The Technological and Workload Drivers of Nursing Care Efficiency: A Systematic Literature Review

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Abstract

Nursing services face mounting pressures from rising patient acuity, administrative burden, and fragmented workflows, which collectively compromise the efficiency and reliability of frontline care delivery. While significant investments have been made in electronic records, artificial intelligence, mobile health, telehealth, and virtual nursing, these tools do not consistently yield efficiency gains when implemented without deliberate workflow redesign and structured workload governance. This systematic literature review examines how technological integration and workload management contribute to nursing care efficiency through the mediating role of workflow optimization. Following internationally recognized standards for systematic reviews, fifty-one studies were synthesized across diverse care environments, including intensive care units, emergency departments, general hospital wards, and community health settings. The evidence highlights that efficiency gains are not inherent to technology or staffing models alone but emerge when interoperable systems, acuity-based staffing, predictive scheduling, and digital dashboards are embedded into workflows that reduce duplication, standardize processes, and balance workloads. These findings carry particular significance for healthcare systems such as the Madinah Health Cluster, where digital transformation is a cornerstone of national reform. The review concludes that co-designed, interoperable, and acuity-aware systems that foreground workflow optimization can strengthen workforce resilience, improve patient safety, and advance the goals of healthcare transformation.

Keywords: Nursing Care Efficiency; Workflow Optimization; Technological Integration; Workload Management

1. Introduction

Nursing services are increasingly constrained by rising patient acuity, administrative burden, and fragmented workflows, all of which threaten the efficiency and reliability of frontline care. Investments in electronic health records, artificial intelligence, mobile health, telehealth, and virtual nursing have expanded rapidly; however, these technologies do not reliably translate into measurable gains when they are layered onto legacy processes without deliberate workflow

redesign and explicit workload governance. Evidence across multiple care settings shows that documentation burden and duplication can persist or even worsen when interoperability and usability are not addressed, thereby eroding time available for direct care and undermining staff morale (Redley et al., 2020; Strudwick et al., 2023; Congdon et al., 2020). Conversely, when technological tools are paired with structured workload strategies such as acuity-based staffing, predictive scheduling, and real-time allocation organizations can anticipate demand, minimize variability, and stabilize nurse-to-patient ratios (Lear et al., 2025; Song et al., 2024; Wang et al., 2025). The Madinah Health Cluster, operating within the Kingdom of Saudi Arabia's Vision 2030 transformation, provides a salient context in which digital health scale-up intersects with workforce redesign. National ambitions to improve access, quality, and efficiency mean that digital investments ought to be coupled with governance mechanisms for equitable workload distribution and with implementation models that foreground nurse involvement, training, and local readiness (Alnasser et al., 2024; Allen et al., 2023; Thomas, 2024). This review responds to that practical imperative by assembling and interpreting the evidence on how technological integration and workload management jointly influence nursing care efficiency through changes in workflow.

Grounding the review in Donabedian's framework and socio-technical systems theory clarifies the causal logic that motivates our synthesis. In Donabedian's terms, technologies and staffing models constitute structures; the routines by which work is coordinated and information moves constitute processes; and time-to-documentation completion, direct-care time, error rates, and related indicators constitute outcomes. Socio-technical theory adds that structures succeed only when jointly optimized with human capabilities and organizational practices. We therefore conceptualize Technological Integration (e.g., EHR usability, decision support, telehealth, digital dashboards) and Workload Management (e.g., acuity-based staffing, predictive scheduling, real-time allocation) as structural levers; Workflow Optimization (e.g., duplication reduction, standardized handover, visible workload signals) as the principal process; and Nursing Care Efficiency as the outcome that reflects the cumulative effect on timeliness, safety, and staff experience (Neumann & Purdy, 2023; Redley et al., 2020). The mediation thesis guiding this review is that improvements in workflow transmit, and often condition, the effects of technological and workload interventions on efficiency; without process change, structural inputs may not yield outcome gains and could increase burden. Accordingly, our objectives are to synthesize evidence on the effects of Technological Integration and Workload Management on both Nursing Care Efficiency and Workflow Optimization; to assess whether Workflow Optimization mediates or conditions the relationships between Technological Integration and efficiency and between Workload Management and efficiency; and to identify salient measurement signals and implementation conditions such as interoperability, validity of acuity tools, transparency of predictive models, digital literacy, and the balance of demands and resources described in job demand–resources theory that appear necessary for sustained improvement (Strudwick et al., 2023; Jacobsen et al., 2024; Lear et al., 2025).

