

Differential Risk Profiles of Needlestick versus Sharps Injuries Among Dental Healthcare Workers: An 11-Year Retrospective Analysis in a Tertiary Stomatological Hospital

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Abstract

Background

Dental healthcare workers (DHCWs) are at high risk of occupational exposure to bloodborne pathogens through percutaneous injuries, including sharps injuries and needlestick injuries. This study aimed to investigate the epidemiological characteristics and risk factors of occupational percutaneous injuries among DHCWs in a tertiary specialized stomatological hospital over an 11-year period.

Methods

A retrospective analysis was conducted on 363 occupational percutaneous exposure incidents reported between January 2015 and 2025 at a tertiary specialized stomatological hospital with three campuses in Guangzhou, China. Data were extracted from the hospital's standardized surveillance system. Chi-square tests compared sharps and needlestick injuries, and two binary logistic regression models identified independent risk factors for needlestick injuries, with results reported as odds ratios (ORs) and 95% confidence intervals (CIs).

Results

A total of 363 percutaneous exposure incidents were reported, including 204 (56.2%) sharps injuries and 159 (43.8%) needlestick injuries. The annual number of incidents increased from 10 in 2015 to 58 in 2025. Needlestick injuries predominated in oral surgery (79.0%) and implantology (60.0%), whereas sharps injuries were more common in orthodontics and endodontics. In the comprehensive logistic regression model, independent risk factors for needlestick injuries were oral surgery (OR = 53.55), implantology (OR = 19.30), periodontal care, prosthodontics, endodontics, dental nurse and student status, and younger or female patients, while the fingers were the principal exposure site. Annual reported incidents increased nearly six-fold, from 10 in 2015 to 58 in 2025. Needlestick injuries predominated in oral surgery (79.0%) and implantology (60.0%), contrasting sharply with orthodontics (13.3%). Multivariable analysis revealed oral surgery (OR = 53.55, 95% CI: 11.86–241.68) and implantology (OR = 19.30, 4.23–88.01) as the strongest independent predictors. Dental nurses (OR = 2.22) and students (OR = 1.89) were at significantly higher risk than dentists, and younger staff (< 25 years) had nearly twice the risk of those aged ≥ 30 years. Male patients and those aged < 20 years were independently associated with needlestick injuries. A distinct third-quarter peak (32.5% of incidents) coincided with the annual intake of new trainees.

Conclusions

Occupational percutaneous injuries remain a substantial and increasing burden in tertiary stomatological hospitals. Sharps and needlestick injuries exhibit distinct epidemiological and risk profiles, supporting the implementation of specialty-specific, personnel-targeted, and temporally focused prevention strategies. Needlestick injuries and sharps injuries exhibit fundamentally different risk profiles in dental settings. Oral surgery and implantology represent extreme high-risk specialties for needlestick injuries, while younger staff, students, and nurses are disproportionately affected. These findings strongly advocate for specialty-specific, personnel-targeted safety interventions, timed with academic entry, to mitigate occupational hazards in stomatological hospitals.

1. Introduction

Occupational exposure to bloodborne pathogens through percutaneous injuries represents a serious hazard for healthcare workers worldwide. The World Health Organization estimates that approximately 3 million healthcare workers experience percutaneous exposures to bloodborne pathogens annually, with the risk of transmitting hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) being of paramount concern [1]. Among all healthcare settings, dental healthcare workers (DHCWs) face a disproportionately elevated risk due to the unique nature of dental procedures, which involve extensive use of sharp instruments in a confined oral cavity with limited visibility and frequent patient movement [2, 19, 25]

Dental practice is characterized by the routine use of a wide array of sharp instruments, including needles, scalpel blades, endodontic files, ultrasonic tips, explorers, and burs. The oral cavity, being a highly vascularized and potentially infectious environment, further amplifies the risk of bloodborne pathogen transmission following percutaneous injury [3]. Studies have reported that the incidence of percutaneous injuries among DHCWs ranges from 1.4 to 5.2 injuries per dentist per year, with underreporting being a persistent problem [4, 5].

Sharps injuries and needlestick injuries, the two principal types of percutaneous occupational exposure in dental settings, differ in their mechanisms, circumstances, and potentially their risk profiles. Sharps injuries typically involve instruments such as endodontic files, explorers, scalers, and burs, whereas needlestick injuries specifically involve hollow-bore or suture needles [6]. Understanding the differential risk factors between these two types of injuries is critical for developing targeted prevention strategies. However, most existing studies have treated percutaneous injuries as a homogeneous category, and few have specifically compared the epidemiological characteristics and risk factors between sharps injuries and needlestick injuries in the dental setting [7].

Tertiary specialized stomatological hospitals, as the highest-level dental care institutions in China's three-tier hospital system, handle the most complex and diverse dental cases and employ large numbers of DHCWs, including dentists, nurses, students, and support staff. These institutions therefore represent an ideal setting for studying the full spectrum of occupational percutaneous injuries in dentistry. However, long-term, multicampus surveillance data from such institutions remain scarce in the literature.

This study aimed to: (1) describe the epidemiological characteristics of occupational percutaneous injuries among DHCWs in a tertiary specialized stomatological hospital over an 11-year period (2015–2025); (2) compare the differences between sharps injuries and needlestick injuries; and (3) identify independent risk factors associated with needlestick injuries through binary logistic regression analysis. The findings of this study will provide an evidence base for the development of targeted occupational safety interventions in dental hospitals.

2. Methods

2.1 Study Design and Setting

This was a retrospective observational study conducted at a tertiary specialized stomatological hospital in Guangzhou, China. The hospital operates across three campuses (Yuexiu, Liwan, and Haizhu) and provides comprehensive dental services encompassing endodontics, periodontics, oral and maxillofacial surgery, implantology, prosthodontics, orthodontics, pediatric dentistry, and other specialties. The study period spanned from January 2015 to June 2025 (11 years).

2.2 Study Population

All occupational percutaneous exposure incidents reported to the hospital's infection control department during the study period were included. Percutaneous exposure was defined as any incident in which a sharp instrument or needle penetrated the skin of a healthcare worker during the course of occupational duties. DHCWs included hospital dentists, hospital dental nurses, students (interns, graduate students, and visiting trainees), and other personnel (e.g., cleaning and support staff). technicians and CSSD workers

2.3 Data Collection

Data were extracted from the hospital's standardized occupational exposure surveillance database. The following variables were collected:

- **Temporal characteristics:** Year, quarter, month, day of week, time of day, weekend/holiday status
- **Exposure characteristics:** Type of injury (sharps vs. needlestick), exposure site, timing of exposure, instrument involved, four-hand operation status
- **Personnel characteristics:** Personnel type, gender, age, age group, professional rank, years of work experience, number of prior exposure incidents
- **Specialty and campus:** Hospital campus, dental specialty
- **Contributing factors:** Operational factors, equipment factors, patient factors, personal protective and environmental factors
- **Patient characteristics:** Patient age, age group, gender
- **Source patient infection status:** Negative, HBsAg positive, TPPA positive, anti-HCV positive, unknown

- **Post-exposure management:** Need for post-exposure prophylaxis (PEP), reporting timeliness

2.4 Definitions

Sharps injury

Percutaneous injury caused by sharp dental instruments other than needles (endodontic files, ultrasonic tips, explorers, scalers, burs, blades).

