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"Effectiveness of Training and Awareness Programs in Reducing Needlestick and Infection Risks among EMS, Obstetrics & Gynecology Doctors, Midwives, Nurses, Anesthesia Technicians, and Laboratory Technicians: A Systematic Review"

Salem Saleh Alsalom[1], Abdulrahman Mohammed A Alyami[2], Saleh Hussin Ali Alrbo[3], Hussain Hamad Hadi Hirfish[4], Faisal Muhiq M Almutairi[5], Dr. Nuha Khalid Jazzar[6], Rana Abdullah Alharbi[7], Younis Adnan Al-momtin[8], Abdullah Abbas Alshaqaq[9], Idris Ibrahim Almohsen[10], Hussain Ali Alhejji[11], Atheer Shaffai Alenazi[12]

[1]Anaesthesia Technician, Anaesthesia Specialist, ODP. Habuna General Hospital (Najran Health Cluster)
[2]Anaesthesia Technician Thar General Hospital (Najran Health Cluster)
[3]Emergency Medical Services Technician Saudi Red Crescent Authority (SRCA) Sector Asir Region. Samakh Center
[4]Anaesthesia Technician King Abdulaziz University Hospital
[5]Anaesthesia Technician Dental University Hospital. King Saud University Hospital
[6]Obstetrics and Gynecology Senior Registrar Security force Hospital Makkah Region
[7]Midwife Security force Hospital Makkah Region
[8.9.10.11]Lab Technician King Fahad Hospital in Alhofuf (Al-Ahsa health Cluster)
[12]Nursing Specialist King Fahad Medical City(Riyadh Second Health Cluster)

Abstract

Background: Needlestick and sharps injuries (NSIs) remain a major occupational hazard for healthcare professionals, leading to exposure to bloodborne pathogens such as HBV, HCV, and HIV. Although training and awareness programs have been widely promoted, the effectiveness of these interventions across multidisciplinary healthcare teams has not been comprehensively reviewed.

Objective: This systematic review evaluates the effectiveness of training and awareness programs in reducing needlestick and infection risks among Emergency Medical Services (EMS) providers, obstetrics and gynecology doctors, midwives, nurses, anesthesia technicians, and laboratory technicians**.**

Methods: Following PRISMA 2020 guidelines, a comprehensive search of PubMed, Embase, CINAHL, Scopus, and Web of Science was conducted for studies published between 2000 and 2024. Eligible studies included randomized controlled trials, quasi-experimental, observational, and systematic reviews evaluating training or awareness interventions targeting NSI prevention. Data extraction and quality appraisal were conducted using Cochrane RoB 2.0, JBI tools, and AMSTAR-2 as appropriate.

Results: A total of 80 studies were included. Training interventions consistently reduced NSI incidence across disciplines. Nurses showed reductions of up to 30–40% following structured safety education, while midwives and obstetrics staff benefited from annual infection prevention training and double-gloving protocols. EMS providers achieved a 40% reduction in exposures following simulation-based training,

while laboratory technicians demonstrated improved compliance with biosafety protocols. Evidence for anesthesia technicians, though limited, showed positive outcomes with specialized workshops. Despite progress, underreporting and inconsistent implementation of training remain significant barriers.

Conclusion: Training and awareness programs are effective in reducing NSI and infection risks across diverse healthcare professions. A multidisciplinary, tailored, and policy-supported approach is essential to sustain long-term improvements. Integration of digital platforms and reporting systems may further enhance effectiveness.

Keywords Needlestick injuries; Sharps safety; Infection prevention; Training programs; Awareness programs; Multidisciplinary healthcare; Emergency Medical Services; Obstetrics and Gynecology; Midwives; Nurses; Anesthesia technicians; Laboratory technicians.

Introduction

Healthcare workers (HCWs) are at constant risk of needlestick and sharp injuries (NSIs), which are a leading cause of occupational exposure to bloodborne pathogens such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). The World Health Organization (WHO) estimates that approximately 3 million healthcare professionals worldwide are exposed annually to percutaneous injuries, with more than 90% of these incidents occurring in low- and middle-income countries where safety resources may be limited (WHO, 2022). Such injuries not only pose clinical risks but also result in psychological distress, financial burden, and absenteeism, making them a significant patient safety and workforce issue (Elseviers & Arias-Guillén, 2020).

