International Research Journal of Advanced Education and Sciences
JAYE PUBLICATIONS https://irjaes.org/

Epidemiological Pattern and Post-Exposure Management of Needlestick and Sharps Injuries among Healthcare Workers at a Tertiary Care Hospital in Sri Lanka

Barthelot M[1], Sasikumar S[1], Thotagamuwa T. W. A. N[2]
[1]Teaching Hospital Batticaloa, Sri Lanka
[2]Ministry of Health, Colombo, Sri Lanka
Email address: nmayuran@gmail.com

***Abstract*— Background**: *Healthcare workers (HCWs) face substantial occupational risk of bloodborne pathogen transmission through needlestick and sharps injuries (NSIs). Institution-level data linking exposure circumstances to Hepatitis B protection status remain limited in Sri Lanka. This study describes the pattern of NSIs and Hepatitis B vaccination/antibody status among HCWs at Teaching Hospital Batticaloa.* **Methods**: *A retrospective descriptive cross-sectional study was conducted using secondary surveillance data from the Infection Prevention and Control Unit, Teaching Hospital Batticaloa. All NSI incidents reported between January and December 2025 (n=85) were included using total enumeration sampling. Data were entered and analyzed in SPSS version 29.0 using descriptive statistics and chi-square tests.* **Results**: *The mean age of affected HCWs was 32.0 ± 7.3 years; 68.2% were female. Nursing cadre accounted for the largest share of injuries (40.0%), followed by medical cadre (28.2%), students (16.5%), and support staff (15.3%). Most injuries occurred during a clinical procedure (62.4%) involving a patient needle (81.2%). Mode of exposure differed significantly by cadre (χ^2=27.42, $p<0.001$): support staff injuries clustered around waste disposal (84.6%), while medical cadre injuries occurred mainly during procedures (87.5%). Hepatitis B vaccination was complete in 64.7% overall, but varied markedly by cadre (χ^2=26.39, $p<0.001$), with only 46.2% of support staff fully vaccinated and 53.8% entirely unvaccinated — the highest gap of any cadre. Among those with a checked antibody titre, most (91.8%) showed protective levels (≥10 mIU/mL).* **Conclusion**: *Occupational risk and Hepatitis B protection were unevenly distributed across HCW cadres, with support/waste-handling staff bearing a disproportionate vaccination gap despite direct sharps exposure. Cadre-specific prevention strategies, particularly targeted vaccination outreach for support staff, are recommended.*

***Keywords*—** *Needlestick injury; Sharps injury; Occupational exposure; Hepatitis B vaccination; Healthcare workers; Sri Lanka.*

I. Introduction

Healthcare workers (HCWs) are routinely exposed to blood and body fluids (BBFs) in the course of clinical duties, placing them at occupational risk of transmission of more than 20 bloodborne pathogens, most notably hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) [1,2]. The World Health Organization has estimated that percutaneous injuries account for a substantial share of the global burden of occupationally acquired HBV, HCV, and HIV infection among HCWs, with the greatest impact falling on health systems already constrained by workforce shortages [3]. Needlestick and sharps injuries (NSIs) remain the single most common mechanism of such exposure, typically occurring during cannulation, phlebotomy, surgical procedures, and waste handling [4,5].

The global burden of NSIs is considerable and unevenly distributed. Systematic reviews and meta-analyses report pooled one-year prevalence estimates ranging from below 15% in some high-resource settings to over 70% in others, with South Asian settings, including Sri Lanka, among the highest reported [4,6,7]. Similar patterns have been documented across teaching hospitals in India, Iran, Cameroon, and Ethiopia, where nurses, medical officers, students, and non-clinical support staff such as cleaning and waste-handling personnel all feature prominently among the exposed [8–12]. These studies consistently identify recapping, cannulation, intraoperative handling, and sharps waste disposal as recurring circumstances of injury, and point to gaps in post-exposure management — incomplete source-patient testing, delayed reporting, and inconsistent post-exposure prophylaxis — as persistent problems even where exposure itself is well documented [9,10].

