-17 years	Boys: 42 Girls: 27
(DeYoung et al., 1994)	High School athletes	40	Not Mentioned	Male: 20 Female: 20
(Persic et al., 2006)	Participants from three countries (Switzerland, Germany and France)	653	10-75 years	Squash players: 600 Coaches: 53
(Perunski et al., 2005a)	Swiss team players	302	100 young players up to 18 years of age	
(Miller et al., 2016)	Middle and high school athletes	503	14-18 years	
(Bhadana et al., 2015)	Athletes and coaches from various sports	413	Average age of athlete	Athletes: 335 Coaches: 78

	complexes and schools		population: 15.75 years	
(Dhindsa et al., 2019)	High school children	1105	8-16 years	
(Godwin et al., 1982)	Junior football players	280	9-12 years	
(Yamada et al., 1998)	High school children	2670	16-17 years	
(Bastian et al., 2020)	Schoolchildren	75	11-18 years	Football: Male: 22 Basketball: Male: 27 Female: 26
(Upson, 1982)	Club players	100	12-18 years	
(Brebner and Marshall, 1977)	Secondary school players	290	Not mentioned	
(de Wet et al., 1981)	Primary school players	150	10-13 years	
(Maestrello-deMoya and Primosch, 1989)	High school varsity players	1020	Not mentioned	
(Raaii et al., 2011)	Players of hockey association	180	9-12 years	Boys: 178 Girls: 2
(Chapman and Nasser, 1996)	High school	130	Under 13 to under 16 years	
(Tanaka et al., 2015)	Rugby team players	500	Mean ages of Groups 1 (17.0 ± 0.7 years)	
(Spinas and Savasta, 2007)	Sporting club participants	300	8-11 years	Male:200 Female:100
(Spinas et al., 2014)	Adolescent from sports group	60	12-15 years	
(Fakhruddin et al., 2007a)	Schoolchildren	270	12-14 years	Boys: 152 Girls: 118
(Cornwell et al., 2003)	Youths and adults	496	12-15 years (youths)	
(Rodd and Chesham, 1997)	Schoolchildren	557	14-15 years	

(Galic et al., 2018)	Young athletes	229	5-19 Years	
(Collins et al., 2015)	School players	1636	5-19 years	Male: 55.9%, Female: 43.8% Unknown: 0.3%
(Onyeaso, 2004)	Secondary school athletes	1127	12-19 years	Male: 683 Female: 444
Guinot and Manrique (2021)	Federated sports clubs	207	6-18 years	Male: 106 Female: 101
Alomer et al. (2022)	Schoolchildren	1116	8-16 years	Male: 628 Female: 488

3.4 Type of Sport and History of Sports-related Dentoalveolar Trauma

As shown in Tables 3 and 4, in 72.7% (n=26) of the included studies, the specific type of sports was mentioned, while in the rest the type of sport either was not mentioned or was reported under a general category (e.g., indoor, outdoor, competitive, contact or non-contact). The type of sport was categorized broadly into four groups as set out by the American Dental Association (ADA). The category of sports mentioned most frequently was contact/collision sports, reported in 69.4% of the included studies. In 19 of the studies, the details of any dentoalveolar injury were collected from participants, while in the rest, there was no history of trauma or history of trauma was not reported. Further details of the type of sport and sport-related dentoalveolar trauma mentioned in the included studies are provided in Table 5.

Table 5: Type of sport and history of sports-related dental trauma in the included studies.

Study	History of Dental Trauma	Type of Sport*			
		Contact/Collision Sports (25)	Limited-contact Sports (05)	Non-contact Sports (02)	Others (04)
(Rosenberg, 1963)	NA	American football			
(Sethi et al., 2016)	NA				Competitive sports
(Emerich and Nadolska-Gazda, 2013)	YES	Boxing			
(Ramagoni et al., 2007)	NA	Boxing Football Martial arts Judo Hockey Basketball	Cricket Volleyball Skating	Cycling Swimming Athletics	
(Nachman et al., 1965)	YES	American football			
(Ozbay et al., 2013)	YES	Handball			
(Goswami et al., 2017)	YES	Football Basketball Judo	Volleyball Gymnastic Squash	Tennis Table tennis Swimming	
(Eroglu et al., 2006)	NA	Taekwondo			
(Morton and Burton, 1979)	YES	Rugby			
(Matalon et al., 2008)	YES				
(DeYoung et al., 1994)	YES	Lacrosse			
(Persic et al., 2006)	YES		Squash		
(Perunski et al., 2005a)	YES	Basketball			

(Miller et al., 2016)	YES	Basketball Field hockey Football Lacrosse Soccer Wrestling	Baseball Softball Volleyball		
(Bhadana et al., 2015)	Yes				Outdoor games Indoor games
(Dhindsa et al., 2019)	NA				Outdoor games
(Godwin et al., 1982)	NA				
(Yamada et al., 1998)	YES	Soccer Rugby			
(Bastian et al., 2020)	NA	Basketball Football			
(Upson, 1982)	YES	Rugby			
(Brebner and Marshall, 1977)	YES	Rugby			
(de Wet et al., 1981)	NA				
(Maestrello-deMoya and Primosch, 1989)	NA	Basketball			
(Raaii et al., 2011)	YES	Hockey			
(Chapman and Nasser, 1996)	NA	Rugby			
(Tanaka et al., 2015)	NA	Rugby			
(Spinas and Savasta, 2007)	YES	Basketball			
(Spinas et al., 2014)	NA	Basketball			
(Fakhruddin et al., 2007a)	NA				

(Cornwell et al., 2003)	NA	Basketball			
(Rodd and Chesham, 1997)	YES				
(Galic et al., 2018)	YES	Water polo Karate Taekwondo Handball			
(Collins et al., 2015)	NA	Basketball	Baseball Softball		
(Onyeaso, 2004)	NA				Contact and non-contact sports
Guinot and Manrique (2021)	Yes	Hockey Rugby Football Basketball Karate or other martial arts Rollerblading			
Alomer et al. (2002)	NA				
*** Category of sport according to ADA.**					

3.5 Mouthguards

As shown in Table 3, details of mouthguard usage were collected in 58.3% (n=21) of the studies. Custom-made mouthguards were the most frequently used type (64.6%), followed by boil-and-bite (35.2%) and stock type (29.4%).

Details of the types of mouthguard mentioned in the included studies are presented in Table 6. As shown in Figure 3-2, the terms used to describe the type of mouthguard differed in six of the included studies.

Table 6: Types of mouthguard mentioned in the included studies.

Study	**History of Mouthguard Usage**	**Type of Mouthguard Used** *(as reported in each study)*
(Rosenberg, 1963)	NO	Latex custom-fitted mouth protector Vinyl custom-fitted mouth protector
(Sethi et al., 2016)	YES	Boil-and-bite mouthguards Custom-made mouthguards
(Emerich and Nadolska-Gazda, 2013)	YES	Custom-made mouthguards Boil-and-bite type mouthguard
(Ramagoni et al., 2007)	NO	NA
(Nachman et al., 1965)	YES	NA
(Ozbay et al., 2013)	NO	NA
(Goswami et al., 2017)	YES	NA
(Eroglu et al., 2006)	NO	Custom-made mouthguard
(Morton and Burton, 1979)	YES	Individual casted mouthguard
(Matalon et al., 2008)	NO	Custom-made mouthguards
(DeYoung et al., 1994)	YES	Custom mouthguards Self-adapted mouthguards
(Persic et al., 2006)	YES	Stock mouthguard Custom-made mouthguard
(Perunski et al., 2005a)	NO	Custom-made mouthguards Stock mouthguards
(Miller et al., 2016)	YES	Stock mouthguards Custom mouthguards
(Bhadana et al., 2015)	YES	NA
(Dhindsa et al., 2019)	YES	NA
(Godwin et al., 1982)	No	Sta-Guard mouth protector Pro-Form mouth protector
(Yamada et al., 1998)	NO	Stock mouthguard Mouth-formed mouthguard Custom-made mouthguard
(Bastian et al., 2020)	YES	Stock mouthguard Boil-and-bite mouthguard Custom mouthguard
(Upson, 1982)	YES	Stock type mouthguard Laboratory-made type mouthguard Mouth-fitted type mouthguard
(Brebner and Marshall, 1977)	NO	Shield mouthguard
(de Wet et al., 1981)	YES	Custom-made mouthguard
(Maestrello-deMoya and Primosch, 1989)	NO	Mouth-formed mouthguard Stock-formed mouthguard Custom-made mouthguard
(Raaii et al., 2011)	YES	Stock mouthguard

		Boil-and-bite mouthguard Custom-made mouthguard
(Chapman and Nasser, 1996)	NO	Professionally fitted type mouthguard Mouth-formed mouthguard
(Tanaka et al., 2015)	NO	Custom-made mouthguards
(Spinas and Savasta, 2007)	NO	NA
(Spinas et al., 2014)	NO	Custom-made mouthguards
(Fakhruddin et al., 2007a)	YES	Boil-and-bite mouthguard Stock type mouthguard Custom-made mouthguard
(Cornwell et al., 2003)	YES	Professionally fitted mouthguard Boil-and-bite mouthguard Stock mouthguard
(Rodd and Chesham, 1997)	YES	NA
(Galic et al., 2018)	YES	NA
(Collins et al., 2015)	YES	NA
(Onyeaso, 2004)	NO	NA
Guinot and Manrique (2021)	NO	Pre-fabricated Mouthguards Adaptable mouthguards Custom-made mougthguards
Alomer et al. (2002)	Yes	Boil-and-bite mouthguards Custom-fabricated mouthguards