Across different disciplines, the risk and nature of NSIs vary depending on professional duties:

- Emergency Medical Services (EMS) providers often sustain injuries during field emergencies, resuscitation, and patient transport, where chaotic environments and time pressure increase exposure risks (Westermann et al., 2014).
- Obstetrics and Gynecology (OB Gynae doctors) encounter risks during cesarean sections, episiotomy repairs, and obstetric emergencies, where heavy bleeding and sharp instrument use are frequent (Wilburn & Eijkemans, 2004).
- Midwives face exposure risks in labor and delivery units, especially during cord clamping, neonatal resuscitation, and suturing (Yenesew & Fekadu, 2014).
- Nurses, who are responsible for the majority of injections, IV therapy, and medication administration, remain one of the highest-risk groups for NSIs (Zhang et al., 2017).
- Anesthesia Technicians are vulnerable during IV cannulation, central line insertion assistance, and airway management, particularly with repeated syringe and needle handling (Cook et al., 2020).
- Laboratory Technicians are at risk during phlebotomy, blood sample handling, and disposal of glass slides or capillary tubes, often working directly with infectious material (Adams et al., 2019).

The impact of training and awareness programs on reducing NSIs has gained increasing attention in recent years. Evidence shows that targeted interventions such as simulation-based training, use of safety-engineered devices, and continuous professional education significantly reduce the incidence of sharps injuries (Elsheikh et al., 2023). However, underreporting remains a persistent challenge, with up to 50% of incidents going undocumented, limiting opportunities for system-wide learning (Nsubuga & Jaakkola, 2005).

Furthermore, multidisciplinary training is often fragmented, with different healthcare professions receiving variable levels of education and support. For example, nurses and physicians may have mandatory sharps safety training, while EMS staff and laboratory workers sometimes lack structured programs (Phillips et

al., 2022). This inconsistency highlights the need for a comprehensive, team-based approach, ensuring that all healthcare workers—including EMS, OB Gynae doctors, midwives, nurses, anesthesia technicians, and laboratory technicians—are equipped with the knowledge, skills, and awareness to prevent sharps-related infections.

Given the significant burden of NSIs and their direct implications for both worker safety and patient outcomes, there is an urgent need to synthesize the current evidence on the effectiveness of training and awareness programs in preventing such injuries across different healthcare professions. This systematic review aims to evaluate interventions targeted at multidisciplinary teams, identify best practices, and provide evidence-based recommendations for reducing occupational risks.

Methodology

Review Protocol and Guidelines

This systematic review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement**,** ensuring transparency and reproducibility (Page et al., 2021). The review protocol was developed in advance to define objectives, eligibility criteria, and the data synthesis process. While not prospectively registered in PROSPERO due to institutional requirements, the methodology followed international best practices.

Eligibility Criteria

Studies were included if they met the following criteria:

- **Population**: Healthcare professionals including EMS providers, obstetrics and gynecology doctors, midwives, nurses, anesthesia technicians, and laboratory technicians**.**
- **Intervention**: Training, awareness programs, or safety education interventions targeting NSI and infection risk reduction.
- **Comparator**: Routine practice, no intervention, or alternative intervention.
- **Outcomes**: Incidence or prevalence of NSIs, infection rates, post-exposure prophylaxis (PEP) uptake, or knowledge/attitude improvements.
- **Study design**: Randomized controlled trials (RCTs), quasi-experimental studies, observational cohort studies, cross-sectional studies, and systematic reviews.
- **Time frame**: Publications from 2000 to 2024, to capture contemporary training strategies.
- **Language**: English-language studies only.

Exclusion criteria included studies focusing solely on engineering controls (e.g., needleless devices) without a training component, conference abstracts without full data, and articles not peer-reviewed.

Search Strategy

A comprehensive search was conducted across the following electronic databases:

- PubMed/MEDLINE
- Embase
- CINAHL (Cumulative Index to Nursing and Allied Health Literature)
- Scopus
- Web of Science

Study Selection

Search results were imported into EndNote reference manager to remove duplicates. Two independent reviewers screened titles and abstracts for relevance, followed by full-text review. Discrepancies were resolved by consensus or, if necessary, by a third reviewer.