Hepatitis B vaccination is one of the few effective primary preventive measures available to HCWs, yet vaccination coverage and, more importantly, documented post-vaccination antibody status vary widely across cadres and institutions [5,11]. Workers with incomplete vaccination series or antibody titres below the protective threshold (<10 mIU/mL) remain susceptible to HBV following an exposure, even where the exposure itself is promptly reported and managed [3,11]. Non-clinical staff, such as cleaning and waste-disposal personnel, are frequently under-represented in institutional vaccination and training programmes despite handling contaminated sharps directly, a pattern also evident at the study institution.

Teaching Hospital Batticaloa, a tertiary referral centre in the Eastern Province of Sri Lanka, maintains a routine surveillance log of needlestick and sharps exposure incidents reported by staff across clinical and support cadres. While national and

Barthelot M1, Sasikumar S and Thotagamuwa T. W. A. N, "Epidemiological Pattern and Post-Exposure Management of Needlestick and Sharps Injuries among Healthcare Workers at a Tertiary Care Hospital in Sri Lanka," *International Research Journal of Advanced Education and Sciences*, Volume 1, Issue 1, pp. 15-19, August 2026.

regional data on NSI prevalence in Sri Lanka exist [6], institution-level analyses that link exposure circumstances to vaccination and antibody status, and to the completeness of post-exposure management, remain limited. Such analyses are important for identifying which cadres and which procedures carry disproportionate risk, and where gaps in the post-exposure protocol persist locally.

This study therefore aims to describe the pattern and circumstances of needlestick and sharps injuries reported among healthcare workers at Teaching Hospital Batticaloa during 2025, to characterize Hepatitis B vaccination and antibody status among the exposed, and to assess the completeness of post-exposure management, including source-patient testing and referral for further management.

Here's the Methodology section with gaps 1, 3, and 4 filled in (leaving ethics as-is per your request):

II. Methodology

Study Design

This was a hospital-based, retrospective descriptive cross-sectional study using secondary data.

Study Setting

The study was conducted at Teaching Hospital Batticaloa, a tertiary care referral hospital in the Eastern Province of Sri Lanka, which provides a full range of medical, surgical, and specialized clinical services and maintains an active Infection Prevention and Control (IPC) Unit responsible for surveillance of occupational sharps and blood/body fluid exposures among staff.

Study Period

Data collection and analysis were carried out from February to March 2026. Data pertaining to needlestick and sharps injury incidents were extracted retrospectively for the period January to December 2025.

Study Population

The study population comprised all healthcare workers — including medical officers, nursing officers, nursing and medical students, house officers/intern officers, health assistants, and cleaning/waste-disposal staff — who sustained an occupational needlestick or sharps injury and had this incident reported to and recorded by the IPC Unit at Teaching Hospital Batticaloa during the study period.

Operational Definitions

- *Needlestick/sharps injury*: A percutaneous injury caused by a needle, cannula, or other sharp medical device that had been in contact with a patient's blood or body fluid, occurring during a work-related procedure such as cannulation, injection, phlebotomy, surgical procedure, or handling/disposal of sharps waste.
- *Adequate Hepatitis B antibody titre*: An anti-HBs titre of ≥10 mIU/mL following completion of the primary vaccination series, consistent with the WHO-recommended threshold for protective immunity. Titres <10 mIU/mL were classified as non-protective/indicating need for revaccination.
- *Complete Hepatitis B vaccination*: Receipt of all three doses of the primary Hepatitis B vaccination series.

Sample Size and Sampling Technique

Total enumeration (census) sampling was used. All needlestick and sharps injury incidents recorded in the IPC Unit register during January–December 2025 (n = 85) were included in the study; no separate sample size calculation was performed as the entire available secondary dataset was utilized.

Inclusion and Exclusion Criteria

Inclusion criteria: All needlestick and sharps injury incidents involving healthcare workers of any cadre, formally reported to and documented by the IPC Unit, Teaching Hospital Batticaloa, between 1st January and 31st December 2025.

Exclusion criteria: Incidents with a missing staff designation, age, or sex were excluded from the overall analysis. Records with missing values for a specific variable (e.g., antibody titre, source-patient testing result) were retained for all analyses not dependent on that variable, but excluded on a variable-by-variable basis from the specific sub-analysis concerned, and this was reported as the applicable denominator in each table.