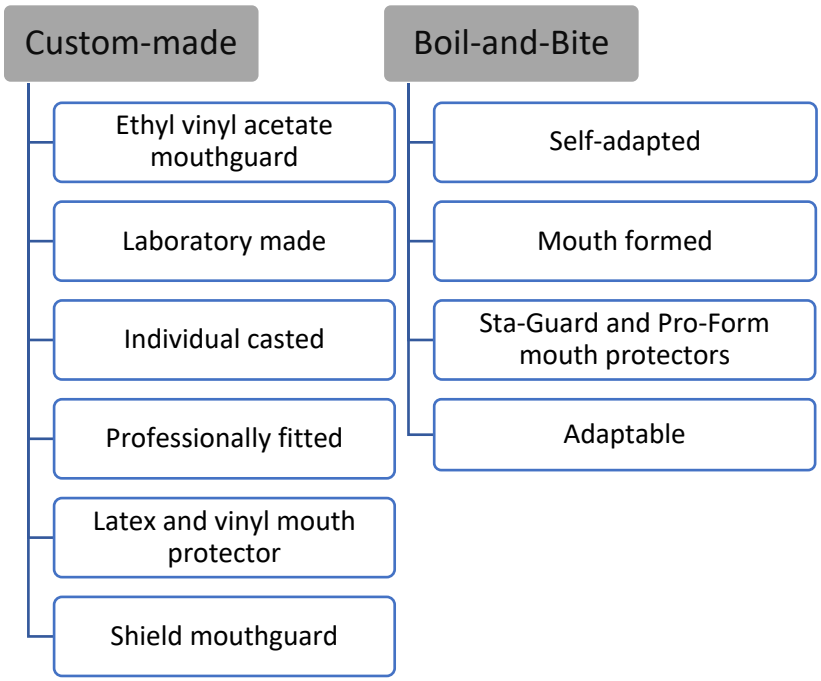

Figure 3-2: The variety of terms reported in the included studies in reference to the type of mouthguard used

3.6 Barriers and Facilitators Identified

All the included articles were studied to identify any barriers and facilitators reported. Furthermore, the verbatim text referring to barriers to and/or facilitators of mouthguard use was qualitatively synthesised, and the relative frequency of each was described according to the theoretical domains framework (TDF). The barriers and facilitators described in the studies mapped onto seven of the 14 theoretical domains: (1) knowledge; (2) beliefs about consequences; (3) intentions; (4) memory, attention, and decision process; (5) environmental context and resources; (6) social influence; and (7) emotions. Some of the barriers were not clear in the sense that they could be coded in different domains according to the way in which they were presented in the article, for example, aesthetic and appearance issues. The authors of these articles were contacted, but none replied, so these barriers were coded as un-codable. The specific TDF domains under which the barriers to and facilitators of wearing mouthguards were listed are presented in Table 7 (see Appendix 5 for full details).

Table 7: Barriers and facilitators identified.

TDF Domain (N)	N*	Barriers Identified	N**	Facilitators Identified
Knowledge (18)	13	Lack of awareness about mouthguards	7	Awareness of mouthguards
	1	Lack of knowledge about where to get a mouthguard	4	Previous experience with mouthguards
Beliefs about consequences (23)	4	Belief that mouthguards provide little protection	13	Belief that mouthguards provide protection
	2	Belief that there is no reason to wear a mouthguard	1	Belief that mouthguards are necessary
	3	Belief that without having an injury mouthguard use not needed	2	Belief that wearing a mouthguard during sports should be compulsory
	12	Belief that wearing a mouthguard is unnecessary/not important		
	1	Preferred playing without a mouthguard		
	1	Belief that a mouthguard is not needed during practice as play is not as intense as it is during competition		
Intentions (12)	5	Never thought of using a mouthguard	5	Willingness to wear a mouthguard
	6	Limited willingness to wear a mouthguard		
Memory, attention, and decision process (8)	6	Lost the mouthguard		

	4	Forgets to wear a mouthguard		
Environmental context and resources (30)	8	Wear and fit problems (biting or chewing/cutting)	3	Did not have any problem
			1	Comfortable to wear
	20	Discomfort/uncomfortable/bothered the player	1	No complaints about gagging
	7	Nausea/retching/gagging/feel sick	1	No complaints about taste
	24	Interference with breathing	1	No complaints about irritation
	23	Interference with speech/communication	1	No complaints about speech
	3	Bad taste or odour		
	7	Dryness		
	8	Expensive/cost		
	9	Feeling loose/retention/fixing problem/ instability		
	1	Abnormal tissue reaction		
	1	Lack of storage place for mouthguard		
	4	Too bulky/foreign body sensation		
	2	Swallowing/drinking problems		

	1	Too tight		
	1	Not provided by authorities		
	1	Affects concentration		
	6	Pain/soreness/irritation in tooth/gingiva/muscle/ pressure/jaw fatigue		
Social influence (15)	8	Lack of encouragement/No effort by coaches/parents/dentists/teachers/sports group to encourage mouthguard use	8	Awareness of/Advice about mouthguard use by media/parent/dentist/coach/official/ friend/club/team
	3	Friends/teammates do not or hardly ever wear mouthguards		member/school/another player
			1	Looked cooler
	2	Lack of mandatory rule requiring that mouth protectors by governing bodies/authorities	1	Knew other people who wore a mouthguard
Emotions (4)	3	Did not like wearing mouthguard	1	Favourable feelings towards mouthguards
	1	Embarrassment		
Un-codable (10)	1	Durability		
	6	Aesthetic/esthetic		
	3	Appearance issues		
	1	Saliva		
N refers to the number of included studies that identified the TDF domain				

N refers to the number of included studies that identified the barrier described*
*N** refers to the number of included studies that identified the facilitator described*

3.6.1 "Knowledge" Domain

Eighteen articles mentioned the "knowledge" domain. The primary barrier identified in this domain was insufficient knowledge about mouthguards among children; this was mentioned in 13 articles (Yamada et al., 1998; Onyeaso, 2004; Perunski et al., 2005; Ramagoni et al., 2007; Spinas and Savasta, 2007; Ozbay et al., 2013; Bhadana et al., 2015; Collins et al., 2015; Sethi et al., 2016; Goswami et al., 2017; Dhindsa et al., 2019; Guinot and Manrique, 2021; Alomer et al., 2022). It was found that either they were not familiar with the mouthguards, or they did not know about the pivotal role mouthguards play in preventing various sports-related dental injuries. Moreover, it was reported that children lacked knowledge about where to purchase mouthguards (Goswami et al., 2017) and did not know that mouthguards can also provide protection when playing sports with a low risk of injury (Collins et al., 2015). Of the facilitators in this domain, the most common was the children's awareness of the existence of the mouthguards and knowledge about its use (n=7: Yamada et al. 1998; Onyeaso, 2004; Ramagoni et al. 2007; Spinas and Savasta, 2007; Goswami et al., 2017; Galic et al., 2018; Guinot and Manrique, 2021). A child having previous experience using a mouthguard was the facilitator identified least often in this domain (n=4: Morton and Burton, 1979; DeYoung et al., 1994; Persic et al., 2006; Bastian et al., 2020).

3.6.2 "Belief about consequences" Domain

As presented in Table 7, in this domain the most frequently reported barrier was the children's belief that it was unnecessary for them to wear a mouthguard (n=12:

Yamada et al., 1998; Cornwell et al., 2003; Perunski et al., 2005; Persic et al., 2006; Fakhruddin et al., 2007; Emerich and Nadolska-Gazda, 2013; Collins et al., 2015; Goswami et al., 2017; Galic et al., 2018; Dhindsa et al., 2019; Guinot and Manrique, 2021; Alomer et al., 2022). Four of these studies found that children believed that mouthguards provided "little" protection or only "a few" benefits. It also was reported that some children thought that since they had not sustained or suffered from any sports-related injury, they did not need to wear a mouthguard. Other children and young people chose not to wear a mouthguard while playing games because they did not think of games as “dangerous” and therefore did not perceive themselves to be at risk (n=1: Sethi et al., 2016). While others thought the particular sport, they were pursuing was not dangerous and therefore they did not need a mouthguard (Miller et al., 2016); these barriers were found to be the least common. Regarding facilitators, the most common was young people’s belief that mouthguards could be beneficial in protecting them from dental injury while playing sport. This facilitator was found in 13 articles (Rosenberg, 1963; Nachman et al., 1965; Chapman and Nasser, 1996; Rodd and Chesham, 1997; Onyeaso, 2004; Cornwell et al., 2003; Ramagoni et al., 2007; Miller et al., 2016; Sethi et al., 2016; Galic et al., 2018; Bastian et al., 2020; Guinot and Manrique, 2021; Alomer et al., 2022). It also was reported that some children believed that wearing a mouthguard at some stage should be made compulsory when playing their sport (n=2: Brebner and Marshall, 1977; Chapman and Nasser, 1996). However, feeling that wearing a mouthguard was a must was found to be one of the least common facilitators in this domain (n=1: Yamada et al., 1998).

3.6.3 "Intentions" Domain

Twelve of the articles featured the "intentions" domain, in which the major barrier noted was the reluctance of children to wear a mouthguard (n=6: de Wet et al., 1981; DeYoung et al., 1994; Chapman and Nasser, 1996; Rodd and Chesham, 1997; Matalon et al., 2008; Alomer et al., 2022). The least common barrier for children, which was mentioned in five articles (Maestrello-deMoya and Primosch, 1989; Cornwell et al., 2003; Sethi et al., 2016; Bastian et al., 2020; Alomer et al., 2022) was never having thought of wearing a mouthguard. By contrast, the readiness and eagerness of some youths to use a mouthguard was the only facilitator to be found in this domain (n=5: Morton and Burton, 1979; de Wet et al., 1981; Rodd and Chesham, 1997; Spinas and Savasta, 2007; Alomer et al., 2022).

