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The mediation role of Workflow Optimization on the relation between Technological Integration and Nursing Care Efficiency in Madinah health cluster

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Abstract

This research sought to identify the influence of workflow optimization as a mediator of the relationship between technological integration and nursing care efficiency in Madinah Health Cluster. This research is in the context of the advancement of digital transformation in healthcare. In this case, the use of integrated systems of electronic health records, artificial intelligence to support and enhance clinical and care workflows, mobile health applications, and hospital information systems. The methodology used a quantitative approach with a deductive cross-sectional design. The study population involved registered nurses in healthcare institutions in the Madinah Health Cluster. The research study distributed 450 questionnaires and received 361 completed questionnaires. Data analysis employed descriptive statistics and Smart Partial Least Square. The analysis also included an assessment of the normality and measurement and structural mediation model, among others. The study findings indicate that technological integration positively influenced nursing care efficiency and workflow optimization. The study findings also indicate that workflow optimization positively influenced nursing care efficiency. Finally, mediation analysis revealed that workflow optimization mediated the relation of technological integration and nursing care efficiency. Because the direct effect was still significant, mediation was considered partial. The study also recommends that technological integration can enhance nursing care efficiency directly and/or indirectly through digital systems that enhance the organization of workflows and support task and care communication and coordination.

Key Words: Technological Integration, Workflow Optimization, Nursing Care Efficiency, Digital Health, Madinah Health Cluster.

1. Introduction

Healthcare systems are changing rapidly. Nurse practitioners must consider these shifts because nurses makeup the largest segment of the workforce and are integral to patient care. The pressures of digital transformation, heightened patient expectations, a strained workforce, and delivering care that is safer and more efficient, are forcing a drastic change to how care is delivered and managed. Hospitals and health services are adopting tools such as electronic health records, artificial intelligence, digital clinical decision support systems, and smart nursing technologies. Integration of these tools is becoming the main focus of improving nursing practice. Integration of

technologies involves more than the mere presence of a digital system. Technologies are integrated when a digital system is purposely embedded into the routine practice of nursing, clinical, and digital communications and documentation, as well as into daily decision-making. Recent studies indicate that modern health technologies can improve patient care, support nursing performance, enhance access to information, and strengthen care coordination when they are accepted and properly used by healthcare professionals (Alrahbi et al., 2021). In Saudi Arabia, the adoption of modern technology in public health has also become more visible due to national healthcare transformation efforts and the broader objectives of Vision 2030, which emphasize investment, digital modernization, quality improvement, and health system sustainability (Alfahad et al., 2024).

Though digital health technologies can be advantageous, the incorporation of technology does not inherently achieve greater efficiency in care service delivery. Digital systems can create burdens with documentation, interrupt nursing staff workflow, and cause duplication when the systems are not designed in conjunction with clinical practices and the needs of the users. Research into electronic medical records indicates that the systems have the potential to improve healthcare delivery and outcomes; however, they create challenges to health practitioners due to poor usability, insufficient training, and poor interoperability and workflow alignment (Amponin & Britiller, 2023). Research on nurses' acceptance of electronic health records describes that the perceived improvement in patient care from these systems hinges on nurses' experiences with the technology in practice and the degree to which the systems integrate and do not obstruct nursing activities (dela Cruz & Mallari, 2025). In the field of nursing, the significance of a technological system focuses on its synergistic relationship with other systems, the framework within which the systems operate, and the human users that interact with the systems. This becomes particularly relevant in environments where practitioners are faced with greater demands, constraints with time, and the need to provide safe and effective services.

Optimizing workflow is understood to be one of the major ways that the integration of technology can make nursing care more efficient. It describes the refinement of the order, structure, and synchronization of nursing tasks to reduce unnecessary work and delays, redundant tasks, interruptions, and any tasks that do not contribute value. Non-nursing tasks and non-value adding tasks interfere with the efficiency of nursing tasks. This shows there is a need to design work in such a way that it allows more of the work to be focused on patient care (Chung et al., 2025). Also, if used correctly, artificial intelligence and automated smart workflows can improve the management of resources and reduce the pressure of workload. They can also help improve the workflow of nursing and increase the safety of patients (Alanazi et al., 2024). With this in mind, the optimization of workflow can also be considered a means of crossing technology and the efficiency of nursing care, since the usefulness of digital tools relies on the technology being integrated to organized responsive workflows that center around the nurse.

Nursing care efficiency refers to the ability of nurses to provide timely, accurate, safe, and high-quality care while using available resources effectively. It is closely related to patient safety, clinical outcomes, care quality, staff productivity, and the reduction of avoidable delays. Nursing care quality significantly impacts patient safety and clinical outcomes. Therefore, strengthening the operational conditions that nurses work in has importance. Digital competencies of nurses are also linked to the quality of nursing care. Digital competencies among nurses are closely related to the quality of nursing care, especially in critical care contexts where timely and accurate digital practice supports better care delivery (Elmansy et al., 2026). Technological capabilities can enhance the quality of care; however, nurses must be sufficiently skilled and confident with digital systems to use them. Care delivery cannot be realized with the use of technology in isolation. Instead, it requires consideration of the organization of the work as well as the design of the workflows. It is evident that care delivery and efficiency cannot be realized from the use of technology alone. Technology and the organization of work, as well as the design of workflows, must be considered.

The Saudi healthcare sector provides an important context for examining these relationships because healthcare transformation is strongly connected to digital modernization, artificial intelligence adoption, service quality improvement, and patient-centered care. Effective health administration practices play an important role in improving healthcare quality because managerial support influences service coordination, resource use, and operational performance (Majeed et al., 2024). Studies conducted in Saudi Arabia have highlighted both the opportunities and challenges associated with artificial intelligence applications and digital transformation in healthcare delivery, particularly in relation to Vision 2030 and the need to improve care quality and operational performance (Muafa et al., 2024). Healthcare quality enhancement models emphasize that innovation and service improvement should be linked to operational processes and measurable care outcomes (Mashabab et al., 2025). At the same time, several healthcare and nursing organizations will look for evidence to show the ways in which the digital technologies employed may enhance the efficiency of caring for clients in the workplace. The Madinah Health Cluster is a suitable context for the research under consideration, as health clusters in Saudi Arabia are set to achieve improvements in service integration, operational efficiency, and quality of care as part of the national transformation program. Nevertheless, very little has been researched regarding the integration of technology and how it impacts the efficiency of nursing care by the optimization of workflows within this particular healthcare system.