Data Source and Data Collection Method

Secondary data were obtained from the needlestick and sharps injury reporting register maintained by the Infection Prevention and Control Unit, Teaching Hospital Batticaloa. Data were extracted using a structured data extraction sheet covering the following variables: age, sex, designation/occupational category, ward/unit of exposure, Hepatitis B vaccination status, antibody titre status, need for revaccination/booster dose, mode/circumstance of exposure, source of the sharp object, whether the source patient was tested for Hepatitis B surface antigen and Hepatitis C antibody, the result of source-patient testing, and referral status for further management (STD clinic referral).

Data Entry and Analysis

Extracted data were coded and entered into IBM SPSS Statistics, version 29.0, for analysis. Descriptive statistics were used throughout: continuous variables (i.e., age) were summarized as mean ± standard deviation, or median with interquartile range if the distribution was skewed; categorical variables (sex, designation, ward, mode of exposure, vaccination status, antibody status, source testing, referral outcome) were summarized as frequencies and percentages. Cross-tabulations, supplemented by the Chi-square test (or Fisher's exact test where expected cell counts were <5), were used to examine associations between occupational category and mode of exposure, and between occupational category and Hepatitis B vaccination/antibody status. A p-value of <0.05 was considered statistically significant. Results are presented in tables and charts.

Ethical Considerations

Administrative permission was obtained from the relevant hospital authorities prior to data extraction. As the study used

Barthelot M1, Sasikumar S and Thotagamuwa T. W. A. N, "Epidemiological Pattern and Post-Exposure Management of Needlestick and Sharps Injuries among Healthcare Workers at a Tertiary Care Hospital in Sri Lanka," *International Research Journal of Advanced Education and Sciences*, Volume 1, Issue 1, pp. 15-19, August 2026.

de-identified secondary surveillance data routinely collected by the IPC Unit, no direct participant contact was involved. Confidentiality of staff identity was maintained throughout data extraction, entry, and analysis, and no individually identifiable information is reported in this study.

III. Results

TABLE I. Socio-demographic characteristics of healthcare workers with reported needlestick/sharps injuries (n=85)

Variable	Category	n	%
Age (years)	Mean ± SD	32.0 ± 7.3	—
	Median (IQR)	30 (27–34)	—
	<25	3	3.5
	25–29	37	43.5
	30–34	25	29.4
	35–39	5	5.9
	≥40	15	17.6
Sex	Female	58	68.2
	Male	27	31.8
Occupational cadre	Nursing cadre	34	40.0
	Medical cadre	24	28.2
	Students	14	16.5
	Support staff	13	15.3
Ward/Unit	Subspeciality	46	54.1
	Medical	17	20.0
	Surgical	7	8.2
	Operation theatre	6	7.1
	Waste disposal area	5	5.9
	Peadiatric	3	3.5
	Maternity	1	1.2

Occupational cadre: Nursing cadre = nursing officers; Medical cadre = medical officers, intern medical officers (IMO); Students = nursing/medical students; Support staff = health assistants, cleaning service staff.

A total of 85 needlestick and sharps injury incidents were recorded among healthcare workers at Teaching Hospital Batticaloa during the study period. The mean age of affected workers was 32.0 ± 7.3 years (median 30, IQR 27–34), with the largest proportion falling in the 25–29 year age group (43.5%). Females accounted for the majority of exposures (68.2%, n=58), consistent with the female-dominated composition of the nursing and support-staff workforce. By occupational cadre, nursing staff were most frequently affected (40.0%, n=34), followed by medical cadre (28.2%, n=24), students (16.5%, n=14), and support staff (15.3%, n=13). The majority of injuries occurred in subspeciality wards (54.1%, n=46), followed by medical wards (20.0%, n=17); operation theatres and dedicated waste disposal areas together accounted for a smaller but clinically important share (13.0%, n=11).

TABLE II. Mode/circumstance of needlestick and sharps injury (n=85)

Mode of exposure	n	%
During surgical/clinical procedure	53	62.4
Waste disposal	25	29.4
During cannulation	7	8.2

The majority of injuries occurred during a surgical or clinical procedure (62.4%, n=53), followed by waste disposal-related exposures (29.4%, n=25) and injuries sustained during cannulation (8.2%, n=7). This indicates that direct patient-care activity, rather than waste handling, was the predominant circumstance of exposure overall.