Needlestick injury

Percutaneous injury caused by needles, including local anesthetic needles and suture needles.

Four-hand operation

A technique in which a dentist works with a dental assistant to manage instruments and materials during treatment.

Reporting timeliness

Reports submitted within 24 hours of the exposure incident were considered timely.

2.5 Statistical Analysis

Categorical variables were summarized as frequencies and percentages. Continuous variables were described as means $\pm$ SD or medians with IQR. Differences between sharps injuries and needlestick injuries were compared using the chi-square test or Fisher's exact test.

Two binary logistic regression models were constructed to identify independent risk factors for needlestick injuries (vs. sharps injuries). Model A (Demographic Model) included hospital campus, specialty, staff age, and staff gender. Model B (Comprehensive Model) retained all variables from Model A except staff age, which was omitted because of collinearity with the newly added variable personnel type; the model further included personnel type, exposure site, four-hand operation status, patient gender, and patient age. Other candidate variables, including years of work experience, professional rank, and number of prior exposure incidents, were initially considered but were excluded from the binary models owing to high collinearity with staff age and personnel type. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided $P < 0.05$ was considered significant. Analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

2.6 Ethical Considerations

This study was approved by the Institutional Review Board of the hospital. All data were de-identified prior to analysis. The requirement for informed consent was waived due to the retrospective nature of the study.

3. Results

3.1 General Characteristics

A total of 363 occupational percutaneous exposure incidents were reported during the 11-year study period (2015–2025). Of these, 204 (56.2%) were sharps injuries and 159 (43.8%) were needlestick injuries. The annual number of reported incidents demonstrated a general increasing trend, rising from 10 cases in 2015 to 58 cases in 2025, as illustrated in Fig. 1. The stacked bar chart reveals that while sharps injuries consistently outnumbered needlestick injuries across most years, the gap narrowed in certain periods, particularly around 2017–2018 and 2021. The overall trend line shows a 5.8-fold increase over the 11-year period (Table 1; Fig. 1). The third quarter (Q3) of the year had the highest number of incidents (118, 32.5%), followed by Q2 (83, 22.9%), Q4 (82, 22.6%), and Q1 (80, 22.0%) (Table 2).

Table 1
Annual distribution of occupational percutaneous injuries by dental specialty (2015–2025)

Year	Endo.	Oral surg.	Implant.	Perio.	Ortho.	Prosth.	Others	Total
2015	4	2	1	1	0	0	2	10
2016	8	3	1	2	1	1	3	19
2017	6	0	3	3	2	2	3	19
2018	11	6	5	4	4	3	2	35
2019	14	5	7	2	2	1	0	31
2020	7	6	3	2	4	5	4	31
2021	9	10	10	4	4	1	1	39
2022	12	6	5	7	3	4	3	40
2023	9	5	6	6	1	8	1	36
2024	20	7	5	7	3	2	1	45
2025	21	12	4	10	6	3	2	58
Total	121	62	50	48	30	30	22	363

Table 2
Quarterly distribution of occupational percutaneous injuries by dental specialty

Quarter	Endo.	Oral surg.	Implant.	Perio.	Ortho.	Prosth.	Others	Total
Q1	34	12	11	8	4	8	3	80
Q2	26	11	8	17	8	5	8	83
Q3	30	22	26	9	13	12	6	118
Q4	31	17	5	14	5	5	5	82
Total	121	62	50	48	30	30	22	363

3.2 Characteristics of Exposed Personnel

The majority of exposed personnel were female (262, 72.2%), with a mean age of 29.2 +/- 7.5 years (range: 18–64 years). Hospital dentists constituted the largest group (139, 38.3%), followed by students (126, 34.7%), hospital nurses (78, 21.5%), and other personnel including cleaning staff (20, 5.5%). The median years of work experience was 2.0 years (IQR: 0–5 years). Most exposed personnel held junior professional rank or below (286, 78.8%), while 68 (18.7%) held middle rank and 9 (2.5%) held senior rank. Among the 363 incidents, 242 (66.7%) involved personnel experiencing their first exposure incident, 83 (22.9%) involved a second exposure, and 38 (10.5%) involved three or more exposures (Table 3).

The composition of exposed personnel and the anatomical distribution of injuries are summarized in Fig. 2. Hospital dentists, students, and dental nurses together accounted for 94.5% of all exposures. The fingers were overwhelmingly the most common site of injury, accounting for 78.8% of all exposures (Fig. 2B), consistent with the manual nature of dental procedures where the fingers are in closest proximity to sharp instruments.

3.3 Distribution by Specialty and Campus

Endodontics was the most frequently involved specialty (121, 33.3%), followed by oral surgery (62, 17.1%), implantology (50, 13.8%), periodontics (48, 13.2%), orthodontics (30, 8.3%), prosthodontics (30, 8.3%), and other specialties (22, 6.1%). By campus, the Yuexiu campus reported the most incidents (193, 53.2%), followed by Liwan (150, 41.3%) and Haizhu (20, 5.5%).

A more detailed comparison of the injury type distribution across specialties is presented in Fig. 3. The proportion of needlestick injuries varied substantially across specialties: oral surgery showed the highest proportion (79.0%), followed by implantology (60.0%), while orthodontics had the lowest (13.3%). Endodontics, despite having the highest absolute number of incidents ($n = 121$), had a relatively balanced distribution with 64.5% sharps injuries and 35.5% needlestick injuries, reflecting the dual use of both sharp instruments (files) and needles (local anesthesia) in endodontic practice.

3.4 Exposure Circumstances

Four-hand operation was performed in 119 incidents (32.8%), and was associated with a higher proportion of needlestick injuries (51.3% vs. 40.2%, $\chi^2 = 4.00$, $P = 0.045$) (Table 3). 119 (32.8%) of the incidents and was not performed in 244 (67.2%).

The temporal distribution of incidents across months and time periods is depicted in Fig. 4. July, August, and September (Q3) exhibited a distinct peak in incident counts, with July alone accounting for 50 cases (13.8% of the total). In terms of diurnal variation, the majority of incidents occurred during morning (42.4%) and afternoon (39.7%) shifts, which correspond to the periods of highest clinical activity. The evening shift accounted for only 2.5% of incidents, likely reflecting reduced clinical operations during those hours.

The timing of exposure varied significantly by years of work experience. Less experienced personnel (< 1 year) had a higher proportion of exposures after treatment (44.2%), while more experienced personnel (≥ 5 years) had a higher proportion during treatment procedures (62.7%). This pattern is visualized in the heatmap presented in Fig. 5, which demonstrates a clear gradient: as work experience increases, the proportion of during-treatment exposures rises from 44.2% to 62.7%, while post-treatment exposures decrease from 44.2% to 24.6% (χ^2 for trend = 10.56, $P = 0.032$). This finding suggests that experienced personnel are more likely to sustain injuries during active clinical procedures, whereas novices are vulnerable during the instrument handling and disposal phases.

