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Original Article

# Epidemiology of needlestick injury exposures among dental students during clinical training in a major teaching institution of China: A cross-sectional study

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## KEYWORDS

Bloodborne infection;  
Dental student;  
Infection control;  
Needlestick injury;  
Occupational exposure

**Background/purpose:** Dental students are particularly vulnerable for needlestick injuries (NSI). However, the epidemiology of NSI exposures among Chinese dental students was rarely reported. The objectives of this study were to determine the prevalence of NSI among dental students in a major teaching institution of China, and to identify associated factors.

**Materials and methods:** A self-administrated online questionnaire was developed based on previously published studies, and distributed to dental students of Class 2011–2015 recruited from Peking University School and Hospital of Stomatology.

**Results:** Two hundred and sixty-eight dental students including 38.8% of males and 61.2% of females (response rate of 90.0%) completed the survey. Approximately 36.2% of the respondents had sustained at least one NSI. A total of 112 NSI cases were reported. The majority of NSIs were related to the procedures of local anesthesia administration (15.2%) and tooth cleaning or scaling (15.2%). Syringe needles, dental burs and ultrasonic chips were the most notorious

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devices. Statistical analysis showed significant distribution in NSI occurrence between July–September and October–December. The main cause was lapse in concentration (67.9%), followed by fatigue (22.3%). Up to 66.1% of the exposures occurred when the student was working alone, while only 10.7% with assisting. Unfortunately, 26.8% of the incidents were under-reported.

**Conclusion:** Dental students are prone to needlestick injuries. The present study clearly reveals a need for increased awareness of NSI prevention among dental students. The quality of infection control education at dental teaching institutions is crucial and indispensable for reducing NSI exposures.

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## Introduction

Needlestick injury (NSI), which accounted for the largest part of occupational exposures in dentistry, is also the most common way to accidentally transmit bloodborne infections. It was defined as any contact of non-intact skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious material which occur during diagnosis and treatment of patients or when handling orally soiled impressions and prosthetic devices, as well as during the disposal of needles or other sharp instruments.<sup>1</sup>

The oral cavity is a natural habitat for various microorganisms, many of which are pathogenic and contagious. The intimate nature of dental treating environment and the frequent using of sharp instruments combine to make the dental clinic a hazardous workplace.<sup>2,3</sup> Therefore, dental professionals are at a high risk of exposing to potentially infectious pathogens. Among all the pathogenic microorganisms, HBV, HCV, and HIV constitute most of infections and culminate in severe or even fatal chronic diseases.

Numerous published studies had analyzed NSI exposures of registered dentists and dental assistants, while dental students were investigated less frequently.<sup>4</sup> However, reporters concurred that dental students might be a particularly vulnerable group for NSI exposures.<sup>1,5,6</sup> Junior dental students appeared to experience more occupational exposures than senior ones. It's been reported that undergraduate students caused the highest number of NSIs (17.2%), followed by dental residents (14.0%) and graduate students (12.6%).<sup>2</sup> Beyond the high prevalence of NSI exposures among dental students, many incidents were under-reported.<sup>7</sup> Previous studies on this topic were mostly conducted in developed countries or regions, however, comprehensive data from developing country was rarely reported. Since there was a lack of epidemiological evidence relating to NSI exposures among Chinese dental students, this survey was conducted to determine the prevalence of NSIs in China, to identify associated factors, to assess the under-reporting rate, and to discuss the implications for prevention.

## Materials and methods

### Study design

A cross-sectional survey was conducted to investigate the epidemiological profile of NSIs among dental students of Peking University School and Hospital of Stomatology (PKUSS) in June 2020. This study had been approved by the Ethics Committee of Peking University School and Hospital of Stomatology (PKUSSIRB-202056081). A self-administrated questionnaire was developed and modified based on previously published studies and review of the literature.<sup>1,8,9</sup> Informed consent was included on the front page of the questionnaire and it was assumed completed when the questionnaires were returned. Prior to data collection, the questionnaire was pilot tested on a group of registered dentists to ensure practicability, validity and interpretation of respondents. After amendments, the structured online questionnaire was distributed to the designated dental students. Participation of the study objects were entirely voluntary and completely anonymous.