3.6.4 "Memory, attention, and decision process" Domain

As shown in Table 7, eight of the studies mentioned this domain. The most common barrier facing children in this context was losing their mouthguards (n=6: Rosenberg, 1963; Nachman et al., 1965; de Wet et al., 1981; Godwin et al., 1982; Matalon et al., 2008; Miller et al., 2016). The fact that children often either left their mouthguards somewhere or misplaced them was cited as the primary reason they did not use them. It also was mentioned that children forgot to wear their mouthguards; this was found to be the least common barrier in the studies in this domain (n=4: de Wet et al., 1981; Matalon et al., 2008; Miller et al., 2016; Bastian et al., 2020). No facilitators were identified in this domain.

3.6.5 "Environmental context and resources" Domain

This domain encompassed most of the studies (30 of 34 articles), and it was under this heading that the most common barriers and facilitators appeared. In this context, the most common barrier to children wearing their mouthguards was their feeling that this protective device prevented them from breathing normally (n=24: Rosenberg, 1963; Nachman et al., 1965; Morton and Burton, 1979; de Wet et al., 1981; Upson, 1982; Maestrello-deMoya and Primosch, 1989; DeYoung et al., 1994; Chapman and Nasser, 1996; Yamada et al., 1998; Cornwell et al., 2003; Perunski et al., 2005; Eroglu et al., 2006; Persic et al., 2006; Fakhruddin et al., 2007; Spinas and Savasta, 2007; Raaii et al., 2011; Emerich and Nadolska-Gazda, 2013; Collins et al., 2015; Tanaka et al., 2015; Sethi et al., 2016; Galic et al., 2018; Dhindsa et al., 2019; Bastian et al., 2020; Alomer et al., 2022). The feeling that wearing a mouthguard caused young people difficulty in speaking and talking with their peers was also another common barrier (n=23: Rosenberg, 1963; Nachman et al., 1965; Morton and Burton, 1979; de Wet et al., 1981; Upson, 1982; Maestrello-deMoya and Primosch, 1989; DeYoung et al., 1994; Yamada et al., 1998; Cornwell et al., 2003; Eroglu et al., 2006; Persic et al., 2006; Perunski et al., 2005; Fakhruddin et al., 2007; Raaii et al., 2011; Emerich and Nadolska-Gazda, 2013; Collins et al., 2015; Tanaka et al., 2015; Miller et al., 2016; Sethi et al., 2016; Galic et al., 2018; Dhindsa et al., 2019; Bastian et al., 2020; Alomer et al., 2022). Some players found that the mouthguard was uncomfortable, as was noted in 20 articles (Rosenberg, 1963; Morton and Burton, 1979; de Wet et al., 1981; Upson, 1982; Maestrello-deMoya and Primosch, 1989; Chapman and Nasser, 1996; Yamada et al., 1998; Cornwell et al., 2003; Fakhruddin et al., 2007; Matalon et al., 2008; Raaii et al., 2011; Emerich and Nadolska-Gazda, 2013; Spinas et al., 2014; Tanaka et al., 2015; Miller et al., 2016;

Sethi et al., 2016; Goswami et al., 2017; Galic et al., 2018; Bastian et al., 2020; Alomer et al., 2022). It was also found that children often faced retention issues with their mouthguards, because the mouthguard was either too loose or too tight; this barrier was noted in nine of the articles (de Wet et al., 1981; Upson, 1982; Maestrello-deMoya and Primosch, 1989; DeYoung et al., 1994; Yamada et al., 1998; Eroglu et al., 2006; Raaii et al., 2011; Sethi et al., 2016; Alomer et al., 2022). Surprisingly, storing the mouthguard posed another challenge for children (Nachman et al., 1965). This, and the fact that protective devices were not sponsored by the sports department concerned (Dhindsa et al., 2019), were mentioned least often, in one article each. By contrast, children reported no issues with taste, gag reflex, irritation, or speech while wearing a mouthguard (Godwin et al., 1982). Likewise, never having faced any issue with the use of mouthguards was a facilitator for some children (Sethi et al., 2016). However, each of these facilitators was mentioned in only one of the articles in this domain.

3.6.6 "Social influence" Domain

Various barriers and facilitators were mentioned in 15 of the included articles that comprise the "social influence" domain. The children in these studies often found themselves in a situation in which their mentors were not motivated and made no attempt to implement their utilisation of the protective device, which discouraged them from wearing it; this barrier persistently appeared in this domain (n=8: Rosenberg, 1963; Fakhruddin et al., 2007; Ramagoni et al., 2007; Spinas and Savasta, 2007; Bhadana et al., 2015; Collins et al., 2015; Sethi et al., 2016; Goswami et al., 2017). It also was found that children did not wear a mouthguard because

none of their peer group was wearing one; hence, they preferred not to wear them (Cornwell et al., 2003; Collins et al., 2015; Bastian et al., 2020). Additionally, the fact that no compulsory rules were implemented by the sports academy or the authorities that would have obligated every youth playing sports to wear a mouthguard was found to be the least frequent barrier, having been mentioned in only two articles (Rosenberg, 1963; Ramagoni et al., 2007). By the same token, encouragement by their mother, father, siblings, peers, colleagues, or mentors and therefore being acquainted with the shielding nature of the mouthguards was the facilitator that was mentioned most frequently (n=8: Nachman et al., 1965; Cornwell et al., 2003; Ramagoni et al., 2007; Spinas and Savasta, 2007; Collins et al., 2015; Miller et al., 2016; Bastian et al., 2020; Guinot and Manrique, 2021). By contrast, being on a team whose members wore mouthguards (Cornwell et al., 2003), or a desire to look “cooler” by wearing one (Miller et al. 2016), was found to be the least often mentioned facilitator in this domain.

3.6.7 “Emotions” Domain

The “emotion” domain was mentioned in only four of the articles. Of these, three noted that children felt that they do not like mouthguards (Maestrello-deMoya and Primosch, 1989; Yamada et al., 1998; Emerich and Nadolska-Gazda, 2013), making this the most frequently mentioned barrier in this domain. Only one study mentioned that youths who were involved in sports activities often felt self-conscious when wearing mouthguards (Matalon et al., 2008), making this the least common barrier in this domain. In this domain, the only facilitator reported by children was feeling good when wearing a mouthguard (Yamada et al., 1998).

3.6.8 "Un-codable" Domain

The following barriers could not be coded in a single domain without further clarification from the authors of the original studies.

Six articles (Perunski et al., 2005; Eroglu et al., 2006; Persic et al., 2006; Ramagoni et al., 2007; Galic et al., 2018; Dhindsa et al., 2019) referred to issues arising from the aesthetics of mouthguards; it was unclear whether if this was about the appearance of the mouth guard (environmental context and resources domain) or their own physical appearance while wearing the mouthguard (social influence or emotions domains). This barrier was the most common reason given for why children did not wear them. Likewise, three of the articles (Alomer et al., 2002; Fakhruddin et al., 2007; Tanaka et al., 2015) reported that children had an issue with their appearance while wearing a mouthguard. Some children had problems with salivation; It was not specific if this mean excessive salivation or mouth dryness (Yamada et al., 1998), while others found that mouthguards were not lasting for long time; it was unclear if this because of the mouthguard durability or due to teeth exfoliation and eruption (Maesttrello-deMoya and Primosch, 1989); each of these barriers was found in only one article. No facilitators were coded in this domain (see Table 7).

3.7 Sociological Influences

Each of these seven TDF domains was further associated with sociological influences which were divided into five parameters: individual, interpersonal, organisational, community, and public policy. The barriers and facilitators identified above were

categorised according to these sociological influences, as shown in Table 8 and Table 9, respectively.

Th most common barriers, including interference with breathing, speech difficulties, discomfort, and many others, were those that children confronted individually, rather than on any other level of sociological influence. However, in some of the studies, children also described the influence of the surrounding environment (including their parents, coaches, teammates, and the media) which acted as barriers to or facilitators of wearing sports mouthguards. As noted in relation to the "social influence" domain (Section 3.6.6), the failure of advisors within a child's social circle to persuade them to use a mouthguard was one of the barriers documented in eight of the studies. Likewise, seven of the studies documented the positive role of various interpersonal relationships in facilitating the use of mouthguards. These interpersonal relationships are linked to the children's social circle.

Table 8: Barriers to wearing sports mouthguards ("sociological influences" domain)

TDF Domains	Level of Sociological Influence				
	Individual	**Interpersonal**	**Organisational**	**Community**	**Public Policy**
Knowledge	Lack of awareness about mouthguards Lack of knowledge about where to get a mouthguard				
Beliefs about consequences	Belief that mouthguards provide little protection Belief that there is no reason to wear a mouthguard Belief that without having an injury, mouthguard use not needed Unnecessary/not important to wear a mouthguard Preferred to play without a mouthguard Belief that a mouthguard is not needed during practice as play is not as intense as it is during competition				
Intentions	Never thought of using a mouthguard Limited willingness to wear a mouthguard				
Memory, attention, and	Lost the mouthguard				

decision process	Forgot to wear mouthguard				
Environmental context and resources	Wear and fit problems (biting or chewing/cutting) Discomfort/uncomfortable/bothered the player Nausea/retching/gagging/feeling sick Interference with breathing Interference with speech/communication Bad taste or odour Dryness Expensive/cost Feeling loose/retention/fixing problem/instability Abnormal tissue reaction Lack of storage place for mouthguard Too bulky/foreign body sensation Swallowing/drinking problems				

	Too tight Not provided by authorities Affects concentration Pain/soreness/irritation in tooth/gingiva/muscle/ pressure/jaw fatigue				
Social influence	Friends/teammates do not or hardly ever wear mouthguards	Lack of encouragement/No effort from coaches/parents/dentists/teachers/sports group to use a mouthguard			Lack of formal requirement from governing bodies/authorities that mouth protectors be worn
Emotion	Did not like wearing a mouthguard Embarrassment				

Table 9: Facilitators of wearing sports mouthguards ("sociological influences" domain)

TDF Domains	Sociological Influence				
	Individual	**Interpersonal**	**Organizational**	**Community**	**Public Policy**
Knowledge	Awareness of mouthguards Previous experience with mouthguards				
Beliefs about consequences	Belief that mouthguards provide protection Belief that mouthguards are necessary Belief that wearing a mouthguard during sports should be compulsory				
Intention	Willingness to wear a mouthguard				
Memory, attention, and decision process					
Environmental context and resources	Did not have any problem wearing a mouthguard Comfortable to wear No complaints about gagging No complaints about taste				

	No complaints about irritation No complaints about speech				
Social influence	Looked cooler Knew other people who wore a mouthguard	Awareness of/Advice about mouthguard use from the media/parents/dentist/coaches/ officials/ friends/club/team member/school/another player	Advice from school and club	Awareness of/Advice about mouthguard use by media/dentist	
Emotion	Favourable feelings towards mouthguards				

3.8 Quality Assessment

The quality assessment of all included studies was performed using the NOS. Thirty studies were cross-sectional and were assessed based on the NOS designed for cross-sectional studies (Table 11), while the quality of the remaining six studies being cohort studies, were analysed using the NOS specified for cohort studies (Table 12).