Thus, this study explores the role of workflow optimization mediation in the integration of technology and the efficiency of nursing care in the Madinah Health Cluster. This study improves current research by going beyond the assumption that technology has a direct and positive impact on nursing outcomes. This study argues that workflow optimization is the important step to the integration of technology regarding efficiency of nursing care. This study is of value to nursing leaders, healthcare managers and decision makers in the field of digital health, by showing the best ways to optimize the value of technology being implemented. This can be achieved when digital systems converge with nursing workflows, mitigate the burden of redundant tasks, and empower the delivery of efficient care. It is anticipated that the outcomes of the study will promote informed and rational decisions regarding nursing, improve the design of healthcare processes, and facilitate the delivery of safe, efficient, and advanced healthcare services in the context of the transformation initiatives of the Saudi healthcare system.

2. Literature Review

2.1 Theoretical Discussion

This study is anchored in the Donabedian Model and Sociotechnical Systems Theory, both of which explain the impact of advanced technology and system innovation on the efficiency of nursing care by way of improving and streamlining workflow. The Donabedian Model describes the interaction of structure, process, and outcome in describing healthcare quality. In this study, the addition of technology is a structural element and includes the digital systems (i.e., electronic health records, artificial intelligence, clinical decision support systems, and smart nursing technologies) which are present to enhance the practice of nursing. Process, in this case, is the optimization of workflow and is demonstrated by the nursing tasks in the workflow that are organized, coordinated, streamlined, and assisted in the performance of daily nursing activities. Outcome is represented by the efficiency of nursing care in that it indicates how well the resources at the nurses' disposal are utilized to deliver nursing care that is prompt, safe, relaible, and of a high standard. The recent popularity of the Donabedian Model in healthcare quality research indicates that the model is still relevant in connecting the resources and processes of care of an organization with the quality outcomes of care in clinical practice (Yang et al., 2025).

This study appreciates the Donabedian Model in particular for its recognition that technology resources are not enough. If care processes are not improved, technological resources are wasted. A hospital can implement highly advanced digital systems, but those systems will not make care delivery more efficient if they enhance the documentation burden, break the communication network, and systematize the recording of nursing tasks out of order. Only through the optimization of nursing practice workflows will digital systems translate to value and work in practice. This applies to the integration of digital health technologies within nursing practice in a way that promotes the safety of service users and the efficient delivery of health services. The integration of digital technologies within nursing practice should not be in a way that builds additional layers of technology to clinical practice. Rather, the focus should be on the workflow of the nursing practice (OuYang & De Ala, 2026). Electronic health records should demonstrate the capacity to support and enhance the flow of nursing practice in the hospital. System design and the use of Electronic Health Records should fulfill the real practice of nurses in the hospital (Farajalla et al., 2026).

Sociotechnical Systems Theory promotes the idea of the interaction of people, tasks, and the structures of organizations and technology when considering technological innovations in health care. Recent systems engineering literature also confirms the importance of sociotechnical thinking when evaluating how technical systems interact with people, tasks, and organizational structures (Polojaervi et al., 2023). The integration of technology, in this case, is dependent on users' acceptance and digital skills, as well as the support of the organization, the fit of the technology to the workflow, and, in particular, the relationship between technology and the human work the technology serves. This theory is applicable to nursing as an interactive occupation that involves simultaneous clinical judgment, communication, coordination, documentation, and monitoring of patients. For this reason, the technological systems adopted in nursing must fit the social and clinical workspace of the nurse. Because of the relationship between technical systems and the human users of these systems, sociotechnical theory has a great appeal in nursing informatics to illustrate the impact of technology on care work.

The sociotechnical perspective is most applicable when analyzing a particular subset of health care practices that have digital technology intertwined. This is because, when digital technology is introduced in health care, it has the potential to yield good or bad outcomes. For example, AI and communications technology may help organize, and improve, care and facilitate decision making and improve documentation and the coordination of care. Conversely, technology that is unintegrated and poorly designed may create new, additional burden instead. The most recent research on the digital transformation of nursing has indicated that 'smart' nursing systems support advanced technologies. However, their support is directly related to health care organizations' abilities to incorporate the technologies into clinical practice and intrude upon the sacred nursing workflow (Wang et al., 2024). Integration of technology in nursing practice has also been studied in the context of the design of future patient care rooms, and indicated that technologies advanced to simplify and help support nursing tasks (particularly patient care), and that do not make nursing practice more difficult or complex, are the most valued (Stevens et al., 2025).

Hence, the main argument presented in this paper is that the optimization of workflows is the element that joins the technological component with the efficiency of nursing care. The integration of technology builds the digital infrastructure. In contrast, optimization of workflows establishes if this infrastructure positively impacts the process of care delivery. If technology leads to reduced duplication, faster access to information, better coordination of tasks, and non-value-adding tasks, nursing care efficiency will be positively impacted. This opinion is evidenced by the presence of non-value-adding and non-nursing tasks that hinder nursing tasks. This proves that workflow design is imperative around the primary care functions of nurses (Chung et al., 2025). It is also backed by the study that disturbance of workflow and perception of the workload contribute to the neglect of nursing tasks and the state of health of nurses. This shows that the efficient management of workflow impacts positively both care delivery and the state of health of staff (Liu et al., 2026).

In the Saudi context of healthcare, the presumed relationship among technological integration, optimal workflows, and the efficiency of nursing care is of even greater relevance. The Saudi Vision 2030 agenda aim for extensive investment in healthcare alongside the digital transformation and improved modern systems of healthcare delivery. Strong opportunities are created to enhance the quality and effectiveness of nursing care, but provide little guidance on how technology can be translated to bring genuine changes to clinical practice. Saudi healthcare transformation reviews emphasize the role of investment, innovation, and digital modernization in shaping future healthcare systems and their performance (Alfahad et al., 2024). Studies on the application of artificial intelligence in Riyadh report that digital transformation in healthcare generates opportunities for making healthcare delivery better while generating a gap in the preparedness of the system and a challenge in the design of the system and organizational adaptability (Muafa et al., 2024). In view of the theory and the context, this research intends to claim that workflow optimization acts as a mediator in the nexus of technological integration and the efficiency of nursing care in the Madinah Health Cluster.