Table 3
Comparison between sharps injuries and needlestick injuries among dental healthcare workers
(2015–2025)

Category	Details	Sharps (n = 204)	Needlestick (n = 159)	chi2	P
Hospital campus	Yuexiu	117 (60.6)	76 (39.4)	6.54	0.038
	Liwan	73 (48.7)	77 (51.3)		
	Haizhu	14 (70.0)	6 (30.0)		
Personnel type	Hospital dentists	89 (64.0)	50 (36.0)	13.05	0.005
	Dental nurses	39 (50.0)	39 (50.0)		
	Students	60 (47.6)	66 (52.4)		
	Others	16 (80.0)	4 (20.0)		
Specialty	Endodontics	78 (64.5)	43 (35.5)	57.22	< 0.001
	Periodontics	31 (64.6)	17 (35.4)		
	Implantology	20 (40.0)	30 (60.0)		
	Prosthodontics	19 (63.3)	11 (36.7)		
	Orthodontics	26 (86.7)	4 (13.3)		
	Oral surgery	13 (21.0)	49 (79.0)		
	Others	17 (77.3)	5 (22.7)		
Staff gender	Male	54 (53.5)	47 (46.5)	0.42	0.515
	Female	150 (57.3)	112 (42.7)		
Staff age	< 25	48 (45.7)	57 (54.3)	9.13a	0.003
	25–30	68 (55.3)	55 (44.7)		
	>=30	88 (65.2)	47 (34.8)		
Professional rank	Junior and below	154 (53.9)	132 (46.1)	1.56a	0.212
	Middle	46 (67.7)	22 (32.3)		
	Senior	4 (44.4)	5 (55.6)		
Years of experience	< 1	63 (48.8)	66 (51.2)	3.67a	0.060
	1–5	74 (59.7)	50 (40.3)		
	>=5	67 (60.9)	43 (39.1)		

Category	Details	Sharps (n = 204)	Needlestick (n = 159)	chi2	P
Exposure site	Fingers	151 (52.8)	135 (47.2)	10.09	0.018
	Palm	12 (85.7)	2 (14.3)		
	Dorsum of hand	12 (80.0)	3 (20.0)		
	Others	29 (60.4)	19 (39.6)		
Four-hand operation	Yes	58 (48.7)	61 (51.3)	4.00	0.045
	No	146 (59.8)	98 (40.2)		
Timing	During treatment	102 (52.9)	91 (47.1)	2.20	0.334
	Instrument changes	28 (63.6)	16 (36.4)		
	After treatment	74 (58.7)	52 (41.3)		
Exposure incidents	Once	131 (54.1)	111 (45.9)	9.06	0.011
	Twice	43 (51.8)	40 (48.2)		
	>=Three times	30 (79.0)	8 (21.0)		
Contributing factors	Operational	184 (58.0)	133 (42.0)	-	0.023b
	PPE & environmental	12 (54.6)	10 (45.4)		
	Patient factors	2 (15.4)	11 (84.6)		
	Equipment factors	6 (54.6)	5 (45.4)		
Patient gender	Male	66 (44.0)	84 (56.0)	15.45	< 0.001
	Female	138 (64.8)	75 (35.2)		
Patient age	< 20	11 (27.5)	29 (72.5)	26.17	< 0.001
	20–40	121 (68.0)	57 (32.0)		
	40–60	50 (51.0)	48 (49.0)		
	>=60	22 (46.8)	25 (53.2)		
Source status	Negative	135 (54.9)	111 (45.1)	-	0.691
	HBsAg positive	20 (62.5)	12 (37.5)		
	TPPA positive	3 (75.0)	1 (25.0)		
	Anti-HCV positive	0 (0.0)	1 (100.0)		
	Unknown	46 (57.5)	34 (42.5)		

Data are presented as n (%). *a* Linear-by-linear association. *b* Fisher's exact test.

3.5 Source Patient Characteristics and Post-Exposure Management

Among the 363 source patients, 198 (54.5%) were female and 140 (38.6%) were male (25 had unknown gender). The mean patient age was 36.8 +/- 17.5 years (range: 3–88 years). The majority of source patients tested negative for bloodborne pathogens (246, 67.8%), while 80 (22.0%) had unknown infection status, 32 (8.8%) were HBsAg positive, 4 (1.1%) were TPPA positive, and 1 (0.3%) was anti-HCV positive. Timely reporting (within 24 hours) was achieved in 341 (94.0%) of cases.

The infection status of source patients and the subsequent post-exposure management are illustrated in Fig. 6. In total, 37 source patients (10.2%) tested positive for at least one bloodborne pathogen. Regarding post-exposure management, post-exposure prophylaxis was required in only 18 cases (5.0%), while 84 cases (23.1%) required clinical follow-up, and the remaining 261 cases (71.9%) did not require prophylaxis. The low rate of PEP requirement is consistent with the predominantly negative or low-risk source patient profile in this dental hospital setting (Fig. 6).

3.6 Comparison Between Sharps Injuries and Needlestick Injuries

Significant differences between sharps injuries and needlestick injuries were observed across multiple variables (Table 3). Needlestick injuries were more prevalent at the Liwan campus (51.3%) compared to the Yuexiu (39.4%) and Haizhu (30.0%) campuses ($\chi^2 = 6.54$, $P = 0.038$). Students had the highest proportion of needlestick injuries (52.4%), while other personnel had the lowest (20.0%) ($\chi^2 = 13.05$, $P = 0.005$).

By specialty, oral surgery had the highest proportion of needlestick injuries (79.0%), followed by implantology (60.0%), whereas orthodontics had the lowest (13.3%) ($\chi^2 = 57.22$, $P < 0.001$). Younger staff (< 25 years) had a higher proportion of needlestick injuries (54.3%) compared to those aged >= 30 years (34.8%) ($\chi^2 = 9.13$, $P = 0.003$).

Patient-related factors also showed significant associations: male patients were more frequently associated with needlestick injuries (56.0% vs. 35.2% for female patients) ($\chi^2 = 15.45$, $P < 0.001$), and patients aged < 20 years had the highest proportion of needlestick injuries (72.5%) ($\chi^2 = 26.17$, $P < 0.001$).

3.7 Binary Logistic Regression Analysis

Two binary logistic regression models were constructed to identify independent risk factors for needlestick injuries (Table 4). Both models demonstrated good fit (Hosmer–Lemeshow test: Model A, $P = 0.696$; Model B, $P = 0.269$). The forest plot of Model B is presented in Fig. 7.