To operationalize these aims, the review addresses the following research questions in an integrated manner. First, how and to what extent do specific elements of Technological Integration improve Nursing Care Efficiency, and under what conditions are improvements observed (e.g., interoperable EHRs, audit-log analytics, AI decision support, telehealth, dashboards)? Second, how and to what extent do Workload Management practices including acuity-based staffing, predictive scheduling, and real-time allocation improve Nursing Care Efficiency and reduce variability and turnover (Song et al., 2024; Bruyneel et al., 2025)? Third, does Workflow Optimization mediate the effects of Technological Integration on Nursing Care Efficiency, and

through which mechanisms (e.g., reduced duplication, improved handover quality, standardized documentation pathways) (Redley et al., 2020; AL Enezi et al., 2024)? Fourth, does Workflow Optimization mediate the effects of Workload Management on Nursing Care Efficiency by stabilizing task distribution and enhancing situational awareness (Tsang et al., 2021; Lear et al., 2025)? Fifth, which measurement signals most consistently index change in Workflow Optimization and Nursing Care Efficiency (e.g., documentation turnaround, direct-care time, error rates, understaffing days), and how should they be reported for comparability (Peutere et al., 2024; Walsby et al., 2024)? Sixth, which implementation conditions interoperability, usability, nurse co-design, leadership engagement, and training appear necessary or sufficient for successful translation of structural changes into outcomes (Allen et al., 2023; Neumann & Purdy, 2023)? Seventh, how do effects vary by context and design, including Saudi versus non-Saudi settings, emergency departments versus intensive care units versus general wards, and study designs such as pre–post evaluations versus cross-sectional analyses (Lucchini et al., 2020; Thomas, 2024)? By mapping these questions to the Donabedian and socio-technical logic model, the review aims to generate actionable insights for systems pursuing Vision 2030 goals, while offering a generalizable framework for aligning digital transformation with equitable workload governance.

2. Methodology

The study selection process adhered strictly to the PRISMA 2020 statement (Page et al., 2021), which provides internationally recognized standards for transparent reporting of systematic reviews. A comprehensive search strategy was implemented across multiple databases, resulting in the identification of 198 articles from the first search string that targeted literature on technological integration and nursing efficiency, and a further 74 articles from the second search string, which focused on workload management and workflow optimization. This yielded a combined total of 272 records prior to screening. In accordance with best practices for systematic reviews (Higgins et al., 2023), all records were exported into EndNote, where automated and manual checks were conducted to remove duplicate entries. A total of 52 duplicates were identified and excluded, leaving 219 unique records available for further evaluation. These records were then assessed against pre-specified inclusion and exclusion criteria derived from the PICOS framework, ensuring that the evidence base was clearly aligned with the review's objectives (Liberati et al., 2009).

The 219 unique records were first screened at the level of title and abstract. This stage was carried out independently by two reviewers, who compared records against eligibility criteria emphasizing population (registered nurses), exposures (technological integration and workload management), and outcomes (nursing care efficiency and workflow optimization). Discrepancies in reviewer judgment were resolved by discussion, with referral to a third reviewer in line with recommended consensus approaches. During this stage, 168 records were excluded. The main reasons for exclusion were lack of relevance to nursing practice, insufficient reporting of outcomes related to efficiency or workflow, and methodological limitations such as purely technical simulations without real-world application. Consistent with the principles of transparent reporting (Moher et al., 2009), editorials, commentaries, and protocols without empirical data were also excluded, although protocols were checked for potential backward citation. This rigorous two-step screening process was designed to minimize bias and ensure that only studies providing substantive empirical evidence were advanced to full-text assessment (Page et al., 2021).

