

Direct Clinical Observation of Infection Control and Safe Medication Practices in Pediatric Inpatient Care: A Multicenter Cross-Sectional Audit

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Abstract

Background: Inadvertent medication administration errors and secondary contamination during pediatric pharmaceutical preparation represent critical global patient safety threats. Direct bedside observation provides an authentic clinical audit of actual nursing practice compared with self-reported survey methods. **Objective:** To investigate pediatric nurses' real-world clinical adherence to basic infection prevention protocols and safe medication storage and handling regulations across public referral hospitals. **Methods:** A multicenter cross-sectional observational audit was conducted across pediatric departments in four governmental hospitals: Shandi Teaching Hospital, Al-Mak Nimr Teaching Hospital, Hosh Bannaga Hospital, and Al-Misktab Hospital. A total-coverage sample of 130 frontline bedside pediatric nurses was directly observed during routine medication rounds using an expert-validated clinical checklist comprising 11 basic infection control items and 3 medication storage parameters. Bivariate associations between nursing characteristics and clinical adherence were evaluated using Chi-square tests with statistical significance defined at $p \leq 0.05$. **Results:** Direct clinical audits identified widespread compliance gaps across frontline pediatric units. Procedural hand hygiene was correctly performed in only 50.0% of encounters before and after drug handling, and in 53.8% upon direct patient contact. Strict aseptic injection preparation technique was observed in 46.2% of participants. Serious vulnerabilities were noted in parenteral device handling: only 40.0% segregated multi-dose vials within centralized clean medication stations, and dedicated single-patient insulin pen usage was restricted to 40.0%. Compliant pharmaceutical storage aligned with manufacturer temperature and light recommendations was observed in 46.2% of nurses. Bivariate analysis revealed that bachelor's degree qualification and extended clinical experience were significantly associated with higher clinical compliance ($p < 0.05$). **Conclusion:** Routine nursing compliance with basic infection control and safe medication handling remains critically compromised in public pediatric inpatient settings. Hospital administrations must establish centralized aseptic preparation stations, institute strict patient-specific device labeling policies, and sustain regular observational audits.

Keywords: Clinical Audit; Infection Control; Pediatric Nursing; Medication Handling; Patient Safety; Observational Study; Sudan.

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1. INTRODUCTION

Medication administration represents one of the most critical, high-frequency, and error-prone clinical tasks executed by nurses in pediatric inpatient wards [1, 2]. Safe pediatric pharmaceutical care necessitates precise weight-based dosage calculation alongside uncompromising adherence to basic infection prevention standards and environmental storage protocols [3, 4]. Hospitalized pediatric patients, particularly neonates and infants, have physiologically immature immune defenses that render them exceptionally susceptible to healthcare-associated infections (HAIs) transmitted via contaminated parenteral solutions, unsterile

reconstitution techniques, or cross-contamination from shared multi-dose devices [3, 10].

Both the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) mandate standard precautions as non-negotiable safety benchmarks, emphasizing hand decontamination, aseptic technique within designated clean preparation areas, and strict single-patient dedication of multi-dose vials and insulin injection pens [5, 6]. Nevertheless, in resource-limited and conflict-affected healthcare infrastructures, acute nurse shortages, excessive patient-to-nurse ratios, unpredictable supply chains, and limited

institutional continuing education frequently foster procedural workarounds and safety breaches [7, 8]. Direct clinical observation remains the gold standard for auditing bedside nursing practices, eliminating self-reporting bias and revealing actual procedural vulnerabilities [9, 13]. This study delivers a multicenter observational audit of basic infection control compliance and medication storage practices among pediatric nurses in public hospitals across Shendi Locality, Sudan [1].

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A descriptive, multicenter cross-sectional observational audit was executed across the pediatric inpatient departments of four governmental hospitals situated in Shendi Locality, River Nile State, Sudan.

- 1) **Shandi Teaching Hospital:** A key tertiary governmental referral facility staffed by 45 pediatric nurses.
- 2) **Al-Mak Nimr Teaching Hospital:** A university teaching hospital facility staffed by 63 pediatric nurses.
- 3) **Hosh Bannaga Hospital:** A district hospital facility staffed by 21 pediatric nurses.
- 4) **Al-Misktab Hospital:** A community-level rural facility staffed by 21 pediatric nurses.

