International Journal of Pathology and Genetics of Disease in Nursing Management
Vol. 1, Issue 1 (January – April, 2026) pp: (23-30)

Breaking the Chain: Eliminating Bloodborne Pathogen Transmission Through Safe Injection Practices in Healthcare Settings

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Abstract

Unsafe injection practices remain a preventable cause of healthcare-associated infections worldwide, despite comprehensive guidelines from the Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO). Bloodborne pathogens such as hepatitis B virus (HBV), Hepatitis C Virus (HCV), and Human Immunodeficiency Virus (HIV) can be transmitted through syringe/needle reuse, improper multidose vial handling, and inadequate aseptic technique. Historical WHO estimates (circa 2000–2010) attributed approximately 1.67 million HBV infections, 315,000 HCV infections, and 34,000 HIV infections annually to unsafe injections. Although global interventions including safety-engineered devices and HBV vaccination programs have substantially reduced this burden, unsafe practices persist in resource-limited settings. The WHO Global Hepatitis Report 2024 indicates that viral hepatitis caused 1.3 million deaths in 2022, with unsafe medical injections remaining a preventable transmission route.
This article reviews evidence-based injection safety standards, highlights common unsafe practices (including "double-dipping," vial reuse, and syringe reuse), and outlines organizational strategies to foster a safety culture. By consistently applying the principle "One Needle, One Syringe, Only One Time," healthcare providers can eliminate preventable transmission of bloodborne pathogens and protect patients and staff.

Keywords: Bloodborne Pathogen, Safe injection, Transmission, Healthcare, HBV

Article History

Received Date: Feb 17, 2026
Published Date: Feb 27, 2026

INTRODUCTION

Injections are among the most frequently performed medical interventions in healthcare worldwide. According to estimates from the World Health Organization (WHO), 16 billion injections are given annually throughout the world, mostly for curative purposes.[1,9] Hospitals, primary health centers, outpatient clinics, and long-term care institutions are among the several healthcare settings where these

injections are administered Given their widespread use, even minor lapses in injection safety can result in serious consequences for patients, healthcare workers, and the community.[1,7]

The World Health Organization defines, "A safe injection does not harm the recipient, does not expose the healthcare provider to avoidable risks, and does not result in waste that poses danger to others."[1] despite thorough evidence-based recommendations from the Centers for Disease Control and Prevention (CDC) and WHO, hazardous injection practices continue to be a common and avoidable cause of healthcare-associated infections (HAIs)[2,7] The Common violations includereusing syringes and needles, handling multidose prescription vials incorrectly, contaminating medications while preparing them, and not maintaining aseptic technique..[2,3]

In addition to outbreaks of bacterial and fungal illnesses, unsafe injections can spread bloodborne pathogens like the human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV).[2,3,8] Global progress through safety-engineered injection devices, HBV vaccination programs, and enhanced infection prevention practices has substantially reduced the burden of infections attributable to unsafe injections.[5,6] However, according to the WHO Global Hepatitis Report 2024, viral hepatitis continues to cause approximately 1.3 million deaths annually (2022 data). While unsafe medical injections now represent a smaller proportion of transmission routes, they remain an entirely preventable risk factor, particularly in resource-limited settings.[6,10]

This review article synthesizes current evidence on safe injection practices, examines common unsafe practices leading to preventable infections, highlights the epidemiological burden with particular attention to the Indian context, and outlines organizational and individual strategies to establish sustainable safety cultures. In order to eradicate avoidable bloodborne disease transmission and maintain the highest levels of quality and safety in healthcare delivery, healthcare professionals should constantly implement the "One Needle, One Syringe, Only One Time"[2] Standard.