Table 4

Binary logistic regression models for predicting needlestick injuries versus sharps injuries.Binary

Model	Influence factors	beta	SE	Z	P	OR (95% CI)
Model A	Hospital campus					
(Demographic)	Yuexiu (Ref.)	-	-	-	-	1.00
	Liwan	0.77	0.26	3.00	0.003	2.15 (1.31–3.56)
	Haizhu	-0.33	0.57	-0.59	0.526	0.72 (0.23–2.18)
	Specialty					
	Orthodontics (Ref.)	-	-	-	-	1.00
	Oral surgery	3.24	0.65	5.01	< 0.001	25.56 (7.19–90.93)
	Implantology	2.53	0.63	4.00	< 0.001	12.54 (3.63–43.30)
	Periodontics	1.46	0.64	2.29	0.022	4.32 (1.23–15.12)
	Prosthodontics	1.33	0.67	1.98	0.048	3.80 (1.01–14.20)
	Endodontics	1.21	0.58	2.09	0.037	3.37 (1.08–10.51)
	Others	0.57	0.76	0.74	0.457	1.76 (0.40–7.83)
	Staff age					
	< 25 (Ref.)	-	-	-	-	1.00
	25–30	-0.50	0.30	-1.65	0.099	0.60 (0.33–1.10)
	>=30	-0.63	0.31	-2.01	0.045	0.54 (0.29–0.99)
	Female (vs. Male)	0.36	0.28	1.29	0.198	1.43 (0.83–2.48)
Model B	Hospital campus					
(Comprehensive)	Yuexiu (Ref.)	-	-	-	-	1.00
	Liwan	0.39	0.28	1.39	0.163	1.48 (0.85–2.55)
	Haizhu	-0.40	0.62	-0.65	0.519	0.67 (0.20–2.26)
	Specialty					
	Orthodontics (Ref.)	-	-	-	-	1.00
	Oral surgery	3.98	0.77	5.18	< 0.001	53.55 (11.86–241.68)
	Implantology	2.96	0.77	3.82	< 0.001	19.30 (4.23–88.01)

Model	Influence factors	beta	SE	Z	P	OR (95% CI)
	Periodontics	2.13	0.77	2.76	0.006	8.40 (1.85–38.15)
	Prosthodontics	2.17	0.82	2.64	0.008	8.77 (1.75–44.07)
	Endodontics	1.57	0.70	2.25	0.025	4.82 (1.22–19.01)
	Others	2.19	1.59	1.38	0.169	8.94 (0.39–202.73)
	Personnel type					
	Dentists (Ref.)	-	-	-	-	1.00
	Dental nurses	0.80	0.36	2.23	0.026	2.22 (1.10–4.46)
	Students	0.64	0.31	2.06	0.040	1.89 (1.03–3.48)
	Others	-0.77	1.58	-0.49	0.625	0.46 (0.02–10.25)
	Exposure site					
	Fingers (Ref.)	-	-	-	-	1.00
	Palm	-2.02	0.89	-2.27	0.023	0.13 (0.02–0.76)
	Dorsum of hand	-1.59	0.79	-2.01	0.044	0.20 (0.04–0.96)
	Others	-0.19	0.38	-0.49	0.626	0.83 (0.39–1.76)
	Four-hand: No (vs. Yes)	-0.17	0.30	-0.57	0.570	0.85 (0.47–1.51)
	Patient gender					
	Male (Ref.)	-	-	-	-	1.00
	Female	-0.71	0.26	-2.71	0.007	0.49 (0.30–0.82)
	Patient age					
	< 20 (Ref.)	-	-	-	-	1.00
	20–40	-2.31	0.50	-4.64	< 0.001	0.10 (0.04–0.26)
	40–60	-1.75	0.53	-3.29	0.001	0.17 (0.06–0.49)
	≥60	-1.57	0.58	-2.70	0.007	0.21 (0.07–0.65)

Model A (Demographic Model) The Liwan campus had 2.15 times higher odds of needlestick injury than the Yuexiu campus (OR = 2.15, 95% CI: 1.31–3.56, $P = 0.003$). All dental specialties showed significantly higher odds of needlestick injuries compared to orthodontics, with oral surgery having the highest odds (OR = 25.56, 95% CI: 7.19–90.93, $P < 0.001$), followed by implantology (OR = 12.54, 95% CI: 3.63–43.30, $P < 0.001$). Staff aged ≥ 30 years had a 46% lower risk of needlestick injury than those < 25 years (OR =

0.54, 95% CI 0.29–0.99, $P = 0.045$); in other words, younger staff (< 25 years) had 1.85 times higher risk than those ≥ 30 years. No significant difference was observed between male and female staff ($P = 0.198$).

Model B (Comprehensive Model) After further adjustment, the effect of campus became non-significant. Oral surgery (OR = 53.55, 95% CI: 11.86–241.68, $P < 0.001$) and implantology (OR = 19.30, 95% CI: 4.23–88.01, $P < 0.001$) remained the strongest predictors. Dental nurses (OR = 2.22, 95% CI: 1.10–4.46, $P = 0.026$) and students (OR = 1.89, 95% CI: 1.03–3.48, $P = 0.040$) had significantly higher odds compared to hospital dentists. Compared with finger injuries, palm injuries (OR = 0.13, 95% CI 0.02–0.76, $P = 0.023$) and dorsum of hand injuries (OR = 0.20, 95% CI 0.04–0.96, $P = 0.044$) were associated with significantly lower odds. Female patients had 51% lower odds than male patients (OR = 0.49, 95% CI: 0.30–0.82, $P = 0.007$). All patient age groups ≥ 20 years had significantly lower odds compared to patients aged <20 years (all ORs < 1, all $P \leq 0.007$); in other words, patients younger than 20 years were at substantially higher risk (Fig. 7).

4. Discussion

This 11-year retrospective study provides a comprehensive analysis of occupational percutaneous injuries among DHCWs in a tertiary specialized stomatological hospital. The key findings include: (1) an increasing trend in reported incidents over the study period; (2) significant differences in the distribution of sharps injuries and needlestick injuries across specialties, personnel types, and patient characteristics; and (3) oral surgery and implantology as the strongest independent risk factors for needlestick injuries [23, 27].

4.1 Increasing Trend of Reported Incidents

The annual number of reported percutaneous injury incidents increased from 10 in 2015 to 58 in 2025, representing a nearly six-fold increase. As shown in Fig. 1, this upward trajectory was relatively consistent, with the steepest increases observed between 2017–2018 and 2024–2025. This trend may reflect two concurrent phenomena: a genuine increase in exposure incidents and an improvement in reporting behavior. The expansion of hospital services, including the addition of new campuses and the growing number of DHCWs and dental students over the past decade, has likely contributed to the absolute increase in incidents. Additionally, enhanced occupational safety awareness and improved surveillance systems may have led to better reporting compliance. The improved reporting rate observed in our study (94.0% timely reporting) suggests that the hospital's occupational exposure management system has been effective, although the true incidence may still be higher than reported [8, 9].

4.2 Specialty-Specific Risk Patterns

One of the most striking findings of this study is the strong association between dental specialty and the type of percutaneous injury. Oral surgery had the highest proportion of needlestick injuries (79.0%), with an OR of 53.55 in the comprehensive model, followed by implantology (60.0%, OR = 19.30). As illustrated

in Fig. 3, the within-specialty proportions reveal a clear gradient: specialties with heavy needle use (oral surgery, implantology) cluster at the high end of needlestick proportions, while orthodontics, which primarily involves wire bending and bracket manipulation, anchors the low end at 13.3%. Endodontics and periodontics occupy intermediate positions, reflecting their mixed use of sharp instruments and needles [3, 7, 30]

The persistence and amplification of these specialty effects even after adjustment for multiple confounders in the comprehensive model, as demonstrated in Fig. 7, underscores the importance of specialty-specific prevention strategies. For oral surgery and implantology, emphasis should be placed on safe needle handling techniques, including the use of safety-engineered needles, avoidance of needle recapping, and proper use of sharps disposal containers [11].

