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Systematic Review

Global prevalence, risk factors, and reporting practice of needlestick and sharps injuries among dental students: a systematic review and meta-analysis

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SUMMARY

Background: Dental students are vulnerable to needlestick injuries (NSIs) due to their inadequate training. However, the global prevalence of NSI among dental students is unknown.

Aim: To determine the pooled prevalence among dental students, epidemiological profile, and risk factors for NSI.

Methods: A systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The review protocol was registered at the International Prospective Register of Systematic Reviews (CRD 42022312778). Eligible studies were identified from PubMed, Scopus, Web of Science, Embase, OVID, and EBSCO databases. A meta-analysis with a random effects model was performed to estimate the pooled prevalence, and meta-regression was conducted to explore heterogeneity among studies.

Findings: A total of 25 studies from 15 countries met the inclusion criteria. The estimated pooled prevalence of NSI among dental students was 44% (95% confidence interval: 38–51%). Local anaesthesia, tooth cleaning or scaling, and waste disposal were associated with highest risk for NSI. Most studies observed under-reporting of NSI. Dental students had inadequate knowledge regarding post-exposure management.

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Conclusion: Dental students had a high prevalence and low reporting rate of NSI exposure. Inadequate knowledge might increase the probability of NSI exposure.

Introduction

Needlestick injury (NSI) is one of the most common occupational hazards in healthcare. NSI is defined as 'any needlestick injury, cut, abrasion, instrument puncture, or exposure to blood or other body fluids, such as splashes into the eyes, nose, mouth, or broken skin' [1]. Contaminated NSI can transmit serious infectious diseases, including more than 25 bloodborne virus infections [2]. Globally, each year NSIs are responsible for 16,000, 66,000, and 1,000 infections with hepatitis C, hepatitis B, and human immunodeficiency viruses, respectively [3].

Compared to other healthcare workers, dental professionals are at higher risk for acquiring occupational infections because they use sharp devices under a restricted-visibility workfield [4]. Dental students are particularly vulnerable to NSI because of their insufficient professional skills and experience, and lack of assistance during procedures [5,6]. Dental students are more likely to sustain NSI compared to well-trained staff [7,8]. Most previous studies have demonstrated under-reporting of NSI, with dental students frequently unaware that NSI exposures should be reported to the designated authority. Therefore, they might not receive appropriate and timely post-NSI management [6]. The 'Profile and Competencies for the Graduating European Dentist' document states that dental graduates must be competent at implementing cross-infection control in their practice [9]. However, dental students have inadequate education and experience regarding NSI exposure [10].

Although dental students are at high risk of NSI, the lack of reliable estimates regarding the prevalence of NSI in dentists hinders the implementation and evaluation of preventive measures. Thus, identifying the global prevalence of, and risk factors for, NSI among dental students is essential to design interventions to prevent NSI. This systematic review and meta-analysis estimates the pooled prevalence and risk factors of NSI among dental students, and considers the currently available preventive methods.

Methods

The literature search, the study selection, and the data extraction and reporting of the results were performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [11]. The review protocol was registered at the International Prospective Register of Systematic Reviews (CRD42022312778).

Search strategy

A comprehensive literature search for studies published in English was performed in February 2022. PubMed, Scopus, Web of Science, Embase, OVID, and EBSCO (MEDLINE, Dentistry & Oral Sciences Source) databases were searched. The search strings of the structured terms in the Medical Subjects Headings dictionary were combined using Boolean functions: (needle injur* OR needlestick injur* OR needle stick injur* OR needle-stick injur* OR sharp*injur* OR percu*injur* OR percutaneous exposure* OR occupation*injur* OR occupation*exposure OR accident*exposure OR accidental occupational exposure OR body fluid*-exposure OR occupational hazard* OR occupational transmission OR cross infection) AND (dental OR stomatolog*) AND (student* OR undergraduate* OR postgraduate* OR intern* OR trainee* OR teaching OR school) AND (rate* OR risk* OR ratio*). Additional articles, including those in the grey literature, were identified by screening the reference lists of eligible articles.

Eligibility criteria

Two researchers independently screened studies according to the inclusion and exclusion criteria. Then the studies were reviewed on the basis of their titles, abstracts, and full text. Any disagreement between the researchers was resolved by discussion and consultation with a third researcher, if required. The full-text version was screened to confirm the eligibility of articles. Because of likely changes in dental education and dental practice in recent decades, only articles published between 2000 and 2022 were considered.

Observational studies were included if they provided quantitative estimates of the prevalence and causes of NSI among dental students. Studies in which NSI prevalence was reported in a mixed healthcare worker population (dental students and staff, assistants, residents, and surgeons) where NSI prevalence among dental students was not reported or could not be calculated were excluded. Studies including surveillance data as part of case reports, case series, review articles, short communications, personal opinions, letters to the editor, posters, conference abstracts, and qualitative studies were excluded.

