

# Needle Stick Injury Among Healthcare Workers in a Tertiary Care Setting in Dehradun, Sub-Himalayan Region: A Four-Year Record-Based Study

Review began 04/08/2024  
Review ended 04/13/2024  
Published 04/17/2024

© Copyright 2024

Singh et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Rajender Singh <sup>1</sup>, Garima Mittal <sup>1</sup>, Abhay Srivastava <sup>2</sup>

<sup>1</sup>. Department of Microbiology, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Dehradun, IND <sup>2</sup>. Department of Community Medicine, Himalayan Institute of Medical Sciences, Dehradun, IND

**Corresponding author:** Rajender Singh, panwar.rajendra@gmail.com

## Abstract

**Introduction:** Needlestick injuries (NSIs) represent a significant occupational health risk in healthcare settings. These injuries, caused by contaminated sharps such as needles, vials, and scalpel blades, can lead to percutaneous exposure to infectious materials. Despite the severity of NSIs, they often go unreported, highlighting a critical gap in occupational safety protocols.

**Aims:** This study aimed to investigate the occurrence of NSIs among healthcare workers (HCWs) by sex, profession, and working areas. It also sought to explore the underlying reasons for these injuries and the factors contributing to their underreporting.

**Methodology:** Adhering to the RECORD guidelines (Reporting of studies Conducted using Observational Routinely Collected Data), this record-based study involved a retrospective analysis of reported NSIs. Data were collected from voluntary reports by HCWs who experienced NSIs or exposure to potentially infectious materials such as blood and body fluids. Statistical analysis was conducted using IBM SPSS Statistics for Windows, Version 16 (Released 2007; IBM Corp., Armonk, New York) and Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington).

**Results:** Data from 142 participants indicated a higher proportion of females experiencing NSIs compared to males, with rates of 57.7% pre-COVID and 60.6% during COVID. There were notable shifts in NSI rates across professions, with increases observed among staff nurses and ward attendants/helpers. Analysis of injury circumstances revealed a decrease in sampling procedure-related injuries but an increase during intravenous procedures and biomedical waste segregation. Injuries occurring on the right-hand index finger decreased from 52.1% pre-COVID to 31% during COVID, while those on the left-hand index finger increased from 19.7% pre-COVID to 39.4% during COVID. Statistically significant associations were found between the injury site and the place of occurrence ( $p=0.021$ ). Healthcare professionals commonly cleansed the site with disinfectants and used personal protective equipment (PPE) kits, with increased PPE usage noted during the COVID-19 pandemic. These findings emphasize the evolving dynamics of NSIs among HCWs and underscore the importance of tailored preventive measures during pandemics.

**Categories:** Epidemiology/Public Health, Environmental Health, Occupational Health

**Keywords:** hepatitis b, occupational health hazard, health-care worker, hiv diseases, needle stick and sharp injury

## Introduction

Needlestick injuries (NSIs) represent a significant occupational health hazard in healthcare settings, resulting from contact with needles or sharp objects such as hypodermic needles, blood collection needles, intravenous stylets, and needles used in intravenous delivery systems. These injuries, characterized by breaks in skin continuity caused by contaminated needle sticks or infected sharps like vials and scalpel blades, pose a risk of percutaneous exposure for healthcare workers (HCWs).

HCWs face an elevated risk of NSIs due to their work environment, with potential exposure to blood-borne pathogens like hepatitis B virus (HBV), hepatitis C virus (HCV), and HIV, particularly when handling patients' blood, urine, and saliva [1]. The United States Centers for Disease Control and Prevention estimates an annual occurrence of 600,000 to 1,000,000 NSIs, with infection risks accounting for 0.2-0.5% for HIV, 3-10% for HCV, and 40% for HBV [2,3].

Major cases of NSIs often result from improper use of personal protective equipment (PPE) such as gloves, attempts to recap needles, improper sharps disposal, and the insertion of IV (intravenous) cannulas and drips. Inadequate work experience and low knowledge of blood-borne infections also contribute to NSI occurrences among HCWs.

### How to cite this article

Singh R, Mittal G, Srivastava A (April 17, 2024) Needle Stick Injury Among Healthcare Workers in a Tertiary Care Setting in Dehradun, Sub-Himalayan Region: A Four-Year Record-Based Study. Cureus 16(4): e58448. DOI 10.7759/cureus.58448

NSIs vary among HCWs based on workplace and environmental factors. Studies suggest that approximately 40% of NSIs in the past three months and 75% in the past year have gone unreported, posing a significant barrier to exposed HCWs receiving post-exposure prophylaxis and leading to serious consequences [4].

