

Development and Evaluation of a Digital Nursing Monitoring Application Based on a Best Practice Protocol for Intensive Care Patients

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ABSTRACT

Background: Intensive care units (ICUs) represent a central sector of critical care, where the quality of nursing monitoring directly conditions the survival of critically ill patients. Despite technological advances and the development of clinical protocols, significant disparities persist in the application of best practices, compromising patient safety and care efficiency. In resource-limited settings such as the Democratic Republic of Congo, these challenges are amplified by insufficient infrastructure, lack of specialized training, and restricted access to digital technologies.

Objective: This study aimed to identify the needs, constraints, and perceptions of ICU nurses regarding patient monitoring, and to evaluate the potential of a digital nursing monitoring application based on a standardized best practice protocol.

Methods: A descriptive cross-sectional study was conducted at Wangata General Reference Hospital, Democratic Republic of Congo. A total of 50 ICU nurses participated in the study. Data were collected using a structured 22-item self-administered questionnaire covering sociodemographic characteristics, current practices, perceived constraints, and expectations regarding a digital monitoring application. Descriptive statistics and chi-square tests were used for data analysis.

Results: The sample was predominantly female (56.0%), aged 24-33 years (44.0%), with a majority holding a bachelor's degree in nursing (56.0%). Most participants had 5-9 years of

professional experience (44.0%). The majority (72.0%) considered current monitoring tools insufficient. All participants (100.0%) reported that material and organizational constraints limited care quality and traceability. Only 32.0% considered current practices harmonized, and 56.0% believed practices did not comply with international recommendations. Automated alerts (54.0%) were the most desired functionality, and the smartphone was the preferred support device (60.0%). All participants (100.0%) unanimously agreed that a digital application would reduce errors, improve care quality, and enhance the nursing role in ICUs. Significant associations were found between age ($\chi^2=15.296$, $p<0.05$), education level ($\chi^2=7.225$, $p<0.05$), and perception of compliance with international recommendations.

Conclusion: ICU nurses face significant material, organizational, and procedural challenges that hinder optimal patient monitoring. Despite these constraints, there is strong acceptance and readiness for digital solutions. The development of a smartphone-based application featuring automated alerts, care checklists, and patient history tracking represents a promising intervention to harmonize practices, reduce errors, and align care with international standards in resource-limited ICU settings.

Keywords: Intensive care unit, nursing monitoring, digital application, best practice protocol, patient safety, resource-limited settings, Democratic Republic of Congo.

1. INTRODUCTION

1.1 Background

Intensive care units (ICUs) represent a central sector of critical care, where the quality of nursing monitoring directly conditions the survival of patients with life-threatening conditions. The complexity of ICU care demands continuous and rigorous surveillance to maintain hemodynamic stability, prevent complications, and ensure timely therapeutic interventions (Vincent, 2020).

Globally, the World Health Organization (WHO, 2019) estimates that over 30 million patients require intensive care annually, with mortality rates reaching 20-40% depending on the underlying critical pathology. Despite technological advances and the development of clinical

protocols, significant disparities persist in the application of best practices, compromising patient safety and care efficiency (Evans et al., 2021).

1.2 The Nursing Role in Critical Care

Nurses play a central role in ICU patient monitoring, ensuring the stability of vital parameters, preventing complications, and implementing prescribed treatments. The evolution of critical care nursing has transitioned from a primarily technical execution role to an advanced practice encompassing clinical decision-making and scientific research (Poiroux et al., 2023; Naudin et al., 2021).

However, the diversity of practices and high workload can lead to variations in care quality. Continuous nursing monitoring has been recognized as a fundamental pillar of critical care, contributing to reduced mortality, complication prevention, and improved post-ICU quality of life (Šabanè et al., 2022; Duvivier, 2019).

1.3 The Digital Health Context

The integration of digital tools in healthcare is increasingly recognized as a strategic priority. The WHO (2023) emphasizes that adopting standardized protocols in ICU patient management contributes to reducing mortality and associated complications while improving care efficiency. Digital tools facilitate real-time data collection, visualization, and analysis, enabling faster and better-informed clinical decision-making (Kyeremanteng et al., 2019).

In resource-limited settings, the challenges are amplified by insufficient hospital infrastructure, lack of specialized training, and restricted access to digital technologies. The Democratic Republic of Congo (DRC) exemplifies these difficulties, with a shortage of qualified personnel, equipment deficits, and a general absence of formalized protocols in ICU services (WHO, 2019).

1.4 Study Objectives

General objective: To design, develop, and evaluate a digital nursing monitoring application for ICUs, adapted to resource-limited hospital contexts, to improve care quality, safety, and efficiency.