Study selection and data extraction

The identified articles were imported into EndNote software (version X9) and duplicate files were removed. Two investigators (H.J. and X.H.) independently screened articles based on their titles, abstracts, and full-text versions according to the predetermined eligibility criteria. Data from the eligible articles were extracted using a checklist, which consisted of the first author's name, publication year, country, study population, sample size, sex, NSI prevalence, reporting rate, and related factors. Two independent investigators (H.J. and L.Y.) extracted the data from each article. The extracted data were cross-checked to confirm the accuracy of data. Disagreements in the extracted content were resolved through a detailed review of the article and discussion.

Publication bias and quality assessment

The Joanna Briggs Institute's (JBI) critical appraisal framework for studies reporting prevalence data was used to determine the heterogeneity within the studies [12]. Two reviewers (H.J. and L.Y.) assessed the quality of studies, and a third

reviewer (X.H.) was consulted in cases of ambiguity. The studies were assigned high, moderate, or low risk of bias if they fulfilled 3, 4–6, and 7–9 criteria, respectively. Heterogeneity of data was quantified using I^2 index statistics, wherein a value >75% indicated high heterogeneity.

Statistical analysis

The study outcomes were prevalence among dental students, associated procedures and instruments, and reporting rates for NSI. Relative risks with appropriate 95% confidence intervals (CIs) were used to calculate the effects in studies. A meta-analysis with a random effects model was performed to estimate the pooled NSI prevalence rate. A funnel plot was constructed to summarize the results. Meta-regression analysis was performed to evaluate the association between NSI prevalence rate and publication year of the selected studies. Egger's regression statistics were used to evaluate heterogeneity within the studies. The analyses were performed using RevMan 5.4 software. $P < 0.05$ was considered statistically significant.

Results

A total of 1754 articles were identified from the databases. After exclusion of duplicate reports, 1360 articles remained. Review of the titles and abstracts excluded a further 1309 articles; full-text versions of the remaining 51 articles were screened. Twenty-seven of these were excluded because they were review articles, short communications and aggregate reports of NSI data; ultimately, 24 articles fulfilled the eligibility criteria. One additional article was identified through manual searching [13], so that ultimately 25 articles were included in the analysis (Figure 1). Among studies that investigated NSI prevalence among different healthcare professional groups, only those that reported discrete data for dental students were analysed [14,15]. Studies based on surveillance records were excluded due to a high under-reporting rate, which may have led to underestimation of the total number of NSIs [4,16].

Characteristics of included studies

All 25 studies had a descriptive observational study design and used self-administered questionnaires for data collection. The general characteristics of the included studies are presented in Table I. The sample sizes varied considerably, ranging from 72 [17] to 334 [18]. The majority of included studies achieved a response rate of >70%, and several achieved a 100% response rate [18–22]. Only one study reported a very low (28%) response rate [23]; for two studies the response rate was not reported, and could not be calculated [24,25].

A total of 5506 dental students were surveyed. Two studies (441 dental students) did not report the sex ratio of participants [15,18]. The remaining studies included 2250 males and 2815 females. Seven studies did not report participant age [6,10,18–20,24,26]; the ages of the participants in the remaining studies ranged from 20 to 29 years.

The majority of included studies were conducted in developing countries, with only four in developed countries (UK and USA) [6,19,20,23]. Several studies investigated NSI prevalence combined with the knowledge, attitude, and practice for