4.3 Personnel Type and Experience

Students and dental nurses had significantly higher odds of needlestick injuries compared to hospital dentists in the comprehensive model. Students, who accounted for 34.7% of all exposed personnel, may lack proficiency in safe needle handling. Dental nurses, who handle instrument transfer and sharps disposal, are exposed to needles during multiple procedural phases [10, 13, 22, 29]

The relationship between staff age and injury type is further elucidated in Fig. 8A. Younger staff (< 25 years) had a higher proportion of needlestick injuries (54.3%), while older staff (≥ 30 years) had a lower proportion (34.8%), with staff aged 25–30 falling in between (44.7%). This age-dependent gradient, combined with the finding that staff aged ≥ 30 years had significantly lower odds of needlestick injuries (OR = 0.54) in the binary logistic regression model, strongly supports a protective effect of clinical experience.binary

Complementary to the staff age analysis, Fig. 8B reveals an equally striking pattern on the patient side: patients aged < 20 years were predominantly associated with needlestick injuries (72.5%), while the 20–40 age group had the lowest proportion (32.0%). This may reflect the greater procedural complexity and behavioral management challenges associated with pediatric and adolescent dental care [3].

The experience-timing gradient visualized in Fig. 5 provides additional mechanistic insight: less experienced personnel (< 1 year) had a higher proportion of post-treatment exposures (44.2%), which may reflect insufficient training in safe post-procedural sharps management. These findings highlight the critical need for comprehensive occupational safety training, particularly for students and junior staff, with emphasis on both procedural and post-procedural sharps handling.

4.4 Four-Hand Operation

Interestingly, four-hand operation was associated with a higher proportion of needlestick injuries in the univariate analysis (51.3% vs. 40.2%), although it was not significant in the binary logistic regression model (Fig. 7). This counterintuitive finding may be explained by the fact that four-hand operation is more commonly employed during complex procedures that inherently involve greater needle use, such

as surgical extractions and implant placements [14]. While four-hand operation is generally recommended as a safety measure [12], its benefits may be offset by the increased complexity of procedures in which it is employed.binary

4.5 Patient-Related Factors

The association between patient characteristics and injury type is a novel finding. Male patients and younger patients (< 20 years) were significantly associated with needlestick injuries, as shown in both the univariate analysis (Table 3) and the binary logistic regression model (Fig. 7, Fig. 8B). This may reflect the types of procedures performed on these patient populations: younger patients may require behavioral management strategies that complicate needle use, while male patients may undergo more surgical procedures [15, 17].binary

4.6 Exposure Site

Fingers were the most common exposure site (78.8%) and were the only site significantly associated with needlestick injuries in the binary logistic regression model (Fig. 7). The finding that palm and dorsum of hand injuries were predominantly sharps injuries reflects the mechanism of injury: sharps instruments can cause injuries at various hand locations during instrument transfer, whereas needlestick injuries typically occur at the fingertips during injection or suturing [7, 4].binary

4.7 Source Patient Infection Status and Post-Exposure Management

Although 37 source patients (10.2%) were confirmed positive for bloodborne pathogens (32 HBsAg, 4 TPPA, 1 anti-HCV), no HIV-positive source patients were identified. As depicted in Fig. 6A, the majority of source patients tested negative (67.8%), while 22.0% had unknown infection status, highlighting the need for improved pre-procedural screening. Post-exposure prophylaxis was required in only 5.0% of cases (Fig. 6B), which is lower than rates reported in general hospital settings [16, 24, 26]

4.8 Temporal Patterns

The finding that Q3 (July-September) had the highest number of incidents (32.5%) may be attributed to the admission of new students and trainees at the beginning of the academic year. The radar chart in Fig. 9 provides a multidimensional view of this seasonal pattern, showing that Q3 peaks are particularly prominent in oral surgery and implantology specialties, where the combination of high procedural complexity and the influx of inexperienced trainees may synergistically elevate risk. The monthly distribution (Fig. 4A) further corroborates this pattern, with July alone accounting for 50 cases (13.8% of the total). This temporal pattern suggests that targeted safety training should be intensified at the beginning of academic terms [8].

4.9 Strengths and Limitations

This study has several strengths. First, it is based on 11 years of comprehensive surveillance data from a tertiary specialized stomatological hospital with three campuses. Second, the study specifically compared sharps injuries and needlestick injuries, providing insights not available from studies treating all percutaneous injuries as a single category. Third, two binary logistic regression models were constructed to identify independent risk factors while controlling for potential confounders.

However, several limitations should be acknowledged. First, as a retrospective study, the analysis is subject to reporting bias. Second, the study was conducted at a single institution, which may limit generalizability. Third, data on injury severity and clinical outcomes were not included. Fourth, as an observational study, causal inferences cannot be made. Finally, the study period included the COVID-19 pandemic (2020–2022), which may have influenced dental practice patterns [18].

4.10 Implications for Practice and Future Research

The findings of this study have several practical implications for occupational safety:

1. **Specialty-targeted interventions:** Oral surgery and implantology departments should implement enhanced needle safety protocols, including safety-engineered devices and mandatory training on safe injection and suturing techniques [20, 21, 28, 31].
2. **Focus on high-risk personnel:** Students and dental nurses should receive intensive occupational safety training upon entry and periodically thereafter, with emphasis on both procedural and post-procedural sharps handling.
3. **Temporal targeting:** Safety training should be intensified at the beginning of academic terms (Q3) when new personnel arrive, and additional supervision should be provided during this period.
4. **Four-hand operation optimization:** While four-hand operation remains recommended, its implementation should be accompanied by specific safety protocols for needle-related procedures.
5. **Post-exposure management:** The high proportion of source patients with unknown infection status underscores the need for expanded pre-procedural screening, and the post-exposure management system should be continuously improved.

Future research should focus on evaluating the effectiveness of targeted interventions, investigating the role of safety-engineered devices, and exploring the impact of the COVID-19 pandemic on occupational exposure patterns. Multi-center studies involving multiple tertiary stomatological hospitals would provide more generalizable data.

5. Conclusions

This 11-year retrospective study demonstrates that occupational percutaneous injuries remain a significant and increasing hazard in tertiary specialized stomatological hospitals. Sharps injuries (56.2%) and needlestick injuries (43.8%) differ significantly in their epidemiological characteristics and risk factors. Oral surgery and implantology are the strongest independent risk factors for needlestick injuries, while younger staff, students, and dental nurses are disproportionately affected. These findings support

the development of specialty-specific, personnel-targeted, and temporally-focused occupational safety interventions to reduce the burden of percutaneous injuries among DHCWs.