The quality of the studies as determined by NOS scale was as follows. Most studies (N=24, 66.6%; score: 4–6) were of fair quality. A further nine studies (25%), all with scores of ≤3, were noted to be of poor quality, and only three studies (8.3%; scored: ≥7) were graded as good quality. The details are provided in Table 10.

Recognising that, only 3 articles in this review were scored as good quality articles on NOS. Unsurprisingly, if only these three articles (DeYoung et al., 1994, Eroglu et al., 2006, Spinas et al., 2014) were included in this review, most of the domains would be excluded for example, Beliefs about consequences, social influences and emotions. Interestingly, the majority of the barriers would be remained placed under environmental context and resources domain. Regarding the facilitators of children wearing sport mouthguard, only one facilitator in knowledge domain [children previous experiences with mouthguard (DeYoung et al., 1994)] would remain.

Considerably, excluding the studies having poor quality NOS scores in this review did not affect the main features of the outcomes. Although, if the poor quality studies were excluded, 10.8% (n=4) of the barriers would be missing from two

domains as these four barriers were mentioned in only two poor quality studies, in the belief about consequences domain, some children prefer to play without a mouthguard (Nachman et al., 1965) or they believed they do not need to use a mouthguard during the practice as the play is not intense as in competitions (Miller et al., 2016). Furthermore, two barriers mentioned in Nachman et al. (1965) were placed under the environmental context and resources domain where the children reported having an abnormal tissue reaction due to the usage of a mouthguard, and the children in the same article considered the unavailability of a storage place to their mouthguard as a barrier. On other side, 12.5% (n=2) of the facilitators would be missed in case of exclusion of poor quality studies. These two facilitators are mentioned in two different domains (belief about consequences and environmental context and resources). Both facilitators [believe mouthguard usage should be compulsory during sports activities (Brebner and Marshall, 1977, Chapman and Nasser, 1996) and looked cooler (Miller et al., 2016)] were mentioned in two and one articles, respectively. Overall, although the number of barriers and facilitators identified were affected by only including the fair and good quality papers in this review, however, the presence and order of the barriers and facilitators were unaffected. Table 13 lists both barriers and facilitators, excluding nine poor quality articles.

Table 10: Quality assessment of included studies.

Study	Score	NOS Grade
	(Score ≥7)	Good (3: 8.3%)
Eroglu et al. (2006)	7	
DeYoung et al. (1994)*	7	
Spinas et al. (2014)*	7	
	(Score 4–6)	Fair (24: 66.6%)
Sethi et al. (2016)	5	
Emerich and Nadolska-Gazda (2013)	4	
Ozbay et al. (2013)	5	
Morton and Burton (1979)	6	
Matalon et al. (2008)	6	
Persic et al. (2006)	5	
Perunski et al. (2005)	5	
Dhindsa et al. (2019)	4	
Yamada et al. (1998)	5	
Bastian et al. (2020)	4	
De Wet et al. (1981)	5	
Maestrello-deMoya and Primosch (1989)	4	
Raaii et al. (2011)	4	
Fakhruddin et al. (2007)	4	
Cornwell et al. (2003)	6	
Rodd and Chesham (1997)	5	
Galic et al. (2018)	6	
Collins et al. (2015)	5	
Rosenberg (1963)*	5	
Godwin et al. (1982)*	6	
Upson (1982)*	5	
Tanaka et al. (2015)*	4	
Guinot and Manrique (2021)	4	
Alomer et al. (2022)	5	
	(Score ≤3)	Poor (9: 25%)
Ramagoni et al. (2007)	3	
Nachman et al. (1965)	2	
Goswami et al. (2017)	3	
Miller et al. (2016)	3	
Bhadana et al. (2015)	3	
Brebner and Marshall (1977)	3	
Chapman and Nasser (1996)	3	
Spinas and Savasta (2007)	2	
Onyeaso (2004)	3	
***Cohort studies**		

3.8.1 Quality Assessment of Cross-Sectional Studies (total: 10 stars)

In terms of quality of the studies, almost one third of the studies (N=9) scored five stars (Fair quality). These studies were: de Wet et al. (1981); Rodd and Chesham (1997); Yamada et al. (1998); Perunski et al. (2005); Persic et al. (2006); Ozbay et al. (2013); Collins et al. (2015); Sethi et al. (2016); and Alomer et al. (2022). By contrast, the highest score achieved by any study was seven stars; this score was achieved by only one study (Eroglu et al., 2006). A further four studies (Morton and Burton, 1979; Cornwell et al., 2003; Matalon et al., 2008; Galic et al., 2018) scored six stars. Two of the studies (Nachman et al., 1965; Spinas and Savasta, 2007) achieved two stars, the lowest score recorded (Table 11).

In general, of the 30 cross-sectional studies included in this review, the greatest number (N=20) were graded as being of fair quality; a further nine studies were graded as poor. Only one of the studies was deemed to be good. The details are summarized in Table 11.

3.8.2 Quality Assessment for Cohort (total: 9 stars)

Two studies, DeYoung et al. (1994) and Spinas et al. (2014), achieved the maximum score of seven stars, followed by one study (Godwin et al., 1982) which scored six stars. A further two studies (Rosenberg, 1963; Upson, 1982) scored five stars. Only one study (Tanaka et al., 2015) achieved the lowest score of four stars (Table 11).

Four of the six cohort studies included in the survey met the criteria for fair quality as per the NOS scale, while the remaining two were deemed of good quality. The details are provided in Table 12.

Table 11: Newcastle-Ottawa scale for cross-sectional studies.

Study	SELECTION (Maximum 5 stars)				COMPARABILITY (Maximum 2 stars)	OUTCOME (Maximum 3 stars)		TOTAL STARS
	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure	Comparability based on study design	Assessment of the outcome	Statistical test	
Sethi et al. (2016)	*	-	-	**	NA	*	*	5
Emerich and Nadolska-Gazda (2013)	*	-	-	*	NA	*	*	4
Ramagoni et al. (2007)	*	-	-	-	NA	*	*	3
Nachman et al. (1965)	*	-	-	*	NA	*	-	2
Ozbay et al. (2013)	*	-	-	**	NA	*	*	5
Goswami et al. (2017)	*	-	-	**	NA	-	-	3
Eroglu et al. (2006)	*	-	-	**	*	*	*	7
Morton and Burton (1979)	*	-	*	*	*	*	*	6
Matalon et al. (2008)	*	-	*	*	*	*	*	6
Persic et al. (2006)	*	-	-	**	NA	*	*	5
Perunski et al. (2005)	*	-	-	**	NA	*	*	5
Miller et al. (2016)	*	-	-	*	NA	*	-	3
Bhadana et al. (2015)	*	-	-	*	NA	*	-	3
Dhindsa et al. (2019)	*	-	-	*	NA	*	*	4
Yamada et al. (1998)	*	-	-	**	NA	*	*	5
Bastian et al. (2020)	*	-	-	*	NA	*	*	4
Brebner and Marshall (1977)	*	-	-	-	*	*	-	3

de Wet et al. (1981)	*	-	-	*	*	*	*	5
Maestrello-deMoya and Primosch (1989)	*	-	-	**	NA	*	-	4
Raaii et al. (2011)	*	-	-	*	NA	*	*	4
Chapman and Nasser (1996)	*	-	-	*	NA	*	-	3
Spinas and Savasta (2007)	*	-	-	-	NA	*	-	2
Fakhruddin et al. (2007)	*	-	-	*	NA	*	*	4
Cornwell et al. (2003)	*	-	-	**	*	*	*	6
Rodd and Chesham (1997)	*	-	*	*	NA	*	*	5
Galic et al. (2018)	*	-	*	**	NA	*	*	6
Collins et al. (2015)	*	-	-	**	NA	*	*	5
Onyeaso (2004)	*	-	-	-	NA	*	*	3
Guinot and Manrique (2021)	*	-	*	-	NA	*	*	4
Alomer et al. (2002)	*	-	-	**	NA	*	*	5

Table 12: Newcastle-Ottawa scale for cohort studies.