Specific objectives:

1. Identify the needs and constraints of ICU nurses regarding patient monitoring
2. Define a structured best practice protocol for nursing monitoring aligned with international recommendations
3. Design a digital application integrating this protocol adapted to resource-limited settings
4. Test and evaluate the application's effectiveness in terms of traceability, error reduction, and practice harmonization
5. Analyze the tool's impact on care quality and nursing role valorization

1.5 Research Hypotheses

H1: The use of a digital nursing monitoring application based on standardized protocols improves care quality and safety in ICUs.

H2: The digital tool promotes harmonization of nursing practices and reduces variability in critical patient care.

H3: The application contributes to better care traceability and reduced errors associated with manual or empirical monitoring.

H4: The integration of a digital device enhances the nursing role by strengthening decision-making autonomy and efficiency in constrained environments.

2. METHODS

2.1 Study Design and Setting

A descriptive cross-sectional study was conducted at Wangata General Reference Hospital (HGR Wangata), located in Équateur Province, Democratic Republic of Congo. This facility is a

referral hospital admitting a large number of patients requiring intensive care and represents a relevant setting for evaluating nursing practices in resource-limited contexts.

2.2 Study Population and Sampling

The target population comprised all nurses working in the ICU of HGR Wangata. Exhaustive sampling was employed due to the limited number of ICU nurses, ensuring maximum representativeness. A total of 50 nurses participated in the study.

Inclusion criteria:

- Licensed nurse working in the ICU
- Present during the data collection period
- Provided voluntary informed consent

Exclusion criteria:

- Nurses on leave or absent during the collection period
- Refusal to participate

2.3 Data Collection Instrument

A structured 22-item self-administered questionnaire was developed based on the study objectives. The questionnaire included:

- **Section I:** Sociodemographic data (age, sex, education level, years of experience, hospital type, digital tool availability)
- **Section II:** Needs and constraints (challenges in patient monitoring, tool sufficiency, material and organizational constraints)
- **Section III:** Current practices and protocols (practice harmonization, compliance with international recommendations)
- **Section IV:** Digital application design (usefulness, priority functionalities, preferred support device, barriers)

- **Section V:** Effectiveness evaluation (error reduction, practice harmonization, impact measurement)
- **Section VI:** Impact on care quality and nursing role

The questionnaire was pre-tested on five nurses to verify clarity and relevance before final administration.

2.4 Variables

Independent variables: Age, sex, education level, years of experience, digital tool availability.

Dependent variables: Identified needs, constraints, current practices, perception of digital application, expected impact on care quality and nursing role.

2.5 Data Collection Procedure

Data were collected through direct administration of paper questionnaires. Participants received a preliminary explanation of the study objectives, and informed consent was obtained before questionnaire distribution. The researcher remained available to clarify any questions during completion.

2.6 Data Analysis

Quantitative data were analyzed using descriptive statistics (frequencies, percentages, cross-tabulations). Chi-square tests were used to examine associations between categorical variables, with statistical significance set at $p < 0.05$. Qualitative responses from open-ended questions were analyzed using thematic analysis.

2.7 Ethical Considerations

The study received institutional approval from HGR Wangata. Ethical principles included:

- Informed consent obtained from all participants

- Anonymity and confidentiality of responses guaranteed
- Data used exclusively for scientific and academic purposes
- Right to withdraw from the study at any time without consequence

3. RESULTS

3.1 Sociodemographic and Professional Characteristics

Table 1 presents the characteristics of the 50 participating ICU nurses.

Table 1. Sociodemographic and Professional Characteristics of Participants (N=50)

Variable	n	%
Age		
24-33 years	22	44.0
34-43 years	16	32.0
44-53 years	6	12.0
54-63 years	4	8.0
64-73 years	2	4.0
Sex		
Female	28	56.0
Male	22	44.0
Education level		
Other	4	8.0
Nursing diploma	18	36.0
Bachelor's degree	28	56.0
Years of experience		

Variable	n	%
1-4 years	14	28.0
5-9 years	22	44.0
10-14 years	6	12.0
15-19 years	8	16.0
Digital tool availability in service		
No	24	48.0
Yes	26	52.0

The sample was predominantly young (44.0% aged 24-33 years), female (56.0%), with a majority holding a bachelor's degree (56.0%) and 5-9 years of professional experience (44.0%). Slightly over half (52.0%) reported having digital tools available in their service.

3.2 Current Practices and Perceived Constraints

Table 2. Adequacy of Current Patient Monitoring Tools

Response	n	%
No	36	72.0
Yes	14	28.0
Total	50	100.0

The majority (72.0%) considered current patient monitoring tools insufficient.