This figure(Fig. 10) synthesizes the study's key findings into five domains: (1) High-Risk Specialties – oral surgery (OR = 53.55) and implantology (OR = 19.30) are the strongest independent risk factors for needlestick injuries, with needlestick injuries accounting for 43.8% versus sharps injuries at 56.2% of all percutaneous injuries; (2) At-Risk Personnel – students (OR = 1.89) and dental nurses (OR = 2.22) face significantly elevated odds of needlestick injuries compared to hospital dentists (reference); (3) Patient-Related Risk Factors – male patients and younger patients (aged < 20 years) are significantly associated with needlestick injuries; (4) Temporal Patterns – Q3 (July-September) exhibits a distinct peak, coinciding with the admission of new students and trainees; and (5) Prevention and Control Measures – five targeted strategies are recommended, including specialty-targeted interventions (safety-engineered devices, safe injection/suturing training), high-risk personnel training (mandatory orientation, periodic refreshers, post-procedure sharps management), temporal targeting (intensified training at term start, enhanced supervision in Q3), four-hand operation optimization (safety protocols for needle-related procedures), and post-exposure management (expanded pre-procedural screening, improved PEP protocols).

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Stomatological Hospital, School of Stomatology, Guangzhou Medical University(Approval No. LCYJ20250618012). All data were de-identified prior to analysis. The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study, which involved only the review of routinely collected surveillance records and contained no identifiable patient information. The study was conducted in accordance with the Declaration of Helsinki and the relevant national guidelines for human research.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form (including individual details, images, or videos). All data are reported in aggregate form at the institution level.

Competing interests

The authors declare that they have no competing interests, financial or otherwise, that could have influenced the work reported in this paper.

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Author Contribution

W.J.L., Z.X.B., and Y.D. conceptualized and designed the study. W.J.L., S.M.Y., and Z.L. developed the methodology. W.J.L., S.M.Y., Z.L., Y.F.G., and X.X.H. contributed to the investigation and data curation. W.J.L. performed the formal analysis and wrote the original draft. S.M.Y., Z.L., Y.F.G., X.X.H., Z.X.B., and Y.D. critically reviewed and edited the manuscript. Z.X.B. and Y.D. supervised the study, administered the project, and secured the funding. X.X.H. also contributed resources. All authors read and approved the final manuscript and agree to be accountable for all aspects of this work.

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Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to institutional confidentiality policies and the inclusion of potentially identifiable occupational health information. De-identified data may be made available from the corresponding author on reasonable request, subject to approval by the Institutional Review Board of Stomatological Hospital, School of Stomatology, Guangzhou Medical University and a data use agreement.

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Figures

Figure 1. Annual trend of occupational percutaneous injuries (2015-2025)

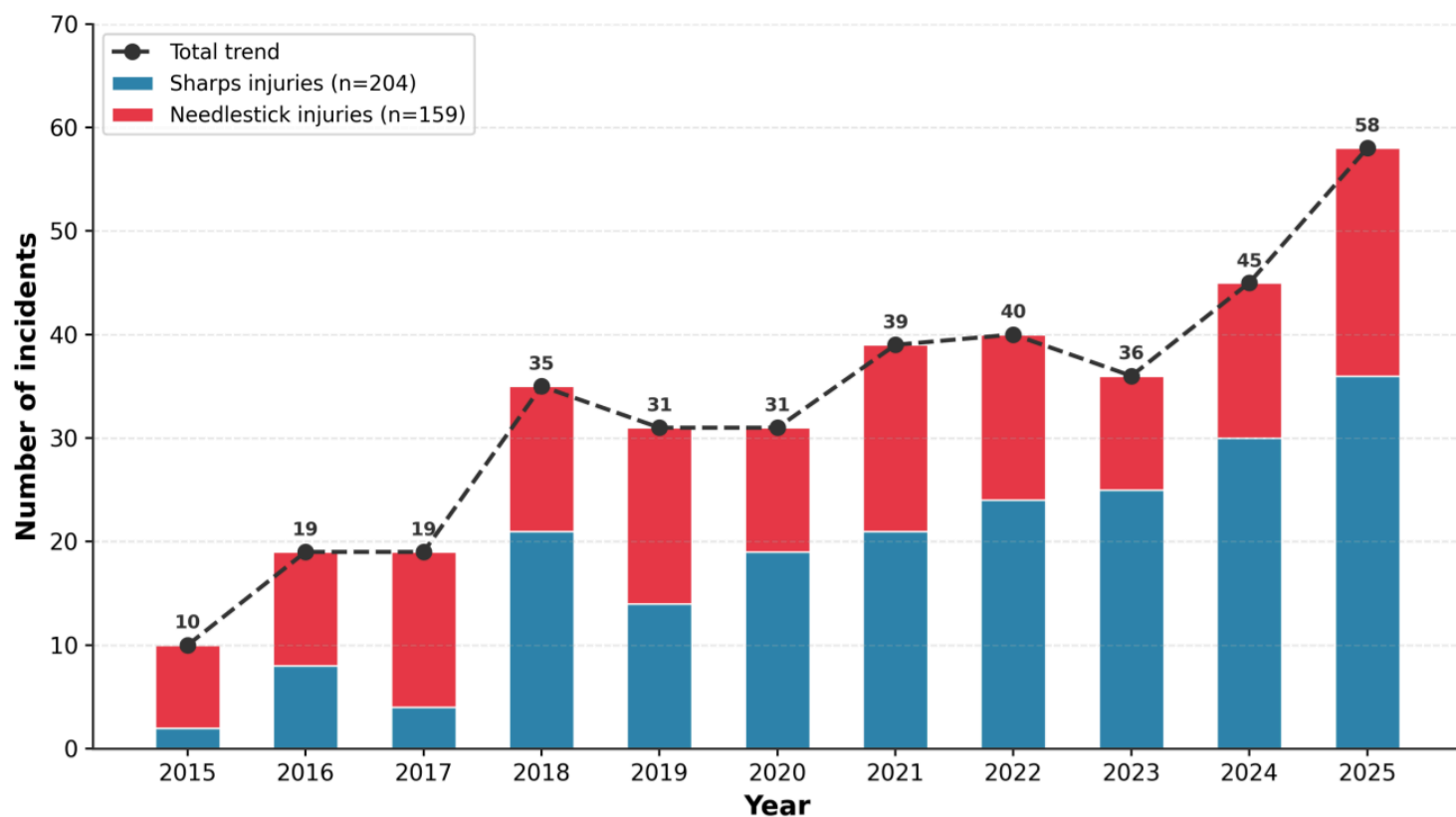


Figure 1

Annual distribution of occupational percutaneous injuries (2015-2025), stratified by injury type. Bars represent the number of sharps injuries (blue) and needlestick injuries (red) per year. The dashed line with markers shows the total number of incidents per year.