## Literature review

Numerous studies have investigated reasons for the underreporting of NSIs among HCWs, citing factors such as unawareness of reporting systems, heavy workloads, fear of repercussions including job loss, and inadequate understanding of the importance and hazards associated with NSIs [5–7]. Further studies are needed to assess HCWs' behavior regarding NSI reporting.

The recent COVID-19 pandemic has not only impacted global lifestyles but also brought significant changes to the healthcare system. The pandemic highlighted HCWs' vulnerability to occupational hazards and emphasized the importance of ensuring their safety [8].

The use of PPE during the pandemic not only protected against infectious agents but also contributed to a reduction in NSI incidence [9]. The pandemic heightened awareness of health, hygiene, and preventive measures, emphasizing the importance of precautions against occupational risks to effectively fulfill healthcare duties.

This study aims to report NSI incidence in our hospital over the past four years (2018–2021) and compare results between the pre-pandemic and pandemic eras. It also examines the circumstances, locations, and sites of NSIs, incorporating routine anti-HBsAg titer testing conducted for NSI individuals. The study uniquely analyzes NSI occurrence and consequences across two distinct timeframes.

## Materials And Methods

### Study design

This study conforms to the guidelines set forth by the Reporting of Studies Conducted Using Observational Routinely Collected Health Data (RECORD), ensuring rigorous reporting standards for healthcare studies utilizing routinely collected data [10]. It is a record-based investigation conducted in alignment with RECORD guidelines, scrutinizing reported occurrences of NSIs within a tertiary care hospital in Dehradun. The study period encompasses the onset of the COVID-19 pandemic in late 2019, distinguishing NSIs reported on or before December 31, 2019, as pre-COVID, and those reported on or after January 1, 2020, as during COVID-19 times to assess the impact of the COVID-19 pandemic on infection control practices.

### Inclusion criteria

HCWs from various departments including doctors, nurses, lab technicians, ward attendants, and housekeeping staff were eligible for inclusion. Participation in the study required HCWs to provide informed consent for the use of their data.

### Exclusion criteria

Those who did not provide informed consent were excluded from the study.

### Variables

Blood samples collected from HCWs underwent screening for HIV-1 and HIV-2, testing for hepatitis B surface antigen (HBsAg), antibodies against the hepatitis C virus, and hepatitis B surface antibodies titer (anti-HBs titer). These tests were performed as part of the baseline tests for those who reported NSIs because it may later be difficult to attribute whether the infection was acquired due to this occupational exposure or any prior exposure. The study's sample size is contingent upon the number of self-reported NSIs in the hospital during the specified four-year period, resulting in a sample size of 142.

### Data sources and analysis

Data retrieval involved extracting information from past HICC-NSI records spanning from 2018 to 2021. Before the commencement of the study, informed consent was secured from reporting HCWs, alongside ethical clearance from the institute's ethics committee. Screening for HIV-1, HIV-2, HBsAg, and antibodies against HCV adhered to national guidelines. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 16 (Released 2007; IBM Corp., Armonk, New York) and Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington), with a significance level set at  $P < 0.05$ .

### Bias

Given its record-based nature, bias is mitigated; however, potential bias may manifest during HCWs' completion of questionnaires due to apprehension of consequences. Fear of job loss or other repercussions could influence reporting accuracy, while non-reporting events may introduce bias.

## Quantitative variables

Data categorization was based on HCWs' sex, profession, working area, circumstances, and site of injury. Further stratification occurred based on patient status (known/unknown) and HCWs' anti-HBs titer presented the data in number and percentage.

## Results

### Descriptive data

The demographic characteristics of the 142 study participants who experienced NSIs and reported the events to HICC are presented in Table 1. A higher proportion of females (57.7% in the pre-COVID period and 60.6% during the COVID period) reported NSIs compared to males (42.3% in the pre-COVID period and 39.4% during the COVID period).

This study sheds light on various aspects related to NSIs occurring in the hospital, offering a comparison between the pre-COVID and during COVID periods. It highlights how the profession of HCWs correlates with NSI occurrence and provides insight into frequently injured areas and body sites.

The profession-wise distribution indicates a decrease in exposed doctors (from 21.1% to 11.3%) and an increase in affected staff nurses (from 25.4% to 31%). Nursing students experienced NSIs both pre-COVID (14.1%) and during COVID times (8.5%). Lab/OT technicians showed no significant change. Resident doctors and ward attendants/helpers demonstrated fluctuations in NSI occurrences (Table 1).