Study	SELECTION (Maximum 4 stars)				COMPARABILITY (Maximum 2 stars)	OUTCOME (Maximum 3 stars)			Total Score
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis controlled for confounders	Assessment of the outcome	Follow-up of sufficient length for outcomes to occur	Adequacy of follow-up of cohorts	
Rosenberg (1963)	*	*	-	*	*	-	*	-	**5**
DeYoung et al. (1994)	*	*	-	*	**	-	*	*	**7**
Godwin et al. (1982)	*	*	*	*	*	-	*	-	**6**
Upson (1982)	*	*	*	*	*	-	-	-	**5**
Tanaka et al. (2015)	*	-	-	*	-	-	*	*	**4**
Spinas et al. (2014)	*	*	-	*	**	-	*	*	**7**

Table 13: Barriers and facilitators identified including only fair and good quality articles.

TDF Domain (N)	N*	Barriers Identified	N**	Facilitators Identified
Knowledge (13)	8	**Lack of awareness about mouthguards**	3	**Awareness of mouthguards**
	1	**Lack of knowledge about where to get a mouthguard**	4	**Previous experience with mouthguards**
Beliefs about consequences (16)	3	**Belief mouthguards provide little protection**	8	**Belief mouthguards provide protection**
	2	**Believe there is no reason to wear a mouthguard**	1	**Belief mouthguards are necessary**
	3	**Belief that without having an injury mouthguard use not needed**	2	**Belief wearing a mouthguard during sports should be compulsory**
	11	**Unnecessary/not important to wear a mouthguard**		
Intentions (9)	5	**Never thought of using a mouthguard**	4	**Willingness to wear a mouthguard**
	5	**Limited willingness to wear a mouthguard**		
Memory, attention, and decision process (5)	4	**Lost the mouthguard**		
	3	**Forget to wear mouthguard**		

Environmental context and resources (22)	7	**Wear and fit problems (biting or chewing/cutting)**	2	**Did not have any problem**
	17	**Discomfort/uncomfortable/bother the player**	1	**No complaints of gagging**
	7	**Nausea/retching/gagging/feel sick**	1	**No complaints of taste**
	21	**Interference with breathing**	1	**No complaints of irritation**
	21	**Interference with speech/communication**	1	**No complaints of speech**
	2	**Bad taste or odour**		
	6	**Dryness**		
	5	**Expensive/cost**		
	9	**Feeling loose/retention/fixing problem/ instability**		
	4	**Too bulky/foreign body sensation**		
	1	**Swallowing/drinking problems**		
	1	**Too tight**		
	1	**Not provided by authorities**		
	1	**Affects concentration**		

	4	**Pain/soreness/irritation in Tooth/gingiva/muscle/ pressure/jaw fatigue**		
Social influence (7)	4 3 2	**Lack of encouragement/No effort from Coaches/parents/dentists/teachers/sport group about mouthguard** **Friends/teammates do not or hardly ever wear mouthguards** **Lack of mandatory rule requiring that mouth protectors by governing bodies/authorities**	4 1	**Awareness/Advice of mouthguard use by media/parents/dentist/coaches/officials/ friends/club/team member/school/another player** **Know other people who wear a mouthguard**
Emotions (4)	3 1	**Did not like wearing mouthguard** **Embarrassment**	1	**Favourable feelings towards mouthguards**
Un-codable (10)	1 5 3 1	**Durability** **Aesthetic/esthetic** **Appearance issues** **Saliva**		
N refers to the number of included studies that identified the TDF domain N* refers to the number of included studies that identified the barrier described N** refers to the number of included studies that identified the facilitator described				

Chapter 4
Discussion

4.1 Summary of Main Results

Thirty-six studies targeting children's perception of mouthguard use were identified for inclusion in the systematic review. The barriers to and facilitators of mouthguard use in children were identified and further categorized by level of sociological influence.

The majority of the barriers in this study were categorised in the environmental context and resources domain. The children in these studies considered the mouthguard itself to be the main barrier. The most common barrier is related to the physical properties of the mouthguard in that it was perceived to interfere with key functions, such as natural breathing (mentioned in 24 articles), speaking (mentioned in 23 articles) and comfort (mentioned in 20 articles).

Additionally, a child's knowledge and beliefs about the mouthguard and its role as a protective device was found to be an important influence on its usage. The child's social circle (i.e., their parents/legal guardians, coaches, peers, or the media), also has some impact on their perception of mouthguard use.

Table 14: Most common barriers identified.

Identified barrier to mouthguard usage	**Number of studies addressing this barrier**	**Theoretical domain linked to this barrier**
Interference with breathing	24	Environmental context and resources
Interference with speech/communication	23	Environmental context and resources
Discomfort/uncomfortable/bothered the player	20	Environmental context and resources
Lack of awareness about mouthguards	14	Knowledge
Belief that it is not necessary/not important to wear a mouthguard	12	Beliefs about consequences

Many facilitators have been identified in this review. Though, the facilitators are less frequently mentioned than barriers. This might be due to the approaches used in the included studies in investigating the negative and positive reactions to mouthguard usage. Mainly the questioners provided in the articles were focused on capturing the hurdle of mouthguard usage. The most common facilitator (13 studies) was the child's conviction that they needed to wear a mouthguard to protect themselves from injury. Similarly, the acknowledgment of mouthguards within children's social circles was identified as a facilitator in eight of the articles. In a further seven studies, children who were aware of mouthguards were more likely to use them. Other, less common facilitators included children's readiness to wear a mouthguard, past experience with a mouthguard, children's perception that they had no problems with the mouthguard, and the children's belief that wearing a mouthguard during sports should be mandatory.

Table 15: Most common facilitators identified.

Facilitator identified to mouthguard usage	**Number of studies addressing the facilitator**	**Theoretical Domain linked with the facilitator**
Belief mouthguards provide protection	13	Beliefs about consequences
Awareness/Advice of mouthguard use by media/parents/dentist/coaches/officials/ friends/club/team member/school/another player	8	Social influence
Awareness of mouthguards	7	Knowledge
Willingness to wear a mouthguard	5	Intention
Previous experience with mouthguards	4	Knowledge

4.2 Methodology

The aim of this systematic review was to provide a comprehensive and current overview of the barriers to and facilitators of mouthguard usage among children. Before starting the review, it was registered and published with PROSPERO. Six different databases were thoroughly searched using a developed search strategy and 34 articles were ultimately selected for inclusion in the review.

According to Marshman et al. (2007) the children are seen but not listened to or heard in most child dental research, it was also suggested that researchers try to involve children as much as possible in their studies to make sure that their views are taken into account, and it is noteworthy to mention that, out of 3266 included articles in the same review, 87.1% were classified as research in which children were treated as objects, 5.7% were found to include proxies (parents or clinicians), 7.0% used children to some extent and only 0.3% actively involved children. Furthermore,

it is surprising to note that, only 5.4% of the articles that were published in specific paediatric dentistry journals were classified as “involved research with children”. Hence, this study focused on the children’s voice only recognising that each level needs more investigations to capture all related barriers and facilitators to sport mouthguard usage among children.

Although an upper age limit of 18 years was one of the inclusion criteria, studies with a higher age limit were included when data regarding the relevant sub-groups (within the age limit specified by the inclusion criteria) were analysed. However, three articles (Galic et al., 2018, Collins et al., 2015, Onyeaso, 2004) in which the age of the participants was up to 19 years were included even though no subgroup analysis was provided because they contained interesting data regarding barriers to and facilitators of mouthguard use.

The students usually start the university at age 18 or over. For-example, University of Kent stated on their website that students should be at least 18 years old to be enrolled in the university, but, in individual basis where the age is over 16 years, their parents or guardians need to provide a written agreement for additional safeguarding-related matters. So, the papers that dealt with college or university students, a very distinct population/and or cohort without subgroup analysis were deemed inadmissible as they are frequently no longer supervised directly by their families. Overall, all of the studies that were considered for inclusion in this systematic review were conducted on children who were enrolled in schools.

Obviously, there are multiple levels (for-example: parents, coaches, dentists, teammates, friends, etc) that play a role in children's mouthguard usage. Interestingly, during the literature search, ten different articles (Aysha et al., 2020, Berg et al., 1998b, Chatterjee and Hilton, 2007a, Diab and Mourino, 1997, McNutt et al., 1989b, Mojarad et al., 2020b, Nowjack-Raymer and Gift, 1996b, O'Malley et al., 2012c, Pribble et al., 2004a, Priya et al., 2016) presenting the views of parents and coaches were identified, but their findings in relation to barriers and facilitators did not differ from those reported in studies that focused on the child's perspective. In these studies, questionnaires were used to collect the views of parents/coaches regarding children's mouthguard usage.

Following completion of the review on 1 May 2022, the electronic search was updated, and two additional recently published articles that met the inclusion criteria were identified (Guinot and Manrique, 2021; Alomer et al., 2022). Both were considered for inclusion in this review. It is interesting to note that no new barriers or facilitators were identified in neither of these articles. This indicates that, the majority of the existed barriers and facilitators are captured in this study by employing the qualitative research approach to enhance the rigour of the findings.

4.3 Coding the Barriers and Facilitators according to Theoretical Domain Framework (TDF)

The qualitative approach was used in this review to strengthen the reliability of the findings. A constant comparison of condensed information in both subthemes and themes was performed while coding them within the TDF. In knowledge translation

and implementation studies, TDF is a useful tool for identifying barriers and facilitators that influence behavior change.

The barriers and facilitators that emerged from the included articles were coded into the seven TDF domains previously identified: (1) knowledge; (2) beliefs about consequences; (3) intentions; (4) memory, attention, and decision process; (5) environmental context and resources; (6) social influence; and (7) emotions. Each was then coded to a specific domain according to their perceived meaning as presented in the articles. For instance, the barriers and facilitators in the "environmental context and resources" domain were placed there because the main problem was caused by the mouthguard itself. The barrier "interference with breathing or speaking" was placed in this domain because the mouthguard was the cause of this barrier.