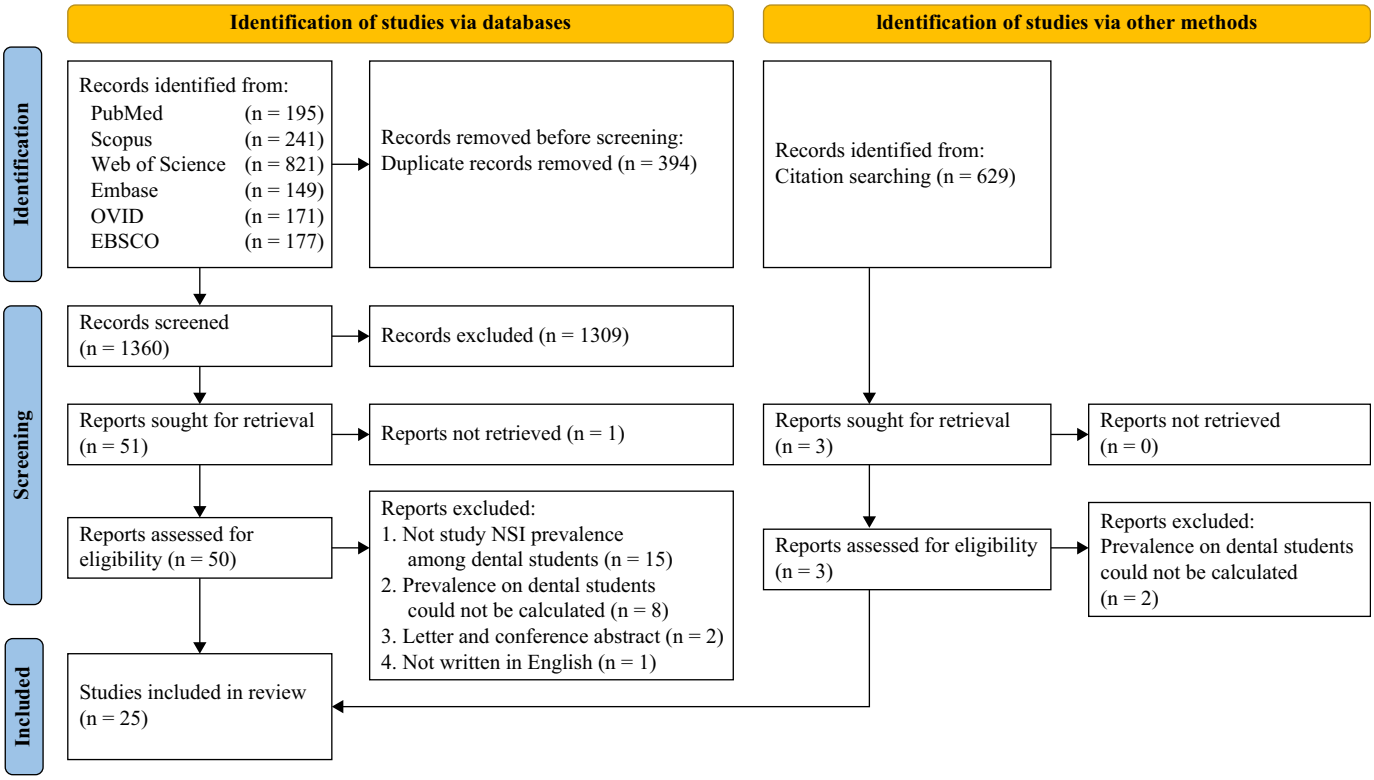

Figure 1. The PRISMA flow diagram of literature search, screen, and selection criteria.

Table I
Summary of descriptive characteristics of included articles in the meta-analysis of the prevalence of needlestick injury among dental students ($N = 25$)

First author	Year	Country/ region	Student sample population	Effective response rate	Gender		Age (years)	NSI prevalence	Report rate	Procedures involved	Instruments involved	Related factors
					Male	Female						
Huang [32]	2022	China	298	90.0%	104	164	25	36.2%	73.2%	Local anaesthesia 15.2% Cleaning or scaling 15.2% Endodontic treatment 11.6% Restorative treatment 10.7% Surgical suture 9.8% Disposal of wastes 9.8% Surgical exodontia 8.9% Chair-side assistance 8.9%	Syringe needle 25.0% Dental bur 23.2% Ultrasonic chip 14.3%	Insufficient clinical experience/ skills. Lack of appropriate chair-side assisting. Stress and fatigue.
Musekene [33]	2020	South Africa	256 2^{rd}, 3^{rd}, 4^{th}, 5^{th} year	99%	107	141	24 ± 4	41%	92%	Injecting 34% Scaling and polishing 26%	Syringe needles 52% Scalers 31%	Lack of concentration 36% Anxiety 19% Lack of experience 13% Fatigue 10% Lack of training 6%
Madhumitha [24]	2019	India	NR 3^{rd}, 4^{th} year	100 students	48	52	NR	70%	34%	Recapping of needle ≈60% Disposal of needles ≈20% Suturing ≈8%	NR	Recapping of needle. Disposal of needle.
Ravoori [27]	2018	India	218 3^{rd}, 4^{th} year	89.9%	70	126	22.4 ± 2.1	44.4%	NR	Injection 36.7% Recapping needle 29.6% Bending needles 15.3% Suturing 15.8%	NR	Careless attitude 49% Stress 36.2% Overburden 14.8%

Hbibi [28]	2018	Morocco	117 5th year	70.9%	14	69	22.93	42.7%	40%	Recapping needle 41.7% Disassembling 19.4% Cleaning instruments 16.7%	NR	Oral surgery 51% Restorative dentistry 17% Periodontology 10.6%
Gilavand [22]	2018	Iran	124	100%	84	40	<25, 58.1%	45.2%	NR	NR	Needle 17.9% Splash 8.9% Both 17.9%	Significant relation with year of admission, academic semester, and educational environment
Al-Essa [26]	2017	Saudi Arabia	363 3rd, 4th, 5th year	83.4%	156	147	NR	65%	NR	NR	Needle 21.1% Bur 21.1% Endodontic file 18.2%	More common in 5th year students
Wu [10]	2016	China	88 undergraduates 118 graduates	83%	59	104	NR	34%	1.8%	Inserting/ removing burs 48% Mucous exposure 38%	Burs	No significant relation with sex and educational grade
Pinelli [31]	2016	Brazil	228 3rd, 4th, 5th year	75.9%	49	124	22	40%	47.9%	Puncture/cut/ abrasion 56.3% Mucous exposure 25.4%	NR	Significant correlation with academic year, age, and gender. No significant correlation with dominant hand and use of protective eyewear.
Kuma [25]	2016	India	NR 3rd, 4th, 5th year	100	57	43	NR	35%	85%	NR	NR	Only 37% knew about universal precaution guidelines
Al-Maweri [34]	2015	Saudi Arabia	600 4th, 5th, 6th year	85%	235	277	23 ± 3.28	34.2%	NR	NR	Needle 14.8% Endodontic file 6.9% Bur 6.7%	Significant differences between students in different years of study