Category	Details	Pre-COVID, N (%)	During COVID, N (%)	Chi-square/P-value
Gender wise distribution	Male	30 (42.3)	28 (39.4)	0.0291/0.86
	Female	41 (57.7)	43 (60.6)	
Profession wise distribution	Doctors	15 (21.1)	8 (11.3)	8.416/0.209
	Staff nurse	18 (25.4)	22 (31)	
	Nursing students	10 (14.1)	6 (8.5)	
	Lab/OT technicians	7 (9.9)	7 (9.9)	
	Residents (SR/JR)	12 (16.9)	15 (21.1)	
	Ward attendants/helpers	4 (5.6)	11 (15.5)	
	Housekeeping staff	5 (7)	2 (2.8)	
Place of occurrence	Emergency	4 (5.6)	4 (5.6)	5.843/0.441
	OT	17 (23.9)	9 (12.7)	
	ICU	5 (7)	11 (15.5)	
	Lab and Blood Bank	7 (9.9)	6 (8.5)	
	Surgical Department	7 (9.9)	6 (8.5)	
	Medicine Department	23 (32.4)	29 (40.8)	
	Others	8 (11.3)	6 (8.5)	
Circumstances of injury	During sampling procedure	18 (25.4)	6 (8.5)	10.43/0.03
	During intravenous administration (recapping)	16 (22.5)	25 (35.2)	
	During surgical procedure	31 (43.7)	2 (2.8)	
	Biomedical waste segregation	6 (8.5)	14 (19.7)	
	Others	0 (0)	24 (33.8)	
Site of injury reported	Right-hand index finger	37 (52.1)	22 (31)	12.69/0.013
	Right thumb	4 (5.6)	7 (9.9)	
	Left-hand index finger	14 (19.7)	28 (39.4)	
	Left thumb	5 (7)	9 (12.7)	
	Others	11 (15.5)	5 (7)	

**TABLE 1: Baseline characteristics of study participants**

SR/JR: senior resident/junior resident, OT: operation theater, ICU: intensive care unit

In terms of injury occurrence locations, NSIs in the emergency department remained constant, while the ICU witnessed an increase. NSIs in the operating theater (OT), labs, blood bank, surgical department, and medicine department showed variable trends between the pre-COVID and during COVID periods. Other hospital areas also displayed fluctuations in NSI occurrences (Table 1).

Analyzing the circumstances of injury revealed changes in patterns. Sampling procedure-related injuries decreased during COVID-19 times, while injuries during intravenous procedures increased. NSIs during surgical procedures drastically declined during the COVID phase. Biomedical waste segregation-related NSIs showed an increase, along with various other circumstances causing injuries during COVID-19 times (Table 1).

Data analysis based on the site of injury indicated changes in patterns. Injuries on the right-hand index finger decreased, while those on the left-hand index finger increased. Injuries on the thumbs also showed varying trends between the pre-COVID and during COVID periods, along with a decrease in injuries on other body parts like the left and right palms of the hand (Table 1).

Statistical significance

A statistically significant association was found between the site of injury and the place where the injury occurred (p=0.021) (Table 2).

Place	Site of injury, N (%)					Chi-square/P-value
	Right-hand index finger	Right Thumb	Left-hand index finger	Left thumb	Other	
Ward						40.073/0.021
Emergency	3 (5.1%)	0 (0%)	1 (2.4%)	4 (28.6%)	0 (0%)	
OT	17 (28.8%)	1 (9.1%)	2 (4.8%)	4 (14.3%)	4 (25%)	
ICU	5 (8.5%)	1 (9.1%)	8 (19.0%)	1 (7.1%)	1 (6.3%)	
Ward lab and blood bank	3 (5.1%)	1 (9.1%)	7 (16.7%)	1 (7.1%)	1 (6.3%)	
Surgical department	8 (13.6%)	0 (0%)	3 (7.1%)	0 (0%)	2 (12.5%)	
Medicine department	19(32.2%)	7 (63.6.%)	16(38.1%)	5 (35.7%)	5 (31.3%)	
Others	4 (6.8%)	1 (9.1%)	5 (11.9%)	1 (7.1%)	3 (18.8%)	

TABLE 2: Association between the site of injury and the place where the injury occurred
OT: operation theatre, ICU: intensive care unit

Table 3 compares NSI data based on the site of injury across both COVID-19 phases. The majority of cases involved the index finger of the right hand, with a significant difference noted in NSIs affecting both hand index fingers (Table 3).