Figure 2. Distribution of exposed personnel and exposure sites

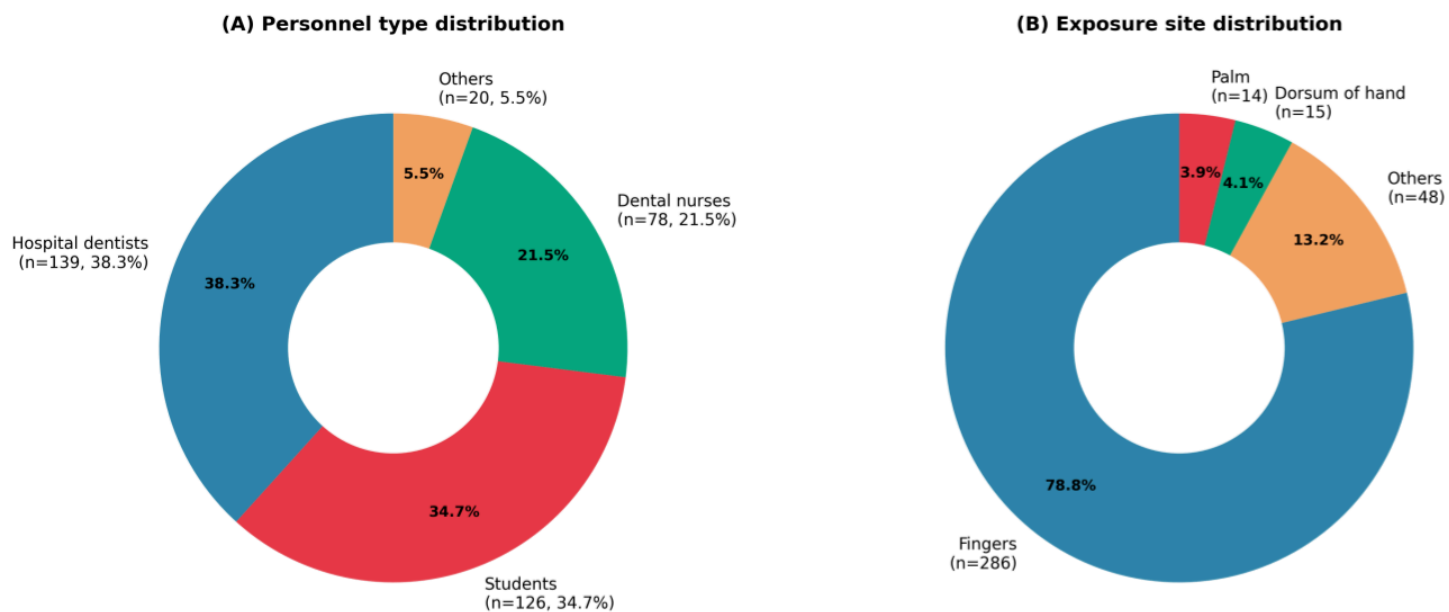


Figure 2

Distribution of exposed personnel (A) and exposure sites (B). Hospital dentists, students, and dental nurses together accounted for 94.5% of all exposures, with the fingers being the predominant exposure site (78.8%).

Figure 6. Source patient bloodborne pathogen status and post-exposure management

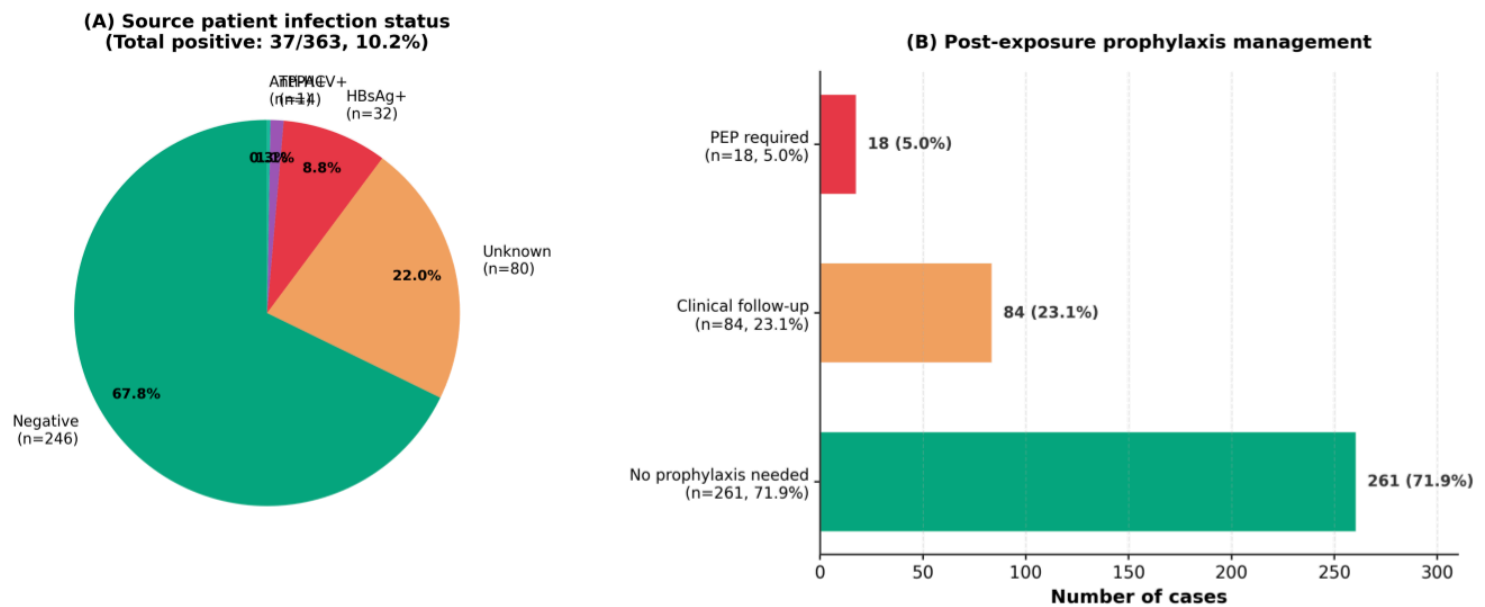


Figure 6

Source patient bloodborne pathogen infection status (A) and post-exposure prophylaxis management (B). Of the 363 source patients, 10.2% (n = 37) tested positive for at least one bloodborne pathogen.

**Figure 7. Forest plot of multivariable logistic regression (Model B)
Risk factors for needlestick injuries vs. sharps injuries**