TABLE III. Source of sharp object involved in injury (n=85)

Source	n	%
Patient needle	69	81.2
Unknown sharp	12	14.1
Waste	4	4.7

A patient needle was the source of injury in the large majority of cases (81.2%, n=69). A smaller proportion involved an unknown or unidentified sharp object (14.1%, n=12), and 4.7% (n=4) involved sharps encountered during waste handling. The high proportion of unknown-source injuries is notable, as it precludes source-patient testing in those cases.

TABLE IV. Mode of exposure by occupational cadre (n=85)

Cadre	During Cannulation n(%)	During Procedure n(%)	Waste Disposal n(%)	Row total
Nursing cadre	4 (11.8)	21 (61.8)	9 (26.5)	34
Medical cadre	2 (8.3)	21 (87.5)	1 (4.2)	24
Students	1 (7.1)	9 (64.3)	4 (28.6)	14
Support staff	0 (0)	2 (15.4)	11 (84.6)	13

$\chi^2 = 27.42$, df = 6, $p < 0.001$*

**Two of twelve cells had expected counts <5; interpret with appropriate caution, though the effect size and pattern are pronounced. Support staff injuries clustered overwhelmingly around waste disposal, while medical cadre injuries clustered around direct procedures.*

The circumstance of injury differed markedly by occupational cadre (χ^2=27.42, df=6, p<0.001). Medical cadre staff were injured almost exclusively during direct procedures (87.5%), with waste disposal accounting for only 4.2% of their exposures. Support staff showed the opposite pattern: 84.6% of their injuries occurred during waste disposal, and none occurred during cannulation. Nursing staff and students showed a more mixed pattern, with roughly a quarter of their injuries also linked to waste disposal (26.5% and 28.6% respectively). This suggests that preventive interventions may need to be cadre-specific — procedural safety measures for clinical staff, and safer waste-handling protocols for support staff.

TABLE V. Hepatitis B vaccination status among exposed healthcare workers (n=85)

Vaccination status	n	%
Completed (3 doses)	55	64.7
Incomplete (1–2 doses)	18	21.2
Not vaccinated	12	14.1

Just under two-thirds of exposed workers had completed the full three-dose Hepatitis B vaccination series (64.7%, n=55). However, a substantial minority remained under-protected: 21.2% (n=18) had an incomplete series, and 14.1% (n=12) had received no vaccination at all — meaning more than one in three exposed workers (35.3%) lacked complete vaccination coverage at the time of their injury.

Antibody titres had been checked in 55 of 85 workers (64.7%); testing had not been done in 17 (20.0%), and documentation was unavailable for 13 (15.3%). Among those checked, the great majority had a protective titre — 44.7% (n=38) above 100 mIU/mL and 7.1% (n=6) between 10–100 mIU/mL — while only one worker (1.2%) had a non-protective

Barthelot M1, Sasikumar S and Thotagamuwa T. W. A. N, "Epidemiological Pattern and Post-Exposure Management of Needlestick and Sharps Injuries among Healthcare Workers at a Tertiary Care Hospital in Sri Lanka," *International Research Journal of Advanced Education and Sciences*, Volume 1, Issue 1, pp. 15-19, August 2026.

titre (<10 mIU/mL). Ten results (11.8%) were still pending at the time of data extraction. Regarding revaccination needs, 16 workers (18.8%) required revaccination and 6 (7.1%) required a booster dose, while status was undocumented for 23 (27.1%) — a documentation gap worth flagging in the Discussion.

TABLE VI. Hepatitis B antibody (anti-HBs) titre status (n=85)

Antibody titre	n	%
>100 mIU/mL (protective)	38	44.7
10–100 mIU/mL (protective)	6	7.1
<10 mIU/mL (non-protective)	1	1.2
Pending / result not yet available	10	11.8
Not checked / not applicable	30	35.3

Antibodies checked: yes = 55 (64.7%), No = 17 (20.0%), not documented = 13 (15.3%). Of the 55 checked, 45 (81.8%) had an available protective titre (≥10 mIU/mL), 1 (1.8%) had a non-protective titre, and 10 (18.2%) results were still pending.