2.2 Study Population and Sampling

A total-coverage sampling framework was implemented to include all eligible nursing staff actively administering pediatric medications. From a total base population of 150 pediatric nurses, 10 were excluded during the preliminary checklist pilot testing, and 10 were unavailable due to annual leave, maternity leave, or official resignation during data collection. Consequently, an exhaustive sample of 130 bedside pediatric nurses was enrolled (100% participation of the accessible working cohort). The mean age of participants was 33.6 ± 2 years. Males constituted 88.5% ($n = 115$) of the cohort. Regarding educational attainment, 80.0% ($n = 104$) held a three-year Diploma in Nursing, 16.9% ($n = 22$) possessed a Bachelor of Science in Nursing, and 3.08% ($n = 4$) held a Master of Science in Nursing.

2.3 Observational Audit Instrument

Bedside clinical performance was systematically recorded through unannounced, direct clinical observations utilizing an expert-validated clinical practice checklist (Content Validity Index = 0.90; Cronbach's alpha = 0.90). The checklist comprised 14 standardized operational parameters divided into two operational domains:

- **Basic Infection Control and Safety Regulations (11 items):** Auditing procedural hand hygiene immediately before and after medication preparation/administration, hand hygiene upon direct patient contact, clean (aseptic) technique during parenteral injection preparation, exclusive single-patient use of disposable needles, cannulas, and syringes, centralized maintenance of multi-dose vials in dedicated clean

areas, restriction of multi-dose vials to single-patient use if introduced into immediate patient cubicles, single-patient dedication of insulin pen devices, legible patient-specific labeling of insulin delivery pens, sanitary containment of insulin devices, compliant utilization of personal protective equipment (PPE), and segregated disposal of pharmaceutical waste.

- **Medication Storage and Handling (3 items):**

Evaluating pharmaceutical storage alignment with manufacturer specifications (temperature and light control), physical locking of ward medication stocks when unattended, and adherence to institutional disposal protocols for expired or unused pharmaceuticals.

Every clinical action was scored objectively as: Done correctly (2 points), Done incorrectly (1 point), or Not done (0 points).

2.4 Ethical Considerations and Academic Disclosure

Ethical approval was granted by the Ethics Review Board of the College of Nursing Sciences at the University of Bahri, complemented by official administrative clearance from the medical directorships of the four participating hospitals. Informed written consent was obtained from all participating nurses prior to the commencement of observations, with guaranteed anonymity and confidentiality.

Academic Disclosure:

This manuscript represents an independent, focused secondary cross-sectional observational analysis derived from baseline clinical audit data collected as part of the primary author's doctoral dissertation entitled: "The Effect of a Training Program on Medication Administration Errors on Nurses' Knowledge and Practice, Pediatric Departments,

Governmental Hospitals _Shendi Locality, Sudan – 2024", submitted to the College of Nursing Sciences, University of Bahri, under the academic supervision of the co-author [1].

2.5 Statistical Analysis

Statistical computations were carried out using SPSS version 28. Descriptive parameters, including frequencies, percentages, means, and standard deviations, were generated to summarize compliance rates across each checklist item. Bivariate cross-tabulations and Chi-square (χ^2) tests of independence were performed to examine associations between nursing compliance rates and demographic characteristics (educational qualification, years of clinical experience, and working shift allocation). The statistical significance threshold was established a priori at $p \leq 0.05$.

3. RESULTS

3.1 Sociodemographic Profile of Nurses

Among the 130 observed nurses, 53.8% ($n = 70$) were aged 30–39 years, 29.2% ($n = 38$) were aged 20–29

years, 12.3% (n = 16) were aged 40–49 years, and 4.6% (n = 6) were aged 50 years or older [1]. In terms of cumulative professional experience, 24.6% (n = 32) possessed 4–6 years of clinical service, 22.3% (n = 29) had 1–3 years, 21.6% (n = 28) had 7–9 years, 20.0% (n = 26) had ≥ 10 years, and 11.5% (n = 15) had < 1 year. Regarding shift assignments, 50.0% (n = 65) worked fixed morning shifts, 33.0% (n = 43) were assigned to night shifts, and 17.0% (n = 22) worked rotating shifts.

3.2 Direct Observational Compliance with Infection Control

Direct bedside audits documented pronounced clinical compliance deficits across infection prevention benchmarks (Table 1). Procedural hand hygiene immediately before and after medication administration was executed correctly in only 50.0% (n = 65) of observed encounters, while 38.5% (n = 50) performed it incorrectly, and 11.5% (n = 15) omitted hand hygiene entirely]. Similarly, hand hygiene upon necessary patient contact was properly practiced by 53.8% (n = 70) of nurses. Aseptic injection preparation in clean designated workstations was executed correctly by only 46.2% (n =

60) of the participants, with 46.2% (n = 60) demonstrating incorrect technique, and 7.7% (n = 10) neglecting aseptic safeguards altogether.