### Setting and study participants

The investigation was conducted on dental students recruited from PKUSS, which was one of the major teaching institutions in China and provides clinic training to hundreds of dental students every year. Students of Class 2011/2012/2013/2014/2015 were invited to participate in the survey, and they were asked to submit all NSI exposures during their clinic training before graduation. Among all the participants, students of Class 2011/2012/2013 were uniquely from 8-year program, however, due to the reform of dental education, students of Class 2014/2015 were divided into 8-year program and 5-year program. The 8-year program consist of two stages: the first 5 years for preclinical, clinical medicine and basic dentistry training, and the second 3 years for resident dentist education and clinical based research training.

## Questionnaire

The questionnaire form was highly structured and consist of the following information:

Demographic profile: Gender, age, seniority, dominant hand, etc;

NSI characteristics: injury rate, time of exposure, procedure and causative instrument involved, anatomic site of injury, presence of assistant, average number of patients attended, etc;

Psychological reaction after exposures: depression, anxiety, fear, anger, sad, social dysfunction, etc;

Reporting practices: reporting rate, reasons for not reporting.

## Statistical collection and analysis

The questionnaire consisting of 30 close-ended questions was used for data collection. Descriptive statistics such as frequency counts and percentages, mean and standard deviation were computed to analyze under study. The statistical analysis was performed with the Student's t-test or  $\chi^2$ -test to compare two events and with one-way analysis of variance (ANOVA) to compare multiple events. Results were considered statistically significant with a two-sided  $P < 0.05$ . All the analyses employed SPSS ver. 20.0 software (SPSS, Inc, Chicago, IL, USA).

## Results

268 dental students completed the survey questionnaires altogether, for an overall response rate of 90.0% ( $n = 268/298$ ), including male 38.8% ( $n = 104/268$ ) and female 61.2% ( $n = 164/268$ ) respectively. The median age was 25 years (range 22–29 years). Generally, 36.2% ( $n = 97/268$ ) of the respondents had sustained at least one NSI exposure. Among these 97 respondents with NSIs, 15 experienced 2

times of accidental exposures. A total of 112 ( $n = 97 + 15$ ) cases of NSI exposure were reported. An overview of study participants is given (Table 1).

The NSI exposures could occur at anytime throughout the academic year. Analysis by time showed that more incidents occurred during the 3-month period of October to December (33.9%,  $n = 38$ ). Further statistical analysis showed that significance was found in annual occurrence time distribution ( $P = 0.023$ , one-way ANOVA test). There was significant distribution between July–September and October–December (Table 2). The high incidence of NSI exposures mainly resulted from a significantly higher NSI occurrence in the beginning of clinical training among the first year students.

As for daily occurrence time distribution of NSI exposures, more NSIs was noted in late morning and early afternoon. A total of 41 cases (36.6%) occurred at the hours of 10:00 to 12:00 AM, which was closed to the lunch break, and 30 cases (26.8%) occurred at the hours of 13:00–15:00 (Table 3).

From the various procedures described by respondents, the majority of NSIs occurred while performing local anesthesia (15.2%,  $n = 17$ ) and tooth cleaning or perio scaling (15.2%,  $n = 17$ ). This was followed by endodontic procedures (11.6%,  $n = 13$ ) and restorative treatments (10.7%,  $n = 12$ ). Activities reported to be associated with NSI exposures are displayed (Table 4).

The most common instruments involved with NSI exposures were syringe needle, dental bur, ultrasonic chip and suture needle (Table 5). Among 57 NSI exposures occurred during treating procedure, dental burs were the most notorious (9.8%,  $n = 11$ ), followed by suture needles (8.9%,  $n = 10$ ). Among 55 NSI exposures occurred during preparation/cleanup, syringe needles caused most injuries (19.6%,  $n = 22$ ), followed by dental burs (13.4%,  $n = 15$ ). Other penetrating instruments included ultrasonic chip, endodontic file, periodontal curette, elevator, surgical scalpel, dental explorer and others ( $p < 0.001$  by  $\chi^2$ -test analysis).