Global Burden and Epidemiology

According to estimates from the World Health Organization (WHO), around 16 billion injections are given annually throughout the world, 90% of which are given for therapeutic purposes, often without clear medical indication.[1,9] Historically, unsafe injection practices represented a major source of bloodborne infections worldwide. WHO models (circa 2000–2010) estimated that unsafe injections resulted annually in approximately 1.67 million new HBV infections, 315,000 HCV infections, and 34,000 HIV infections, contributing significantly to long-term morbidity and mortality.[4,5]

Although the attributable burden has declined due to improved infection control practices, expanded hepatitis B vaccination coverage, and adoption of safety-engineered devices, viral hepatitis continues to impose a substantial global burden. Current WHO data estimate approximately 1.2 million new HBV infections and 1 million new HCV infections annually, with 1.3 million deaths reported in 2022.[6,10] The risk of transmission following percutaneous exposure to contaminated injection equipment remains considerable—approximately 30% for HBV, 1.8% for HCV, and 0.3% for HIV. Despite progress, transmission risks following percutaneous exposure remain substantial, underscoring the importance of strict adherence to safe practices, particularly in resource-limited settings[1,2].

Injection Safety Challenges in India

In India, unsafe injection practices remain a significant public health concern despite national guidelines and growing awareness.[11–15] Multiple factors contribute to the persistence of unsafe practices.

1. High demand for therapeutic injections**:** Cultural preferences and patient expectations contribute to high injection usage rates, particularly for minor illnesses. Injection overuse has been documented in healthcare settings, increasing exposure risk.[11,13]
2. Medically unnecessary injections**:** Research from Indian healthcare institutions reports that a considerable proportion of injections prescribed for common conditions such as fever, respiratory infections, and gastrointestinal complaints lack clear evidence-based indications.[11,14]
3. Reuse of needles and syringes**:** Economic constraints, inadequate supervision and supply chain gaps lead to reuse of injection equipment in some settings.[11,15]
4. Inadequate waste management**:** Studies assessing safe injection practices highlight deficiencies in biomedical waste segregation, disposal systems, and sharps container management in some facilities.[12,14]
5. Scavenging and resale of used equipment: Reports and surveillance observations indicate

that improper disposal can enable collection, repackaging, and informal resale of used injection equipment, posing serious public health risks.[11,13]

6. Sectoral and geographic variations: Significant differences in compliance with safe injection practices have been observed between public and private facilities and across rural and urban settings.[12_15]

CASE STUDIES

Documented incidents and surveillance data in India continue to demonstrate the real-world consequences of unsafe injection practices, especially in community and facility settings where reuse, poor sterilization, or unnecessary injections occur.

Rising Hepatitis Cases Linked to Unsafe Practices in Ghaziabad, Uttar Pradesh (2024–2025): In 2024–2025, Ghaziabad district in Uttar Pradesh recorded its highest number of hepatitis cases in the past three years, reporting 1,481 cases of hepatitis C and 691 cases of hepatitis B. Health officials partly attributed this increase to unsafe injection practices, including syringe reuse, along with contributing factors such as poor sanitation and inadequate vaccination coverage. This surge highlights ongoing gaps in infection control across urban and rural healthcare settings and underscores the urgent need to strengthen safe injection practices, ensure strict use of single-use equipment, and enhance public awareness to prevent iatrogenic transmission.[16]

HIV Cluster and High HCV Prevalence in Unnao, Uttar Pradesh (2020 Investigation, with Ongoing Relevance): A case-control study identified unsafe injection equipment as a key factor in an HIV cluster and extremely high HCV prevalence. Practices such as needle/syringe reuse in healthcare settings were strongly associated with infections, emphasizing breaks in asepsis despite guidelines.[17]

Standard Precautions and Safe Injection Practices

Standard Precautions form the foundation of infection control in healthcare, establishing minimum safety standards that all providers should follow. Safe injection practices including single-use needle and syringe protocols and appropriate medication vial management constitute essential elements of these precautions.[2]

Every injection must begin with sterile medication that is properly prepared and administered while maintaining sterility and minimizing infection risk. Safe administration depends on consistent adherence to evidence-based practices.[1,2]

Safe injection practices serve four fundamental and interconnected purposes in healthcare delivery:

1. **Prevent transmission of infections from patient to patient** through contaminated injection equipment or medications.
2. **Prevent transmission from patient to healthcare provider** via needlestick injuries or exposure to contaminated materials.
3. **Prevent transmission from healthcare provider to patient** through breaches in aseptic technique.
4. **Prevent occupational harms** such as needlestick injuries, sharps injuries, and exposure to hazardous waste.[1,2,7]

Common Unsafe Practices and Their Consequences

Despite well-established guidelines, outbreaks and patient exposures linked to unsafe injection practices continue to be reported. Such incidents have been associated with the transmission of viral, bacterial, and fungal pathogens.[2,3,8]

1. **Syringe Reuse for Multiple Patients:** This unsafe practice includes situations where only the needle is changed or when medication is administered through intravenous (IV) tubing. After a single use, both the needle and syringe are considered contaminated and must be discarded. Reusing a syringe even if a new needle is attached can facilitate pathogen transmission due to contamination of the syringe barrel and internal components.[2,3]
2. **Double Dipping:** Accessing a medication vial or container with a previously used syringe, then using medication from that container for another patient, causes vial contamination and subsequent patient infections[1,2].
3. **Reusing Single-Dose Medications:** Using single-dose vials for multiple patients violates fundamental safety principles, as these vials lack antimicrobial preservatives and are designed strictly for single-patient use[1,2].
4. **Failing to follow Aseptic Technique:** Improper preparation and administration of injections increase the risk of contamination and infection transmission.[2,3]
5. **Additional Unsafe Practices**

a. Leaving needles inserted in vial septa, providing a direct pathway for contamination.
b. Preparing multidose vial injections in patient care areas.
c. Recapping needles after use, a common cause of

needlestick injuries.

d. Overfilling sharps containers, increasing the risk of sharps injury.
e. Using one IV bag for multiple patients, allowing backflow contamination.
f. Reusing insulin pens for different patients, leading to blood backflow contamination of cartridges. [2,3,8]

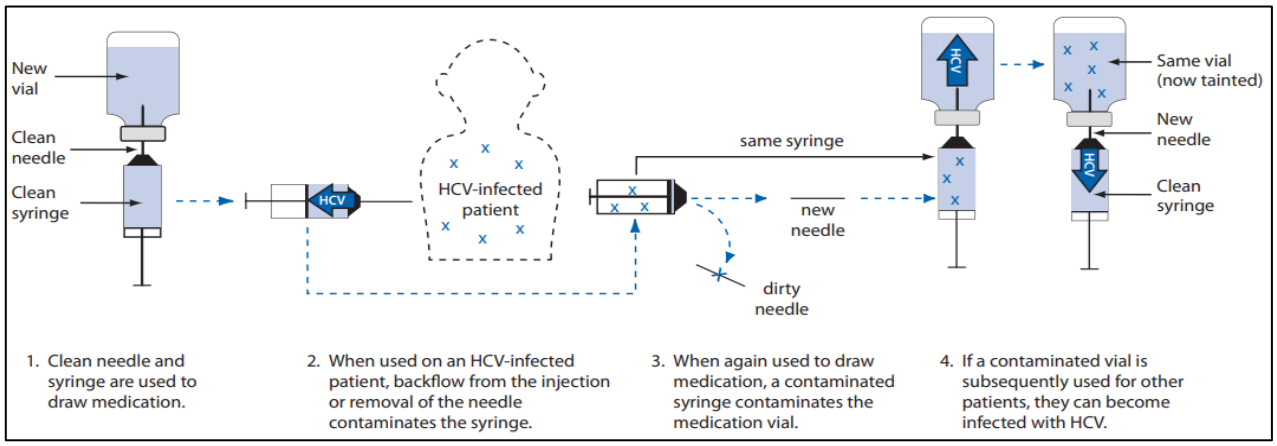

Figure 1. Transmission Pathway of Unsafe Syringe Reuse.
Source: CDC. Acute hepatitis C virus infections attributed to unsafe injection practices at an endoscopy clinic Nevada, 2007. [4]

Safe Management of Medication Vials
Single-Dose Vials (SDV)

A single-dose vial is a liquid medication container intended for parenteral administration (injection or infusion) and is meant to be used for only one patient during a single procedure, case, or injection.[2]
Key Characteristics:

1. Labelled by the manufacturer for one-time use.
2. Usually do not contain antimicrobial preservatives.
3. Can become a source of infection if reused or contaminated.
4. Can come in any shape and size.