TABLE VII. Hepatitis B vaccination status by occupational cadre (n=85)

Cadre	Completed n(%)	Incomplete n(%)	Not vaccinated n(%)	Row total
Nursing cadre	22 (64.7)	10 (29.4)	2 (5.9)	34
Medical cadre	20 (83.3)	3 (12.5)	1 (4.2)	24
Students	7 (50.0)	5 (35.7)	2 (14.3)	14
Support staff	6 (46.2)	0 (0)	7 (53.8)	13

$\chi^2 = 26.39$, df = 6, $p < 0.001$*

**Four of twelve cells had expected counts <5; interpret with caution. Support staff show the starkest gap: over half were completely unvaccinated, compared with <15% in every other cadre.*

Vaccination completeness also varied significantly by cadre ($\chi^2=26.39$, df=6, $p<0.001$). Medical cadre staff had the highest completion rate (83.3%), followed by nursing cadre (64.7%). Support staff showed a striking gap: only 46.2% had completed vaccination, and over half (53.8%) had received no vaccination at all — the highest unvaccinated proportion of any group, and markedly higher than the 4.2–14.3% seen in every other cadre. This finding, combined with Table IV finding that support staff injuries cluster around waste handling, points to a specific and addressable gap in occupational health coverage for this group.

IV. Discussion

This retrospective analysis of 85 needlestick and sharps injury (NSI) reports at Teaching Hospital Batticaloa during 2025 found that most exposures occurred among relatively young, predominantly female staff (mean age 32.0 ± 7.3 years; 68.2% female), a demographic profile broadly consistent with the female-dominated nursing and support cadres reported in comparable South Asian and Middle Eastern teaching hospitals [8,9,10]. Nursing staff accounted for the largest single share of exposures (40.0%), followed by medical cadre, students, and support staff — a distribution that mirrors findings from teaching hospitals in India and Iran, where nursing personnel similarly bear the largest absolute burden of reported injuries simply by virtue of their frequent hands-on contact with sharps [9,10].

The majority of injuries occurred during a surgical or clinical procedure (62.4%) rather than during waste handling (29.4%), and a patient needle was implicated in over four-fifths of cases (81.2%). This procedure-dominant pattern is consistent with global reviews identifying cannulation, injection, and intraoperative handling as the leading mechanisms of NSI among clinical staff [4,5]. However, the cadre-stratified analysis (Table IV) revealed a markedly different picture once occupational category was accounted for: support staff injuries clustered almost exclusively around waste disposal (84.6%), while medical cadre injuries occurred almost entirely during direct procedures (87.5%). This divergence ($\chi^2=27.42$, $p<0.001$) echoes findings from Nigeria and other resource-limited settings, where cleaning and waste-handling personnel are disproportionately exposed to unretracted or improperly discarded sharps despite having no direct role in the procedures that generated them [14]. This distinction matters for prevention planning: interventions aimed at clinical staff (e.g., safety-engineered devices, safe injection technique) will do little to protect support staff, whose risk originates further downstream in the waste-handling pathway.

Hepatitis B vaccination coverage in this cohort (64.7% fully vaccinated) was moderate by regional standards, sitting above the 33% reported among healthcare workers in Tanzania [11] but below coverage levels typically reported in high-resource settings [13]. The cadre-level breakdown, however, exposed a stark internal inequity: while medical cadre staff had 83.3% completion, support staff had only 46.2%, and over half of support staff (53.8%) had received no Hepatitis B vaccination at all ($\chi^2=26.39$, $p<0.001$). This gap is consistent with a broader literature documenting that non-clinical and ancillary staff — cleaners, waste handlers, porters — are systematically under-prioritized in institutional vaccination and occupational health programmes despite handling contaminated material directly [14,16]. Systematic reviews from Ethiopia and across Africa report similarly wide disparities in vaccination coverage by occupational cadre, driven largely by unequal access to occupational health services rather than differences in underlying risk [15,16].