**Table 1** Characteristics of survey dental students.

Class	Program	Gender	Number (n=)	Age (Years)	Response rate (%)	Respondents with NSIs (%)
2011	8 year	Male	21	26–29		
		Female	41			
2012	8 year	Male	24	25–28		
		Female	37			
2013	8 year	Male	20	24–27		
		Female	35			
2014	8 year	Male	16	23–26		
		Female	13			
	5 year	Male	14			
		Female	18			
2015	8 year	Male	9	22–25		
		Female	23			
	5 year	Male	10			
		Female	17			
<b>Total</b>		Male	114	22–29	91.2% (104/114)	30.8% (32/104)
		Female	184		89.1% (164/184)	39.6% (65/164)

NSI, needlestick injury.

**Table 2** Monthly exposures of NSI among dental students.

Month \ Year	2015	2016	2017	2018	2019	2020	Total	Mean	S.D.	%
1–3	0	1	2	3	7	1	14	2.33	1.08	12.5
4–6	0	5	5	9	11	1	31	5.17	1.15	27.7
7–9	1	4	7	11	6	0	29	4.83	1.09	25.9
10–12	2	1	1	11	23	0	38	6.33	1.05	33.9
Total	3	11	15	34	47	2	112	18.67	1.13	100.0

NSI, needlestick injury; S.D., standard deviation.

**Table 3** Analysis of NSI exposures among dental students by daily time.

Hours	During treating procedure n	During preparation/cleanup n	Total n (%)
Early than 8:00	0	1	1 (0.9%)
8:00–10:00	8	8	16 (14.3%)
10:00–12:00	21	20	41 (36.6%)
12:00–13:00	0	1	1 (0.9%)
13:00–15:00	16	14	30 (26.8%)
15:00–16:30	7	10	17 (15.2%)
16:30–19:00	4	0	4 (3.6%)
Late than 19:00	1	1	2 (1.8%)

NSI, needlestick injury.

**Table 4** Clinical procedures involved with NSI exposures among dental students.

Procedure	Amount/n (%)
Local anesthesia	17 (15.2%)
Tooth cleaning or perio scaling	17 (15.2%)
Endodontic treatment	13 (11.6%)
Restorative treatment	12 (10.7%)
Surgical suture	11 (9.8%)
Disposal of wastes	11 (9.8%)
Surgical exodontia	10 (8.9%)
Chairside assistance	10 (8.9%)
Prosthodontic treatment	2 (1.8%)
Pediatric dental treatment	2 (1.8%)
Other	7 (6.2%)
<b>Total</b>	<b>112 (100.0%)</b>

NSI, needlestick injury.

As for the anatomic sites of NSI exposures, the index fingers were the most frequent injured sites (Fig. 1). Most of the NSI exposures were related to the hands, especially the right hands.

In the question referring to causes of NSI exposures, the result showed that “Lapse in concentration” (67.9%,  $n = 76$ ) was cited as the most common reason, followed by fatigue (22.3%,  $n = 25$ ) and lack of time (18.8%,  $n = 21$ ). Overall 77.7% ( $n = 87$ ) of the NSI exposures were caused by dental students themselves, 11.6% ( $n = 13$ ) through colleagues, 6.3% ( $n = 7$ ) through patients, and 4.5% ( $n = 5$ ) gave no response concerning this question. 66.1% ( $n = 74$ )