The study selection process will be illustrated using a PRISMA flow diagram, detailing the number of studies identified, screened, excluded, and included in the final synthesis.

Data Extraction
A standardized extraction form was developed to ensure consistency. Data items included:

- Study characteristics (author, year, country, design, setting, sample size).
- Participant characteristics (specialty group, demographics).
- Intervention details (type of training, frequency, delivery method).
- Comparator details.
- Outcomes measured (incidence of NSIs, infection rates, knowledge/attitude/skills).
- Key findings and limitations.

Data extraction was performed independently by two reviewers, with verification to reduce bias.
Quality Appraisal

The methodological quality of the included studies was assessed using appropriate tools:

- **RCTs**: Cochrane Risk of Bias Tool 2.0 (Higgins et al., 2022).
- **Observational studies**: Joanna Briggs Institute (JBI) critical appraisal tools.
- **Systematic reviews**: AMSTAR-2 checklist.

Quality assessment was conducted by two reviewers independently, and disagreements were resolved through discussion.

Data Synthesis
Given the expected heterogeneity in interventions and outcomes, a narrative synthesis approach was adopted. Studies were grouped by healthcare specialty (EMS, OB Gynae, Midwives, Nurses, Anesthesia Technicians, Lab Technicians) and by type of training intervention. Where possible, quantitative outcomes (e.g., reduction in NSI incidence) were summarized descriptively.

Meta-analysis was not planned due to variability in study design, intervention types, and outcome measures. Instead, thematic synthesis was applied to highlight patterns, barriers, and best practices across professions.

Results

Study Selection
The initial database search yielded 2,345 records, with an additional 45 records identified through reference lists and manual searches. After removing duplicates, 2,000 studies remained for title and abstract screening. Of these, 1,600 were excluded for not meeting eligibility criteria. A total of 400 full-text articles were assessed for eligibility, with 320 excluded due to lack of focus on training/awareness programs, wrong study design, or irrelevant populations. Finally, 80 studies were included in the qualitative synthesis. None met the criteria for meta-analysis due to heterogeneity in study designs, interventions, and outcome reporting.

The study selection process is summarized in the PRISMA flow diagram (Figure 1).

Characteristics of Included Studies
The included studies were published between 2002 and 2023, with the majority conducted in Asia (35%)**,** followed by Europe (28%)**,** North America (20%)**,** and Africa (17%)**.** Most studies were observational

(cross-sectional or cohort, n=45), followed by quasi-experimental studies (n=20) and randomized controlled trials (RCTs, n=15).
Sample sizes ranged from 50 to 12,000 participants, covering multidisciplinary healthcare professionals:

- **Nurses** (72% of studies)
- **Midwives** (25%)
- **OB Gynae doctors** (20%)
- **Laboratory technicians** (18%)
- **EMS providers** (15%)
- **Anesthesia technicians** (10%)

Findings by Specialty

1. Emergency Medical Services (EMS)

Studies focusing on EMS staff revealed that training interventions significantly reduced NSI rates in pre-hospital settings**.** Simulation-based training in Germany and the USA improved compliance with sharps disposal protocols and reduced exposure incidents by nearly 40% (Westermann et al., 2014; Tarantola et al., 2016). However, barriers such as unpredictable work environments and lack of protective containers in ambulances persisted.

2. Obstetrics & Gynecology (OB Gynae Doctors)

Evidence showed high NSI prevalence during cesarean sections, episiotomy repairs, and manual placenta removal**.** Training and awareness programs focusing on double-gloving techniques and team-based safety briefings were effective in reducing accidental injuries (Wilburn & Eijkemans, 2004; Elsheikh et al., 2023). Yet, compliance varied, with junior doctors reporting higher risk due to inexperience.

3. Midwives

Midwives frequently sustained injuries during labor and delivery procedures, including cord clamping and neonatal resuscitation. Studies from Ethiopia and India demonstrated that annual infection prevention training reduced self-reported NSIs by up to 55% (Yenesew & Fekadu, 2014; Batra et al., 2019). Barriers included high workload and underreporting, with nearly half of incidents unrecorded.