Severe deviations were audited regarding the management of injectable multi-dose devices. Only 40.0% (n = 52) of nurses maintained multi-dose vials within centralized clean preparation zones, whereas 52.3% (n = 68) handled them incorrectly, often carrying open vials into active patient cubicles. Correspondingly, restricting multi-dose vials to a single patient once inside a patient room was adhered to by only 42.3% (n = 55). Dedicating multi-dose insulin pen devices exclusively to a single pediatric patient was maintained in only 40.0% (n = 52) of clinical observations, with 52.3% (n = 68) incorrectly sharing pens across different patients. Proper patient-specific identification labeling on insulin pens was audited in 47.7% (n = 62) of instances, sanitary pen storage was practiced by 44.6% (n = 58), appropriate PPE utilization was recorded in 46.2% (n = 60), and compliant disposal of medical and pharmaceutical waste was achieved by 53.8% (n = 70).

Table 1: Direct Observational Audit of Infection Control Practices Among Pediatric Nurses (N = 130)

Clinical Audit Checklist Item	Correct Practice n (%)	Incorrect Practice n (%)	Not Done n (%)
Hand hygiene before and after medication administration	65 (50.0%)	50 (38.5%)	15 (11.5%)
Hand hygiene if patient contact is necessary	70 (53.8%)	50 (38.5%)	10 (7.7%)
Clean (aseptic) technique during preparing injections	60 (46.2%)	60 (46.2%)	10 (7.7%)
Use needles, cannulas, and syringes for one patient only	68 (52.3%)	55 (42.3%)	7 (5.4%)
Keep multi-dose vials in centralized clean area	52 (40.0%)	68 (52.3%)	10 (7.7%)
If multi-dose vials enter treatment area, single-patient use only	55 (42.3%)	65 (50.0%)	10 (7.7%)
Use insulin pens for single-patient use only	52 (40.0%)	68 (52.3%)	10 (7.7%)
Clear labeling of insulin pens with patient identifier	62 (47.7%)	58 (44.6%)	10 (7.7%)
Store insulin pens in sanitary manner	58 (44.6%)	65 (50.0%)	7 (5.4%)
Wear appropriate personal protective equipment (PPE)	60 (46.2%)	55 (42.3%)	15 (11.5%)
Dispose of medication waste properly	70 (53.8%)	45 (34.6%)	15 (11.5%)

3.3 Observational Compliance with Medication Storage and Disposal

Medication handling audits demonstrated widespread non-compliance with pharmaceutical storage mandates (Table 2). Storage of medications in strict compliance with manufacturer recommendations regarding temperature control and light protection was correctly executed by only 46.2% (n = 60) of nurses,

while 50.0% (n = 65) exhibited incorrect storage practices, and 3.8% (n = 5) failed completely. Ensuring that ward medication cupboards and emergency drug stocks remained securely locked when unattended was correctly performed by 47.7% (n = 62) of nurses. In addition, formal protocol-directed disposal of expired, contaminated, or discontinued pediatric pharmaceuticals was observed in 53.8% (n = 70) of clinical encounters.

Table 2: Direct Observational Audit of Medication Storage and Disposal Practices (N = 130)

Medication Storage and Handling Parameter	Correct Practice n (%)	Incorrect Practice n (%)	Not Done n (%)
Store medications per manufacturer recommendations	60 (46.2%)	65 (50.0%)	5 (3.8%)
Keep medications securely locked when not in use	62 (47.7%)	60 (46.2%)	8 (6.2%)
Dispose of expired or unused medications per protocol	70 (53.8%)	50 (38.5%)	10 (7.7%)

3.4 Factors Associated with Nursing Compliance

Bivariate Chi-square analysis demonstrated that educational level was significantly associated with aseptic injection technique ($\chi^2 = 11.42$, $p = 0.003$) and manufacturer-compliant drug storage ($\chi^2 = 9.85$, $p = 0.007$), with Bachelor's degree holders displaying substantially higher compliance rates compared to

diploma-educated colleagues. Furthermore, nursing clinical experience exceeding 6 years was significantly associated with higher adherence to hand hygiene protocols ($\chi^2 = 13.18$, $p = 0.001$) and locked pharmaceutical storage ($\chi^2 = 8.74$, $p = 0.013$). Conversely, working night shifts was correlated with

higher frequencies of unsegregated multi-dose vial usage and skipped hand hygiene moments.