Site of injury	Period		Chi-square/P-value
	Pre-COVID	During COVID	
Right-hand index finger	37(62.7%)	22(37.3%)	6.524/0.011
Right thumb	4(36.4%)	7(63.6%)	0.887/0.532
Left-hand index finger	14(33.3%)	28(66.7%)	6.627/0.010
Left thumb	5(35.7%)	9(64.3%)	1.268/0.399
Others	11(68.8%)	5(31.2%)	2.536/0.183

TABLE 3: Association between the site of injury and the time period of COVID

Table 4 presents data on hepatitis B vaccination status and anti-HBs titer of exposed HCWs, revealing variations between pre-COVID and during COVID times (Table 4).

Era	Year	Unvaccinated/incomplete vaccination	Complete vaccination (all three doses)	Anti-HBs titer		
				>10 mIU/mL	<10 mIU/mL	Not done (ND)
Pre-COVID	2018	6	20	10	2	8
	2019	10	46	20	3	22
During COVID	2020	12	28	14	3	11
	2021	10	21	12	4	5
Total		38	104	56	12	46

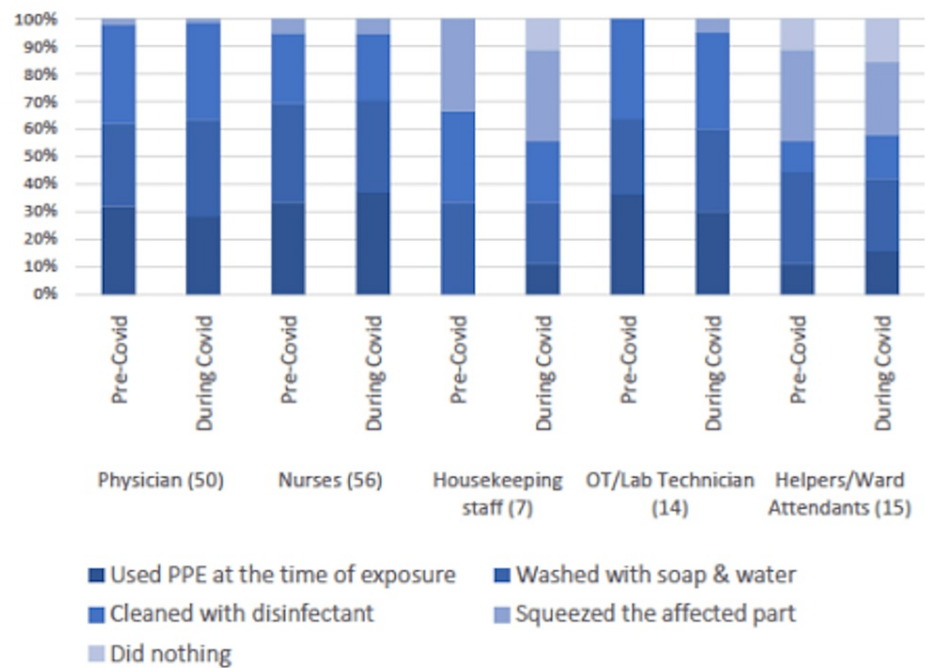
TABLE 4: Hepatitis B vaccination status and anti-HBs titer of NSI-exposed HCWs
Anti-HBs: hepatitis B surface antibody, NSI: needlestick injury, HCW: healthcare worker

The study also examined whether the source status of the injury to the exposed worker was known or not. Cases with unknown source status decreased during COVID-19 times, while known and reactive cases exhibited a decline. Known and non-reactive cases increased during COVID-19 times (Table 5).

Era	Year	Unknown	Known and reactive			Known and non-reactive
			HIV	HBV	HCV	
Pre-COVID	2018	1	1	3	0	21
	2019	5	3	3	7	27
During COVID	2020	0	1	2	2	35
	2021	3	0	2	5	21
Total		9	5	10	14	104

TABLE 5: Source status (known/unknown) of viral markers among NSI-exposed HCWs
NSI: needlestick injury, HCW: healthcare worker, HIV: human immunodeficiency virus, HBV: hepatitis B virus, HCV: hepatitis C virus