Some of the barriers identified in six of the included studies were not easily coded into any of the seven TDF domains because of their ambiguous meaning. These barriers were durability, salivation, aesthetic, and appearance issues. The authors of the six articles concerned were contacted for further clarification regarding these barriers, but none of them responded. Thus, these barriers were coded into the "un-codable" domain.

4.4 Barriers to and Facilitators of Mouthguard Use by Children

In most of the papers included in this review, the barriers and facilitators were either noted as a secondary outcome of the research or were reported by

participants as additional information. As a result, extracting the barriers and facilitators from these papers was laborious, and they were difficult to code.

Mouthguard awareness is a critical factor in whether mouthguards are used during different sports activities. In six of the included studies, awareness of mouthguard usage was noted to be high, from 65.3% in Onyeaso (2004) to 97.3% in Galic et al. (2018). Goswami et al. (2017) and Ramagoni et al. (2007) reported awareness of 71.3% and 79.3%, respectively; Persic et al. (2006) reported 91.7% awareness, while Yamada et al. (1998) reported 72.5% awareness among soccer players and 93.7% among rugby players. The players who took part in these studies were involved in a mix of contact, non-contact, and limited-contact sports. The four (Goswami et al. (2017), Persic et al. (2006), Yamada et al. (1998), and Galic et al. (2018)) of these six articles, had mentioned a history of sports dental trauma among participants.

In another study by Bhadana et al. (2015), in which the players were involved in outdoor and indoor games, it was noted that a high percentage (71.3%) of participants were unaware of mouthguards. Also, in that study, 69.6% of participants had experienced a dental injury during sports.

Overall, it is noteworthy to mention that, a positive relationship between self-declared knowledge of mouthguards and their use in sports couldn't be claimed for all the cases. In some of the studies that mentioned an awareness of mouthguards, there is some percentage of participants who claimed knowledge about mouthguards and still did not wear them while playing sports. This could possibly explain why there was a high prevalence of oral injuries even among those who reported to be aware of sports mouthguard and its role in protection. These findings

accord with those of various previous studies in which very few participants were found to use mouthguards even though they were well aware of them (Çetinbaş and Sönmez, 2006, Ferrari and De Medeiros, 2002, Hersberger et al., 2012, Vidovic-Stesevic et al., 2015). These other studies also highlighted that athletes are often hesitant to wear mouthguards regularly during play (Lephart and Fu, 1991, Newsome et al., 2001, Diab and Mourino, 1997).

Interestingly, a similar type of result was noted in Spinas and Savasta (2007), in which only 30 out of 300 (10%) subjects knew about mouthguards. From the same sample size 30 participants (10%) agreed to participate in knowledge/education program regarding mouthguard awareness. These participants were given useful advice for improving their knowledge about the prevention of orofacial trauma. A random sample of 30 subjects who agreed to cooperate, were given mouthguards to wear during training sessions and official games. Only three athletes stopped wearing mouthguards after three months of use (due to some other unexplained barrier), whereas the remaining 27 young athletes expressed positive acceptance of the mouthguards and reported readiness to continue using the devices. Overall, it is proven that there is not a clear relationship between claimed knowledge of mouthguards and their use. However, emphasizing the use of mouthguards by increasing the children's knowledge has indicated a positive impact on mouthguard usage.

The belief that a mouthguard provides protection was noted in 13 of the articles, and in nine of these (Sethi et al., 2016, Ramagoni et al., 2007, Nachman et al., 1965, Bastian et al., 2020, Brebner and Marshall, 1977, Chapman and Nasser, 1996, Rodd

and Chesham, 1997, Galic et al., 2018, Onyeaso, 2004), the percentage of participants who believed that mouthguards provide protection was very high. All these studies involved a mix of contact and limited contact sports. Interestingly, in two of the articles (Galic et al., 2018, Nachman et al., 1965), not only did a higher proportion of the sample believe that mouthguards provide protection, but a considerable number of participants – 40% in Nachman et al. (1965) and 37% in Galic et al. (2018), respectively –preferred to play without a mouthguard and thought that mouthguards were unnecessary.

In several prior studies, athletes cited the same reason for not wearing a mouthguard: they deemed it unnecessary (Hersberger et al., 2012, Perunski et al., 2005b, Petrović et al., 2016, Lang et al., 2002). Likewise, a previous study involving the parents of children who played sports reported the belief that mouthguard use is not necessary (Chatterjee and Hilton, 2007a).

A player's intention to use a mouthguard during sports also was a significant influence on usage, as was found in six of the included studies. In three of these studies, the participants were involved in a contact sport (rugby), in two of these, the willingness to wear a mouthguard was very high: 98.7% in Wet et al. (1981) and 83% in Morton and Burton (1979). By contrast, in the third article, approximately one-third of mouthguard wearers (30%) were nevertheless willing to play without wearing their mouthguards (Chapman and Nasser, 1996). Overall, there appears to be a relationship between the type of sport played and the use of mouthguards. Among players of high-contact sports, the willingness to use a mouthguard is comparatively high.

Unsurprisingly, given that children were the primary source of information for this systematic review, and that children tend to express things that they themselves have experienced rather than describe the effect that their surroundings have had on them, most of the barriers and facilitators that emerged from the studies included in the review operated on the individual level. However, as the children also influence by their social circle, children express their ability to be positively or negatively affected in the use of mouthguard by their coaches, parents, dentists and clubs or authorities.

4.5 Quality of the Evidence

The Cochrane Collaboration has recommended the NOS to be used to evaluate the quality of observational studies in its 2011 handbook (Higgins and Green, 2011). Furthermore, the NOS has been widely used since at least 2004 (Stang, 2010), and results from several validation studies have been published (Brandenberger et al., 2019, Herzog et al., 2013).

In evaluating the quality of the 30 cross-sectional studies that were included in this review, it was found that around two-thirds scored a rating of “fair” using the NOS tool. It was interesting to note that none of the included studies justified the sample size. Likewise, in only five of the studies (Rodd and Chesham 1997; Galic et al. 2018; Guinot and Manrique 2021; Morton and Burton 1979; Matalon et al. 2008) the comparability between those who responded to the survey and those who did not was determined. The response rate of the remaining articles was evaluated based on the data provided in the articles themselves; it was noted that all met the inclusion criterion of a response rate greater than 60%. This inclusion criterion

accords with the previous literature, which also focused on the higher expectations for survey response rates and approximating 60% of response rate to be the goal of researchers (Fincham, 2008).

Furthermore, approximately twelve of the studies validated their measurement tool (questionnaires, surveys, interviews, etc.) prior to use (Table 10). In these articles, the validation was performed either by piloting the tool on some portion of their sample, or by using a previously validated measurement tool drawn from the published literature, or by seeking the opinion of an expert or other relevant professional. On the other hand, as shown in Table 11, 13 of the articles identify the measurement tool but did not provide details or any description of its validation. It is important to note that five of the articles (Brebner and Marshall, 1977; Onyeaso, 2004; Ramagoni et al., 2007; Spinas and Savasta, 2007; Guinot and Manrique, 2021) provided no information at all about the measurement tool that was used.

Overall, the majority of the articles included in this systematic review failed either to describe the validated tool used or even to use one. It is strongly recommended that the measurement tool be validated or piloted because scale development and validation are important and critical to much of the work in the health, social, and behavioural sciences and research process (Elangovan and Sundaravel, 2021, Boateng et al., 2018).

Another major shortcoming was that eight of the articles reported no details of their statistical analysis. An improper application of statistical techniques may result in inaccurate findings that can influence clinical practices in the wrong way. Similarly for a paper to be published, it should include a section on statistical analysis,

including details of the statistical software and statistical tests that were used in order to establish the significance threshold (Voidăzan et al., 2014).

Overall, the quality of the cohort studies was significantly better than that of the cross-sectional. The cohort studies were better in the total NOS scoring since no low-quality research was identified in them (all of the cohort studies were either good or fair quality) studies. However, because the participants self-reported the outcomes in all the cohort studies, they lacked the assessment of outcome as there was no record linkage or independent blind assessment.

4.6 Agreements and Disagreements with Other Studies or Reviews

No previously published review was found that mainly focused on the barriers to and facilitators of mouthguard usage among children.

4.7 Implications

4.7.1 For Practice

The published data was scrutinised for possible barriers to and facilitators of wearing sports mouthguards as perceived by children, with the aim of helping parents, legal guardians, coaches and dentists to explain the use of mouthguards appropriately to children. In addition, these barriers and facilitators can be reviewed after children have used a mouthguard; this data collected could be used to guide the manufacturers of sports mouthguards in future.

4.7.2 For Research

It is proven and explained in 1.9 that any behaviour change intervention would have more power if it's linked to theoretical base. All the identified barriers and facilitators of mouthguard usage among children in this research are classified according to TDF guide. Thus, these barriers could be used in future by researchers investigating the children behaviour toward the sport mouthguards, generally or individual types.

Considering the outcomes of this systematic review and any confounding bias that it may involve, it is recommended that further advanced research specifically focused on the investigation of barriers to and facilitators of mouthguard usage among children during sports activities should be considered in future, since these barriers and facilitators were an additional or side outcome in most of the studies discussed above.

Chapter 5

Conclusion

The importance of sport mouthguards in the prevention of traumatic dental injuries during sports activities is much acknowledged, particularly among children'. In this systematic review, various barriers to and facilitators of children wearing a sports mouthguard were recorded, with most of the included studies drawing on samples comprised of school-age children. The children in these studies were involved mostly in contact or collision sports. Custom-made mouthguards were used most often, followed by the boil-and-bite type. The barriers and facilitators identified were classified first into TDF domains and then by sociological level based on their attributed meanings. The majority of barriers were encountered in the most prevalent domain, "environmental context and resources". The domains of "knowledge", "belief about consequences", and "social influences" were also significant, containing barriers and facilitators from most of the included papers. The belief that mouthguards provide protection, awareness of mouthguards, and the provision of guidance on using mouthguards by the child's social circle were the most frequently identified facilitators. The primary barriers were the interference of mouthguards with breathing/communication and discomfort; these were identified in almost all the studies. In general, children considered the mouthguard itself to be the main barrier while the greatest facilitator presented was awareness about the mouthguard and its role in protection.