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Table I (*continued*)

First author	Year	Country/ region	Student sample population	Effective response rate	Gender		Age (years)	NSI prevalence	Report rate	Procedures involved	Instruments involved	Related factors
					Male	Female						
Shaghaghian [21]	2015	Iran	191 4th, 5th, 6th year	100%	85	106	24.8	43.5%	6.4%	Recapping 19.4% Injection 13.6%	Needle 38.8% Endodontic file 24.3% Lab knife 13.6% Dental probe 6.8% Elevator 6.8%	Finger injuries 91.3%
Halboub [36]	2015	Yemen	204 4th, 5th year	72%	41	104	23.13 ± 1.68	62.8%	NR	NR	Explorer 18.6% Needle 11.7%	Longer clinical exposure for 5th year students
Kuru [18]	2014	Turkey	334 3rd, 4th, 5th year	100%	NR	NR	NR	71.9%	<4%	Cleaning instruments 27% Local anaesthesia 25% Endodontic treatment 23%,	Probe 36% Needle 27% File 22% Orthodontic wire 21%	NR
Sedky [38]	2013	Egypt	350 4th, 5th year	90%	158	157	21.46 ± 0.93	61.9%	4th year: 40.00% 5th year: 46.43%	NR	NR	NR
Myers [6]	2012	USA	305	72.1%	117	103	NR	16.3%	NR	University hospital 75.7% Affiliate hospital 13.5% Operating room 10.8%	Sharp object 62.5% Needle 25.0%	NR
Jaber [13]	2011	United Arab Emirates	250	92%	64	166	20	23%	39.6%	Recapping a needle 26% Scaling and polishing 21% Local anaesthesia 13%	NR	NR
Mungure [17]	2010	Kenya	72 Undergraduates + postgraduates	81%	33	29	24 ± 4.1	29%	39%	Local anaesthesia 36% Scaling 23% Recapping needles 18% Clearing up 18%	NR	NR

Machado [29,30]	2007/2008	Brazil	331 Final 3 years	86.4%	95	191	22.4 ± 2.4	29.0%	28.1%	Cutaneous exposure 34.3% Mucous exposure 6.6% Percutaneous exposure 29.0%	Hollow-bore needle 10.1% Suture needle 2.8% Probe 8.4% Excavator 11.5% Drill 5.2%	No significant association with age or gender
Sofola [1]	2007	Nigeria	181	84.5%,	91	62	>26 years 52.6%	58.8%	None formally reported.	Scaling & polishing 44.40% Local anaesthesia 34.40% Washing instruments 25.60%	Puncture 46.7% Splash to eyes 26.7% Splash of blood 16.7% Cuts 7.7% Abrasions 2.2%	No significant association with sex, age, and location of school. 76.5% reported working unassisted.
Smith [15]	2006	West Indies	107 3rd, 4th, 5th, and interns	79%	NR	NR	78% within 20—29 years	45%	13%	NR	Scaler 36% Needle 18% Bur 18% Ultrasonic tip 18%	NR
Stewardson [20]	2004	UK	185 93 199 176 (four dental schools, 3rd, 4th, 5th year)	100% 80% 86% 78%	89 24 79 73	96 50 92 64	NR	40% 12% 22% 27%	62% 57% 47% 72%	Local anaesthesia Tooth cleaning + root planning Use of dental handpiece Disposal of sharps	NR	No significant association with sex, dominant hand, use of protective glasses or time of day. Slightly more exposures in males, right-handed students, and in the afternoon. A significant decrease within final year, and with assistance.