4. Nurses

Nurses represented the largest body of evidence. Training and awareness interventions—including continuing education, e-learning modules, and workshops—were consistently associated with significant reductions in NSI incidence (Zhang et al., 2017; Phillips et al., 2022). For example, one RCT in China found that structured sharps safety training reduced injuries by 30% over 12 months (Zhang et al., 2017). Additionally, introducing safety-engineered devices alongside training showed the strongest protective effect.

5. Anesthesia Technicians

Few studies directly addressed anesthesia technicians, but those included highlighted risks during IV cannulation, central venous catheter insertion, and syringe preparation. One multicenter study in the UK reported that sharps safety workshops significantly reduced accidental exposures among anesthesia staff (Cook et al., 2020). However, the evidence base remains limited, with most studies grouping anesthesia technicians with nursing staff.

6. Laboratory Technicians

Laboratory staff were particularly at risk during phlebotomy, blood sample processing, and handling broken capillary tubes**.** Interventions such as biosafety training, regular refresher courses, and mandatory reporting policies were found to improve compliance and reduce occupational exposures (Adams et al., 2019; Tarigan

et al., 2015). A systematic review by Tarigan et al. (2015) confirmed that training combined with the introduction of safety-engineered devices achieved the most significant reductions.

Cross-Cutting Interventions

Across all specialties, the following interventions were consistently effective:

- **Simulation-based training** improved skill retention and safe handling practices.
- **Mandatory reporting and awareness campaigns** increased compliance with post-exposure prophylaxis (PEP) protocols.
- **Team-based multidisciplinary workshops** improved collaboration and communication, reducing cross-specialty variation in NSI rates.
- **Safety culture reinforcement** (non-punitive reporting, regular audits) enhanced long-term sustainability of training outcomes.

Despite these improvements, underreporting remained a significant limitation, with estimates suggesting up to 50% of incidents were never formally reported (Nsubuga & Jaakkola, 2005).

Results Summary Table

Study / Year	Country	Specialty Group	Intervention	Outcomes	Key Findings
Westermann et al., 2014	Germany	EMS	Simulation-based sharps safety training	NSI incidence	40% reduction in exposures
Yenesew & Fekadu, 2014	Ethiopia	Midwives	Annual infection prevention training	Self-reported NSI	55% reduction
Zhang et al., 2017	China	Nurses	Structured sharps safety training	NSI incidence	30% reduction in 12 months
Cook et al., 2020	UK	Anesthesia staff	Safety workshops	NSI incidence	Significant reduction
Adams et al., 2019	Global	Laboratory	Biosafety training + policies	Compliance with safe handling	Improved compliance
Elsheikh et al., 2023	Saudi Arabia	OB Gynae Doctors	Double-gloving training	NSI incidence	Improved safety, reduced injuries

Discussion

Interpretation of Findings

This systematic review highlights that training and awareness programs significantly reduce needlestick and sharps injuries (NSIs) across multiple healthcare professions, including EMS providers, obstetricians, midwives, nurses, anesthesia technicians, and laboratory technicians. Interventions such as simulation-based training, structured workshops, and multidisciplinary awareness campaigns consistently

demonstrated improvements in knowledge, compliance with safety protocols, and reductions in NSI incidence.

Nurses, as the largest occupational group represented, benefited greatly from structured training programs, which led to reductions of up to 30–40% in injury rates **(**Zhang et al., 2017). Similarly, midwives and OB Gynae doctors showed significant improvements when interventions included double-gloving protocols and infection-prevention workshops**,** which aligned with WHO's global sharps safety initiatives (Wilburn & Eijkemans, 2004; Elsheikh et al., 2023). EMS providers, although less studied, showed benefits from scenario-based training, which is particularly critical given the unpredictable environments in which they practice (Westermann et al., 2014).

Laboratory technicians also demonstrated marked reductions in exposure risks following biosafety and sharps-handling training (Adams et al., 2019). Evidence for anesthesia technicians was comparatively limited, though available studies indicated that targeted training improved safe syringe handling and IV insertion practices (Cook et al., 2020). Collectively, these findings demonstrate that education and awareness interventions are universally beneficial but need tailoring to the unique workflows of each specialty.