Safety Guidelines for SDVs

1. **Single Use Only**: Access each single-dose vial once; never use for more than one patient.
2. **Proper Disposal:** If a single-dose vial has been opened or punctured, it must be discarded either within the time frame specified by the manufacturer after opening or at the completion of the procedure for which it was used, whichever occurs first.
3. **No Saving or Pooling:** Leftover medication from a single-dose vial should never be retained, combined, Pooled or stored for future administration, even for the same patient.
4. **Label Verification:** Always check the label to confirm whether a vial is designated single-dose or multidose. Do not assume based on size and volume of medication.
5. **Sterility Maintenance:** Any vial must be discarded immediately if there is doubt about its sterility or if contamination is suspected.
6. **Waste Prevention:** To minimize wastage and discourage reuse, healthcare facilities should procure the smallest appropriate vial size required for clinical use.
7. **Special Circumstances:** Even if a single-dose vial appears to contain sufficient medication for multiple doses, it must not be kept for subsequent use.
8. **Expiration:** Unopened single-dose vials should be discarded once the manufacturer's stated expiration date has been reached.[2,3,19]

Multidose Vials (MDV)

Multidose vials contain liquid medication with more than one dose and are FDA-approved for repeated use.

Key Characteristics

1. Labelled by the manufacturer for multiple uses.
2. Generally, contain an antimicrobial preservative to reduce bacterial growth
3. Preservatives do not protect against viruses nor provide complete protection against bacterial contamination.

Safety Guidelines for MDVs

1. **Dedicated Use:** Whenever possible, dedicate multidose vials to one patient.
2. **Storage Location:** Store multidose vials used for multiple patients in clean medication

preparation areas away from immediate patient treatment areas.

3. **Patient Area Restriction:** If a multidose vial enters an immediate patient treatment area (operating rooms, procedure rooms, and patient rooms), dedicate it for single-patient use only.
4. **Expiration Guidelines:**

a. Discard unopened vials according to the manufacturer's expiration date
b. After first puncture, label the vial with the date and discard within 28 days unless otherwise specified by the manufacturer.
c. The beyond-use date must not extend beyond the original manufacturer's expiration date.[2,3,19]

There are Ten Essential Injection Safety Measures for Multidose Vials. [2,3,19]

1. **Designated Preparation Area:** Always prepare injections (including drawing from multidose vials) separate from patient care area in a clean, designated preparation area. This helps ensure proper handling and decreases the chance for errors or contamination.
2. Hand Hygiene Perform hand hygiene (clean hands thoroughly) before touching the vial to prevent transferring microorganisms from your hands to the vial or medication.
3. **Verification of Label and Integrity:** Check the manufacturer's label to confirm whether the vial is single-dose or multidose vial (or multidose vaccine vial) approved for multiple uses. If it is labelled as a single-dose vial, use it only once for a single patient and discard after use, never attempt to use it for multiple patients or doses. Verify the expiration date and any beyond-use date (after first puncture). Do not use expired or compromised vials (e.g., past expiration, unusual color, cloudiness, particles)—discard immediately.
4. **Visual Inspection:** Ensure the medication/vaccine appears as described by the manufacturer. Any unusual color, cloudiness, particles, or signs of contamination indicate the vial should not be used.
5. **Sterile Equipment:** For each dose use a new sterile needle and syringe, if the syringe has been used before, blood or other contaminants may get into the vial when drawing up the medication which increase the risk of HIV or hepatitis C virus transmission.
6. **Disinfection of Vial Septum:** Clean the rubber stopper with 70% alcohol before each access to reduce surface microbial contamination.
7. **Drying the Stopper:** Allow the alcohol on the stopper to dry completely before inserting the needle to maximize antiseptic effectiveness.
8. **Labelling after First Access:** As soon as the first dose is drawn, clearly mention the date and time on the vial label to indicate when was it first accessed/punctured. Follow your institutional policy and manufacturer instructions for the beyond-use date.
9. **Storage Compliance:** Follow the manufacturer's recommendations for storage conditions (e.g., temperature requirements) and maximum duration of use after first access (often 28 days unless otherwise specified). Discard any vial that is beyond its use date, improperly stored, or questionable.
10. **No Pooling Never combine (pool):** Do not combine residual medication from multiple vials to prepare a single dose, as this practice increases contamination and infection risk.[2,3,19]