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Table I (*continued*)

First author	Year	Country/ region	Student sample population	Effective response rate	Gender		Age (years)	NSI prevalence	Report rate	Procedures involved	Instruments involved	Related factors
					Male	Female						
Al-Sarheed [35]	2004	Saudi Arabia	266 3^{rd}, 4^{th}, 5^{th} year	90.9%	123	118	18–28	68%	3^{rd} year 47.7% 4^{th} year 31% 5^{th} year 25%	Cavity preparation 14.9% Cleaning unit 12.4% Puncture 21.5%	NR	No significant association with age, gender, and dominate hand. More exposures in female students. Decrease exposures when assisted.
Kotelchuck [23]	2004	USA	720 3^{rd}, 4^{th} year	28%	107	95	29.5	32.8%	30%	NR	NR	Felt rushed 49% Needle, instrument, or device faulty/ defective 10% New/ unfamiliar procedure 7% Not enough training 6% Didn't follow correct protocol 6%
Stewardson [19]	2002	UK	185 3^{rd}, 4^{th}, 5^{th} year	100%	88	95	NR	39.9%	68.1%	Local anaesthesia 24.3% Clean up 20% Tooth cleaning 18.6%	NR	NR

NR, not reported.

occupational exposure and hepatitis B virus vaccination [6,10,26–28]. Machado *et al.* [29,30] published two articles based on the same survey of Brazilian dental students; however, these data were included in the analysis only once.

The survey duration was not clearly stated in most articles. Two studies reported NSI from the beginning of dental courses to the time of investigation [19,31], while another two distributed questionnaires to dental students at the end of their clinical training [20,28]. Only one survey was conducted exclusively within an academic year [23].

NSI prevalence among dental students

NSI prevalence among dental students varied significantly between countries, ranging from 11.25% in India [14] to 71.9% in Turkey [18]. The meta-analysis using a random effects model indicated a pooled NSI prevalence estimate of 44% (95% CI: 38–51%; Figure 2). The meta-regression analysis showed no significant association between NSI prevalence and publication year ($P = 0.679$), with NSI prevalence remaining relatively stable over the past two decades (Figure 3).

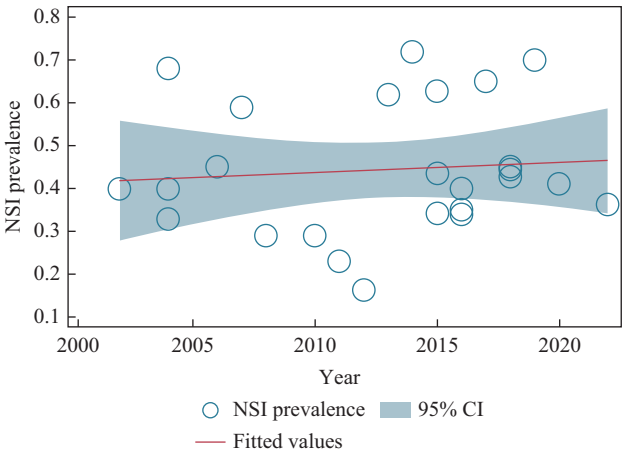

Figure 3. Meta-regression analysis of NSI prevalence based on publication years.

Associated procedures and instruments

Administration of local anaesthesia was associated with the highest rate of NSI [17,19,20,27,32,33], whereas recapping syringe needles accounted for the largest proportion of NSI [13,21,24,27,28]. Substantial proportions of NSI occurred during tooth cleaning, scaling, and polishing [1,19,20,33]. Disposal of contaminated instruments was associated with an exposure rate of 16.7–27% [1,17,18,28].

The highest NSI risk occurred with use of syringe needles [21,22,26,32–34], followed by dental burs, ultrasonic chips, scalers, and endodontic files [15,26]. Most NSIs occurred in the departments of oral surgery, periodontology, and endodontology [28,33]; NSI rarely occurred in orthodontics departments. Only one study reported an NSI prevalence of 21% due to the use of orthodontic wire [18].