Generally, the barriers and facilitators identified in this systematic review were additional or side outcomes of the studies reviewed; hence, it is suggested that more thorough research be conducted in order to fully comprehend the barriers and facilitators of sport mouthguard usage among children.

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Appendices

7.1 Appendix 1: Search strategy

1. exp Sports/ (141163)
2. (sport* or athletic* or athlete* or player*).tw. (108582)
3. or/1-2 [sports] (206104)
4. Mouth Protectors/ (765)
5. (mouth adj1 guard*).tw. (127)
6. (mouth adj1 protector*).tw. (14)
7. (mouthpiece* or mouth piece*).tw. (742)
8. mouthguard*.tw. (502)
9. (gumshield* or gum shield*).tw. (6)
10. (tooth protector* or teeth protector*).tw. (8)
11. or/4-10 [mouthguards] (1594)
12. 3 and 11 [sports and mouthguards] (559)
13. (teen* or youth* or adolescen* or juvenile* or (young adj2 (adult* or person* or individual* or people* or population* or man or men or wom#n)) or youngster* or first-grader* or second-grader* or third-grader* or fourth-grader* or fifth-grader* or sixth-grader* or seventh-grader* or highschool* or college* or ((secondary or high*) adj2 education)).tw. (463584)
14. Adolescent/ (1273429)
15. Child/ (959664)
16. (child* or kid or kids or girl or girls or boy or boys or school* or minors or p?ediatric*).tw. (1100318)
17. or/13-16 [children or adolescents] (2237454)
18. 12 and 17 [sports and mouthguards and children or adolescents] (240)
19. remove duplicates from 18 (240)

7.2 Appendix 2: Data extraction proforma

Researcher name:
Date of application:

Date of data extraction	
Researcher performing data extraction	
Author	
Date/Year of publication	
Article title	
Type of publication (e.g., journal article, conference abstract)	
Country of origin	
Space for additional notes	

Study characteristics	
Aim/objectives of the study	
Study design	
Study inclusion and exclusion criteria	
Recruitment procedures used (e.g. if applicable details of randomization)	

Participant characteristics	
Age:	Gender:
Type of sport they play	
History of TDI	
History of a sport mouthguard use	

Number of participants (in each group if present) eligible, enrolled, or randomized that is reported in the study	

Intervention characteristics	
Setting in which the intervention was delivered	
Type of mouthguards	
Duration of intervention	

Outcome data/results	
Barriers wearing mouthguards	
Facilitators wearing mouthguards	
Statistical technique used	
Any subgroup analysis	

TDF coding and sociological models for Barriers and Facilitators

TDF domains	Sociological influence	Barriers	Facilitators
Knowledge	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Skills	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Social/professional role and identity	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Beliefs about capabilities	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Optimism	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
	Individual		

Beliefs about consequences	Interpersonal		
	Organizational		
	Community		
	Public policy		
Reinforcement	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Intentions	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Motivation and goals	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Memory, attention, and decision processes	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Environmental context and resources	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		

Social influence	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Emotion	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		
Behavioural regulation	Individual		
	Interpersonal		
	Organizational		
	Community		
	Public policy		

7.3 Appendix 3: Newcastle Ottawa scale for cross-sectional studies

Researcher name:
Date of application:

Study	**SELECTION (Maximum 5 stars)**				**COMPARABILITY (Maximum 2 stars)**	**OUTCOME (Maximum 3 stars)**		**Total stars**
	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure	Comparability based on study design	Assessment of the outcome	Statistical test	

Explanation of the Newcastle-Ottawa Scale (NOS) adapted for cross-sectional studies (Herzog et al., 2013)

- **Selection**

1) Representativeness of the sample:

a) Truly representative of the average in the target population. * (all subjects or random sampling)
b) Somewhat representative of the average in the target population. * (non-random sampling)
c) Selected group of users.
d) No description of the sampling strategy.

2) Sample size:

a) Justified and satisfactory. *
b) Not justified.

3) Non-respondents:

a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *
b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.
c) No description of the response rate or the characteristics of the responders and the non-responders.

4) Ascertainment of the exposure (risk factor):

a) Validated measurement tool. **
b) Non-validated measurement tool, but the tool is available or described.*
c) No description of the measurement tool.

- **Comparability**

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
a) The study controls for the most important factor (select one). *
b) The study control for any additional factor. *

- **Outcome**

1) Assessment of the outcome:

a) Independent blind assessment. **
b) Record linkage. **
c) Self-report. *
d) No description.

2) Statistical test:

a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value).
b) The statistical test is not appropriate, not described or incomplete.

7.4 Appendix 4: Newcastle-Ottawa scale for cohort studies

Researcher name:
Date of application:

Study	**SELECTION** (Maximum 4 stars)				**COMPARABILITY** **(Maximum 2 stars)**	**OUTCOME** (Maximum 3 stars)			**Total Score**
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis controlled for confounders	Assessment of the outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow-up of cohorts	

Explanation of Newcastle-Ottawa scale for cohort studies (Wells et al., 2000).

- **Selection**

1) Representativeness of the exposed cohort

a) Truly representative ***(one star)***

b) Somewhat representative ***(one star)***

c) Selected group

d) No description of the derivation of the cohort

2) Selection of the non-exposed cohort

a) Drawn from the same community as the exposed cohort ***(one star)***

b) Drawn from a different source

c) No description of the derivation of the non exposed cohort

3) Ascertainment of exposure

a) Secure record (e.g., surgical record) ***(one star)***

b) Structured interview ***(one star)***

c) Written self report

d) No description

e) Other

4) Demonstration that outcome of interest was not present at start of study

a) Yes ***(one star)***

b) No

- **Comparability**

1) Comparability of cohorts on the basis of the design or analysis controlled for confounders

a) The study controls for age, sex and marital status ***(one star)***

b) Study controls for other factors (list) _____ ***(one star)***

c) Cohorts are not comparable on the basis of the design or analysis controlled for confounders

- **Outcome**

1) Assessment of outcome

a) Independent blind assessment ***(one star)***

b) Record linkage ***(one star)***

c) Self report

d) No description

e) Other

2) Was follow-up long enough for outcomes to occur

a) Yes ***(one star)***

b) No
Indicate the median duration of follow-up and a brief rationale for the assessment above:

3) Adequacy of follow-up of cohorts

a) Complete follow up- all subject accounted for ***(one star)***

b) Subjects lost to follow up unlikely to introduce bias- number lost less than or equal to 20% or description of those lost suggested no different from those followed. ***(one star)***

c) Follow up rate less than 80% and no description of those lost

d) No statement

7.5 Appendix 5: Detailed table for barriers and facilitators identified

Domain (N)	N	Barriers Identified	N	Facilitators Identified
Knowledge (18)	13	**Lack of awareness about mouthguards** (Sethi et al., 2016) (Ramagoni et al., 2007) (Ozbay et al., 2013) (Goswami et al., 2017) (Perunski et al., 2005a) (Bhadana et al., 2015) (Dhindsa et al., 2019) (Yamada et al., 1998) (Spinas and Savasta, 2007) (Collins et al., 2015) (Onyeaso, 2004) (Guinot and Manrique, 2021) (Alomer et al., 2022)	7	**Awareness of mouthguards** (Ramagoni et al., 2007) (Goswami et al., 2017) (Yamada et al., 1998) (Spinas and Savasta, 2007) (Galic et al., 2018) (Onyeaso, 2004) (Guinot and Manrique, 2021)
			4	**Previous experience with mouthguards** (Morton and Burton, 1979) (Persic et al., 2006) (Bastian et al., 2020) (DeYoung et al., 1994)
	1	**Lack of knowledge about where to get a mouthguard** (Fakhruddin et al., 2007a)		
Beliefs about consequences (23)	4	**Belief mouthguards provide little protection** (Rosenberg, 1963) (Sethi et al., 2016)	13	**Belief mouthguards provide protection** (Rosenberg, 1963) (Sethi et al., 2016) (Ramagoni et al. 2007)

		(Rodd and Chesham, 1997) (Onyeaso, 2004)		(Nachman et al., 1965) (Miller et al., 2016) (Bastian et al., 2020)
	2	**Believe there is no reason to wear a mouthguard** (Sethi et al., 2016) (Alomer et al., 2022)		(Chapman and Nasser, 1996) (Cornwell et al., 2003) (Rodd and Chesham, 1997) (Galic et al., 2018) (Onyeaso, 2004)
	3	**Belief that without having an injury mouthguard use not needed** (Sethi et al., 2016) (Upson, 1982) (Alomer et al., 2022)		(Guinot and Manrique, 2021) (Alomer et al., 2022)
	12	**Unnecessary/not important to wear a mouthguard** (Emerich and Nadolska-Gazda, 2013) (Goswami et al., 2017) (Persic et al., 2006) (Perunski et al., 2005a) (Dhindsa et al., 2019) (Yamada et al., 1998) (Fakhruddin et al., 2007a) (Cornwell et al., 2003) (Galic et al., 2018) (Collins et al., 2015) (Guinot and Manrique, 2021)	1	**Belief mouthguards are necessary** (Yamada et al., 1998)
			2	**Belief wearing a mouthguard during sports should be compulsory** (Brebner and Marshall, 1977) (Chapman and Nasser, 1996)