2.2 Hypotheses Development

The integration of new technologies is recognized as one of the key factors in improving the efficiency of nursing care. This is due to the ability of new technologies to enable nurses to obtain information about a patient, document care, and communicate with other nurses and health care professionals, and to make better decisions. This fosters greater efficiency in practice. The efficiency of nursing practice is the ability of the practice to provide safe, timely, and rational care that is free from avoidable errors and delays. When these technologies are integrated into the practice of nursing, they have the potential to be supportive of the goals of care. Critical reviews of the literature show that the adoption of health technologies is influenced by the perception of value, support offered by the organization, and the motivation of the user. This demonstrates that health technologies have the potential to enhance the performance of care, when nurses perceive the technology as relevant and beneficial to their care practices (Alrahbi et al, 2021). Additionally, the research demonstrates that AI and the digitization of health services may enhance the efficiency of nursing care and the quality of care provided to patients by optimizing the use of resources, and decision making and supporting services and operations (Najmi et al., 2024).

In the Saudi Arabian healthcare context, the integration of modern technology is becoming increasingly relevant, particularly because digital transformation is a critical element of Vision 2030, and modernizing healthcare services. Existing studies conducted in Saudi Arabia suggest that telecommunications and information technology are being harnessed to a greater degree to enhance public health services and improve the quality of health services (Almutairi et al., 2024). However, the impact of technology is contingent upon the ability of nurses to effectively engage with digital systems in actual clinical practice. Studies conducted in the area of electronic health records indicate that nurses' acceptance of technology is related to the extent to which they believe that using the technology will enhance the effectiveness of patient care. This finding supports the argument that the incorporation of digital health systems designed to facilitate patient care and address the requirements of nursing will help improve nursing outcomes (dela Cruz & Mallari, 2025). Based on the information shared, this study proposes the following hypothesis.

H1: Technological Integration has a significant positive effect on Nursing Care Efficiency in the Madinah Health Cluster.

Technological integration uses digital systems for more structured and organized nursing tasks. This has the potential to improve nursing tasks and workflows. Workplace optimization aims to foster workplace productivity and efficiency by lessening workplace redundancies and delays and fostering workplace and task communication. Many tools ease nurses' workflows by enhancing access to information and eliminating unnecessary, redundant tasks. Among these tools, electronic health records, digital dashboards, artificial intelligence, and mobile communications have the potential to ease nursing workflows. The integration of digital technologies into workplace processes, combined with the coordination of support and communication, also enhances the optimization of nursing workflows. Empirical evidence regarding digital office technologies indicates improvement of workflow efficiency through use of digital tools integrated into workplace processes, as opposed to using them in isolation (Innocent, 2024). Beyond those mentioned, artificial intelligence has the potential to

reduce nursing workflows through the development of operational decisions in the nursing context (Alanazi et al., 2024).

Although much evidence comes from different clinical specialties, artificial intelligence has been shown to support workflow streamlining, process optimization, and service coordination in healthcare settings (Pierre et al., 2023). Integration of new technology does not automatically result in better workflow. Sometimes gaps in poorly conceived digital systems will create interruptions, excessive documentation, and fragmented workflow. Therefore, technology's greatest value lies in its design in relation to and in support of nursing practice and real-time patient care. Evidence of technology integration in future nursing care constructs demonstrates that nurses expect the technology to support patient care, minimize unnecessary work, and integrate seamlessly with clinical practice (Stevens et al., 2025). Similarly, application of machine learning in nursing practice is related to clinical decision-making, risk, and workflow, and supports the assertion that digital systems will optimize workflow if they are conceived with nursing practice in mind (Suhendro et al., 2025). Thus, the authors of this study hypothesize.

H2: Technological Integration has a significant positive effect on Workflow Optimization in the Madinah Health Cluster.

Improving workflows is expected to improve the efficiency of nursing care because the arrangement, coordination, and completion of nursing tasks rely on the efficient use of available time and resources. Poorly organized workflows lead to repeated, redundant documentation, unnecessary movement, unclear communication, delays in task execution, and interruptions which reduce the ability of nurses to perform the care functions that are most needed. A scoping review identified non-value adding and non-nursing task activities as detrimental to the efficiency of nursing tasks. This suggests that efficiency in caring for patients is achieved through the elimination of redundant tasks and the re-engineering of nursing activities. As a result, workflow optimization enhances nursing care efficiency through task clarity and its duplication, and increased emphasis on the most important nursing tasks. The efficiency of a workflow also determines the safety of a patient, the performance of a nurse, and the wellbeing of a staff member. The existence of workflow interruptions and the perceived workload negatively impact missed nursing tasks and the nurse's wellbeing. This illustrates that a suboptimal workflow system negatively impacts care quality and nurse outcomes. Conversely, an optimal workflow system positively impacts communication, timely task execution, and the elimination of unnecessary task delays. The quality of nursing care impacts the safety of a patient and overall positive clinical outcomes. This provides support for the impact that suboptimal care systems have on the safety of a patient and a positive clinical outcome. Therefore, this study proposes the following hypothesis.

H3: Workflow Optimization has a significant positive effect on Nursing Care Efficiency in the Madinah Health Cluster.

Technological integration and the efficiency of nursing care may relate through the optimization of workflow. Systems established by technology may aid nursing; however, the optimization of workflow helps determine if those systems are transformed to improve the delivery of care. The Donabedian Model is used to support this. In this case, the integration of technology is a part of the structure, the optimization of workflow is a part of the process, and the efficiency of nursing care is a part of the outcome (Yang et al., 2025). Digital systems may positively impact the organization of the nursing workflow through the improvement of workplace communication, the prioritization of tasks, oversight and monitoring of activities, and the allocation of resources. This is likely to result in an improvement in the efficiency of nursing care beyond the mere presence of the technology.

Sociotechnical Systems Theory also supports the abstraction of the optimization of workflow. This is mainly because the optimization of workflow helps determine if systems established by technology are transformed to improve the delivery of care. In nursing, the use of technology must fit the clinical routines, the needs of the patient, and the members of the nursing team and must seamlessly integrate with professional judgment and assistive thinking (Kaminski, 2022). Research on sociotechnical systems in nursing has pointed out the need to view nursing technology as part of a work system and not a technical task in and of itself. Further, research on advanced workflow automation illustrates that nursing and patient safety may increase through the improvement of workplace systems (Damarched, 2026). This leads us to the following hypothesis.

H4: Workflow Optimization significantly mediates the relationship between Technological Integration and Nursing Care Efficiency in the Madinah Health Cluster.