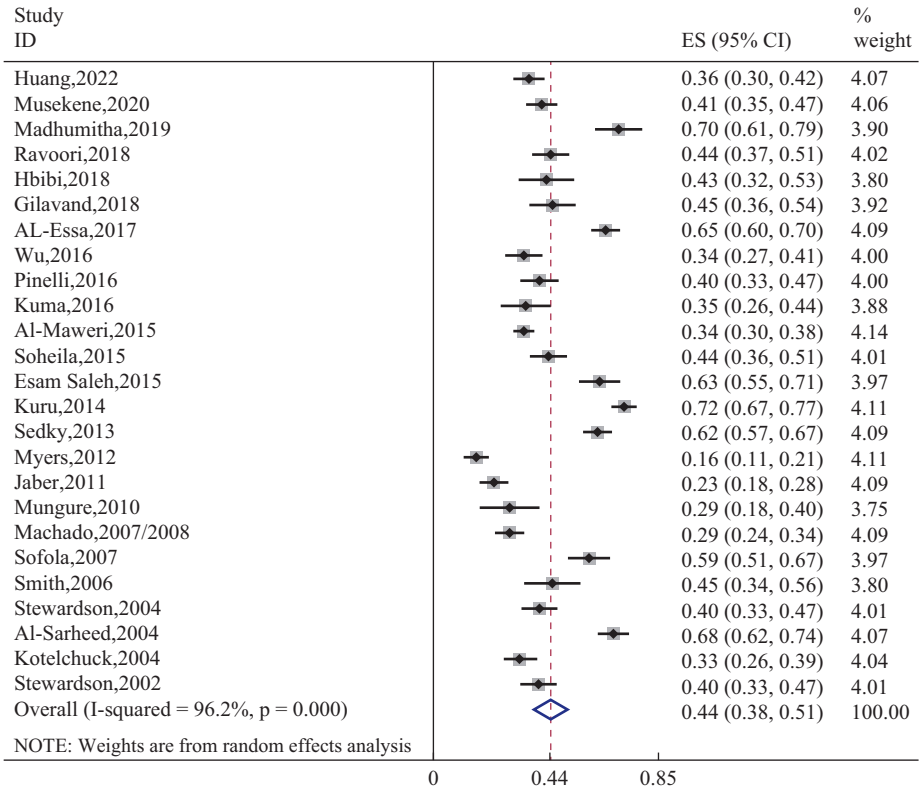

Figure 2. Meta-analysis of the pooled needlestick injury (NSI) prevalence among dental students using random effects model. CI, confidence interval.

Risk factors

Risk factors were divided into the following categories.

Demographic factors

Two studies reported that a higher proportion of NSI occurred in females [31,35], although in most studies there was no significant association with the sex [1,10,17,19,20,22,30]. Likewise, there was no association with the age of students [1,30]. There was a trend towards more risk of NSI exposure in right-handed students, but this was not statistically significant [19,20,31,35]. NSI occurred more frequently among senior than junior students [36]. A significant correlation was observed between number of NSI exposures and course year [19,22,26,31,33,34].

Knowledge, attitude, and practice factors

Several studies investigated knowledge, attitude, and practices towards occupational exposure or infection control among dental students [6,10,24,25,27,28,34,36]. Lack of training was reported as one of the main reasons for NSI exposures [23,33]. Only 37% of dental students were aware of universal precaution guidelines, while only 18.75% were aware of the correct method of using soap and water after exposure [14,25]. Up to 63% of dental students did not have adequate knowledge on the proper method of needle disposal [24]. Almost 49% and 6% of exposures were ascribed to carelessness [27] or lack of protocol adherence, respectively [23].

Technical factors

In an Indian study, up to 60% of exposures were related to needle recapping [24], compared to 18% [17], 19.4% [21], 26% [13], 29.6% [27], and 41.7% [28] in other studies. Students using two-handed recapping technique had two-fold higher risk for percutaneous injuries than those who avoided recapping or who recapped using a single hand [37]. Thus, needle recapping should be avoided or only performed using a needle capping device [14,18].

Psychological factors

The risk of exposure was higher among dental students with higher stress (36.2%) and excessive work (14.8%) [27]. Up to 49% of exposures occurred due to 'feeling rushed' [23]. A recent study published in 2022 reported that 'lapse in concentration' (67.9%) was the most common reason for NSI, followed by 'fatigue' (22.3%) and 'lack of time' (18.8%) [32]. Similarly, a study from 2020 reported that 'lack of concentration' (36%) and 'anxiety' (19%) were the more frequent contributing factors to NSI [33].

Teaching factors

In a Nigerian dental school, 76.5% of NSI occurred when the students were working unassisted [1]. Similar findings were reported from UK dental students [19,20]. The frequency of NSI was higher when there was no chair-side assistance than when there was assistance [32,35].

Post-exposure management

Worldwide, dental students have a high prevalence of NSI non-reporting or under-reporting. In Nigerian dental schools, none of the 90 NSI cases was formally reported [1]. In a Chinese study of two dental schools, only one out of the 56 exposures was reported [10]. Two studies from the Middle East reported that only 4—6.4% of NSIs were reported [18,21]. Most studies with a low reporting rate were conducted in developing countries, whereas studies from developed countries demonstrated higher reporting rates [19,20]. A study of 101 cases from South Africa demonstrated the highest reporting rate of 92% [33]. Other studies did not mention the reporting rate [1,6,22,26—29,38].

The major reasons for non-reporting were that the dental students considered the injury to be insignificant [18,23,24,29] or were afraid of stigmatization and consequences [13,17,33]. In Iran, the main reason for under-reporting was that the students were not aware that all NSIs should be reported [21]. In a Nigerian study, up to 90% of dental students were unaware of guidelines or protocol regarding post-exposure management, which resulted in no reports [1]. Similarly, a study conducted in the United Arab Emirates reported that only 47.8% of students were aware of the protocol for NSI post-exposure management [13].

Several studies reported that blood tests were performed among exposed students; however, prophylactic management after NSI was rarely reported. In a South African study, only 5% of the exposed students were tested for bloodborne infections [33].

Heterogeneity and publication bias

The JBI assessment tool for the methodological quality of studies showed a low and moderate risk for bias in 21 and four studies, respectively (Figure 4). High heterogeneity was observed across the 25 estimates ($P < 0.001$, $I^2 = 96.2\%$).