**Table 5** Analysis of instruments involved with NSI exposures among dental students.

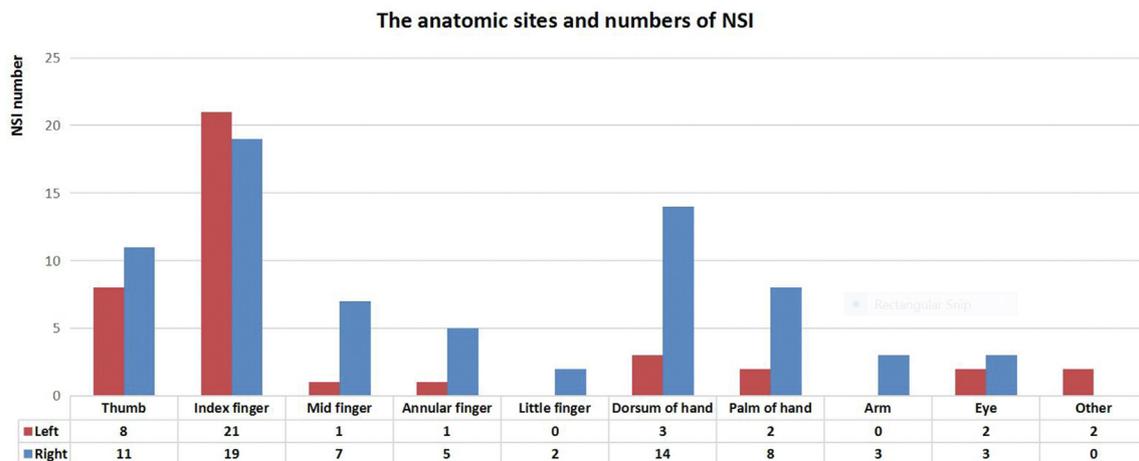
	During treating procedure n	During preparation/cleanup n	Total n (%)
Syringe needle	6	22	28 (25.0%)
Dental bur	11	15	26 (23.2%)
Ultrasonic chip	3	13	16 (14.3%)
Suture needle	10	2	12 (10.7%)
Endodontic file	6	1	7 (6.3%)
Periodontal curette	5	1	6 (5.4%)
Elevator	5	0	5 (4.5%)
Splash in eye	5	0	5 (4.5%)
Surgical scalpel	1	0	1 (0.9%)
Dental explorer	1	0	1 (0.9%)
Other	4	1	5 (4.5%)

NSI, needlestick injury.

of the NSI exposures occurred when the student was working alone, 15.2% ( $n = 17$ ) while assisting someone else, 10.7% ( $n = 12$ ) while being assisted, and 8.0% ( $n = 9$ ) gave no response. 73.2% ( $n = 82$ ) of the exposures were reported to the designated faculty member, most of the victim students ( $n = 79$ ) as well as the patient involved run blood tests, and only 4 of them received medical interventions. The other 26.8% ( $n = 30$ ) of the exposures were under-reported because of the belief that the exposure was not significant. After NSI exposures, students ( $n = 84$ ) frequently felt depressed, anxious, fear, sad or angry, however, 23 exposed students reported “It doesn’t matter” and 5 reported “Emotionally stable”.

## Discussion

In dentistry, NSI exposures occur uninterruptedly because of the close distance treating patients, frequent movements, and the routine use of various sharp instruments under limited or indirect visual contact. Contaminated NSI exposures place dental professionals at high risk of experiencing bloodborne infections and emotional distress. In an investigation of Washington State of USA, it was reported that about 20% of the percutaneous injuries were submitted by dental staffs.<sup>10</sup> 61.7% of the dentists sustained at least one NSI exposure in a German study.<sup>1</sup> According to the recent survey among Malaysian healthcare workers, dental staffs recorded the second highest incidence of NSI exposures nationally, following the medical doctors.<sup>11</sup> All these



**Figure 1** The anatomic sites of NSI exposures of injured dental students. Note: NSI, needlestick injury.

data were mainly focusing on registered dentists, less has been published assessing the association between NSI exposures and dental students. However, in a survey of four Nigerian dental schools, 58.8% ( $n = 90$ ) of the dental students had experienced at least one NSI exposure.<sup>12</sup> It's also been reported that young dental health care workers caused more NSI exposures than did older ones.<sup>13</sup> Therefore, dental students might be at a higher risk of experiencing NSI exposures compared to registered dentists.