After applying the inclusion and exclusion criteria, 51 studies were retained for the final synthesis. These included randomized controlled trials, quasi-experimental evaluations, cross-sectional surveys, qualitative investigations, mixed-methods studies, and implementation research, reflecting the methodological diversity typical of health services research (Grant & Booth, 2009). The included studies spanned a range of care environments such as emergency departments, intensive care units, general hospital wards, and community health settings, thereby providing a broad perspective on how technological integration and workload management influence nursing care efficiency. Several of the retained studies originated from Saudi Arabia, including research conducted within the Madinah Health Cluster, thereby strengthening the contextual relevance of the findings to Vision 2030 health system transformation goals (Alruwaili et al., 2023; Almansour et al., 2024). At the same time, the inclusion of international evidence ensured that the review could draw comparative lessons and highlight global best practices. In total, the process moved systematically from an initial pool of 272 records, through the exclusion of 52 duplicates and 168 irrelevant articles, to a final dataset of 51 studies that met all criteria. This staged and transparent approach enhanced the validity of the review and provided a robust evidence base for the subsequent narrative synthesis and potential meta-analysis (Page et al., 2021; Higgins et al., 2023).

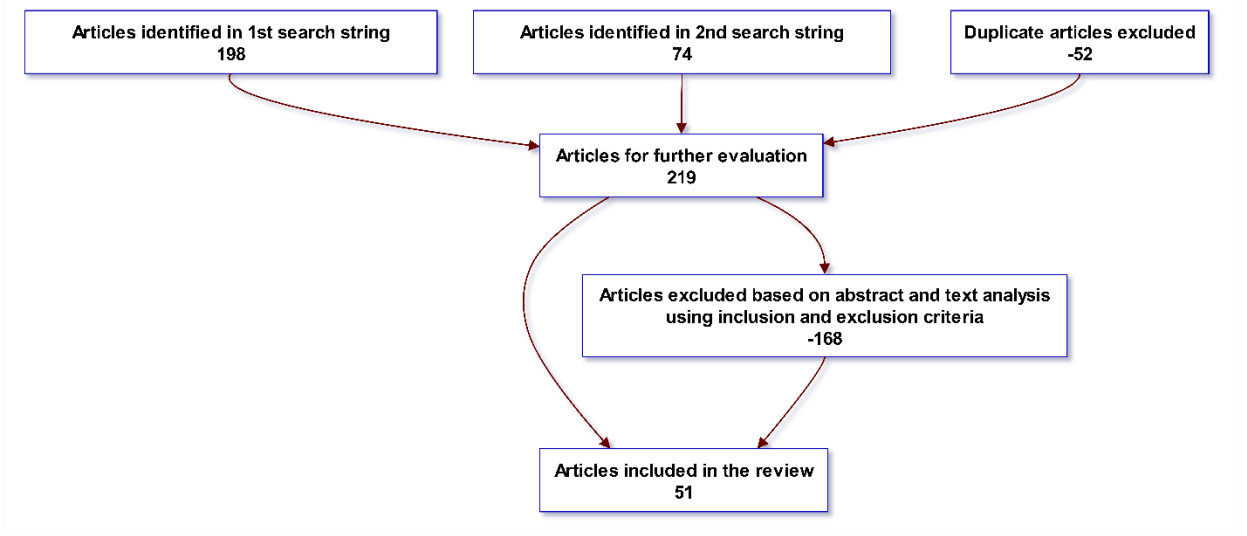

Figure 1: The Systematic Review Process

3. Socio-Demographic and Psychosocial Drivers of Smoking Initiation and Cessation

The synthesis of findings from the 51 studies included in this review highlights that both technological innovations and structured workload management approaches are critical determinants of nursing care efficiency (NCE) and workflow optimization (WFO). Evidence shows that the integration of electronic health records (EHRs), audit-log analytics, and decision support systems significantly reduces documentation burden and duplication, thus improving overall time allocation for direct patient care (Redley et al., 2020; Strudwick et al., 2023). Similarly, telehealth delivery and virtual nursing have emerged as pivotal in extending workforce capacity, particularly during periods of understaffing or increased patient demand, by enabling remote consultations and real-time monitoring (Edelman et al., 2020; Thomas, 2024). The deployment of digital dashboards and predictive analytics has further supported efficient

scheduling, acuity-based staffing, and workload allocation, allowing managers to anticipate peak demand and optimize nurse-to-patient ratios (Lear et al., 2025; Jacobsen et al., 2024). Collectively, these technological advancements do not function in isolation but instead interact with structured workload management strategies to influence error rates, handover quality, and patient safety across settings (Akbal & Doğan, 2025; Bayadsi et al., 2025).