Heterogeneity among the studies was evaluated using funnel plots. The symmetrical distribution indicates a low possibility of publication bias (Figure 5). This outcome was confirmed by Egger's weighted regression statistics. In the Egger plot, the 95% CI included 0 (−7.16 to 10.25) and the result was not significant ($P = 0.717$), which implies that there was no publication bias (Figure 6).

Discussion

Dental practice requires certain skills because of difficult access and poor visibility during procedures in a complex anatomical structure. Aerosol production increases the spread of contagious pathogens. Hence, effective infection control procedures are fundamental in preventing pathogen transmission. Nevertheless, even qualified dentists may not follow recommended guidelines [39]. Dental students are particularly vulnerable to NSI [32]. The procedures and factors that increase NSI risk are identified in the present review, which may aid the development of preventive strategies by increasing awareness of its risk factors [20].

Various procedures and instruments are associated with NSI, e.g. administration of local anaesthesia (including needle recapping, disassembling, and bending), periodontics treatment (including tooth cleaning, polishing, scaling, and root planning), restorative treatment (inserting and removing dental burs), waste disposal, washing instruments, surgical suturing during exodontia, endodontic treatment using various files, and chair-side assistance. The most frequent procedures associated with NSI were the administration of local

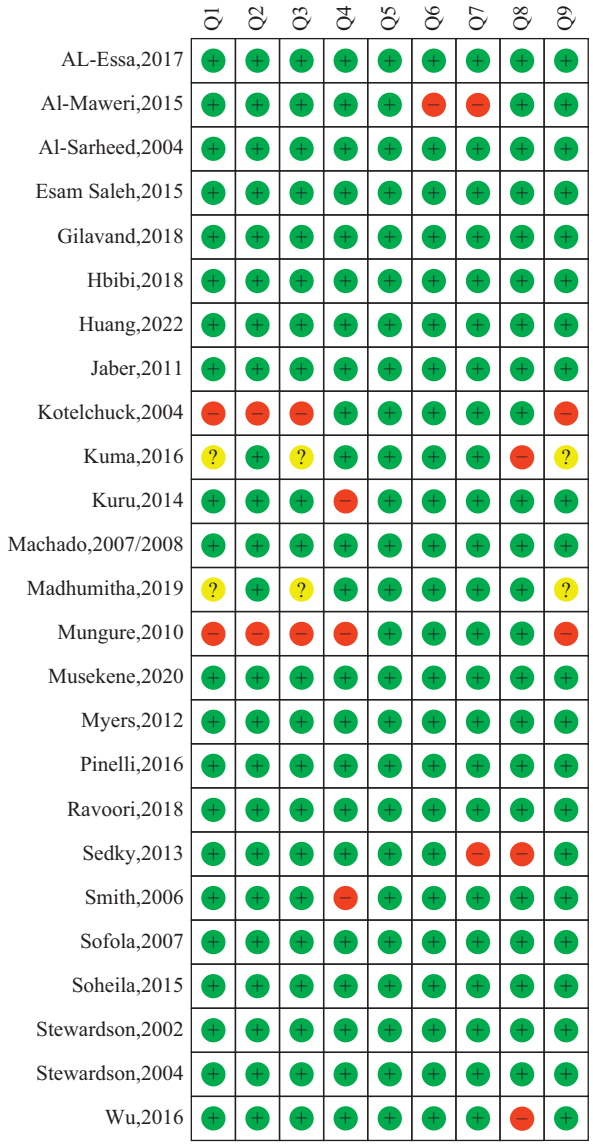

Figure 4. Risk of bias assessment by the Joanna Briggs Institute checklist for prevalence studies. Q1: Was the sample frame appropriate to address the target population? Q2: Were study participants sampled in an appropriate way? Q3: Was the sample size adequate? Q4: Were the study subjects and the setting described in detail? Q5: Was the data analysis conducted with sufficient coverage of the identified sample? Q6: Were valid methods used for the identification of the condition? Q7: Was the condition measured in a standard, reliable way for all participants Q8: Was there appropriate statistical analysis? Q9: Was the response rate adequate, and if not, was the low response rate managed appropriately? +, yes; −, no; ? unclear.

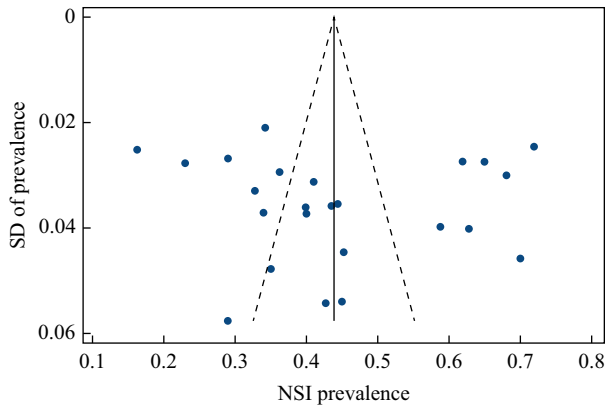

Figure 5. Funnel plot with pseudo 95% confidence limits to assess publication bias for the prevalence of needlestick injury (NSI) among dental students.