4. DISCUSSION

Meticulous adherence to basic infection prevention protocols and safe pharmaceutical storage during pediatric medication delivery is paramount to avert iatrogenic injury, bloodstream infections, and hospital-acquired sepsis in inpatient pediatric settings [3, 4]. This multicenter observational audit exposes substantial, pervasive compliance deficiencies among frontline pediatric nurses, characterized by a hand hygiene adherence rate of only 50.0%, aseptic injection reconstitution rates below 47%, and pervasive breaches in multi-dose vial containment and insulin pen isolation [1]. These direct observational findings align with clinical studies conducted in other low-resource healthcare ecosystems, where heavy workloads, high bed occupancy rates, lack of dedicated medication preparation infrastructure, and absence of structured audit feedback contribute to standard precaution breakdowns [7, 8, 9].

The observed mismanagement of parenteral delivery devices poses an acute epidemiological threat for bloodborne pathogen dissemination [6, 12]. In this study, 60.0% of nurses failed to retain multi-dose vials within centralized clean preparation zones, and 60.0% failed to maintain insulin pens for exclusive single-patient use [1]. Carrying multi-dose vials into immediate patient bedspaces introduces airborne and contact contaminants to vial rubber stoppers [12]. More critically, sharing multi-dose insulin pens among multiple pediatric patients—even when disposable needles are exchanged—represents an extreme biological hazard, as retrograde flow of microscopic blood and cellular debris into the cartridge reservoir can transmit Hepatitis B, Hepatitis C, and HIV [6, 11]. These audit findings indicate that frontline nurses often misunderstand the internal fluid mechanics of multi-dose injection pens, falsely equating needle tip replacement with total sterility [11, 13].

Compliance with manufacturer pharmaceutical storage recommendations was compromised in 53.8% of observations [1]. In tropical environments characterized by elevated ambient temperatures, failure to maintain the cold chain for biologicals (e.g., insulin, reconstituted antibiotics, and vaccines) causes chemical degradation, loss of therapeutic potency, and potential toxic byproduct accumulation [15]. Unlocked medication stocks similarly expose wards to medication misplacement and unauthorized access [15]. The significant association between advanced nursing education and superior compliance reinforces global literature advocating for continuous professional simulation-based training to translate theoretical pharmacovigilance into bedside clinical compliance [14, 16, 17].

5. STRENGTHS AND LIMITATIONS

A primary strength of this study lies in its multicenter total-coverage design and the utilization of unannounced, direct clinical observation, which offers superior ecological validity compared to self-administered surveys susceptible to social desirability bias [1, 9]. However, several limitations should be considered [1]:

- 1) **Potential Hawthorne Effect:** The observational methodology carries the potential for participants to transiently alter their routine behaviors under direct observation; nevertheless, the high prevalence of observed procedural non-compliance suggests that baseline habitual practices predominated [9, 13].
- 2) **Cross-Sectional Constraints:** The cross-sectional audit design precludes establishing longitudinal causality between institutional environmental determinants and nursing non-compliance [1].
- 3) **Geographical Scope:** Data collection was restricted to governmental public hospitals within Shendi Locality in Sudan, which may limit the immediate generalizability of findings to private tertiary hospitals or well-resourced academic medical centers [1, 7].

6. CONCLUSION AND RECOMMENDATIONS

This multicenter observational audit confirms that pediatric nurses in public inpatient facilities exhibit critical compliance gaps in basic infection prevention and medication storage protocols [1]. To mitigate clinical risks, hospital administrations and nursing directorates should implement the following strategic measures [5, 6]:

1. Designate and physically segregate sterile medication preparation zones within all pediatric wards, prohibiting the transportation of multi-dose vials into patient cubicles [6, 12].
2. Enforce a zero-tolerance policy against the multi-patient sharing of insulin pens, mandating individual patient-specific identification labeling and isolated storage containers [6, 11].
3. Install reliable climate-controlled medication storage refrigerators with continuous temperature monitoring logs to protect thermosensitive pediatric drugs [15].
4. Establish continuous professional development programs integrating hands-on clinical simulation, coupled with routine, non-punitive observational audits and constructive peer feedback [13, 14, 16].

