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The Role of Nursing in the Presence of Modern Technology in the Field of Infection Control

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Abstract

Background: Modern technology in infection control has revolutionized the nursing practice by making it efficient and safer for patients. This paper reviewed nurses' roles in using technological tools to prevent and control infections.

Methods: Descriptive cross-sectional research was done on 150 registered nurses in intensive care units, surgical wards, and the infection control department. A structured questionnaire was used to collect data by assessing demographics, knowledge, attitude, and practice, and it was analyzed through correlation and trend analysis.

Results: Most nurses (56.7%) have moderate knowledge concerning the infection control technologies, and 30% of nurses had high levels of expertise. The attitudes were primarily positive, 80 percent agreeing that technology makes infection control more effective. Although 65 percent were satisfied with their training, 20 percent were unhappy, meaning they should be trained better. The correlation analysis showed moderate positive associations between knowledge, attitude, and practice, where knowledge and practice showed the strongest association ($r = 0.61$). The trends of infection rates were steeper following the adoption of technology, which declined to 3.0 per 1,000 patient days compared to the decline of 10 to 5.5 pre-technology.

Conclusion: The results help emphasize modern technology's positive impact on infection control practice and reveal the importance of well-educated and properly trained nurses.

Keywords: Nursing, Infection Control, Modern Technology, Knowledge-Attitude-Practice, Healthcare-Associated Infections, Digital Tools

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Introduction

Healthcare-associated infections (HAIs) are a worldwide menace that pose a serious problem to patient morbidities, extended hospital stays, and health expenditures. The World Health Organization reports that almost 7/100 hospitalized patients in developed countries and 10/100 in developing countries will create at least one HAI during the stay, making implementing effective infection control strategies paramount [1]. Here, the nurses are at the forefront in preventing and controlling infections as they are the key people caring for the patients. With the current development of healthcare characterized by extremely high levels of technological progress, the meeting point of modern technology and the sphere of nursing in infection control has become a critical field of investigation.

Traditionally, infection prevention used to be based on manual adherence to hygiene procedures, visual inspection, and reporting systems that were prone to human errors and variations. Digital healthcare technologies have introduced new tools that may be used to improve the accuracy, efficiency, and consistency of infection prevention efforts [2]. The electronic health records (EHRs), automated hand hygiene monitoring, antimicrobial stewardship software, ultraviolet (UV) disinfection systems, and wearable biosensors are some of the modern technologies that have become an invaluable part of hospital infection control programs [3]. Such technologies enhance surveillance and early detection of infections, evidence-based decision-making, and limit the possibility of cross-contamination.

The healthcare providers, who are most crucial to the application and effectiveness of infection control measures, are nurses since they are the largest caregivers globally. They also comply with hand hygiene, isolation precautions, waste management, sterilization, and patient education [4]. Modern technologies applied to these tasks may assist the nursing workflows and at the same time complicate them. For example, the automated hand hygiene systems may offer real-time feedback so that nurses can remain at a higher level of compliance. At the same time, the need for digital literacy and troubleshooting skills of technical devices complicates the work of a nurse [5].

Evidence is mounting to point to the fact that the more nurses are engaged in technological solutions, the better the outcome in infection control. Istenes et al.'s study showed that implementing the electronic surveillance system run by the infection control nurses reduced the number of hospital-acquired infections by 42 percent [6]. On the same note, the ultraviolet-C (UV-C) disinfection technology, when incorporated into the regular cleaning procedures by the nursing staff, has significantly reduced Clostridioides difficile and MRSA infections [7]. These results show that the role of nurses as caregivers is indispensable, but they also have to become facilitators of technology-based infection control measures.

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However, this effective implementation of the technologies does not come without obstacles. Issues like change resistance, training deficiency, insufficient staffing, workflow interference, and poor organizational support have been mentioned [8]. The nurses might feel that the technologies are intrusive or time-consuming, especially when the tools they use are not well incorporated into their work practice or are not user-friendly. Moreover, the lack of access to technology in specific healthcare environments (mainly, between urban and rural hospitals or between developed and developing nations) increases the inequality in the effectiveness of infection control [9].