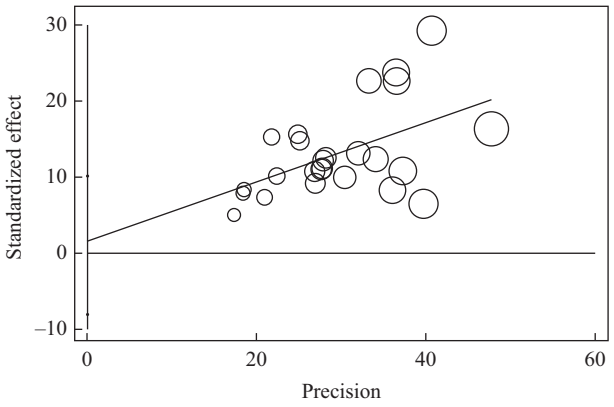

Figure 6. Publication bias assessment using Egger's regression test.

anaesthesia, tooth cleaning, scaling, and waste disposal [1,17—21,24,27,28,33]. Overall, needle recapping was the most common factor associated with NSIs, particularly when the two-hand technique is used.

Numerous risk factors for NSI have been described in individual studies, but no general agreement on these has been reached. It is usually considered that young students have greater risk of NSI due to their inexperience. However, some studies have shown greater NSI exposure in senior students [26,28,36], likely attributed to the greater workload and clinical exposure of these students. Knowledge about NSI may also influence the related attitudes and behaviours. Inadequate knowledge of infection control might predispose dental students to occupational injury [6,10,24,25,27,28,36]. Insufficient clinical experience and skills, as well as practising unfamiliar procedures, might also increase the risk for NSI [1,32,33]. High levels of stress, anxiety, fatigue, and burn-out have been reported among dental students; these same factors may also predispose to NSI. The high frequency of NSI among fifth-year dental students might indicate increased stress levels [28]. Appropriate chair-side assistants may improve the training efficiency and protection of students. However, students frequently work without assistance due to staff shortages, predisposing them to NSI [1,19,20,32,35].

A low NSI reporting rate was observed among dental students. Up to 90% of NSI cases were not reported, indicating that the actual number of NSI exposures might be underestimated [1,10,18,21]. Dental students were unclear regarding the reporting protocol and/or were embarrassed to report incidents [18,24,29]. High workload and time-consuming reporting procedures may also discourage NSI reporting [13,33]. The high

under-reporting rate may contribute to inaccurate data and inappropriate post-exposure management for affected students [6].

The present review found that the NSI prevalence among dental students was alarmingly high, whereas the reporting rate was low. Implementation of universal precautions during clinical training is the most effective strategy to prevent NSI. However, several previous surveys have reported that the education regarding occupational exposure prevention is insufficient [10,13,14,21,24,28]. Dental schools play a crucial role in implementing effective interventions to decrease NSI in dental students. Improved education, training, and compliance with protocols are needed to prevent NSI [10,20,26]. A standard protocol is required to ensure that dental students have achieved the appropriate knowledge and skills before they start performing clinical procedures [10].

Needle recapping is responsible for a significant proportion of NSI; therefore, dental students should avoid needle recapping [8,21]. Standardized training regarding the proper method of managing sharp waste should considerably decrease the frequency of NSI [14]. Preventive strategies have also been suggested during manual teeth cleaning, including restricting the use of fingers for tissue retraction to minimize potential uncontrolled movements of scalers [1]. Other preventive methods for NSI include using a syringe cap with a card, covering the scaler tip and dental bur with a cotton roll and plastic cup, and a modified retraction technique using dental mirrors [40].

Chair-side assistance, a straightforward and effective reporting system, and introduction of safety syringes have been proposed to prevent NSI [19,28]. Electronic reporting systems might overcome barriers to reporting, including inconvenience and lack of motivation [41]. Occupational medicine specialists could increase awareness of NSI among students, both decreasing the incidence and increasing the reporting rate of NSI [28]. Establishing a management centre to monitor exposed personnel may also be beneficial [21].

The current review had several limitations. First, articles published in languages other than English were excluded, which might introduce publication bias and prevent the assessment of data from other countries or regions. Second, regional studies may not be nationally representative of countries. Third, data were mainly collected using self-administered questionnaires, which are associated with a low strength of evidence. However, despite these limitations, this meta-analysis provides a quantitative summary of the global NSI profile over the past two decades. The results raise several concerns regarding the safety and well-being of dental students. Identification of procedures and instruments associated with NSI may help modify practice and improve education to prevent NSI.

In conclusion, the pooled prevalence of NSI among dental students was alarmingly high, while the reporting rate was significantly low. Inadequate knowledge might increase the risk of NSI. Needle recapping and lack of chair-side assistance were significantly associated with NSI. Education and implementation of infection control measures are required for the career development of dental students.

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