At the same time, workload-related factors remain a central determinant of nursing outcomes. Studies examining staffing variability, nurse turnover, and understaffing days consistently show a strong association with burnout, intention-to-leave, and reduced care quality (Bruyneel et al., 2025; Brunt & Bowblis, 2023; Peutere et al., 2024). High workloads in inpatient and critical care settings, especially when not matched by adequate staffing, have been linked to reduced performance, missed care, and negative patient outcomes (Kurnia et al., 2024; Safriani & Efendy, 2023). Predictive scheduling tools and acuity-based staffing models have been proposed as essential strategies to balance workload, minimize turnover, and sustain workforce resilience (Song et al., 2024; Wang et al., 2025). Importantly, while workload measurement tools such as the Nursing Activities Score (NAS) or time-motion studies provide valuable insights, they require integration with digital solutions to effectively inform staffing and reduce inefficiencies (Walsby et al., 2024; Lucchini et al., 2020).

A recurring theme across the literature is the interaction between technological enablers and workload management mechanisms. For example, predictive analytics based on real-time activity scores supports staffing adjustments, while AI-enabled dashboards and telehealth integration simultaneously reduce non-patient-facing tasks and expand workforce reach (Marbouh et al., 2023; Hosseini et al., 2021). Similarly, leveraging audit-log analytics and EHR optimization minimizes redundant documentation, ensuring that efficiency gains do not shift workload pressures to unmeasured aspects of care (Tiase et al., 2023). However, multiple studies caution that poorly designed or inadequately integrated technologies may exacerbate documentation burden or disrupt workflow, reinforcing the need for nurse involvement in technology adoption and design processes (Congdon et al., 2020; Mohammadnejad et al., 2023). Overall, the literature demonstrates that NCE is best achieved through a multidimensional approach where digital innovation complements workload strategies, enhancing not only direct-care time and documentation turnaround but also improving job satisfaction, reducing burnout, and ultimately fostering safer and more adaptive care systems (Neumann & Purdy, 2023; Allen et al., 2023).

Table 1: Literature Review Matrix

No	Author(s) and Year	EHR Usability	Handover Quality	AI Decision Support	Predictive Analytics	Duplication Reduction	Telehealth Delivery	Digital Dashboards	Audit-Log Analytics	Virtual Nursing	Digital Content Management	Acuity-Based Staffing	Predictive Scheduling	Real-Time Allocation	Staffing Variability	Nurse Turnover	Understaffing Days	Documentation Burden
1.	Akbal & Doğan (2025)				✔	✔												
2.	AL Enezi et al. (2024)			✔	✔		✔											
3.	Allen et al. (2023)											✔						
4.	Alnasser et al. (2024)	✔		✔			✔											

No	Author(s) and Year	EHR Usability	Handover Quality	AI Decision Support	Predictive Analytics	Duplication Reduction	Telehealth Delivery	Digital Dashboards	Audit-Log Analytics	Virtual Nursing	Digital Content Management	Acuity-Based Staffing	Predictive Scheduling	Real-Time Allocation	Staffing Variability	Nurse Turnover	Understaffing Days	Documentation Burden
5.	Aslan & Toros (2025)			✔	✔							✔	✔	✔				
6.	Bayadsi et al. (2025)														✔			
7.	Beauséjour & Hagens (2022)						✔											
8.	Brunt & Bowblis (2023)														✔	✔		
9.	Bruyneel et al. (2025)														✔	✔	✔	
10.	Buestan & Perez (2022)				✔								✔					
11.	Cachata et al. (2024)	✔				✔	✔	✔			✔							
12.	Choi & Powers (2025)				✔			✔				✔	✔	✔	✔			
13.	Congdon et al. (2020)														✔			✔
14.	Curtis et al. (2025)		✔															
15.	De Micco et al. (2025)			✔	✔													
16.	Deeds et al. (2025)	✔																✔
17.	Edelman et al. (2020)	✔					✔				✔							
18.	Galiano et al. (2024)							✔				✔						
19.	Hehman et al. (2023)						✔			✔								
20.	Hicks et al. (2024)	✔				✔					✔							
21.	Hosseini et al. (2021)																	✔
22.	Hunstein & Fiebig (2024)			✔	✔							✔	✔	✔				
23.	Jacobsen et al. (2024)				✔							✔	✔					
24.	Keach et al. (2025)				✔	✔		✔						✔				
25.	Kurnia et al. (2024)																	✔
26.	Lear et al. (2025)	✔		✔	✔			✔	✔		✔	✔						
27.	Lee et al. (2025)						✔				✔							
28.	Lucchini et al. (2020)				✔							✔						
29.	Mahmoudi & Moradi (2024)	✔		✔			✔											
30.	Marbouh et al. (2023)			✔	✔		✔	✔										
31.	Mayenti et al. (2024)																	✔
32.	McCord et al. (2022)																	✔
33.	Mohammadnejad et al. (2023)						✔					✔						
34.	Neumann & Purdy (2023)							✔			✔	✔	✔	✔	✔	✔	✔	✔
35.	Neumann et al. (2024)				✔								✔	✔				
36.	Peutere et al. (2024)				✔												✔	
37.	Porcellato et al. (2025)	✔		✔	✔													
38.	Raja (2023)														✔			
39.	Ramoo (2024)			✔	✔	✔												
40.	Redley et al. (2020)	✔				✔												✔
41.	Safriani & Efendy (2023)															✔	✔	
42.	Sandanasamy et al. (2024)			✔	✔													
43.	Song et al. (2024)			✔	✔							✔	✔	✔				