The sources of NSI exposures among dental students could be needles, dental burs, scalpels, perio scalers, endodontic files, surgical elevators, curettes, dental explorers, and orthodontic wires etc. This survey showed that 25.0% of NSIs were related to syringe needles, which accounted for the majority of exposures among dental students. It was consistent with an UK study that local anesthesia caused most NSI exposures.<sup>2</sup> In this study, the most frequent treating procedures involved with NSI exposures were operative dentistry (30.4%), followed by oral surgery (28.6%) and periodontic treatment (25.9%). This is somewhat similar to the findings in German, which was noted that operative dentistry (36.2%) and Oral Surgery (19.6%) were the major sources of NSI exposures.<sup>1</sup> However, this was at variance with findings in other dental schools. It's been reported that the majority of NSI exposures were due to perio scaling and polishing (44.4%), followed by local anesthesia (34.4%) in Nigerian dental schools.<sup>12</sup> Similar findings were also noted in UK dental schools.<sup>9</sup> NSI exposures might occur not only during treating procedures, but also during the clean up of used instruments afterwards. It was reported that a high number of NSI exposures occurred when disposing wastes at the National Taiwan University Hospital.<sup>8</sup> In this study, 9.8% of the NSI exposures were related to the clean up procedures.

According to a study among dentists in Taiwan, the personal factors associated with NSI exposures included experience of the practitioner, number of patients attended per day, knowledge of infectious diseases and compliance with infection control protocols.<sup>14</sup> However, there might be several different risk factors contributing to the high prevalence of NSI among dental students. The first and foremost risk factor could be "Insufficient clinical experience and

skills". During clinic training, dental students were eager to learn invasive procedures, however, lack of knowledge of handling certain instruments and the execution of specific techniques might lead to NSI exposures. For instance, a great number of dental procedures were performed under local anesthesia, including endodontic treatment, perio scaling, oral surgery, and tooth preparation, etc. Unsatisfied anesthesia could cause a sudden jerky move of the patient, which could cause potential NSI exposures. In the question referring to the causes of NSI, 16.1% ( $n = 18$ ) of the students reported lack of technical preparation. Moreover, young dentists were more likely less concentrated compared to experienced ones, "Lapses in concentration" (67.9%,  $n = 76$ ) was cited as the most common cause for NSI exposures in this study. Besides, 15.2% of NSI exposures occurred when performing local anesthetic, while 25.0% were related to syringe needle. This implied that re-sheathing and incorrectly disposing the needle was a common cause of NSI exposure. Therefore, emphasis should be placed on teaching the methods of proper handling of sharp instruments.

The second leading risk factor was "Lack of appropriate chair-side assisting". UK study showed that the absence of chair-side assisting might increase the frequency of NSI exposures because more NSIs were noted when students were working unassisted.<sup>2</sup> Nigerian research reported that dental students frequently working alone might result in high prevalence of NSI exposures.<sup>12</sup> In a Greek national survey, endodontists who usually practiced endodontics with assisting reported significantly fewer percutaneous injuries.<sup>15</sup> Our survey found that most of the exposures (66.1%,  $n = 74$ ) occurred when the students were working without assisting. This might support the call that chair-side assisting could decrease the risk of NSI exposures.

The third possible risk factor might be "Stress and fatigue". Dental students face a variety of stresses associated with their training, including high work demands, examinations, and academic requirements etc. The stress might come from patients, tutors and peer students during their clinic rotation on various dental specialties. They were required to complete a significant number of clinical cases, moreover, the evaluation of student performance is

partially depended on the number of cases they treated, which might increase their stress or even result in anxiety. This survey showed that 21.4% ( $n = 24$ ) of NSI exposures were related to stress. Long work hours and professional fatigue could lead to distraction, which might be related to the occurrence of NSI exposures. A study regarding to physicians have observed that extended work duration were associated with an increased risk of NSI exposures during students' first year of clinical training.<sup>16</sup> Some other reports showed that NSI exposures occurred more frequently in the afternoon than in the morning, which might also be a result of professional fatigue.<sup>8,13</sup> In our survey, 22.3% ( $n = 25$ ) NSI exposures were reported to be associated with professional fatigue. These kind of stress and fatigue might lead to "Distraction or Lapse of concentration", which accounted 67.9% ( $n = 76$ ) of the NSI exposures according to this survey. A lack of appropriate training regarding to the danger of NSI may predispose the students to an occupational exposure. A combination of 25% ( $n = 28$ ) of the victim students reported "It doesn't matter" or "Emotionally stable" after exposures, which implied that the awareness of the consequences of NSI exposures were far from enough for dental students. In a study on hand hygiene of dental students, hand hygiene effectiveness, attitudes and practices decreased as they gained more clinical experience, whereas knowledge did not.<sup>17</sup> Similarly, there might be possible subjective ignorance among dental students regarding to the prevention of NSI exposures, however, this warrants further investigation.