		(Alomer et al., 2022)		
	1	**Preferred playing without mouthguard** (Nachman et al., 1965)		
	1	**Not needed during practice as play not as intense as in competition** (Miller et al., 2016)		
Intentions (12)	5	**Never thought of using a mouthguard** (Sethi et al., 2016) (Bastian et al., 2020) (Maestrello-deMoya and Primosch, 1989) (Cornwell et al., 2003) (Alomer et al., 2022)	5	**Willingness to wear a mouthguard** (Morton and Burton, 1979) (de Wet et al., 1981) (Spinas and Savasta, 2007) (Rodd and Chesham, 1997) (Alomer et al., 2022)
	6	**Limited willingness to wear a mouthguard** (Matalon et al., 2008) (DeYoung et al., 1994) (de Wet et al., 1981) (Rodd and Chesham, 1997) (Chapman and Nasser, 1996) (Alomer et al., 2022)		
Memory, attention, and decision process (8)	6	**Lost the mouthguard** (Rosenberg, 1963) (Nachman et al., 1965) (Matalon et al., 2008)		

		(Miller et al., 2016) (Godwin et al., 1982) (de Wet et al., 1981)		
	4	**Forget to wear mouthguard** (Matalon et al., 2008) (Miller et al., 2016) (Bastian et al., 2020) (de Wet et al., 1981)		
Environmental context and resources (30)	8	**Wear and fit problems (biting or chewing/cutting)** (Rosenberg, 1963) (Eroglu et al., 2006) (Morton and Burton, 1979) (Godwin et al., 1982) (Yamada et al., 1998) (Bastian et al., 2020) (de Wet et al., 1981) (Chapman and Nasser, 1996)	2	**Did not have any problem** (Sethi et al., 2016) (Alomer et al., 2022)
			1	**Comfortable to wear** (Miller et al. 2016)
			1	**No complaints of gagging** (Godwin et al., 1982)
			1	**No complaints of taste** (Godwin et al., 1982)
	20	**Discomfort/uncomfortable/bother the player** (Rosenberg, 1963) (Sethi et al., 2016) (Emerich and Nadolska-Gazda, 2013) (Goswami et al., 2017) (Morton and Burton, 1979)	1	**No complaints of irritation** (Godwin et al., 1982)
			1	**No complaints of speech** (Godwin et al., 1982)

		(Matalon et al., 2008) (Miller et al., 2016) (Yamada et al., 1998) (Bastian et al., 2020) (Upson, 1982) (de Wet et al., 1981) (Maestrello-deMoya and Primosch, 1989) (Raaii et al., 2011) (Chapman and Nasser, 1996) (Tanaka et al., 2015) (Spinas et al., 2014) (Fakhruddin et al., 2007a) (Cornwell et al., 2003) (Galic et al., 2018) (Alomer et al., 2022)		
	7	**Nausea/retching/gagging/feel sick** (Rosenberg, 1963) (Eroglu et al., 2006) (Upson, 1982) (de Wet et al., 1981) (Tanaka et al. 2015) (Yamada et al., 1998) (Morton and Burton, 1979)		
	24	**Interference with breathing** (Rosenberg, 1963)		

		(Sethi et al., 2016) (Emerich and Nadolska-Gazda, 2013) (Nachman et al., 1965) (Eroglu et al., 2006) (Morton and Burton, 1979) (DeYoung et al., 1994) (Persic et al., 2006) (Perunski et al., 2005a) (Dhindsa et al., 2019) (Yamada et al., 1998) (Bastian et al., 2020) (Upson, 1982) (de Wet et al., 1981) (Maestrello-deMoya and Primosch, 1989) (Raaii et al., 2011) (Chapman and Nasser, 1996) (Tanaka et al., 2015) (Spinas and Savasta, 2007) (Fakhruddin et al., 2007a) (Cornwell et al., 2003) (Galic et al., 2018) (Collins et al., 2015) (Alomer et al., 2022)		
	23	**Interference with speech/communication** (Rosenberg, 1963) (Sethi et al., 2016)		

		(Emerich and Nadolska-Gazda, 2013) (Nachman et al., 1965) (Eroglu et al., 2006) (Morton and Burton, 1979) (DeYoung et al., 1994) (Persic et al., 2006) (Perunski et al., 2005a) (Miller et al., 2016) (Dhindsa et al., 2019) (Yamada et al., 1998) (Bastian et al., 2020) (Upson, 1982) (de Wet et al. 1981) (Maestrello-deMoya and Primosch, 1989) (Raaii et al., 2011) (Tanaka et al., 2015) (Fakhruddin et al., 2007a) (Cornwell et al., 2003) (Galic et al., 2018) (Collins et al., 2015) (Alomer et al., 2022)		
	3	**Bad taste or odour** (Rosenberg, 1963) (Nachman et al., 1965) (Yamada et al., 1998)		

	7	**Dryness** (Rosenberg, 1963) (Nachman et al., 1965) (Eroglu et al., 2006) (Morton and Burton, 1979) (Upson, 1982) (de Wet et al. 1981) (Spinas et al., 2014)		
	8	**Expensive/cost** (Sethi et al., 2016) (Nachman et al., 1965) (Goswami et al., 2017) (Maestrello-deMoya and Primosch, 1989) (Fakhruddin et al., 2007a) (Cornwell et al., 2003) (Onyeaso, 2004) (Alomer et al., 2022)		
	9	**Feeling loose/retention/fixing problem/ instability** (Sethi et al., 2016) DeYoung et al. 1994) (de Wet et al., 1981) (Maestrello-deMoya and Primosch 1989) (Raaii et al., 2011) (Upson, 1982)		

		(Eroglu et al., 2006) (Yamada et al., 1998) (Alomer et al., 2022)		
	1	**Abnormal tissue reaction** (Nachman et al., 1965)		
	1	**Lack of storage place for mouthguard** (Nachman et al., 1965)		
	4	**Too bulky/foreign body sensation** (Morton and Burton, 1979) (DeYoung et al., 1994) (Spinas et al., 2014) (Tanaka et al., 2015)		
	2	**Swallowing/drinking problems** (Morton and Burton, 1979) (Nachman et al., 1965)		
	1	**Too tight** (DeYoung et al., 1994)		
	1	**Not provided by authorities** (Dhindsa et al., 2019)		

	1	**Affects concentration** (Yamada et al., 1998)		
	6	**Pain/soreness/irritation in Tooth/gingiva/muscle/ pressure/jaw fatigue** (Yamada et al., 1998) (Tanaka et al., 2015) (Nachman et al., 1965) (Spinas and Savasta, 2007) (Rosenberg, 1963) (DeYoung et al., 1994)		
Social influence (15)	8	**Lack of encouragement/No effort from Coaches/parents/dentists/teachers/sport group about mouthguard** (Rosenberg, 1963) (Sethi et al., 2016) (Ramagoni et al., 2007) (Goswami et al., 2017) (Spinas and Savasta, 2007) (Fakhruddin et al., 2007a) (Collins et al., 2015) (Bhadana et al., 2015)	8	**Awareness/Advice of mouthguard use by media/parents/dentist/coaches/officials/ friends/club/team member/school/another player** (Ramagoni et al., 2007) (Nachman et al. 1965) (Miller et al., 2016) (Bastian et al., 2020) (Spinas and Savasta, 2007) (Cornwell et al., 2003) (Collins et al., 2015) (Guinot and Manrique, 2021)
	3	**Friends/teammates do not or hardly ever wear mouthguards** (Bastian et al., 2020)	1	**Looked cooler** (Miller et al., 2016)

		(Cornwell et al., 2003) (Collins et al. 2015)	1	**Know other people who wear a mouthguard** (Cornwell et al., 2003)
	2	**Lack of mandatory rule requiring that mouth protectors by governing bodies/authorities** (Rosenberg, 1963) (Ramagoni et al., 2007)		
Emotions (4)	3	**Did not like wearing mouthguard** (Emerich and Nadolska-Gazda, 2013) (Yamada et al., 1998) (Maestrello-deMoya and Primosch, 1989)	1	**Favourable feelings towards mouthguards** (Yamada et al., 1998)
	1	**Embarrassment** (Matalon et al., 2008)		
Un-codable (10)	1	**Durability** (Maestrello-deMoya and Primosch, 1989)		
	6	**Aesthetic/esthetic** (Perunski et al., 2005a) (Dhindsa et al., 2019) (Galic et al., 2018) (Ramagoni et al., 2007) (Persic et al., 2006) (Eroglu et al., 2006)		
	3	**Appearance issues**		

		(Tanaka et al., 2015) (Fakhruddin et al., 2007a) (Alomer et al., 2002)		
	1	**Saliva** Yamada et al. 1998)		

7.6 Appendix 6: PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Cover Page
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	127
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	IV
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	21
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	22-23
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	23-24
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	23-24
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	24-25
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	25-26
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	22-26
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	22-26
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	27
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	27

Section and Topic	Item #	Checklist item	Location where item is reported
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	NA
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	NA
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NA
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	25-26
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	29
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	30
Study characteristics	17	Cite each included study and present its characteristics.	31-44
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	63-69
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	46-49
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Table 3-11-12
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA

Section and Topic	Item #	Checklist item	Location where item is reported
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	63-64
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	73-74
	23b	Discuss any limitations of the evidence included in the review.	79
	23c	Discuss any limitations of the review processes used.	-
	23d	Discuss implications of the results for practice, policy, and future research.	85
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	22
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	22
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	-
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	III , 24
Competing interests	26	Declare any competing interests of review authors.	-
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	-

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

7.7 Appendix 7: PRISMA 2020 For Abstract Checklist

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesise results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	No
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			

Section and Topic	Item #	Checklist item	Reported (Yes/No)
Funding	11	Specify the primary source of funding for the review.	No
Registration	12	Provide the register name and registration number.	Yes

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71