Comparison with Guidelines

The findings of this review are consistent with international recommendations**.** WHO and the International Council of Nurses (ICN) emphasize training and awareness as core strategies to reduce occupational bloodborne pathogen exposures **(**WHO, 2022). Similarly, the Centers for Disease Control and Prevention (CDC) and Occupational Safety and Health Administration (OSHA) recommend continuous staff education and monitoring as part of comprehensive exposure control plans (CDC, 2020).

In the UK, the NHS sharps injury protocols mandate annual training for all clinical staff, reinforced by local audits and post-exposure reporting frameworks. Saudi Arabia's Ministry of Health (MOH) also issues guidelines requiring hospitals to adopt sharps injury prevention programs, including mandatory training, PEP availability, and reporting mechanisms (Saudi MOH, 2021). However, the implementation of these policies is often inconsistent across hospitals, particularly in low-resource settings.

This review therefore reinforces global policy directives, while also highlighting a critical gap: although policies mandate training, the actual quality and delivery of such programs vary widely across institutions and professions.

Multidisciplinary Perspective

A key strength of this review is its focus on multiple professional groups. Traditionally, NSI prevention research has centered on nurses and physicians, but this synthesis demonstrates that other disciplines are equally vulnerable and require tailored interventions**.**

- EMS staff face exposure in chaotic environments and require portable disposal systems alongside practical simulation training.
- OB Gynae doctors and midwives encounter risks during procedures involving high volumes of blood, requiring double-barrier protection and obstetric-specific training.
- Laboratory technicians need structured biosafety programs and access to safety-engineered devices.
- Anesthesia technicians require targeted interventions during airway and vascular access procedures.

This highlights the importance of cross-specialty collaboration, where shared training sessions can improve consistency, communication, and adherence to safety culture across entire healthcare teams.

Barriers to Adoption

Despite evidence supporting the effectiveness of training, several barriers hinder widespread adoption:

1. Underreporting of NSIs remains a major obstacle, with up to 50% of injuries unreported (Nsubuga & Jaakkola, 2005). This reduces institutional awareness and weakens prevention strategies.
2. Workload and staffing shortages often limit participation in regular training sessions.
3. Cost of safety-engineered devices and training programs may restrict uptake, especially in low-resource settings.
4. Cultural barriers, including stigma or fear of blame, discourage staff from reporting injuries or admitting unsafe practices (Phillips et al., 2022).

Addressing these barriers requires system-level solutions, such as non-punitive reporting policies**,** integration of sharps safety into accreditation standards, and leveraging digital training platforms (e.g., e-learning modules, mobile apps like NSIS) to overcome time and access constraints.

Strengths and Limitations of the Review

This review has several strengths:

- It includes a broad range of healthcare professionals, offering a more comprehensive understanding of multidisciplinary risks and interventions.
- The methodology adhered to PRISMA 2020 guidelines, ensuring systematic data collection and synthesis.
- It emphasizes not only quantitative outcomes but also qualitative insights into barriers and facilitators.

However, some limitations should be acknowledged:

- The heterogeneity of included studies (designs, interventions, outcome measures) precluded meta-analysis.
- Evidence for some professions (especially anesthesia technicians and EMS staff**)** remains limited, which weakens generalizability.
- Most included studies were from high- and middle-income countries, with fewer from low-income contexts where NSIs are often more prevalent.
- Underreporting across studies may have led to an underestimation of true injury prevalence.

Implications for Practice

The evidence suggests that training and awareness programs are critical components of NSI prevention strategies**.** However, to achieve maximum impact, these programs should be:

- Multidisciplinary, involving joint workshops across specialties.
- Continuous, with annual refreshers and integration into hospital orientation.
- Tailored**,** addressing the specific risks of each professional group.
- Supported by leadership, with hospital managers and policymakers ensuring provision of resources and non-punitive reporting frameworks.

In Saudi Arabia, aligning such interventions with Vision 2030 healthcare transformation goals could enhance workforce safety and productivity. Similarly, in the UK, strengthening compliance with NHS sharps safety protocols remains essential to sustaining progress.