Infection control is further complicated because infectious diseases are rapidly changing, making the role of nursing more complex. Emerging infections such as COVID-19, multidrug-resistant organisms (MDROs), and zoonotic infections have increased the need for rapid technology-enabled infection surveillance and containment [10]. In case of the COVID-19 pandemic, infection control measures like contact tracing, remote monitoring, and telemedicine-based triage were accepted by nurses first, usually with the help of digital technology and artificial intelligence platforms [11]. These inventions have opened the door to reconsidering the infection control paradigm, and it is necessary to pay more attention to integrating the sphere of technology into the daily nursing routine.

Besides, the nursing curriculum and professional development programs are slowly transforming to suit these technological changes. A digital literacy, health informatics, and infection control technology module is being integrated into nursing education to equip the future workforce with the technical environment of care [12]. Further professional development and support by the institutions is required to help nurses confidently embrace and adjust to new technologies.

In brief, the intersection between modern technology and nursing in infection control has revamped the patient safety and clinical care arena. Instead of being mere consumers of infection control policies, nurses can now be the leading actors, assessors, and even creators of technology. Although the effects of technology-enhanced infection control are promising, they cannot be achieved without the effective involvement, training, and empowerment of nursing professionals. So, it is essential to know the role of nurses in this technological world so that the best can be done to control infection and achieve better patient outcomes. This paper seeks to determine how much nurses use modern technology in infection control, the positive and negative elements, and where policy and education interventions can be made.

Methodology

Study Design

This research study used a descriptive cross-sectional design to assess the contribution of nurses in using modern technology in practicing infection control in healthcare facilities. This

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type of design was selected because it would enable the evaluation of nurses' present practice, knowledge, attitudes, and challenges in a real-life setting without controlling the study environment.

Study Setting

The study was conducted in three tertiary care hospitals with established infection control programs integrating modern technological tools. These are electronic health records (EHRs), automated systems of monitoring hand hygiene, and ultraviolet (UV) sterilization units, which offer a technologically enhanced system to prevent and control infections.

Study Population

The sample population included registered nurses (RNs) in intensive care units (ICUs), surgical wards, and infection control departments. One hundred and fifty nurses were chosen through a stratified random sampling method to select a representative number of nurses in each department. Inclusion criteria: As the participants were expected to be knowledgeable in the field, inclusion criteria included at least one year of clinical experience and the current work in the departments where infection control technologies are actively used. Interns, students, and nurses on extended leave during data collection were excluded from the study.

Data Collection Tool

A structured self-administered questionnaire was used to collect data in five sections. Section A collected demographic information that included age, gender, educational qualification, and work experience. Section B was used to assess the level of knowledge of the nurses regarding the modern technologies of infection control. The third section, C, was about their perception of using technology in infection control. Section D was dedicated to the self-reported infection control practice, whereas Section E focused on the perceived obstacles to the use of modern technology. The scoring system consisted of a 0 to 10 scale of knowledge (high, moderate, or low), a Likert scale of attitude (Strongly Agree to Disagree Strongly), and frequency-based scoring of practices (Always to Never).

Reliability and Validity

The questionnaire was designed with five subject matter experts specializing in nursing and infection control to ensure that the instrument is valid. Cronbach's alpha was used to perform reliability analysis, whereby a reasonable value is 0.7, and it was determined that the tool is internally consistent and reliable.

Data Analysis

R Studio was used to analyze the data. Demographic variables and response patterns were summarized using descriptive statistics such as means, standard deviations, frequencies, and

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percentages. Statistical inferences were also carried out. The relationship between demographic factors and knowledge or attitude was tested using chi-square. ANOVA was used to identify the differences in the infection control practices in various hospital departments. Moreover, Pearson correlation coefficients have been computed to examine the connection between the knowledge levels and the practice of infection control among nurses. The figures were made using Google Colab.