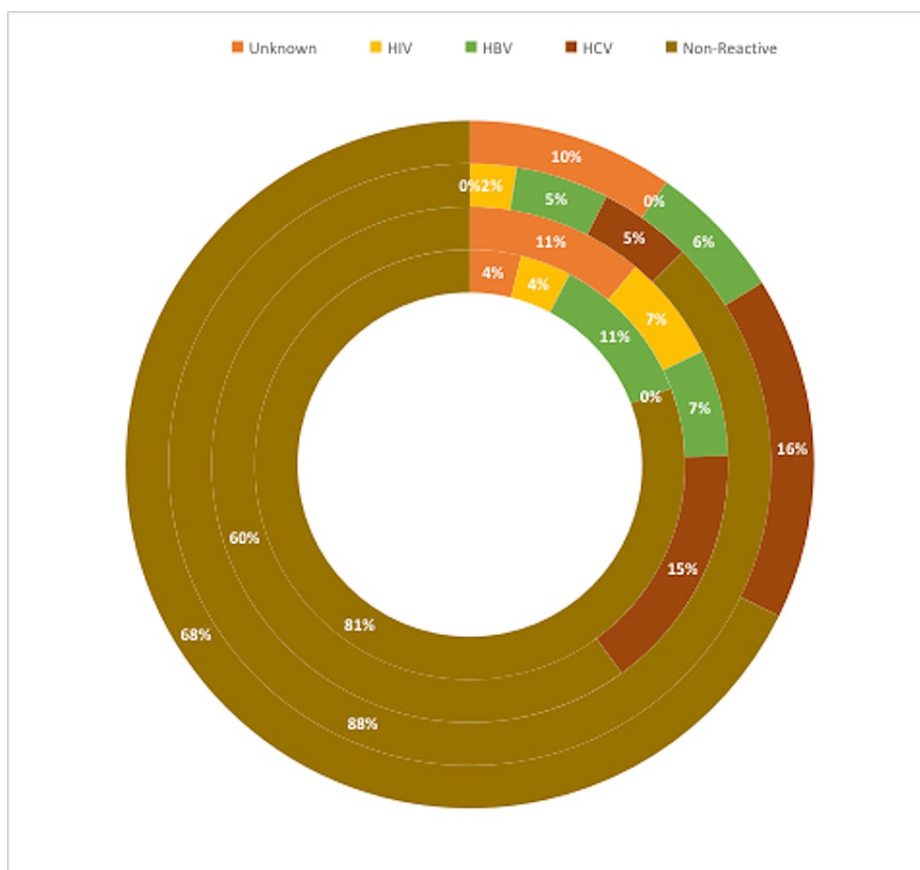
Healthcare professionals' behavior post-exposure was documented, with most cleansing the site with disinfectant or soap and water and utilizing PPE kits during exposure. The usage of PPE kits increased during the COVID times, as illustrated in Figure 1.



**FIGURE 1: Healthcare professional's behavior: pre-COVID and during COVID**

PPE: personal protective equipment

Figure 2 depicts the reactive and non-reactive status of the source patient (Figure 2).



**FIGURE 2: Reactive/non-reactive status of the source**

Outer to inner pie representing the years 2021, 2020, 2019, and 2018

HIV: human immunodeficiency virus, HBV: hepatitis B virus, HCV: hepatitis C virus

## Discussion

Occupational hazards are prevalent across various fields, prompting the implementation of preventive measures and regulations to mitigate accidents. NSIs pose a significant occupational risk, particularly for HCWs, leading to guidelines from organizations like the World Health Organization (WHO), the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Administration (OSHA). NSIs serve as a route for the transmission of serious blood-borne infections such as HIV, Hepatitis B, and C, underscoring the importance of prevention to reduce transmission among HCWs [11].

The study provides a comparative analysis of NSI exposure in a tertiary care hospital before and during the COVID era. While no significant differences in exposure numbers were noted between the two periods, a slight decrease in NSIs among doctors was observed. This decline may be attributed to the proper utilization of PPE during the COVID period. Effective PPE usage not only prevented COVID-19 transmission but also reduced occupational accidents. Comprehensive provision of PPE kits and necessary protective measures to the entire healthcare staff during COVID-19 facilitated the delivery of optimal patient care. Additionally, the decrease in elective surgical interventions during COVID-19 contributed to the reduced number of exposures among doctors.

Female HCWs (59.2%) seem to be exposed more frequently to NSIs than males (41.2%) possibly due to the unequal gender distribution in this study, as nurses were mostly female; however, a few other studies also supported this finding [12,13].