3. Methodology

This research used a quantitative, deductive, and cross-sectional method to study the impact of workflow optimization in the connection of technological integration with the efficiency of nursing care in the Madinah Health Cluster. A quantitative method was the best approach as the relationship the researcher wanted to explore was measurable, and was defined in detail, and the data was to be collected in numbers with the help of a survey. This method was also suitable as the relationship was based on an assumption in a theory which postulated that technological integration in the context of Madinah Health Cluster would improve nursing care efficiency to a certain extent directly and to a greater extent indirectly by improving workflow. The cross-sectional design was

used as it makes it easier to capture the perceptions of the nurses in the clinics regarding the use of digital systems and the organization of workflow and care efficiency at the present time. In this case, the integration of technology was the independent variable, optimization of workflow was the intervening variable, and efficiency of nursing care was the dependent variable.

The target population consisted of registered nurses working in hospitals affiliated with the Madinah Health Cluster in Saudi Arabia. Nurses were selected because they are frontline healthcare professionals who regularly interact with digital systems such as electronic health records, artificial intelligence-supported monitoring platforms, mobile health applications, and hospital information systems. Digital health technology adoption readiness among nursing groups in Saudi Arabia highlights the need to consider preparedness, awareness, and contextual support when examining technology integration in nursing practice (Malki & Alyousef, 2026). These systems are directly connected to documentation, communication, workflow coordination, and patient care delivery. Artificial intelligence has been shown to support nursing workflow and resource management when it is aligned with clinical practice (Alanazi et al., 2024). According to the Saudi Ministry of Health Statistical Yearbook 2024 Special Edition, the Madinah Health Cluster had 12 Hospitals, 1,679 Beds, and 4,416 Nurses. With this, the required sample size indicated 354 nurses. To minimize the effect of non-response, 450 surveys were distributed. This research used stratified sampling to ensure representation of all the various Clinical Departments and the Hospitals within the Health Cluster. Out of the distributed surveys, 361 were returned and taken for the final analysis.

Data were collected using a structured self-administered questionnaire. The questionnaire included demographic items and three main constructs, namely technological integration, workflow optimization, and nursing care efficiency. Elaboration on constructs for this study is as follows. Technology integration focuses on perceptions about the presence of digital systems within clinical practice to support access to patient information, digital notes and documentation, clinical decision support, and training, as well as support and alignment for practice. The adoption of any health care technology will be influenced by its perceived usefulness and the motivation of the user, and thus it is relevant to this study (Alrahbi et al., 2021). Workflow optimization included perceptions on the organization of tasks, clarity of roles, effective communication, reduction of redundancy and tasks that disrupt the workflow, and how support is made available. Efficiency of nursing tasks is highly affected by the presence of non-nursing tasks, and this further justifies the need to address workflow optimization challenges within nursing (Chung et al., 2025). The last construct, nursing care efficiency, included factors such as the timely completion of tasks, proper/resource documentation, decision-making and timing, access to patient data, and the level of disturbance. It is known that the quality of nursing care directly affects patient safety and the overall clinical outcome (Arwan et al., 2024). Each item in the constructs was circumscribed on a five-point Likert scale where 1 is strongly disagree and 5 is strongly agree.

A pilot study involved 45 nurses from the Madinah Health Cluster. These nurses formed no part of the target sample. The pilot study verified the clarity, relevance, and contextual appropriateness of the study tool. Reliability and validity were checked prior to the testing of the structural relationships. In the final measurement model of the study, the results of Technological Integration recorded a Cronbach's alpha of 0.924, a composite reliability of 0.926, and an average variance extracted of 0.569. Workflow Optimization recorded a Cronbach's alpha of 0.943, a composite reliability of 0.944, and an average variance extracted of 0.661. Nursing Care Efficiency recorded a Cronbach's alpha of 0.868, a composite reliability of 0.871, and an average variance extracted of 0.719. The results confirmed the reliability and validity of the final measurement model. Discriminant validity was confirmed by the Heterotrait-Monotrait ratio as well as the Fornell-Larcker criterion.

The analysis of the data was done using SPSS and SmartPLS. Data screening, computation of descriptive statistics, and the normality test were done in SPSS. Partial Least Squares Structural Equation Modeling was done in SmartPLS. For the measurement model, item loadings, reliability, and both convergent and discriminant validity were assessed. In the structural model, path coefficients, t-statistics, p-values, the coefficient of determination, and bootstrapping were evaluated. Direct paths from technological integration to nursing care efficiency and to workflow optimization, as well as the path from workflow optimization to nursing care efficiency, were assessed. The mediation analysis investigated if workflow optimization acted as a mediator in the path from technological integration to nursing care efficiency.

4. Findings

This chapter discloses the empirical data for this research based on the 361 respondents who completed the survey. The purpose of the analysis is to identify the relationship of technological integration and workflow optimization on the efficiency of nursing care within the Madinah Health Cluster. The results are documented beginning with the descriptive statistics and the measurement model. This is followed by the assessment of the model's reliability and validity, the evaluation of the structural model, and the analysis of mediation and direct hypotheses. With the information provided in this chapter, the authors will be able to assess the measurement model and its statistical applicability, and will subsequently be able to determine the direct and indirect relationships among the relevant constructs of the research.

As illustrated in Table 1, and according to the results of the normality test, the data was appropriate for the tests of the subsequent statistical analyses. The skewness of the three constructs ranged from -0.726 to -0.502, while kurtosis ranged from -0.075 to 0.392. These results were indicative of normal univariate distribution of the constructs, and showed that the distribution of Workflow Optimization, Nursing Care Efficiency, and Technological Integration, were very close to normal. Although each of the skewness values were negative, the results of the negative skewness of the distribution were very small and suggested that no major problems existed in the distribution of the data. The kurtosis values which were all very close to 0, suggested that the responses were neither very flat nor peaked, and therefore, there was no need to transform the data. The respondents' data was therefore, adequate for the subsequent analyses which included the measurement model and the structural model.

Table 1: Normality test

Construct	N	Skewness	Kurtosis
WO	361	-0.602	-0.075
NCE	361	-0.502	0.344
TI	361	-0.726	0.392

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

According to Table 2, the descriptive analysis shows response options on the three study constructs were on a slightly positive scale. Nursing Care Efficiency had the highest mean value of 3.633 and a standard deviation of 0.687. This suggests that nurses had the perception that care they delivered was efficient with regard to completing tasks in a timely manner, efficient use of resources, documentation, and engagement in direct care of the patient. The next highest was Workflow Optimization with a mean value of 3.585 and a standard deviation of 0.951. This indicates that respondents were in agreement that nursing workflows were somewhat organized. The higher standard deviation, however, indicates that there was more variation in the clarity and organization of nursing workflows. Finally, Technological Integration had a mean value of 3.584 with a standard deviation of 0.777, reflecting a somewhat positive perception of the use of digital systems in clinical practice. The findings overall show that within the Madinah Health Cluster, Technology Integration, Workflow Optimization, and Nursing Care Efficiency were at a moderate to good level, and therefore justify a more in-depth analysis of the relationships among the study constructs.

