

Knowledge, Attitudes, and Practices of Nurses Regarding Line Reconciliation to Prevent Tubing Misconnections: A Cross-Sectional Study

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Abstract

Tubing misconnections are preventable patient safety events that may result in wrong-route administration and serious patient harm. This study assessed nurses' knowledge, attitudes, and practices regarding line reconciliation for the prevention of tubing misconnections, guided by the Knowledge–Attitude–Practice framework. A descriptive cross-sectional design was employed among 508 registered nurses from selected clinical units of a tertiary hospital using total enumeration sampling. Data were collected through a structured questionnaire covering demographic characteristics, knowledge, attitudes, and practices and were analyzed using descriptive statistics, Pearson's correlation, and independent-samples t-tests. Most nurses demonstrated high knowledge of line reconciliation (78.3%), with a mean knowledge score of 9.46 (SD = 1.38), while 21.7% demonstrated moderate knowledge. Participants generally reported positive attitudes and frequent adherence to recommended practices, including line tracing, handoff verification, labeling, use of standardized connectors, hazard and near-miss reporting, removal of unnecessary lines, and patient and family education. Knowledge was not significantly associated with age, years of nursing experience, gender, or educational attainment. The study concludes that nurses possess strong competencies in line reconciliation; however, continued competency-based education, standardized protocols, consistent labeling, appropriate connectors, and a supportive non-punitive safety culture are recommended to sustain safe practices. The study primarily supports SDG 3 – Good Health and Well-Being through the promotion of patient safety and SDG 4 – Quality Education through continued professional competency development. Its sustainability contribution lies in strengthening public health, educational, and institutional systems by promoting consistent, preventive, and safety-oriented nursing practices.

Keywords: Attitudes; Knowledge–Attitude–Practice; Line Reconciliation; Nurses; Patient Safety; Tubing Misconnections

1. Introduction

Tubing misconnections remain an important patient safety concern because they can result in wrong-route administration and severe patient harm (Mazzella, 2023; Institute for Safe Medication Practices, 2024). Although healthcare systems continue to strengthen clinical safety protocols, preventable errors involving medical tubing persist. Nurses are particularly important in preventing these events because they routinely manage intravenous,

enteral, and other tubing systems. Line reconciliation, which involves tracing each line from the patient to its source to confirm the correct connection, is therefore an important safety practice (Mazzella, 2023). This study examines nurses' knowledge, attitudes, and practices regarding line reconciliation as a means of supporting safer clinical care.

Patient safety is a fundamental priority in healthcare systems worldwide, yet preventable medical errors continue to occur. Tubing misconnections are among the hazards that may cause wrong-route administration and serious adverse outcomes (Mazzella, 2023; Institute for Safe Medication Practices, 2024). In response, World Health Organization (2021) and The Joint Commission (2014) emphasize systematic approaches to preventing tubing-related errors. Nurses have a central role in these prevention efforts because of their direct responsibility for managing intravenous and enteral systems. Line reconciliation provides a practical approach by requiring nurses to trace each line from the patient to its source and verify that connections are correct before use (Mazzella, 2023). Existing literature highlights three closely related dimensions of patient safety practice: knowledge, attitudes, and adherence to recommended clinical behaviors. Differences in these dimensions may influence nurses' ability to recognize hazards and consistently apply safety measures (Huang et al., 2025; Ahmad et al., 2025). The literature also emphasizes the importance of education, standardized safety procedures, appropriate connectors, and a supportive safety environment in preventing tubing-related errors. These elements reinforce the need to examine not only whether nurses understand line reconciliation but also whether they perceive it positively and consistently incorporate it into clinical practice.

At the global level, patient safety organizations have recognized tubing misconnections as a preventable healthcare risk. World Health Organization (2021) promotes systematic action to reduce avoidable patient harm, while The Joint Commission (2014) emphasizes risk management associated with tubing connector systems. Within healthcare institutions, the issue is particularly relevant in clinical areas where nurses manage multiple intravenous lines, feeding tubes, and other medical tubing systems. The source manuscript does not provide specific local or national prevalence estimates; therefore, the study is positioned primarily within the broader global patient safety context and the institutional setting in which line management is routinely performed.