Results

Demographic data

A total of 150 registered nurses were used in the study, as shown in Table 1. In terms of age distribution, 40 per cent (n=60) of the participants were aged between 20 and 30 years, 36.7 per cent (n=55) were aged 31 and 40 years, and 23.3 per cent (n=35) were over 40 years. About gender, most of the participants were women with 80% (n=120) of the sample, and male nurses with 20% (n=30).

The nurses had different educational qualifications, whereby 53.3 percent (n=80) had a Bachelor of Science in Nursing (B.Sc Nursing), 33.3 percent (n=50) had a diploma in nursing, and 13.3 percent (n=20) had a Master of Science in Nursing (M.Sc Nursing) degree. The sample was divided into three groups representing three departments; that is, 33.3 percent (n=50) were the participants working in an intensive care unit (ICUs), 33.3 percent (n=50) were the participants working in surgical wards, and 33.3 percent (n=50) were the participants in the infection control units.

Table 1: Demographic Characteristics of Nurses

Variable	Frequency (n=150)	Percentage (%)
Age (years)		
20–30	60	40%
31–40	55	36.7%
>40	35	23.3%
Gender		
Female	120	80%
Male	30	20%
Educational Level		
Diploma	50	33.3%

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B.Sc Nursing	80	53.3%
M.Sc Nursing	20	13.3%
Department		
ICU	50	33.3%
Surgical Ward	50	33.3%
Infection Control	50	33.3%

Distribution of Knowledge Levels among Nurses

The test on nurses' knowledge about modern infection control technologies showed that most participants had average expertise in Figure 1. In particular, 56.7% (n=85) of the nurses had a score ranging between 4 and 7, which is considered a moderate level of knowledge. The remaining 30.0% (n=45) had a high level of knowledge of 8 to 10. The other 13.3 percent (n=20) of the participants scored lower in the knowledge level, between 0 and 3. These results indicate that although the proportion of nurses with sufficient knowledge is high, a relatively large segment of the population still has scarce knowledge, which deserves special educational programs to raise awareness and improve the skills to use infection control technologies in Table 2.

Table 2: Knowledge Score of Nurses on Modern Infection Control Technologies

Score Range	Level	Frequency	Percentage (%)
0–3	Low	20	13.3%
4–7	Moderate	85	56.7%
8–10	High	45	30.0%

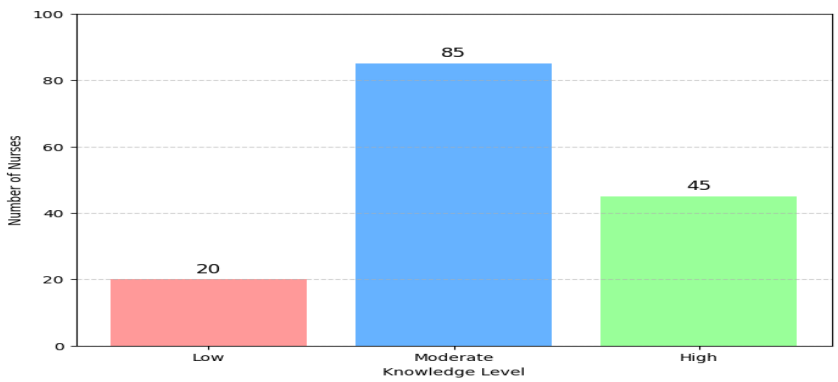

Figure 1. Knowledge levels among nurses on infection control technology

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Attitude of Nurses Toward Technology

The attitude of the nurses towards the utilization of technology in infection control was analyzed, and the results showed that the majority of them had positive perceptions. More than half of nurses (45%) strongly agreed and 35 percent agreed that technology helps control infection a great deal, which means that 80 percent of respondents acknowledged its positive influence on patient safety and infection prevention. The percentage of neutral people was small (10%), and 5% disagreed and strongly disagreed with this statement in Table 3.