Table 2: Summary of Descriptive Analysis

Construct	N	Mean	Std. Deviation
WO	361	3.585	0.951
NCE	361	3.633	0.687
TI	361	3.584	0.777

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

The initial measurement model, as prepared in Figure 1, examines the construct validity of the model indicators used to measure Technological Integration, Workflow Optimization, and Nursing Care Efficiency. As described in the figure, Workflow Optimization exhibited strong item loadings, with a majority of the indicators surpassing the minimum threshold, indicating that the indicators are reliable. In the case of Technological Integration, most item loadings were within the acceptable range; however, the TI1 item exhibited a very low loading, with the item not contributing to the construct, and therefore, would be eliminated from the final model. The Nursing Care Efficiency construct showed the poorest initial measurement evaluation, as a number of items, specifically NCE10, NCE5, NCE6, NCE7, NCE8, and NCE9, exhibited poor item loadings. These NCE items indicated that a number of the items were not appropriate to the construct of Nursing Care Efficiency for the final measurement model. Therefore, the initial model evaluation was the basis for improvement model iterations, specifically the removal of poor items and the retention of items that demonstrated acceptable measurement model statistical performance. The improvement model iterations of measurement model items were intended to enhance construct reliability, improve measurement model, and enhance measurement model validity, prior to the evaluation of the measurement model structural component.

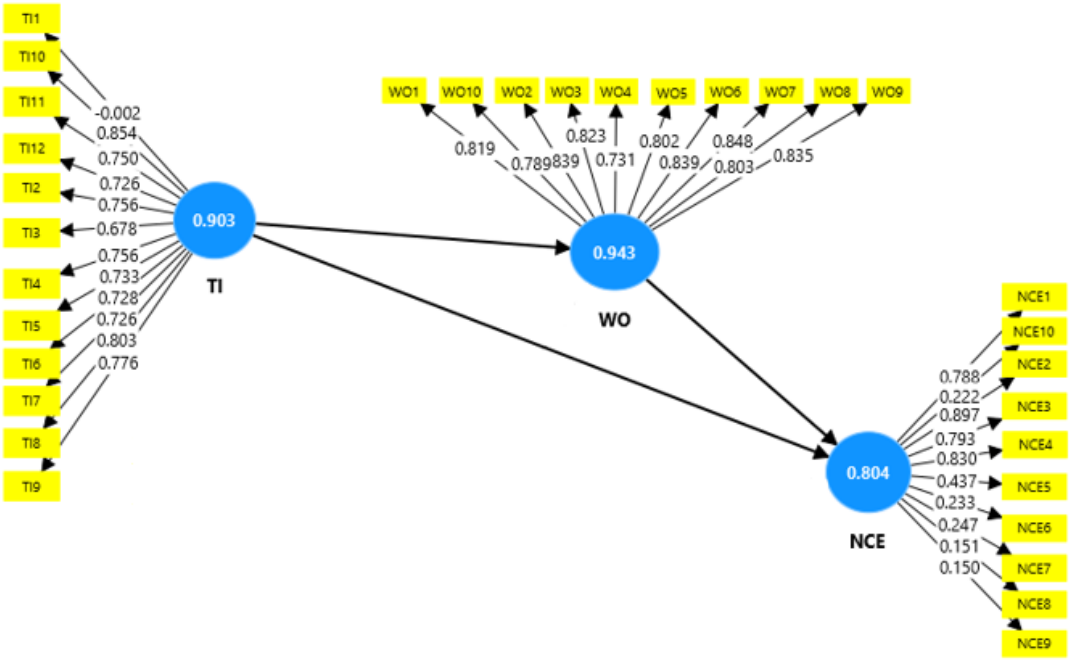

Figure 1: Evaluation of Measurement Model (First order)

Results of construct reliability and validity as indicated in Table 3 showed that the measurement model had to be adjusted prior to undertaking the final analysis. For Nursing Care Efficiency, Cronbach's alpha was 0.804 and Composite Reliability was 0.864, indicating good internal consistency. However, the AVE value was 0.314, which is below the required assessment value of 0.50. The weak AVE value was due to low-loading indicators NCE10, NCE5, NCE6, NCE7, NCE8, and NCE9. On the other hand, NCE1, NCE2, NCE3, and NCE4 had loadings, which were in the range of 0.788 and 0.897 and the remaining indicators having low loadings adversely affected the convergent validity. Therefore, NCE items that had low loadings were removed to improve the Nursing Care Efficiency construct. For Technological Integration, early results showed excellent reliability, with Cronbach's alpha of 0.903 and Composite Reliability of 0.927 and AVE of 0.522, showing improvement with convergent validity. However, TI1 had a negative loading of -0.002, indicating that it did not adequately represent the Technological Integration construct.

The remaining TI indicators were satisfactory with most loadings above 0.70 and the exception of TI3 having a loading of 0.678, which is still acceptable. The only concern in the Technological Integration construct was the negative loading item TI1, which was deleted to enhance the final measurement model. Results for Workflow Optimization were the strongest of the three with Cronbach's alpha of 0.943, Composite Reliability of 0.944, and AVE of 0.661. These results strongly demonstrated internal consistency and convergent validity beyond the specified limits. The item loadings for Workflow Optimization were all good (0.731 to 0.848), indicating that the indicators strongly and consistently measured the construct. Thus, the results from the first measurement model indicated that Workflow Optimization was reliable and valid, and that Nursing Care Efficiency and Technological Integration required item improvement related to the construct before assessing the final model.