The last but not the least risk factor was "Lack of tutorial support". The result of this survey showed that only 2.7% ( $n = 3$ ) of the NSI exposures were due to lack of tutorial support. Vigilant supervision of clinic teaching was crucial in the prevention of NSI exposures, which was one of the basic requirement for clinical faculties in PKUSS. It's been suggested that a hands-on approach in students' learning process should form part of the curriculum to protect the students.<sup>18</sup>

Documenting the frequency and circumstances of NSI exposures was crucial in identifying unsafe instruments and risky treating procedures. However, a large proportion of dental students chose not to report the events. Under-reporting of NSI exposures among dental students was common because they believed that most exposures were not significant.<sup>19,20</sup> In an US study, 67 dental students (32.8%) were exposed to NSIs, however, up to 81% of them did not report to the designated counselors.<sup>5</sup> In our survey, 26.8% of NSI exposures were under-reported. To develop prevention strategies, trends in the frequency and profile of NSI exposures should be carefully monitored and evaluated, which allows identification of hazardous practise and diminishes the risk of future exposures.

The 'profile and competences for the graduating European dentist' document state that dental graduates must have knowledge of cross infection control and be competent at implementing cross infection control in their practice.<sup>21</sup> As future dentists who will provide oral health care for general population, dental students must be trained for effective prevention of occupational exposures.<sup>2</sup> However, most US dental schools did not have an independent course and only used classroom lectures to teach infection

control.<sup>22</sup> In a Chinese survey, 96% of dental students insisted that the occupational exposure education was insufficient.<sup>23</sup> The implementation of standard universal precautions in dental students is the best strategy to prevent occupational exposures. Consistent reinforcement is especially important because novice students are continually recruited for dental schools. Formal pre-clinical teaching and introduction of an infection competency among undergraduate dental students potentially provides clinical application benefits.<sup>24</sup> The deficiencies on infection control management policy can be rectified by changes in core training at undergraduate level.<sup>25</sup>

This study had some strengths. First, it was conducted among dental students engaged in full time clinical training. The study samples were genetically homogeneous, and the structured questionnaire were adjusted with logical correction, thus it could minimize the likelihood of mis-classification bias. Second, PKUSS is one of the major teaching institutions in China, hundreds of dental students are being trained every year. These students would follow various precaution rules to prevent NSI exposures in training, for example, they were required to remove the injection needle using a needle holder; the ultrasonic tips should be taken off from the bracket table or inserted in an opposite direction while not in use; and 4-handed assisting as much as possible, etc. Herein, to some extent, the results of this survey demonstrated the current status of NSI education among dental students in China. Although this survey provides new information concerning NSI prevalence and associated factors among Chinese dental students, it is nevertheless subjected to potential limitations. The retrospective nature of the self-report survey indicates that recall bias could be possible and may not fully reflect dental students' practice. Therefore, precautions are worth considering when interpreting the study findings.

In conclusion, this study attempted to investigate the incidence, associated factors and reporting behavior of NSI exposures among Chinese dental students. The prevalent nature of NSIs in a major teaching dental hospital was reported and key risk factors were identified. Dental students are prone to experience NSI exposures, however, evidence shows that they are more likely choose not to report. The present study clearly reveals a need for increasing awareness of NSI prevention among dental students. The quality of infection control education at dental teaching institutions is crucial and indispensable for reducing NSI exposures.

## Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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