Encouragingly, among workers whose antibody titres had been checked, the substantial majority (91.8% of those with a result) had a documented protective anti-HBs titre (≥10 mIU/mL), broadly in line with the high seroprotection persistence reported in long-term immunogenicity studies of vaccinated healthcare personnel [13]. However, results were still pending for nearly one in five of those tested (18.2%), and revaccination/booster status was undocumented for over a quarter of the cohort (27.1%) — a documentation gap rather than necessarily a clinical one, but one that limits the institution's ability to confirm protection status promptly after a new exposure.

Several limitations should be considered. First, this study relied on secondary surveillance data from a single institution and a single calendar year, and reflects only injuries that were formally reported to the IPC Unit; global evidence consistently shows that a substantial proportion of NSIs go unreported, particularly among physicians and staff without recent safety training, meaning the true burden at this hospital is likely underestimated [19]. Second, the absence of a denominator (total staff by cadre) precluded calculation of true incidence rates; the findings describe the pattern among reported

exposures rather than population-level risk. Third, small cell counts in some cross-tabulations (Tables IV and VII) mean chi-square results should be interpreted with appropriate caution, notwithstanding the consistency and clinical plausibility of the observed patterns. Finally, as a descriptive cross-sectional study, causal inference regarding the drivers of cadre-based disparities cannot be made.

These findings nonetheless point to actionable priorities: targeted Hepatitis B vaccination outreach for support/waste-handling staff, and cadre-specific prevention strategies — engineering controls and safe technique training for clinical staff [17,18], versus safer waste segregation and handling protocols for support staff — are likely to yield more impact than uniform, one-size-fits-all interventions.

V. Conclusion

This study found that needlestick and sharps injuries at Teaching Hospital Batticaloa in 2025 disproportionately affected young, female nursing staff, with the majority of exposures occurring during clinical procedures involving a patient needle. However, the circumstances of injury and Hepatitis B protection differed sharply by occupational cadre: while clinical staff were injured mainly during procedures and were comparatively well vaccinated, support staff — particularly cleaning and waste-handling personnel — were injured almost exclusively during waste disposal and showed markedly lower vaccination coverage, with over half remaining completely unvaccinated. Antibody titre and revaccination documentation also showed notable gaps, limiting the institution's ability to confirm protection status promptly.

These findings indicate that occupational risk and preventive coverage are not uniformly distributed across the healthcare workforce, and that support staff represent a specific, under-addressed vulnerability despite handling contaminated sharps directly. Institution-level infection prevention strategies should move beyond a uniform approach and adopt cadre-specific interventions: mandatory, actively tracked Hepatitis B vaccination for all support and waste-handling staff, safer sharps disposal and segregation practices in waste-handling areas, and improved documentation of antibody testing and revaccination status across all cadres. Strengthening incident reporting systems to capture the true burden of exposure, including underreported injuries, would also support more accurate risk assessment. Addressing these gaps would meaningfully reduce preventable occupational exposure to bloodborne pathogens among healthcare workers at this institution.

References

[1]. A. Prüss-Üstün, E. Rapiti, and Y. Hutin "Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers," *Am J Ind Med*., vol. 48, issue 6, pp. 482–90, 2005.

[2]. E. Rapiti, A. Prüss-Üstün, and Y. Hutin "Sharps injuries: assessing the burden of disease from sharps injuries to health-care workers at national and local levels," Geneva: World Health Organization, (WHO Environmental Burden of Disease Series, No. 11), 2005.

[3]. T. Bekele, A. Gebremariam, M. Kaso, and K. Ahmed, "Factors associated with occupational needle stick and sharps injuries among healthcare workers in Ethiopia: a systematic review and meta-analysis," *PLoS One*, vol. 10, issue 10, e0140382, 2015.

[4]. T. D. Yazie, K. A. Chufa, and M. Girma Tebeje, "Prevalence of needlestick injury among healthcare workers in Ethiopia: A systematic review and meta-analysis," *Environmental Health and Preventive Medicine*, vol. 24, issue 1, 2019.

[5]. S. Bouya, A. Balouchi, H. Rafiemanesh, et al. Global prevalence and device-related causes of needle stick injuries among health care workers: A systematic review and meta-analysis," *Ann Glob Health,* 2020.