Table 3: Construct Reliability and Validity – Initial Model measurements

	Loading	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
NCE1	0.788	0.804	0.864	0.314
NCE10	0.222			
NCE2	0.897			
NCE3	0.793			
NCE4	0.830			
NCE5	0.437			
NCE6	0.233			
NCE7	0.247			
NCE8	0.151			
NCE9	0.150			
TI1	-0.002	0.903	0.927	0.522

TI10	0.854			
TI11	0.750			
TI12	0.726			
TI2	0.756			
TI3	0.678			
TI4	0.756			
TI5	0.733			
TI6	0.728			
TI7	0.726			
TI8	0.803			
TI9	0.776			
WO1	0.819	0.943	0.944	0.661
WO10	0.789			
WO2	0.839			
WO3	0.823			
WO4	0.731			
WO5	0.802			
WO6	0.839			
WO7	0.848			
WO8	0.803			
WO9	0.835			

As shown in Figure 2, the final measurement model demonstrates a substantial improvement after the removal of weak indicators from the initial model. The refined model retained only the items that showed acceptable loading values and stronger representation of their respective constructs. For the case of Technological Integration, weak indicators were removed, and the remaining indicators were in the range of 0.679 to 0.854, meaning they were in the range of acceptable loadings. In the case of Workflow Optimization, all indicators were in the range of 0.730 to 0.848, meaning they were all optimal, and the construct was measured sufficiently. In the case of Nursing Care Efficiency, the final model was an improvement because the restricted model included only four indicators, and the loadings for those four indicators were in the range of 0.810 to 0.912. In the remaining models, the final measurement model shows improvement because the restricted models included fewer indicators that were of greater quality. The final measurement model thus identifies the indicators that were better suited for the next assessment of reliability and validity and for the assessment of the structural model.

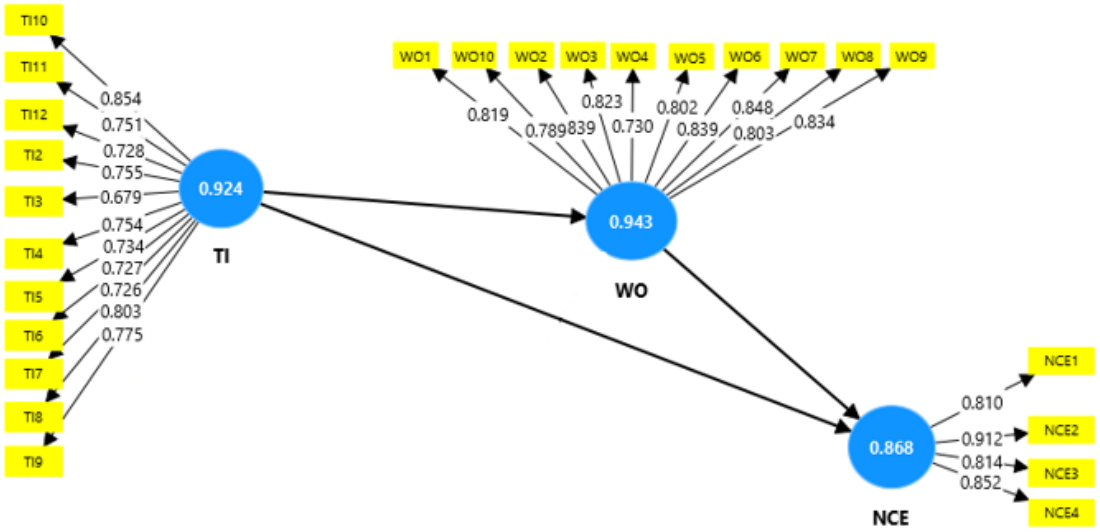

Figure 2: Evaluation of Measurement Model (Final order)

As evidenced in Table 4, the final measurement model, after the removal of weak indicators in the initial model, established reliability and validity in an acceptable range. Of the four indicators that were retained for Nursing Care Efficiency, all of them demonstrated significant loadings, and the construct achieved a Cronbach's alpha of 0.868, composite reliability of 0.871, and AVE of 0.719. Thus, the indicators were shown to have internal consistency, and the construct showed variance. While one of the indicators, retained for Technological Integration,

demonstrated a loading that was a little less than 0.70, its reliability and AVE values were considered to be at an acceptable range, and therefore the construct was retained in the model. The strongest measurement results were demonstrated for the construct Workflow Optimization, with a Cronbach's alpha of 0.943, composite reliability of 0.944, and AVE of 0.661. In general, the results for the final measurement model demonstrated that the three constructs met the internal consistency and convergent validity criteria, thereby allowing the final measurement model for the discriminant validity and the structural model evaluation.

Table 4: Construct Reliability and Validity – Final Model measurements

	Loading	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
NCE1	0.810	0.868	0.871	0.719
NCE2	0.912			
NCE3	0.814			
NCE4	0.852			
TI10	0.854	0.924	0.926	0.569
TI11	0.751			
TI12	0.728			
TI2	0.755			
TI3	0.679			
TI4	0.754			
TI5	0.734			
TI6	0.727			
TI7	0.726			
TI8	0.803			
TI9	0.775			
WO1	0.819	0.943	0.944	0.661
WO10	0.789			
WO2	0.839			
WO3	0.823			
WO4	0.730			
WO5	0.802			
WO6	0.839			
WO7	0.848			
WO8	0.803			
WO9	0.834			

According to Table 5, the HTMT results demonstrated that all the three constructs satisfied discriminant validity. HTMT showed a result of 0.755 for the relationship between Technological Integration and Nursing Care Efficiency, and 0.760 for the relationship between Workflow Optimization and Nursing Care Efficiency. The value of HTMT for the relationship between Workflow Optimization and Technological Integration was 0.601. Given that all results remained below the general threshold of 0.85, the constructs maintained sufficient distinction. Consequently, it was found that Technological Integration, Workflow Optimization, and Nursing Care Efficiency, represented different constructs in the model, without significant overlaps. Therefore, the results of the measurement model provided evidence to support and justify the assessment of the structural model.

Table 5: The heterotrait-monotrait ratio of correlations (HTMT)

	NCE	TI	WO
NCE			
TI	0.755		
WO	0.760	0.601	

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

As indicated in Table 6, the Fornell-Larcker criterion continues to demonstrate the discriminant validity of the final measurement model. The diagonal values the square roots of the AVE values were 0.848, 0.855, and 0.813 for the constructs of Nursing Care Efficiency, Technological Integration, and Workflow Optimization, respectively. The diagonal values for each of the constructs were larger than the values of the correlation for the constructs in the model. The square root of AVE for Nursing Care Efficiency, for example, was greater than the

values of the correlation of other constructs in the model for Nursing Care Efficiency, Workflow Optimization, and Technological Integration. Likewise, the square root of AVE for Technological Integration and Workflow Optimization was greater than the values of the correlation of other constructs in the model. This demonstrates that each of the constructs in the final measurement model was empirically distinct and therefore, validated the inclusion of Technological Integration, Workflow Optimization, and Nursing Care Efficiency in the behavioral structural model.