The body parts most commonly involved in NSIs were the fingers, accounting for 56 cases (45.2%), others included the right and left thumb along with the palm of the hand. This finding aligns with research conducted in Saudi Arabia [14]. The prevalence of finger injuries could be attributed to their frequent involvement in tasks such as needle handling, recapping, suturing, and inserting intravenous lines.

Notably, the percentage of NSIs was higher among nurses compared to doctors, potentially due to their



frequent close contact with patients and involvement in procedures utilizing sharp items, such as phlebotomy and intravenous needle insertion [15].

The exposure to sharps decreased among doctors while it increased among nurses, helpers, and ward attendants. The rise in injuries within these groups suggests potential lapses in proper PPE usage and a lack of carefulness during minor surgical procedures. The surge in patient numbers during the COVID period added to the workload of healthcare staff, many of whom were also infected, leading to increased instances of exposure, particularly among nurses. The heightened workload and decreased efficiency due to extended work hours were contributing factors to the increased incidence of NSIs.

Moreover, healthcare professionals across various fields are mandated to wear PPE due to the highly transmissible nature of COVID-19, while facing the challenge of caring for a surge of patients amidst extremely stressful conditions. Excessive use of PPE can impair vision and mobility, and when combined with the strain of increased workloads, the repetitive nature of medical procedures heightens the risk of NSIs and other potential health complications among HCWs [16].

This trend was also observed among resident doctors, possibly due to similar reasons. Instances of injuries during activities such as recapping and biomedical waste segregation notably increased during the COVID period, aligning with the overall rise in injuries among nurses, helpers, and ward attendants [17].

Moreover, various NSIs were reported without specific scenarios, possibly attributed to the increased layering of PPE. While increased PPE coverage offers protection, it can also reduce efficiency, leading to mishandling and injuries [18]. The decrease in exposure incidents from the operating theater during COVID-19 was due to fewer elective surgeries [19].

The study indicates that occupational hazards are more prevalent in developing countries due to factors such as insufficient staffing, long working hours, lack of experience, and inadequate educational programs [20-23]. Nurses consistently reported the highest number of incidents, highlighting the need for targeted training programs to prevent NSIs among them [24-26].

The aggressive vaccination approach has been effective in reducing the risk of hepatitis B virus (HBV) infection post-exposure [27,28]. While vaccines for HIV and HCV are unavailable, hepatitis B vaccination is essential. Regular monitoring of anti-HBs titers, indicating proper immune response post-vaccination, is crucial for HCWs [29]. Making hepatitis B vaccination mandatory for HCWs could significantly reduce the risk of infection [30].

However, the study has limitations, as it only considers reported incidences, overlooking many unreported cases due to negligence. Awareness programs should emphasize the importance of reporting NSIs and the potential consequences of not doing so, with workshops organized to address this issue.

## Conclusions

It can be inferred that the occurrence of NSIs is influenced by various factors rather than being solely dependent on one aspect. While the proper utilization of PPE during the COVID era reduced exposure rates in certain contexts, increased workload contributed to higher rates in other scenarios.

Furthermore, it is crucial to ensure HCWs are fully aware of the potential consequences of NSIs. Regular workshops should be conducted to educate them about associated risks, provide training on prevention strategies, emphasize adherence to guidelines, and encourage prompt reporting of incidents. HCWs should also be educated on the importance of correct PPE usage to mitigate the risk of NSIs effectively.

## Additional Information

### Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

**Concept and design:** Rajender Singh, Garima Mittal, Abhay Srivastava

**Acquisition, analysis, or interpretation of data:** Rajender Singh, Garima Mittal, Abhay Srivastava

**Drafting of the manuscript:** Rajender Singh, Garima Mittal, Abhay Srivastava

**Critical review of the manuscript for important intellectual content:** Rajender Singh, Garima Mittal, Abhay Srivastava

## Disclosures

**Human subjects:** Consent was obtained or waived by all participants in this study. Research Committee, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University (HIMS/RC/2020/219) issued approval HIMS/RC/2020/219. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

## Acknowledgements

The authors would like to thank the Infection Control Nurses (ICNs) of Swami Rama Himalayan University (SRHU).