Table 3. Impact of Material and Organizational Constraints

Question	Yes (%)
Do material constraints limit monitoring quality?	100.0

Question	Yes (%)
Do organizational constraints affect care traceability?	100.0
Are current nursing monitoring practices harmonized?	32.0
Do current practices comply with international recommendations?	44.0

All participants (100.0%) reported that both material and organizational constraints limited monitoring quality and care traceability. Only 32.0% considered current practices harmonized, and 44.0% believed practices complied with international recommendations.

Main challenges identified by participants:

- Heavy workload making detailed patient follow-up difficult
- Lack of adapted equipment limiting monitoring quality
- Time-consuming manual traceability reducing direct care time
- Insufficient nursing staff relative to patient numbers
- Communication problems between teams complicating care coordination
- Unstable internet connection hindering digital tool use
- Stress and fatigue related to ICU rhythm affecting monitoring quality
- Absence of harmonized protocols leading to practice variations

3.3 Expectations Regarding a Digital Monitoring Application

Table 4. Priority Functionalities for a Digital Application

Functionality	N	%
Automated alerts	27	54.0
Patient history	9	18.0
Care checklist	8	16.0
Other	6	12.0
Total	50	100.0

Automated alerts were the most desired functionality (54.0%), followed by patient history tracking (18.0%) and care checklists (16.0%).

Table 5. Preferred Support Device

Support device	n	%
Smartphone	30	60.0
Tablet	14	28.0
Computer	6	12.0
Total	50	100.0

The smartphone was considered the most adapted support device (60.0%).

Main barriers identified for digital application adoption:

- Lack of training for optimal tool use
- Resistance from colleagues attached to traditional methods
- Unstable internet connection
- Absence of regular equipment maintenance
- Heavy workload
- Insufficient financial resources for equipping the entire service
- Lack of technical support in case of problems

3.4 Perceived Impact of a Digital Application

Table 6. Perceived Impact on Care Quality and Nursing Role

Question	Yes (%)
Would a digital application reduce monitoring errors?	100.0
Would a digital application improve overall care quality?	100.0

Question	Yes (%)
Would a digital tool enhance the nursing role in ICUs?	100.0

All participants (100.0%) unanimously agreed that a digital application would reduce monitoring errors, improve overall care quality, and valorize the nursing role in ICUs.

Proposed indicators for measuring impact:

- Regular quality audits
- Traceability indicators (record completion rate)
- Speed of data access
- Reduction in monitoring errors (pre/post comparison)
- Nursing staff satisfaction with the tool
- Improvement in patient clinical outcomes
- Comparison of practices between equipped and non-equipped services

3.5 Statistical Associations

Table 7. Chi-Square Test Results for Key Associations

Association	χ^2 calculated	χ^2 critical	df	P-value
Age × compliance with international recommendations	15.296	9.94	4	<0.05
Age × priority functionalities	24.035	21.03	12	<0.05
Education level × compliance with international recommendations	7.225	5.99	2	<0.05
Education level × preferred support device	44.686	9.94	4	<0.05
Experience duration × priority functionalities	29.106	16.92	9	<0.05

Significant associations were found between age and both compliance perception and functionality preferences, between education level and both compliance perception and support device preference, and between experience duration and functionality preferences.

4. DISCUSSION

4.1 Interpretation of Findings

The results of this study reveal significant gaps in ICU nursing monitoring practices at Wangata General Hospital. The finding that 72.0% of nurses considered current monitoring tools insufficient aligns with international observations that many ICUs, particularly in resource-limited settings, lack adequate equipment and standardized protocols (Vincent, 2020; WHO, 2019).

The unanimous perception (100.0%) that both material and organizational constraints limit care quality reflects the challenging working conditions in Congolese ICUs. This finding is consistent with studies by Rose and Clarke (2010), who demonstrated that nursing workload and material constraints directly impact patient safety in ICUs. The International Council of Nurses (2021) similarly emphasized that in many contexts, monitoring practices remain heterogeneous and influenced by organizational and material constraints.

The low proportion of nurses who considered current practices harmonized (32.0%) or compliant with international recommendations (44.0%) reveals a significant gap between field practices and recognized standards. This finding supports the work of the Surviving Sepsis Campaign (Evans et al., 2021), which insists on the importance of structured protocols and reliable monitoring systems to reduce morbidity and mortality.

4.2 Comparison with Existing Literature

The preference for automated alerts as the priority functionality (54.0%) reflects the critical need for rapid identification of abnormal clinical situations in ICUs. This finding aligns with Johnson et al. (2021), who demonstrated that predictive algorithms and automated alert systems help anticipate complications and support clinical decision-making.