Table 6: Latent Variable Correlations (Fronell-Lacer criteria)

	NCE	TI	WO
NCE	0.848		
TI	0.768	0.855	
WO	0.779	0.745	0.813

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

The significance of the path model in Figure 3 relates to the interactions between the three constructs. These are the integration of technology, the optimization of workflows, and the efficiency of nursing care. The proposed model indicates that within the constraints of this study, technology integration relates directly to nursing care efficiency, as well as indirectly, through the optimization of workflows. Also, within this model, the optimization of workflows is a mediator, where the integration of technology refines workflow, and the optimization of workflows relates to the efficiency of nursing care. This model logic demonstrates that the efficiency of nursing care is understood not only in reference to the direct influence of the integration of technology, but also through the structuring of workflows. The following dimensions present tables where the coefficients of the path model are described. These include their significance and their explanatory power.

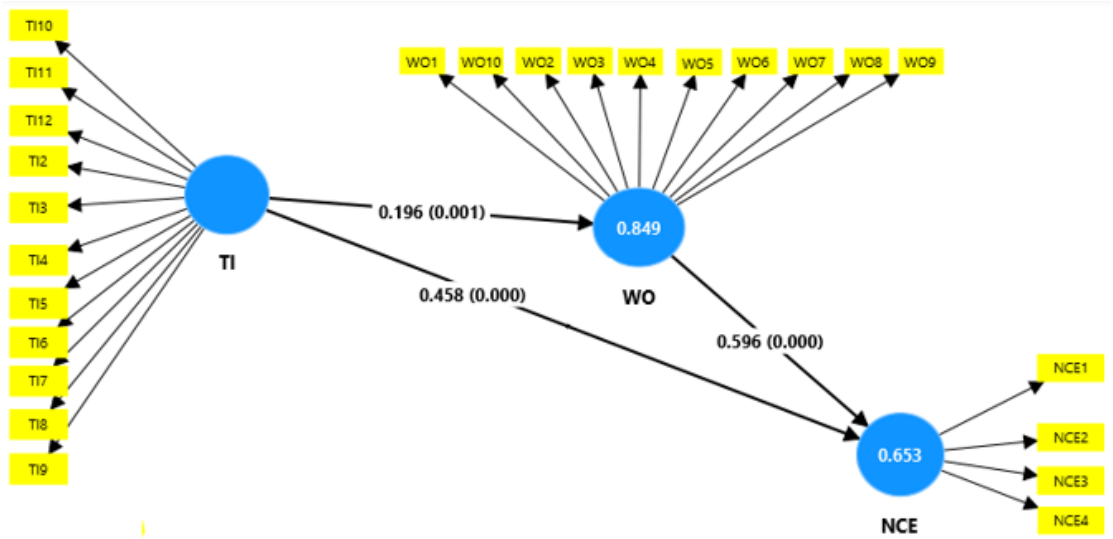

Figure 3: Path Model Significance Results

As indicated in Table 7, the results of the coefficient of determination show that the structural model has power to a large extent. Nursing Care Efficiency had an R-square value of 0.656 and an adjusted R-square of 0.653. Thus, brought together, Technological Integration and Workflow Optimization accounted for 65.6% of the variance in Nursing Care Efficiency. This value is robust, indicating that the model can account for a great deal of variance in the level of nursing care efficiency of the respondents. Workflow Optimization had an R-square value of 0.850 and an adjusted R-square of 0.849. Thus, Technological Integration accounted for 85.0% of the variance in Workflow Optimization. Hence, the results portray that the model which has been presented has power to a great extent, and the variables which have been incorporated are of considerable importance in predicting both the nursing care efficiency and the workflow optimization in the Madinah Health Cluster.

Table 7: Coefficient of Determination (R^2)

	R-square	R-square adjusted
NCE	0.656	0.653
WO	0.850	0.849

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

As shown in Table 8, all direct hypotheses were supported. The results show that Technological Integration had a significant positive effect on Nursing Care Efficiency, with a beta value of 0.458, a t-statistic of 5.664, and a p-

value of 0.000. This indicates that higher levels of technological integration were associated with higher levels of nursing care efficiency in the Madinah Health Cluster. The results also show that Technological Integration had a significant positive effect on Workflow Optimization, with a beta value of 0.196, a t-statistic of 3.342, and a p-value of 0.001. This means that better integration of digital technologies contributed to improved workflow processes among nurses. In addition, Workflow Optimization had the strongest direct effect on Nursing Care Efficiency, with a beta value of 0.596, a t-statistic of 6.073, and a p-value of 0.000. This finding suggests that optimized workflows play a major role in improving nursing care efficiency. Overall, the results confirm that Technological Integration and Workflow Optimization are significant predictors of Nursing Care Efficiency, and that all three direct hypotheses were accepted.

Table 8: Direct Hypotheses

Hypotheses	Beta	Sample Mean (M)	SD	T statistics	P values	Decision
TI -> NCE	0.458	0.467	0.081	5.664	0.000	Accepted
TI -> WO	0.196	0.198	0.059	3.342	0.001	Accepted
WO -> NCE	0.596	0.595	0.098	6.073	0.000	Accepted

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

As shown in Table 9, the indirect hypothesis was accepted, indicating that Workflow Optimization significantly mediated the relationship between Technological Integration and Nursing Care Efficiency. The indirect effect of Technological Integration on Nursing Care Efficiency through Workflow Optimization recorded a beta value of 0.117, a t-statistic of 3.197, and a p-value of 0.001. Since the p-value was below the 0.05 significance level, the mediation effect was statistically significant. This result means that technological integration improves nursing care efficiency not only directly, but also indirectly by enhancing workflow optimization. In practical terms, digital systems can contribute to better nursing care efficiency when they help organize tasks, reduce workflow barriers, improve coordination, and support smoother care delivery processes. Since the direct effect between Technological Integration and Nursing Care Efficiency was also significant, the mediation can be interpreted as partial mediation.