The study is guided by the Knowledge–Attitude–Practice (KAP) framework, which explains the relationship among what individuals know, how they perceive a particular issue, and how these factors may influence their behaviors (Seo & Lee, 2022; Zhou & Liu, 2026). Applied to line reconciliation, the framework provides a basis for examining nurses' understanding of tubing misconnection prevention, their attitudes toward recommended safety measures, and their reported performance of line reconciliation practices. Assessing these dimensions together supports a more comprehensive evaluation of nurses' competencies related to patient safety. Variations in nurses' knowledge, attitudes, and adherence to safety practices may affect patient safety outcomes (Huang et al., 2025; Ahmad et al., 2025). Consequently, assessing these dimensions is necessary to determine how well line reconciliation principles are understood, accepted, and applied in clinical practice. The study therefore focuses on evaluating nurses' knowledge, attitudes, and practices regarding line reconciliation. Such assessment can identify areas in which existing competencies are strong and areas that may require continued education, standardized protocols, or institutional reinforcement to sustain safe tubing-management practices.

The study is most directly aligned with SDG 3 – Good Health and Well-Being because prevention of tubing misconnections contributes to safer healthcare delivery and the reduction of avoidable patient harm. By examining nurses' competencies in line reconciliation, the research supports efforts to strengthen patient safety and the quality of clinical care. The study also has relevance to SDG 4 – Quality Education through its emphasis on continuing competency-based education and reinforcement of safe nursing practices. Maintaining nurses' knowledge and clinical competencies through appropriate training can support consistent implementation of patient safety measures.

The study contributes primarily to public health, educational, and institutional sustainability. From a public health perspective, preventing tubing misconnections supports safer care and reduces risks associated with avoidable clinical errors. Sustained adherence to line reconciliation can therefore contribute to healthcare systems that prioritize prevention and patient protection. From an educational sustainability perspective, the study highlights the importance of maintaining professional competencies through continued training and reinforcement of evidence-based safety practices. Regular competency development can help ensure that patient safety knowledge remains applicable to everyday nursing practice. The study also supports institutional sustainability by emphasizing standardized protocols and a supportive safety culture. Consistent line reconciliation procedures, appropriate communication during clinical handoffs, and organizational support for safe practices can strengthen healthcare systems' capacity to prevent errors and maintain reliable patient safety practices over time.

2. Material and methods

2.1 Research Design

A descriptive cross-sectional design was employed to assess nurses' knowledge, attitudes, and practices regarding line reconciliation at a single point in time. The design also allowed examination of associations between demographic characteristics and knowledge levels. The study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies.

2.2 Locale of the Study

The study was conducted in a tertiary hospital providing specialized clinical services. Data were collected from the emergency room, medical intensive care unit, surgical intensive care unit, pediatric intensive care unit, coronary care unit, medical ward, and surgical ward. These areas were selected because patients frequently require intravenous infusions, feeding tubes, and multiple medical tubing systems, which may increase the risk of tubing misconnections.

2.3 Respondents of the Study

The respondents were registered nurses working in the selected clinical units. Eligible participants were nurses directly involved in patient care and line management, routinely working with intravenous infusion therapy, with at least six months of clinical experience in their current unit, and who voluntarily agreed to participate. Nurses assigned to outpatient or non-infusion areas, those holding purely administrative or managerial positions without direct patient care responsibilities, and those on leave during data collection were excluded.

2.4 Sample and Sampling Procedure

A total enumeration sampling strategy was used to recruit eligible nurses from the identified clinical departments, resulting in 508 participants. The minimum sample required for correlation analysis was estimated using G*Power version 3.1 based on a medium effect size of $r = 0.30$, an alpha level of .05, and a statistical power of .80. The resulting minimum requirement was 84 participants; therefore, the final sample exceeded the required size and provided adequate power for the planned analyses.