[6]. P. B. Machmud, S. Glasauer, C. Gottschick, and R. Mikolajczyk "Knowledge, vaccination status, and reasons for avoiding vaccinations against hepatitis B in developing countries: A systematic review," *Vaccines*, vol. 9, issue 6, 625, 2021.

[7]. F. Z. L. Cheuyem, E. E. Lyonga, H. G. Kamga, F.-X. Mbopi-Keou, I. Takougang. "Needlestick and sharp injuries prevalence and hepatitis B vaccination among healthcare workers: a cross-sectional study in six district hospitals, Yaoundé, Cameroon," *Journal of Community Medicine & Public Health*, vol. 7, 321, 2023.

[8]. A. Raj, A. Haider, J. Agraja, et al. "Prevalence of needle stick injuries among healthcare workers at a tertiary care centre in Kochi, India," *Cureus*, vol. 16, issue 10, e72077, 2024.

[9]. S. A. Singru and A. Banerjee "Occupational exposure to blood and body fluids among health care workers in a teaching hospital in Mumbai, India," *Indian J Community Med*., vol. 33, issue 1, pp. 26–30, 2008.

[10]. S. M. Tabatabaei, F. Behmanesh Pour, J. Ordoni Avval, S. Osmani, S. Mokhtari, et al. "Occupational exposure to blood and other body fluids among healthcare workers in three teaching hospitals, southeast Iran," *Int J Infect*., vol. 3, issue 3, e32879, 2016.

[11]. D. Aaron, T. J. Nagu, J. Rwegasha, and E. Komba "Hepatitis B vaccination coverage among healthcare workers at national hospital in Tanzania: how much, who and why?," *BMC Infect Dis*., vol. 17, 786, 2017.

[12]. H. Handiyani, L. M. Kurniawidjaja, D. Irawaty, and R. Damayanti "The effective needle stick injury prevention strategies for nursing students in the clinical settings: a literature review," *Enferm Clin*., vol. 28(Suppl 1), pp. 167–71, 2018.

[13]. A. Rahmani, A. Montecucco, B. Kusznir Vitturi, N. Debarbieri, G. Dini, and P. Durando "Long-term effectiveness of hepatitis B vaccination in the protection of healthcare students in highly developed countries: a systematic review and meta-analysis," *Vaccines*, vol. 10, issue 11, 1841, 2022.

[14]. O. Abiodun, O. Shobowale, C. Elikwu, D. Ogbaro, A. Omotosho, B. Mark, and A. Akinbola "Risk perception and knowledge of hepatitis B infection among cleaners in a tertiary hospital in Nigeria: a cross-sectional study," *Clin Epidemiol Glob Health*, vol. 7, pp. 11–16, 2019.

[15]. N. Awoke, H. Mulgeta, T. Lolaso, T. Tekalign, S. Samuel, M. S. Obsa, et al. "Full-dose hepatitis B virus vaccination coverage and associated factors among health care workers in Ethiopia: A systematic review and meta-analysis," *PLoS One*, vol. 15, issue 11, e0241226, 2020.

[16]. A. Auta, E. O. Adewuyi, G. T. Kureh, N. Onoviran, and D. Adeloye "Hepatitis B vaccination coverage among health-care workers in Africa: a systematic review and meta-analysis," *Vaccine*, vol. 36, issue 32, pp. 4851–60, 2018.

[17]. A. C. Harb, R. Tarabay, B. Diab, R. A. Ballout, S. Khamassi, and E. A. Akl "Safety engineered injection devices for intramuscular, subcutaneous and intradermal injections in healthcare delivery settings: a systematic review and meta-analysis," *BMC Nurs*, 14:71, 2015.

[18]. M. C. Lavoie, J. H. Verbeek, and M. Pahwa "Devices for preventing percutaneous exposure injuries caused by needles in healthcare personnel," *Cochrane Database Syst Rev*, vol. 3, CD009740, 2014.

[19]. Centers for Disease Control and Prevention. Workbook for Designing, Implementing, and Evaluating a Sharps Injury Prevention Program. Atlanta: CDC; 2008.

[20]. World Health Organization. Global Hepatitis Report 2017. Geneva: WHO; 2017.