Table 9: Indirect Hypothesis

Hypotheses	Beta	Sample Mean (M)	SD	T statistics	P values	Decision
TI -> WO -> NCE	0.117	0.116	0.037	3.197	0.001	Accepted

TI: Technological Integration; NCE: Nursing Care Efficiency; WO: Workflow Optimization

5. Discussion

This study's findings support the idea that the integration of technology has a constructive impact on the efficiency of nursing care in the Madinah Health Cluster. When clinicians view digital systems as valuable, easy to use, and complementing their daily tasks, it correlates with an increase in the efficiency of care. Integration of technology in the healthcare system is practically useful as it speeds up the accessibility of patient data, helps with the documentation process, streamlines communication, and offers support for clinical decisions. This is in line with the perception that adoption of healthcare technology is based on the perceived value and the motivation of the user, as nurses will benefit more from digital systems when these systems are aligned with the digital systems (Alrahbi et al., 2021). It is also in line with the perception that nurses' acceptance of electronic health records is related to their perception of the efficiency of patient care, particularly in case systems that facilitate ease of clinical data and help decrease the time waiting for clinical decisions (dela Cruz & Mallari, 2025). In the Saudi healthcare system, this is especially critical as healthcare systems are undergoing comprehensive digital transformations due to Vision 2030. This would suggest that the infusion of digital technologies may enhance the performance of nursing personnel on the frontlines. This would align with the perception that health systems in Saudi Vision 2030 may enhance the quality of service and the performance of the system when it is transposed to genuine advancements to the health system (Alfahad et al., 2024).

Results also indicate that the integration of technology greatly influences the optimization of the workflow at a positive level. The integration of digital systems in the work environment can improve the organization, and flow, and the coordination of nursing tasks. Systems such as electronic health records, artificial intelligence-assisted systems, mobile applications, and hospital information systems can minimize manual work, improve the communication of the staff, assist the prioritization of tasks, and provide timely access to patient information. Information systems can also support nurse managers by improving performance monitoring, decision-making, and the management of nursing work processes (Saranto et al., 2023). This study agrees with the studies showing

artificial intelligence in systems can assist operational decisions, and can also improve the management of nurse resources and the nursing workflow through the coordination of tasks and processes (Alanazi et al., 2024). This study also agrees with the study indicating that the implementation of electronic health records, in a way that assists the practices within a hospital, reduces the unnecessary tasks of nursing, and increases the efficiency of the nursing workflow (Farajalla et al., 2026). The relationship also demonstrates a practical challenge. Technology integration does not optimize the workflow. Digital systems may create a documentation burden or flow disruption if the systems are poorly constructed, disjointed, and do not support nursing activities. This explains why technology integration is accompanied by a redesign of the workflow, training of the users, and iterative cycles of integration and evaluation with user-nurses. This is due to the fact that integration of a system which introduces additional tasks into the care of the patient is of little value for the nurses, whereas systems which eliminate tasks and integrate seamlessly with the workflow of clinical practice, are greatly valued (Stevens et al., 2025).

The strongest direct relationship in the model was between workflow optimization and nursing care efficiency. This result implies that the arrangement, prioritization, and coordination of nursing tasks significantly impact the effectiveness of nursing care. Optimized workflows allow nurses to carry out tasks with minimal delays, avoid redundant documentation, and excessive movement, thus increasing the time available for direct care of the patients. This result supports the evidence of the positive relationship between the efficiency of nursing care tasks and the limitation of redundant work, due to the positive relationship between the efficiency of care and the avoidance of non-value-adding activities and non-nursing tasks (Chung et al., 2025). It also supports the evidence that perception of work disrupts the nursing care tasks and adversely affects the health of the nurses (Liu et al., 2026). Therefore, in the context of nursing care, the optimization of workflows should be the central operational concern. The result relates strongly to the Donabedian Model, as the optimization of workflows illustrates the process of transforming nursing care from the structuring of resources, especially the incorporation of advanced technology. The Donabedian model has a recent focus on the improvement of health care quality by establishing a framework within the clinical setting to integrate the structure, the process, and care outcomes (Yang et al., 2025). Within this context, the present work illustrates the necessity and impact of advanced technological systems on care delivery frameworks skillfully optimized for advanced nursing care.

The mediation analysis results indicated that workflow optimization partially mediates the relationship of technological integration and nursing care efficiency. Because the direct relationship of technological integration and nursing care efficiency was also significant, mediation was considered partial. This implies that nursing care efficiency can also be enhanced through technological integration by indirect means. This can be achieved through the mediation of workflow progression, and by diminishing the barriers of the process and enhancing the coordination of care. This finding is valuable because it ensures that the assumption that the use of technology to improve nursing care comes from the technology itself, is avoided. The finding shows that technology is valuable if it organizes nursing work effectively. This is also in line with Sociotechnical Systems Theory, which suggests that technology can render value when there is harmony with human work limitations and the requirements of an organization (Kaminski, 2022). Additionally, the theory suggests value in healthcare information technology when the systems are integrated with an organizational and human work system (Song et al., 2026). The nursing directors and health care administrators in the Madinah Health Cluster will be encouraged to not only invest in sophisticated digital systems.Overall, the study adds to the nursing management literature by demonstrating workflow optimization as a mechanism by which employing technology in the rapidly digitizing healthcare environments can improve the efficiency of nursing care.

6. Conclusion

This research explored the presence of workflow optimization as a mediator between technological integration and nursing care efficiency within the Madinah Health Cluster. The findings supported the positive relationship between technological integration and nursing care efficiency. This means digital systems have the potential to improve care delivery for nurses at the point of their optimal placement within the workflow of daily clinical practice. The findings also showed the positive impact of technological integration on workflow optimization. This means digital systems have the potential to improve the organization of tasks and optimal flow and exchange of information and communication concerning patients and the domain of patient care. In addition, the positive impact of workflow optimization on nursing care efficiency implies the need to organize nursing tasks and care activities, as well as the availability of technology.

Results indicated that workflow optimization partially mediates the connection between technological integration and nursing care efficiency concerning the indirect impact of technological integration on nursing care efficiency. Here, technological integration leads to better nursing care efficiency both directly and through the indirect enhancement of workflow. The findings advocate the necessity to address digital transformation more as a workflow concern as opposed to more of a technological investment. For healthcare managers, especially nursing leaders, the findings of the study advocate more refining of nursing care efficiency through the alignment of digital technologies, nursing, and personnel training, as well as the redesign of workflow. The research integrates the nursing managerial and healthcare technology literature by illustrating that workflow optimization mediates the enhancement of nursing care efficiency through the integration of technology. This research can be expanded in

the future to include other healthcare areas, the use of longitudinal studies, and the incorporation of other variables such as the support of leadership, digital competence, patient safety, and the management of workload.

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