## References

1. Pervaiz M, Gilbert R, Ali N: The prevalence and underreporting of needlestick injuries among dental healthcare workers in Pakistan: a systematic review. *Int J Dent*. 2018, 2018:9609038. [10.1155/2018/9609038](https://doi.org/10.1155/2018/9609038)
2. Joukar F, Mansour-Ghanaei F, Naghipour M, Asgharnezhad M: Needlestick injuries among healthcare workers: why they do not report their incidence?. *Iran J Nurs Midwifery Res*. 2018, 23:382-7. [10.4103/ijnmr.IJNMR\\_74\\_17](https://doi.org/10.4103/ijnmr.IJNMR_74_17)
3. Goel V, Kumar D, Lingaiah R, Singh S: Occurrence of needlestick and injuries among health-care workers of a tertiary care teaching hospital in North India. *J Lab Physicians*. 2017, 9:20-5. [10.4103/0974-2727.187917](https://doi.org/10.4103/0974-2727.187917)
4. Hamory BH: Underreporting of needlestick injuries in a university hospital. *Am J Infect Control*. 1983, 11:174-7. [10.1016/0196-6553\(83\)90077-9](https://doi.org/10.1016/0196-6553(83)90077-9)
5. Jan S, Akhund T, Akhtar MJ, Shaikh JM: Needle stick injuries among dental health care providers: a survey done at Hyderabad and Karachi. *PODJ*. 2014, 34:
6. Jahangiri M, Rostamabadi A, Hoboubi N, Tadayon N, Soleimani A: Needle stick injuries and their related safety measures among nurses in a university hospital, Shiraz, Iran. *Saf Health Work*. 2016, 7:72-7. [10.1016/j.shaw.2015.07.006](https://doi.org/10.1016/j.shaw.2015.07.006)
7. Kofi M: Prevalence, underreporting and barriers of needle stick and sharps injuries (NSSIs) among nurses at Primary Healthcare Centers, Riyadh, Saudi Arabia. *J Family Med Prim Care Open Acc*. 2021, 5:.. [10.29011/2688-7460.100067](https://doi.org/10.29011/2688-7460.100067)
8. Weiner-Lastinger LM, Pattabiraman V, Konnor RY, et al.: The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections in 2020: a summary of data reported to the National Healthcare Safety Network. *Infect Control Hosp Epidemiol*. 2022, 43:12-25. [10.1017/ice.2021.362](https://doi.org/10.1017/ice.2021.362)
9. Diktas H, Oncul A, Tahtasakal CA, et al.: What were the changes during the COVID-19 pandemic era concerning occupational risks among health care workers?. *J Infect Public Health*. 2021, 14:1334-9. [10.1016/j.jiph.2021.06.006](https://doi.org/10.1016/j.jiph.2021.06.006)
10. Harron K, Benchimol E, Langan S: Using the RECORD guidelines to improve transparent reporting of studies based on routinely collected data. *Int J Popul Data Sci*. 2018, 3:2. [10.23889/ijpds.v3i1.419](https://doi.org/10.23889/ijpds.v3i1.419)
11. Bloodborne pathogen and needlestick prevention. *Occupational safety and health administration*. (2024). Accessed: March 31, 2024: <https://www.osha.gov/bloodborne-pathogens>.
12. Mbaisi EM, Ng'ang'a Z, Wanzala P, Omolo J: Prevalence and factors associated with percutaneous injuries and splash exposures among health-care workers in a provincial hospital, Kenya, 2010. *Pan Afr Med J*. 2013, 14:10. [10.11604/pamj.2013.14.10.1373](https://doi.org/10.11604/pamj.2013.14.10.1373)
13. Wood AJ, Nadershahi NA, Fredekind RE, Cuny EJ, Chambers DW: Student occupational exposure incidence: perception versus reality. *J Dent Educ*. 2006, 70:1081-8. [10.1002/j.0022-0357.2006.70.10.tb04181.x](https://doi.org/10.1002/j.0022-0357.2006.70.10.tb04181.x)
14. Ismail AA, Mahfouz MS, Makeen A: Injection safety among primary health care workers in Jazan Region, Saudi Arabia. *Int J Occup Environ Med*. 2014, 5:155-63.
15. Alfulayw KH, Al-Otaibi ST, Alqahtani HA: Factors associated with needlestick injuries among healthcare workers: implications for prevention. *BMC Health Serv Res*. 2021, 21:1074. [10.1186/s12913-021-07110-y](https://doi.org/10.1186/s12913-021-07110-y)
16. Keri VC, Kodan P, Gupta A, Jorwal P: Needle stick injury from a COVID-19 patient-fear it or forget it? . *J Bioeth Inq*. 2021, 18:377-8. [10.1007/s11673-021-10117-z](https://doi.org/10.1007/s11673-021-10117-z)
17. Bekele T, Gebremariam A, Kaso M, Ahmed K: Factors associated with occupational needle stick and sharps injuries among hospital healthcare workers in Bale Zone, southeast Ethiopia. *PLoS One*. 2015, 10:e0140382. [10.1371/journal.pone.0140382](https://doi.org/10.1371/journal.pone.0140382)
18. Foula MS, Nwesar FA, Oraby EH, Foula A, Alarfaj MA, Foula HS, Mohamed NE: Does wearing personal protective equipment affect the performance and decision of physicians? A cross-sectional study during the COVID-19 pandemic. *Ann Med Surg (Lond)*. 2021, 67:102488. [10.1016/j.amsu.2021.102488](https://doi.org/10.1016/j.amsu.2021.102488)
19. Oh H, Mak M, Wu T: SG-APSIC1163: a five-year review and analysis of sharp injuries in an acute-care hospital in Singapore. *Antimicrob Steward Healthc Epidemiol*. 2023, 3:s19-20. [10.1017/ash.2023.59](https://doi.org/10.1017/ash.2023.59)
20. Falagas ME, Karydis I, Kostogiannou I: Percutaneous exposure incidents of the health care personnel in a newly founded tertiary hospital: a prospective study. *PLoS One*. 2007, 2:e194. [10.1371/journal.pone.0000194](https://doi.org/10.1371/journal.pone.0000194)
21. Serinken M, Karcioglu O, Kutlu SS, Sener S, Keysan MK: A survey of needlesticks and sharp instrument injuries in emergency health care in Turkey. *J Emerg Nurs*. 2009, 35:205-10. [10.1016/j.jen.2008.02.001](https://doi.org/10.1016/j.jen.2008.02.001)
22. Kakizaki M, Ikeda N, Ali M, Enkhtuya B, Tsolmon M, Shibuya K, Kuroiwa C: Needlestick and sharps injuries among health care workers at public tertiary hospitals in an urban community in Mongolia. *BMC Res Notes*. 2011, 4:184. [10.1186/1756-0500-4-184](https://doi.org/10.1186/1756-0500-4-184)
23. Saia M, Hofmann F, Sharman J, et al.: Needlestick injuries: incidence and cost in the United States, United Kingdom, Germany, France, Italy, and Spain. *Biomed Int*. 2010, 9:41-9.