2.5 Research Instrument

Data were collected using a structured questionnaire developed from patient safety literature and international recommendations concerning tubing misconnection prevention and line reconciliation. The instrument covered demographic characteristics, knowledge, attitudes, and practices. The knowledge component contained 12 dichotomous items scored as 1 for correct and 0 for incorrect responses, yielding possible scores from 0 to 12. The attitude component contained 11 items rated on a 5-point Likert scale and addressed perceived importance, feasibility, safety climate, and self-efficacy. The practice component consisted of 11 items evaluating behaviors such as line tracing, handoff verification, use of standardized connectors and labels, hazard and near-miss reporting, and patient and family education. Content validity was assessed by experts in nursing practice and patient safety for clarity, relevance, and appropriateness. A pilot test with a small group of nurses was conducted to assess the clarity and feasibility of the questionnaire. Internal consistency was evaluated using Cronbach's alpha, with the attitude scale obtaining $\alpha = .82$ and the practice scale $\alpha = .86$, indicating good reliability.

2.6 Data Gathering Procedure

Questionnaires were distributed to eligible nurses in the selected clinical units. Participants were informed of the study purpose, voluntary nature of participation, anonymity, and confidentiality. The questionnaire was self-administered and completed during participants' available time within their work schedules. No personal identifiers were collected.

2.7 Data Analysis Techniques

Data were analyzed using the Statistical Package for the Social Sciences (SPSS). Frequencies, percentages, means, and standard deviations were used to summarize participant characteristics and study variables. Pearson's correlation analysis examined relationships between knowledge scores and continuous demographic variables, particularly age and years of nursing experience. Independent-samples t-tests were used to determine differences in knowledge scores according to gender and educational attainment. Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, and statistical significance was set at $p < .05$.

2.8 Ethical Considerations

The study followed ethical principles for research involving human participants. Administrative approval was obtained from the hospital, and informed consent was secured before questionnaire completion. The study involved an anonymous, non-interventional survey and collected no patient data; therefore, it was classified as minimal risk. Participant information was kept confidential, and research data were stored securely and used solely for research purposes.

3. Results and Discussion

3.1 Nurses' Knowledge, Attitudes, and Practices Regarding Line Reconciliation

3.1.1 Participant Characteristics

The 508 participating nurses ranged from 21 to 48 years of age, with a mean age of 30.73 years ($SD = 5.60$), and had 0 to 28 years of nursing experience, with a mean of 9.00 years ($SD = 6.04$). Most respondents were female (74.6%) and held a Bachelor of Science in Nursing degree (77.6%). Participants represented the medical intensive care unit (20.5%), surgical ward (16.5%), medical ward (15.7%), emergency room (14.4%), surgical intensive care unit (12.4%), coronary care unit (11.4%), and pediatric intensive care unit (9.1%). The distribution indicates that the study included nurses from several clinical areas where intravenous therapy and multiple-line systems are commonly managed. This provided representation from different units involved in direct patient care and line management.

3.1.2 Knowledge of Line Reconciliation

Knowledge scores ranged from 5 to 12, with a mean of 9.46 ($SD = 1.38$). Most nurses demonstrated high knowledge (78.3%), while 21.7% had moderate knowledge, and none were classified as having low knowledge. Although normality testing showed minor deviations, the distribution was approximately symmetric, and parametric analysis was considered appropriate because of the large sample. The high level of knowledge is consistent with previous KAP studies reporting strong competencies among nurses in patient safety practices (Huang et al., 2025; Song et al., 2026). This level of knowledge may reflect effective institutional training and standardized safety policies. International safety recommendations similarly emphasize education and standardized connectors as important strategies for reducing tubing misconnections (Mazzella, 2023; Institute for Safe Medication Practices, 2024). Continued competency-based training and periodic validation may therefore help sustain nurses' knowledge and safe clinical behaviors.