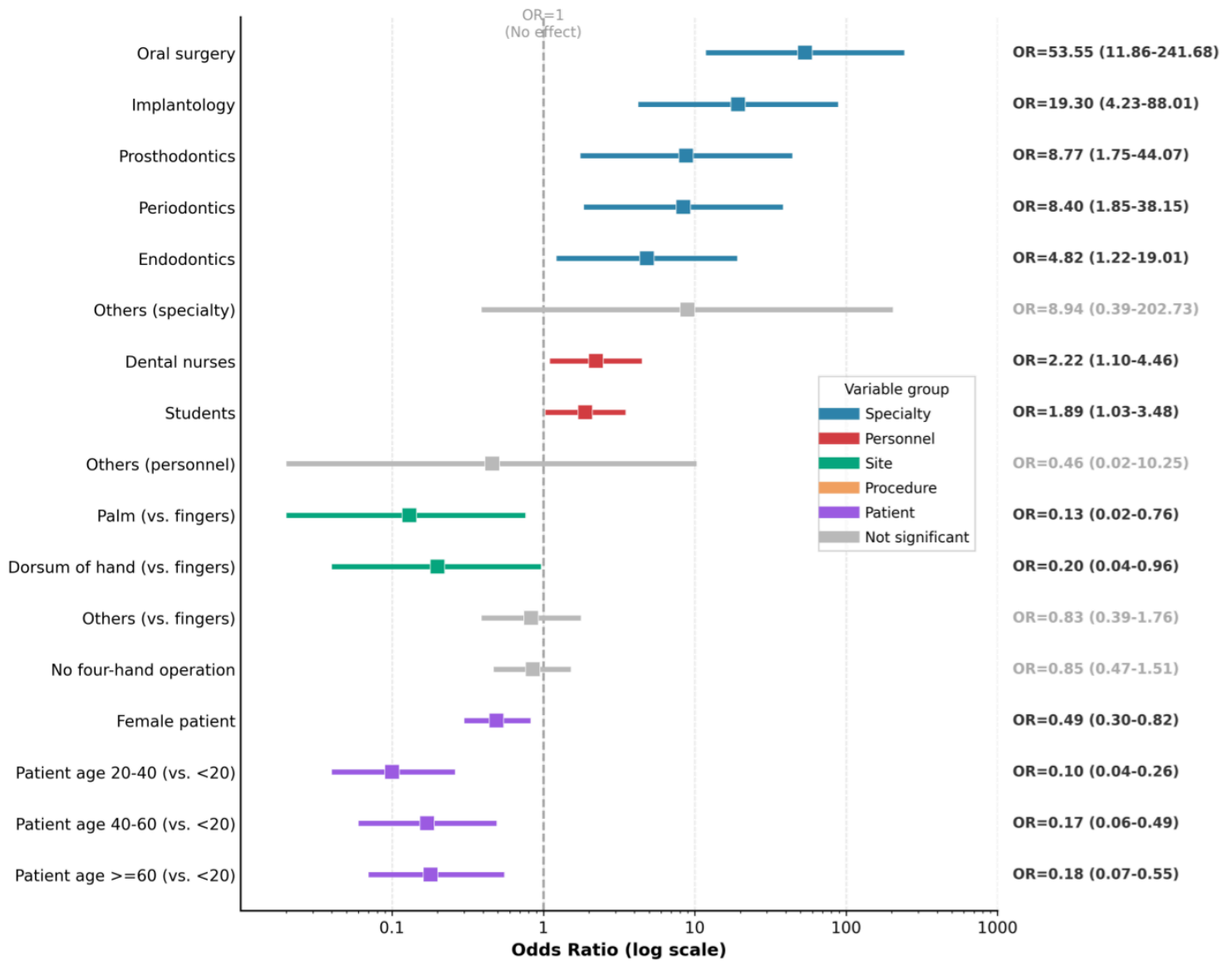


Figure 7

Forest plot of the binary logistic regression (Model B) for independent risk factors of needlestick injuries compared to sharps injuries. Squares represent the odds ratios (ORs) and horizontal lines represent 95% confidence intervals. Colored markers indicate statistically significant associations ($P < 0.05$).

Targeted Prevention of Needlestick Injuries in Dental Healthcare Workers: Risk Factor Analysis in Contrast to Sharps Injuries

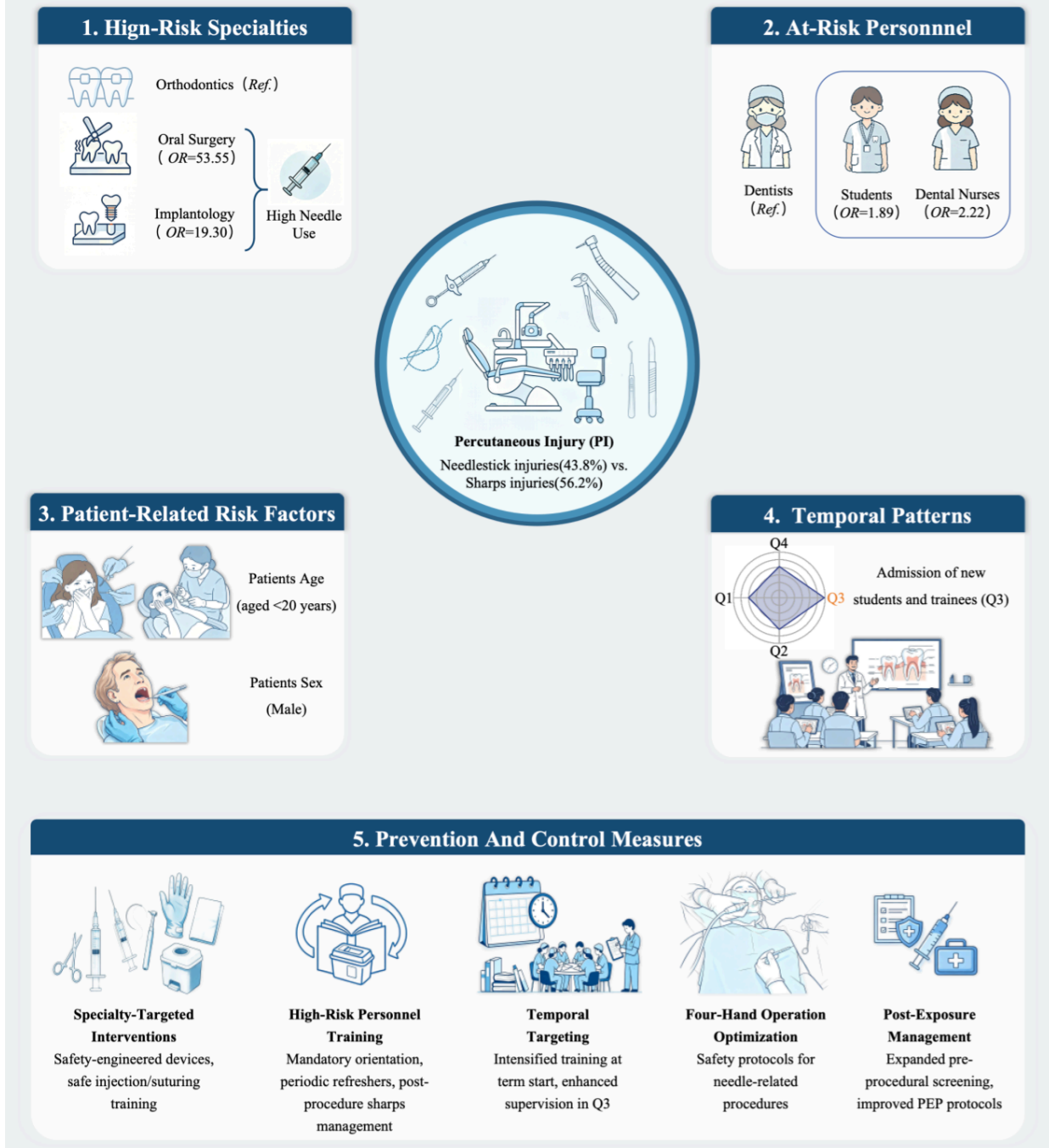


Figure 10

Comprehensive framework for targeted prevention of needlestick injuries among dental healthcare workers.