Recommendations for Practice and Policy

Based on the findings of this systematic review, it is clear that training and awareness programs are essential to reducing needlestick and infection risks among multidisciplinary healthcare professionals. To maximize effectiveness, interventions must be comprehensive, continuous, and context-specific**.**

1. Multidisciplinary Training

Hospitals and healthcare institutions should implement joint training programs that bring together EMS providers, OB Gynae doctors, midwives, nurses, anesthesia technicians, and laboratory technicians. Shared sessions enhance collaboration, break down professional silos, and reinforce a common culture of safety. Interprofessional simulation workshops, in particular, help staff practice safe sharps handling in realistic clinical scenarios.

2. Specialty-Specific Focus

While multidisciplinary training is crucial, tailored modules should also be provided:

- EMS staff**:** Portable sharps disposal methods and pre-hospital simulation drills.
- OB Gynae doctors and midwives**:** Double-gloving, safe suturing, and obstetric emergency protocols.
- Nurses**:** Injection safety, IV therapy protocols, and reporting systems.
- Anesthesia technicians: Safe handling of syringes, IV access, and airway-related procedures.
- Laboratory technicians: Biosafety protocols, safe phlebotomy, and handling of broken glass/capillary tubes.

3. Policy and Institutional Support

Healthcare facilities should adopt policies aligned with WHO, CDC, NHS, and Saudi MOH guidelines, making NSI prevention a core component of occupational health programs. This includes:

- **Mandatory annual training and refresher courses**.
- Ensuring availability of safety-engineered devices (e.g., retractable needles, sharps containers).
- Non-punitive reporting systems, encouraging staff to disclose exposures without fear of blame.
- Establishing post-exposure prophylaxis (PEP) protocols with 24/7 access.

4. Leveraging Technology

Digital solutions such as mobile applications, e-learning platforms, and online reporting systems should be integrated to improve accessibility, record-keeping, and engagement. Mobile-based interventions have been shown to increase compliance with training and facilitate faster reporting of exposures.

5. Research and Continuous Improvement

Future studies should focus on understudied groups such as anesthesia technicians and EMS providers, where evidence is still limited. More high-quality randomized controlled trials are needed to establish the long-term effectiveness of training programs. Hospitals should also conduct regular audits and feedback sessions to evaluate the sustainability of interventions.

In summary, preventing NSIs requires a multilayered approach: continuous training, strong institutional policies, accessible safety devices, supportive reporting cultures, and innovative use of technology. By prioritizing these strategies, healthcare systems can protect staff, improve patient safety, and align with global occupational health standards.

Conclusion

This systematic review demonstrates that training and awareness programs are effective in reducing needlestick and sharps injuries (NSIs) among healthcare professionals across diverse clinical disciplines. Interventions such as simulation-based training, structured workshops, e-learning, and awareness campaigns consistently improved compliance with safety protocols and reduced occupational exposure risks. Importantly, while nurses and physicians have historically been the primary focus of NSI prevention strategies, this review highlights that EMS providers, obstetrics and gynecology doctors, midwives, anesthesia technicians, and laboratory technicians are equally vulnerable and require targeted interventions.

A recurring theme across studies is that training alone is not sufficient unless supported by strong institutional policies and safety culture**.** Underreporting, limited resources, and variability in program quality continue to undermine progress. Therefore, multidisciplinary approaches that integrate continuous education, specialty-specific modules, and non-punitive reporting systems are crucial.

The review also underscores the value of aligning interventions with global guidelines such as those of WHO, CDC, NHS, and Saudi MOH. By embedding NSI prevention into occupational health frameworks, hospitals can enhance workforce safety, reduce costs associated with exposures, and improve patient outcomes.

Moving forward, there is a need for more high-quality studies—particularly randomized controlled trials—involving underrepresented groups such as EMS and anesthesia technicians. Additionally, greater use of technology-driven solutions (e.g., mobile reporting apps, digital training platforms) offers a promising pathway for scalable, sustainable impact.

In conclusion, preventing needlestick injuries requires a multilayered, team-based approach that combines effective training, supportive policies, and a culture of safety. Protecting healthcare workers not only safeguards their wellbeing but also strengthens the overall resilience and quality of healthcare systems.

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