3.1.3 Attitudes Toward Line Reconciliation

Nurses generally demonstrated positive attitudes toward line reconciliation. Most agreed that the practice improves patient safety, helps prevent wrong-route medication errors, and should be performed during clinical handoffs. Respondents also expressed favorable perceptions regarding the feasibility of line reconciliation, safety climate, and their confidence in identifying risks of tubing misconnections. These findings reinforce the importance of attitudes and organizational safety culture in promoting safe clinical behavior (Seo & Lee, 2022). A supportive environment can encourage healthcare professionals to identify and report hazards and near-miss events, thereby contributing to improved patient safety outcomes (Cai et al., 2024). Maintaining a non-punitive safety culture and open communication may further strengthen nurses' willingness to address potential tubing-related risks.

3.1.4 Line Reconciliation Practices

Nurses reported frequent adherence to recommended line reconciliation practices. These included tracing lines from the source to the patient before connection, conducting reconciliation during shift handoffs, verifying the purpose and route of each line, using standardized connectors and labels, reporting hazards and near-miss incidents, removing unnecessary lines, and educating patients and families not to manipulate medical tubing. Strong adherence to line tracing and labeling is consistent with previous findings concerning safe intravenous medication practices (Rajakumar et al., 2025). However, variability in reporting practices indicates the need to strengthen non-punitive safety systems. Standardized reconciliation during handoffs, transfers, therapy initiation, and tubing reconnection, together with structured checklists, consistent labeling, and access to system-specific connectors, may help maintain consistency in practice.

3.2 Association Between Demographic Characteristics and Knowledge

Pearson correlation analysis showed no significant relationship between knowledge scores and age, $r(506) = -.04$, $p > .05$, or years of nursing experience, $r(506) = -.04$, $p > .05$. Independent-samples t-tests likewise showed no significant differences in knowledge according to gender, $t(503) = 1.74$, $p = .083$, or educational attainment, $t(506) = 0.52$, $p = .61$. These results indicate that nurses' demographic characteristics were not significantly associated with knowledge of line reconciliation. Knowledge levels were therefore relatively consistent regardless of age, years of nursing experience, gender, or educational attainment within the study sample.

3.3 Study Limitations

The findings should be considered in light of several limitations. The cross-sectional design did not allow causal relationships among knowledge, attitudes, and practices to be established. The use of self-reported questionnaires may also have introduced social desirability bias because respondents could report expected safety behaviors rather than their actual clinical performance. In addition, conducting the study in a single healthcare setting may limit the generalizability of the findings to other institutions. These limitations indicate the need for further investigation using multi-center studies and methods that more directly evaluate clinical behavior. Future research

may incorporate direct observation, audit data, or pre-post intervention designs to determine the effectiveness of line reconciliation protocols and provide stronger evidence regarding their influence on patient safety.

4. Conclusion & Recommendations

The study concluded that nurses demonstrated strong competencies in line reconciliation, characterized by high knowledge, positive attitudes, and frequent adherence to recommended safety practices. These findings emphasize the importance of maintaining nurses' competencies in preventing tubing misconnections and supporting patient safety through continued education, standardized protocols, and a supportive safety culture.

Healthcare institutions should sustain competency-based training on tubing misconnection prevention and reinforce standardized line reconciliation protocols during patient handoffs, transfers, therapy initiation, and tubing reconnection. Structured checklists, consistent labeling practices, access to system-specific connectors, and a non-punitive safety culture that encourages reporting of hazards and near-miss events should also be maintained to promote consistent and safe clinical practice.

The study is limited by its cross-sectional design, which prevents determination of causal relationships among knowledge, attitudes, and practices; the use of self-reported data, which may be affected by social desirability bias; and its conduct in a single healthcare setting, which may limit generalizability. Future studies may use multi-center designs, direct observation, audit data, or pre-post intervention designs to evaluate the effectiveness of line reconciliation protocols.

5. Compliance with ethical standards

The authors declare no conflicts of interest. The study followed ethical principles for human-participant research, with voluntary participation, informed consent, anonymity, and confidentiality maintained throughout data collection. Hospital administrative approval was obtained, and because the study involved a non-interventional anonymous questionnaire with no patient data, formal Institutional Review Board approval was not required under hospital policy. All collected data were used solely for research purposes and stored securely.

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