24. Becirovic S, Pranjic N, Sarajlic-Spahic S, Ahmetagic S, Huseinagic S: Assessment of reporting, attitudes and knowledge about the stab incidents and professional risk of viral infection among health care professionals in primary health care. *Mater Sociomed.* 2013, 25:113-7. [10.5455/msm.2013.25.113-117](https://doi.org/10.5455/msm.2013.25.113-117)
25. Yang YH, Liou SH, Chen CJ, Yang CY, Wang CL, Chen CY, Wu TN: The effectiveness of a training program on reducing needlestick injuries/sharp object injuries among soon graduate vocational nursing school students in southern Taiwan. *J Occup Health.* 2007, 49:424-9. [10.1539/joh.49.424](https://doi.org/10.1539/joh.49.424)
26. Khursheed M, Khan F, Hashmi Z, Khan H, Sultan A: A study on the prevalence of needle stick injuries among health-care workers of a tertiary care hospital in Aligarh. *J Patient Saf Infect Control.* 2021, 9:87.
27. Mengistu DA, Tolera ST: Prevalence of occupational exposure to needle-stick injury and associated factors among healthcare workers of developing countries: systematic review. *J Occup Health.* 2020, 62:e12179. [10.1002/1348-9585.12179](https://doi.org/10.1002/1348-9585.12179)
28. Joseph B, Joseph M: The health of the healthcare workers. *Indian J Occup Environ Med.* 2016, 20:71-2. [10.4103/0019-5278.197518](https://doi.org/10.4103/0019-5278.197518)
29. Teo EK, Lok AS: Hepatitis B virus immunization in adults. UpToDate. Ted. W. Post (ed): UpToDate, Waltham, MA; 2021. 3-150.
30. Yuen MF, Lim WL, Chan AO, Wong DK, Sum SS, Lai CL: 18-year follow-up study of a prospective randomized trial of hepatitis B vaccinations without booster doses in children. *Clin Gastroenterol Hepatol.* 2004, 2:941-5. [10.1016/s1542-3565\(04\)00384-2](https://doi.org/10.1016/s1542-3565(04)00384-2)