REFERENCES

1. Abduelrahaman SAO. *The Effect of a Training Program on Medication Administration Errors on Nurses' Knowledge and Practice, Pediatric Departments, Governmental Hospitals _Shendi Locality, Sudan – 2024* (Doctoral dissertation). Department of Mother and Child Health Nursing,

- College of Nursing Sciences, University of Bahri; 2025.
2. Hockenberry MJ, Wilson D, Rodgers CC. *Wong's Essentials of Pediatric Nursing*. 11th ed. St. Louis: Elsevier Health Sciences; 2021.
3. Kaushal R, Bates DW, Landrigan C, *et al.*, Medication errors and adverse drug events in pediatric inpatients. *JAMA*. 2001;285(16):2114–2120. doi:10.1001/jama.285.16.2114
4. Koeck JA, Young NJ, Kontny U, *et al.*, Interventions to reduce medication dispensing, administration, and monitoring errors in pediatric professional healthcare settings: A systematic review. *Front Pediatr*. 2021;9:633064. doi:10.3389/fped.2021.633064
5. World Health Organization. *Medication Without Harm - Global Patient Safety Challenge*. Geneva: World Health Organization; 2017.
6. Centers for Disease Control and Prevention. *Clinical Safety: Safe Injection Practices in Healthcare Settings*. Atlanta: U.S. Department of Health and Human Services; 2024.
7. Abdalla EA, Abdoon IH, Osman B, Osman WJA, Mohamed EM. Perception of medication errors' causes and reporting among Sudanese nurses in teaching hospitals. *Appl Nurs Res*. 2020;51:151207. doi:10.1016/j.apnr.2019.151207
8. Bante A, Mersha A, Aschalew Z, Ayele A. Medication errors and associated factors among pediatric inpatients in public hospitals of Gamo zone, southern Ethiopia. *Heliyon*. 2023;9(4):e15132. doi:10.1016/j.heliyon.2023.e15132
9. Chakma SK, Hossen S, Rakib TM, *et al.*, Effectiveness of a hand hygiene training intervention in improving knowledge and compliance rate among healthcare workers in a respiratory disease hospital. *Heliyon*. 2024;10(5):e26533. doi:10.1016/j.heliyon.2024.e26533
10. Baraki Z, Abay M, Tsegay L, *et al.*, Medication administration error and contributing factors among pediatric inpatient in public hospitals of Tigray, northern Ethiopia. *BMC Pediatr*. 2018;18(1):321. doi:10.1186/s12887-018-1300-z
11. Thompson ND, Perz JF, Moorman AC, Holmberg SD. Nonhospital health care-associated hepatitis B and C virus transmission: United States, 1998–2008. *Ann Intern Med*. 2009;150(1):33–39. doi:10.7326/0003-4819-150-1-200901060-00007
12. Patel PR, Srinivasan A, Schulte JM. Infections associated with medication vials and injection devices: A call for safe injection practices. *Infect Control Hosp Epidemiol*. 2009;30(3):209–214. doi:10.1086/595697
13. Custódio IL, Lima FET, Pascoal LM, *et al.*, Nursing training on the administration of medication in pediatrics: An assessment of observed and self-reported behavior. *Rev Bras Enferm*. 2021;74(suppl 6):e20201188. doi: 10.1590/0034-7167-2020-1188
14. Pol-Castañeda S, Carrero-Planells A, Moreno-Mulet C. Use of simulation to improve nursing students' medication administration competence: A mixed-method study. *BMC Nurs*. 2022;21(1):117. doi:10.1186/s12912-022-00898-1
15. Al Rawwad T, Schrader PK, Brooks A, Duong L, Thornton D. Do nursing and pharmacy students practice what they preach on safe drug storage and disposal? A cross-sectional study. *Nurse Educ Today*. 2021;107:105143. doi:10.1016/j.nedt.2021.105143
16. Marufu TC, Bower R, Hendron E, Manning JC. Nursing interventions to reduce medication errors in paediatrics and neonates: Systematic review and meta-analysis. *J Pediatr Nurs*. 2022;62:e139–e147. doi: 10.1016/j.pedn.2021.09.006
17. Elrahman SAOA, Amasha HA. Awareness of pediatric nurses regarding drug preparation and administration in Gaafer Ibn Auf Children Hospital, Sudan. *Saudi J Nurs Health Care*. 2024;7(5):116–121. doi:10.36348/sjnhc.2024.v07i05.003