The smartphone being preferred as the support device (60.0%) corroborates global trends in mobile health (mHealth), where the accessibility, mobility, and user-friendliness of smartphones make them ideal tools for clinical monitoring in constrained environments. This finding is consistent with Kyeremanteng et al. (2019), who highlighted that digital tools facilitate real-time data collection and analysis, enabling faster and better-informed clinical decision-making.

The unanimous agreement that a digital application would reduce errors, improve care quality, and valorize the nursing role (100.0%) demonstrates strong acceptance of digital technologies among ICU nurses. This finding is consistent with Paris (2018), who demonstrated that the use of digital applications in patient monitoring improves traceability and adherence to recommendations, and with Minota (2025), who showed that connected devices promote care continuity and reduce gaps from international standards.

4.3 Study Limitations

Several limitations should be acknowledged:

1. **Sample size:** The relatively small sample (n=50) limits the generalizability of findings to all ICU nurses in other settings.
2. **Single site:** The study was conducted at only one hospital, which may not represent the diversity of ICU contexts in the DRC.
3. **Self-report bias:** Data were based on subjective declarations via questionnaire, exposing results to perception or social desirability biases.
4. **Lack of direct observation:** The absence of direct observations or objective practice measurements limits the ability to verify reported practices.
5. **Context specificity:** The specific organizational and material context of the studied service may have influenced responses, making comparison with better-equipped environments difficult.

4.4 Implications for Practice and Research

Despite these limitations, the study has important implications:

For clinical practice: The findings support the urgent need to invest in digital tools and harmonize nursing practices to ensure optimal ICU patient care.

For hospital administration: The results provide evidence for resource allocation toward digital infrastructure, training programs, and standardized protocol implementation.

For future research: The study opens perspectives for larger multicenter studies, mixed-methods approaches combining questionnaires with direct observation, and experimental or longitudinal studies evaluating the concrete impact of digital tools on care quality and patient safety.

5. CONCLUSION

5.1 Summary of Findings

This study evaluated the needs, constraints, and perceptions of ICU nurses regarding patient monitoring and assessed the potential of a digital nursing monitoring application based on a standardized best practice protocol. Key findings include:

1. Current monitoring tools are considered insufficient by the majority (72.0%) of ICU nurses.
2. Material and organizational constraints universally (100.0%) limit care quality and traceability.
3. Current practices lack harmonization (only 32.0% consider them harmonized) and often fail to comply with international recommendations (56.0% report non-compliance).
4. Nurses express clear needs for standardized protocols and adapted digital tools, with automated alerts (54.0%), patient history (18.0%), and care checklists (16.0%) as priority functionalities.
5. The smartphone is the preferred support device (60.0%), reflecting the importance of mobility and rapid information access.
6. There is unanimous acceptance (100.0%) that a digital application would reduce errors, improve care quality, and valorize the nursing role.

7. Significant associations exist between age, education level, experience duration, and various perceptions and preferences.

5.2 Verification of Hypotheses

Hypothesis	Result
H1: Digital application improves care quality and safety	ACCEPTED (100.0% agreement)
H2: Digital tool promotes practice harmonization	ACCEPTED (100.0% agreement)
H3: Digital application reduces errors and improves traceability	ACCEPTED (100.0% agreement)
H4: Digital tool valorizes the nursing role	ACCEPTED (100.0% agreement)

5.3 Recommendations

For hospital authorities:

- Invest in digital infrastructure, including smartphones and reliable internet connectivity
- Implement standardized protocols integrated with digital monitoring tools
- Organize regular training programs for ICU nurses on digital tool use
- Establish technical support mechanisms for digital tools

For nurses:

- Participate actively in training and continuing education programs
- Provide feedback for continuous improvement of digital tools
- Engage in practice harmonization efforts

For researchers:

- Conduct larger multicenter studies across different DRC hospitals
- Implement mixed-methods approaches combining questionnaires with direct observation
- Perform longitudinal studies to evaluate the concrete impact of digital tools on clinical outcomes

5.4 Final Conclusion

This study confirms the importance of investing in digital tools and harmonizing nursing practices to ensure optimal ICU patient care in resource-limited settings. Despite significant material, organizational, and procedural challenges, there is strong acceptance and readiness for digital solutions among ICU nurses. The development of a smartphone-based application featuring automated alerts, care checklists, and patient history tracking represents a promising intervention to harmonize practices, reduce errors, and align care with international standards. Successful integration requires parallel investment in training, technical support, and change management strategies to overcome resistance and technical difficulties.

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