Table 1. Single-Dose vs. Multidose Vial Comparison Table.

Intended use	One patient, one procedure/case	Multiple doses/patients (if handled safely)
Antimicrobial preservative	Typically, none	Usually present (limits bacterial growth only)
Multi-patient use allowed?	Never	Yes, if dedicated/clean area, new sterile equipment each time
Expiration after first access	Discard immediately after use or end of procedure	Date and discard within 28 days (or per manufacturer)
Storage location recommendation	N/A (single use)	Clean area away from patient treatment zones
Key risk if misused	High contamination risk (no preservative)	Vial contamination from used needle/syringe
Pooling allowed?	No	No (increases contamination risk)

Synthesized from CDC Injection Safety Guidelines and One & Only Campaign recommendation (Table 1).[2,3]

By clearly identifying which practices are safe and which are unsafe, healthcare teams can reinforce adherence to evidence-based standards, minimize

preventable harm, and strengthen overall infection control protocols. This structured comparison also serves as a practical guide for training, auditing, and continuous improvement in clinical environments (Table 2).

Table 2. Safe vs. Unsafe Injection Practices.

Pooling leftover SDV medication	Unsafe	Risk of contamination and infection
Labelling vial access	Safe	Ensures traceability and compliance monitoring
Leaving needles exposed after use	Unsafe	Risk of needlestick injury
Preparing MDV injection in patient area	Unsafe	Increases contamination risk from blood and body fluids in patient treatment areas
Storing leftover SDV medication	Unsafe	SDVs lack preservatives and promotes bacterial/viral growth
Disposing sharps in puncture-proof container	Safe	Prevents injury and infection transmission
Recapping needles after use	Unsafe	Common cause of needlestick injuries
Immediate disposal after injection	Safe	Eliminates reuse and accidental injury
Disinfecting vial septum with 70% alcohol	Safe	Reduces surface microorganisms before access
Reusing syringe with a changed needle	Unsafe	Syringe barrel contamination allows pathogen transmission
Using one IV bag for multiple patients	Unsafe	Backflow contaminates IV fluids
Performing hand hygiene before injection	Safe	Prevents transfer of microorganisms
Using a new sterile needle and syringe every time a medication vial is accessed.	Safe	Prevents vial contamination
Leaving needle inserted in vial septum	Unsafe	Provides direct pathway for contamination
Overfilling sharps containers	Unsafe	Increases risk of sharps injury
Preparing injections in a designated clean area	Safe	Minimizes environmental contamination
Reusing insulin pens for different patients	Unsafe	Blood backflow contaminates cartridges
Wearing facemask during epidural/ subdural injection	Safe	Prevents droplet-related meningitis

Synthesized from CDC Injection Safety Guidelines and One & Only Campaign recommendations.[2,3]

Recommendations for Strengthening Safe Injection Practices

To enhance injection safety and eliminate preventable infections, healthcare organizations should implement comprehensive, multi-level interventions addressing system, provider, and patient factors.