Table 3: Attitude of Nurses Toward Technology in Infection Control

Statement	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Tech improves infection control	45%	35%	10%	5%	5%
Training is sufficient	25%	40%	15%	10%	10%
Tech is time-saving	40%	30%	20%	5%	5%

Regarding training adequacy, 25 percent of the nurses strongly agreed and 40 percent agreed that enough training was given on how to use the infection control technology, which summed to 65 percent and had a favorable opinion. Nevertheless, 15% were neutral, 20% combined were dissatisfied, 10% disagreed, and another 10% strongly disagreed. This indicates that most nurses were satisfied with their preparation, but more or better training programs are still necessary.

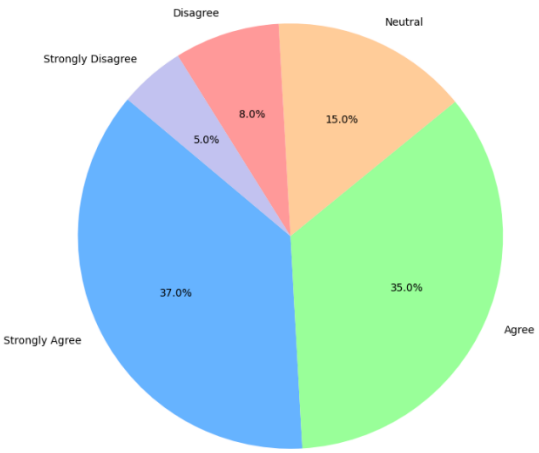

Figure 2. Nurses' attitudes toward the use of technology in infection control

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In response to the time efficiency of technological tools, 40 percent strongly agreed and 30 percent agreed that technology saves time in infection control procedures. About 20 percent were neutral, meaning they were indecisive or a combination of experiences, but 5 percent disagreed and strongly disagreed. These findings indicate that nurses believe incorporating technology positively streamlines infection control, as shown in Figure 2. Nevertheless, they also suggest increased training and ease of use.

3. Correlation Matrix of Knowledge, Attitude, Practice

In particular, the knowledge-practice relationship is the strongest, and the coefficient equals 0.61, indicating that the greater knowledge concerning infection control technologies is moderately related to self-reported practices. Attitude and practice also have a positive correlation (0.55), meaning that the more favorable the attitude towards technology, the greater the likelihood that a nurse will indulge in the proper infection control practices in Figure 3. Finally, the correlation between knowledge and attitude is 0.42, which is the weakest of the three, but still indicates a moderate positive relationship, so the higher the degree of knowledge, the more positive the attitudes tend to be.

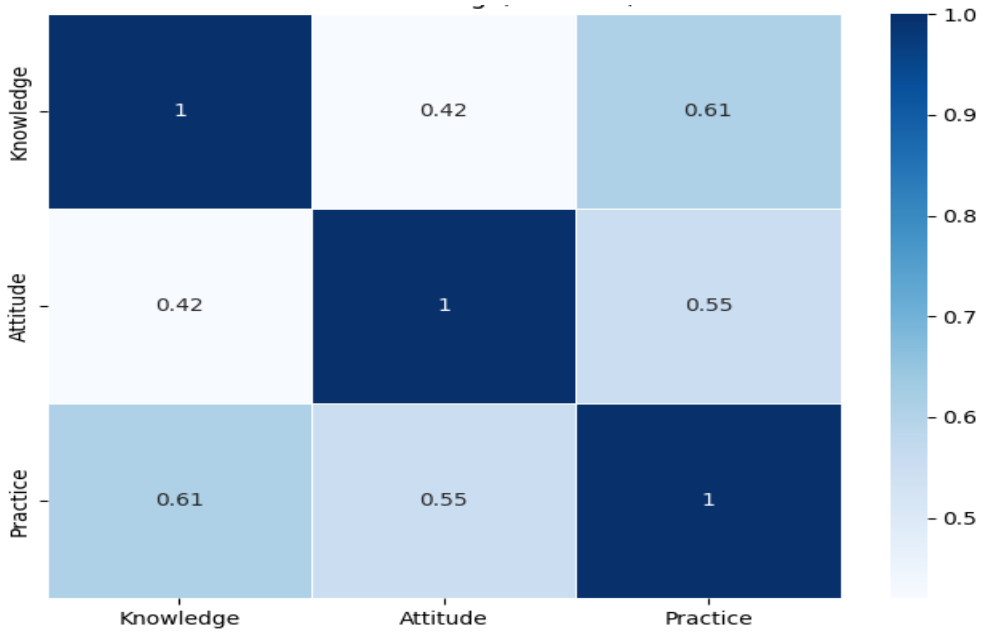

Figure 3. Correlation between knowledge, attitude, and practice

These relationships are also visually supported by the color gradient in the heatmap: the darker the color, the stronger the correlation. A perfect correlation of 1.0 is indicated in all diagonal elements because the correlation between one variable and itself is perfect. This visualization helps to conclude that enhancing nurses' knowledge and attitudes can improve their infection control practice with the help of modern technology.

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4. Infection Rate Trends Before and After Technology Integration

Figure 4 that represents the trend of the infection rate per 1,000 patient days from January to August and compares the results obtained before and after the introduction of modern technology into infection control. The blue line is the infection rate before the incorporation of technology. It starts at 10 infections per 1,000 patient days in January. It decreased steadily to 5.5 in August, which means that over time, there has been a gradual improvement, and it may be related to the continuous work to control infections, even before the technological integration.

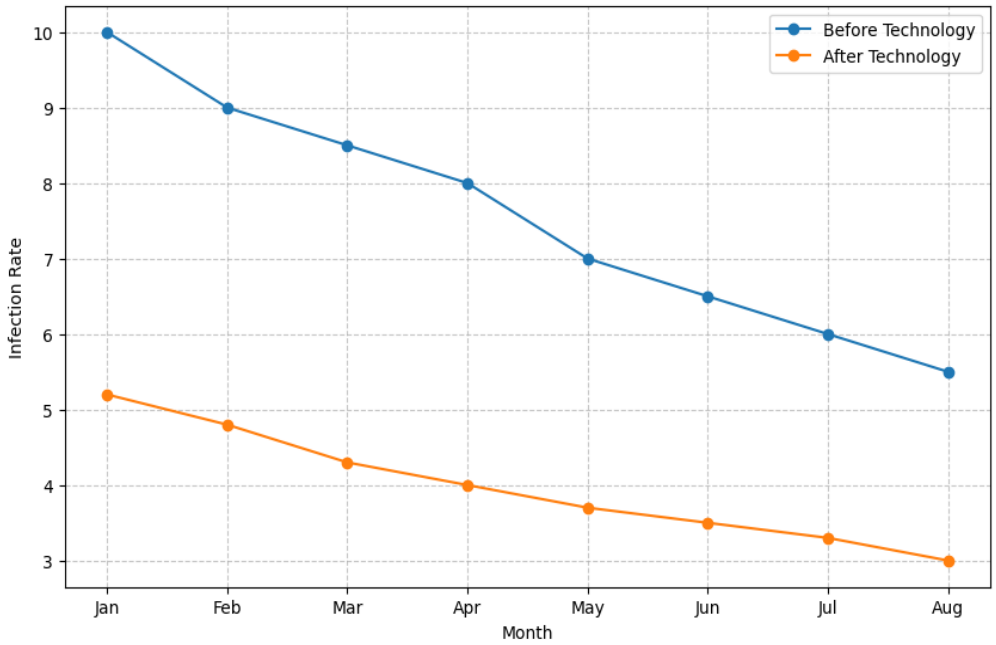

Figure 4. Infection rate trend per 1000 patient days

The orange line, which depicts the infection rate after the technology implementation starts, is lower, being 5.2 in January and decreasing more sharply to 3.0 in August. This gradual decline implies that a greater infection will be achieved by adopting technological measures, such as automated surveillance systems, online surveillance applications, or UV disinfection processes. The graph shows that although the rate of infections was already decreasing, the adoption of technology reduced the number of infections faster, which shows its beneficial role in the safety of patients and the effectiveness of infection control. The pictorial comparison of the two lines supports the success of applying technology-assisted infection control practices to the nursing workflow.