1. Organizational Strategies

Healthcare facilities should establish and maintain robust infrastructure for injection safety:

- Policy Development: Develop written, evidence-based infection control policies aligned with CDC and WHO guidelines.
- Leadership Commitment: Ensure visible support from organizational leadership to establish a culture of safety.
- Resource Allocation: Provide adequate supplies, equipment, and infrastructure to support safe practices.
- Quality Assurance: Conduct regular audits and assessments of injection safety compliance.
- Incident Reporting Systems: Establish non-punitive reporting mechanisms to capture and analyze unsafe practices and near-misses.

2. Enhanced Training and Competency Assessment

Implement comprehensive education programs:

- Mandatory Training: Provide regular, evidence-based training sessions on safe injection practices for all healthcare workers.
- Competency Assessment: Use practical demonstrations and return demonstrations to verify understanding and adherence.
- Simulation-Based Learning: Incorporate simulation exercises to practice aseptic techniques and emergency responses.
- Continuing Education: Include injection safety in orientation programs and annual competency assessments.
- Interprofessional Education: Engage all cadres of healthcare workers in collaborative learning.

3. Monitoring and Surveillance

Establish systems for continuous quality improvement:

- Process Observation: Conduct direct observation of injection practices using standardized checklists.
- Outcome Surveillance: Monitor healthcare-associated infection rates related to injection

practices.
- Feedback Mechanisms: Provide timely, constructive feedback to healthcare workers and units.
- Data Analysis: Use incident reports and audit data to identify trends and areas for improvement.
- Benchmarking: Compare facility performance against regional and national standards.

4. Patient Engagement and Education

Empower patients as partners in safety:
- Patient Education: Inform patients about safe injection practices and their right to expect sterile equipment.
- Encourage Advocacy: Support patients to speak up if they observe concerning practices.
- Accessible Materials: Provide information in multiple languages and formats appropriate for diverse populations.
- Informed Consent: Include injection safety information in procedural consent discussions.

5. Supply Chain Management

Ensure consistent availability of essential supplies:
- Inventory Control: Implement systems to prevent stockouts of single-use needles, syringes, and safety devices.
- Procurement Planning: Select appropriate product sizes to minimize waste and temptation to reuse.
- Quality Assurance: Verify that purchased supplies meet safety standards.
- Emergency Preparedness: Maintain adequate stockpiles for surge situations.

6. Use of Safety-Engineered Devices

Adopt technology to enhance safety:
- Device Selection: Choose safety-engineered syringes and needles designed for preventing needlestick injuries and reuse of syringes and needles.
- Implementation Planning**:** Develop protocols for proper safety device use and disposal
- Staff Training: Provide comprehensive training on new safety technologies.
- Evaluation: Monitor effectiveness and user satisfaction with safety devices.

7. Leadership and Safety Culture

Foster an environment that prioritizes safety:
- Non-Punitive Reporting: Promote cultures where healthcare workers feel safe reporting errors and near-misses.
- Recognition Programs: Acknowledge and reward compliance and safety champions.
- Transparent Communication: Share lessons learned from incidents and near-misses across the organization.
- Continuous Improvement: Use quality improvement methodologies to address identified gaps.[2,3]

CONCLUSION

Safe injection practices are essential to ensuring patient safety and maintaining standards of quality healthcare delivery. Adherence to the principle "One Needle, One Syringe, Only One Time" is central to preventing healthcare-associated infections, reducing occupational exposure, and preserving public trust in healthcare systems. Despite comprehensive guidance issued by the Centers for Disease Control and Prevention and the World Health Organization, unsafe injection practices continue to be reported in certain settings, contributing to preventable morbidity.[2,3]

Ensuring injection safety requires shared accountability among healthcare providers, administrators, and policymakers. Sustained adherence to evidence-based guidelines, continuous professional training, regular monitoring, and system-level quality improvement initiatives are critical to eliminating injection-related infections and protecting patients, healthcare workers, and communities.[1,2]

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CITE THIS ARTICLE

J. Mahathi and Chakali Usha. Breaking the Chain: Eliminating Bloodborne Pathogen Transmission Through Safe Injection Practices in Healthcare Settings. Int J of Patho and Geneti of Dise in Nsg Mgt. 2026 Feb;1(1):23-30.