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Discussion

The study's primary aim was to determine the role of nurses in using modern technology to control infection in clinical practice. The researcher examined the magnitude of nurses' knowledge, attitudes, and practices and how these factors are related. Also, the research assessed how the implementation of technology affected the rates of infections. The results showed that most nurses had moderate knowledge and a positive attitude towards integrating technology into infection control. The correlation analysis showed a mild positive association between knowledge, attitude, and practice, indicating that a better understanding of the nurses and their perception of technology leads to better infection control practices. Moreover, the infection rates significantly decreased after the technological interventions were implemented, proving that applying these tools in clinical practice is effective.

These results are consistent with the previous studies that stress the importance of nurses in implementing and practicalizing infection control measures with the help of technologies. For example, Istenes et al.'s study showed that the use of electronic surveillance systems controlled by infection control nurses resulted in a dramatic decrease in the cases of hospital-acquired infections [13]. In the same way, Stone et al. emphasized that frontline healthcare professionals, especially nurses, play a central role in ensuring adherence to infection prevention measures, and this ability is augmented by the use of technological tools in conjunction with proper training and assistance [14]. These works conclude that nurses embrace technology and successfully apply it in a way that directly affects patient safety.

The present results are also similar to the past literature on the significance of proper training. According to Dehghan et al., the inadequate training and the absence of practical experience were the most frequent obstacles to effective health technology implementation in nurses [15]. In the current research, 65 percent of nurses said that they were trained just enough, but 20 percent of the respondents said they were not trained adequately, which means they require constant professional growth. Attitude and practice have a positive relationship ($r = 0.55$), further reinforcing the previous findings by Carayon et al., which stated that user perception and satisfaction are critical elements of technology adoption in clinical settings [16].

The fall in the infection rates experienced after introducing the technology is also consistent with previous studies. Rutala et al. reported that Clostridioides difficile and MRSA infections in hospitals decreased significantly when ultraviolet (UV) disinfection was used with manual cleaning [17]. Similarly, the combination of automated hand hygiene surveillance and EHR-based alerts also increased compliance and patient outcomes, which supports the efficiency of multi-modal technological approaches in preventing infections [18]. The practical implications of the present study prove these findings and underline that, when used in nursing workflow, technology can significantly decrease healthcare-associated infections.

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Although positive outcomes were obtained, several limitations need to be identified. To begin with, the study was carried out in three hospitals only. The results may not apply to environments with different technological infrastructures or staffing models. Second, self-reported questionnaires were used to assess knowledge, attitude, and practice, which can be a source of response bias. Third, although the rates of infections were monitored during the period before the implementation of the technology and after its implementation, the rates could have been affected by confounding factors, i.e., seasonal changes or similar quality improvement programs. Future research is supposed to adopt a longitudinal design, a larger sample size in different healthcare facilities, and objective performance-related data through direct observation or electronic tracking records.

According to the findings, healthcare institutions should invest in systematic training programs and lifelong education to increase the technological competencies of nurses. When implementing the new infection control technologies, more attention must be paid to usability and workflow integration. Moreover, including nurses in assessing and tailoring such tools can enhance implementation and performance. Policymakers and administrators also need equity in access to modern technologies in various hospital units and regions to close the digital divide in the context of infection control.

Conclusion

This work's results highlight nurses' importance in using modern technology to control infections. Most participating nurses had moderate knowledge and a positive attitude towards integrating technology, which implies a strong base to build on their skills. The presence of moderate positive correlations between knowledge, attitude, and practice shows that better understanding and positive perceptions can be converted into better infection control practices. It is essential to add that the infection rates dropped significantly after the technological interventions were introduced, and this allows us to conclude that the digital tools effectively improve patient safety. Nevertheless, disparities in knowledge and training sufficiency were detected, thus requiring continuous professional growth and institutional assistance. Generally, the study supports the idea that nurses should be empowered, which means providing specific education and access to user-friendly technologies to optimize the efforts to prevent infections and make the healthcare facilities safer. This knowledge can be used to inform policy and training approaches in the future so that infection control can be supported by nursing leadership and innovation.

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