No	Author(s) and Year	EHR Usability	Handover Quality	AI Decision Support	Predictive Analytics	Duplication Reduction	Telehealth Delivery	Digital Dashboards	Audit-Log Analytics	Virtual Nursing	Digital Content Management	Acuity-Based Staffing	Predictive Scheduling	Real-Time Allocation	Staffing Variability	Nurse Turnover	Understaffing Days	Documentation Burden
44.	Strudwick et al. (2023)	✔							✔									✔
45.	Teng et al. (2025)			✔														
46.	Thomas (2024)									✔								
47.	Tiase et al. (2023)	✔				✔			✔									✔
48.	Tiase, Sward & Facelli (2024)			✔	✔				✔									✔
49.	Tsang et al. (2021)				✔								✔	✔				
50.	Walsby et al. (2024)											✔						✔
51.	Wang et al. (2025)											✔	✔	✔				

3.1. Socio-Demographic Drivers

The integration of electronic health records (EHRs) has been one of the most consistently reported technologies driving NCE and WFO. Studies demonstrate that optimized EHR usability not only reduces duplication of documentation but also streamlines access to patient information, minimizing redundant steps and improving time management (Redley et al., 2020; Strudwick et al., 2023). For instance, research on digital health infrastructures has shown that EHR-enabled workflows lead to fewer transcription errors and shorter turnaround times, which directly increases the proportion of time nurses can dedicate to direct patient care (Deeds et al., 2025; Walsby et al., 2024). However, challenges remain in interoperability and usability across settings, where poorly integrated systems have been found to increase documentation burden and staff frustration, particularly in resource-constrained environments (Congdon et al., 2020). In Saudi Arabia and the wider Gulf region, where digital health infrastructure is expanding rapidly, these findings hold special relevance: while national e-health strategies promote EHR adoption, studies highlight barriers of fragmented systems and insufficient training that may undermine expected gains (Alnasser et al., 2024; Mahmoudi & Moradi, 2024).

Clinical decision support systems (CDSS) and artificial intelligence (AI) have also been central in reshaping nursing workflow by enhancing error detection and providing predictive analytics to anticipate patient deterioration. Evidence indicates that CDSS-driven alerts and AI-enhanced dashboards improve handover quality, reduce missed care, and enable proactive decision-making (AL Enezi et al., 2024; Hunstein & Fiebig, 2024). These systems have proven especially valuable in high-acuity units, where predictive algorithms based on NAS or vital-sign monitoring allow nurses to allocate their attention efficiently (Jacobsen et al., 2024). Furthermore, AI-enabled scheduling tools assist managers in balancing workloads by predicting staffing needs in real-time, thereby reducing variability and potential understaffing risks (Song et al., 2024; Wang et al., 2025). Yet, there are mixed findings: while AI increases efficiency when carefully aligned with workflow, studies also caution against overreliance on algorithmic recommendations, noting risks of alert fatigue or diminished reliance on clinical judgment (Neumann & Purdy, 2023). The Saudi context

illustrates both opportunity and challenge healthcare institutions in Madinah have begun piloting AI-supported triage and staffing systems, but nurses report hesitation in trusting machine outputs without clear evidence of cultural and contextual alignment (Ramoo, 2024).

Mobile health applications, wearable devices, and telehealth systems extend the reach of nurses beyond traditional clinical settings, enhancing efficiency in both acute and chronic care. Telehealth delivery has consistently been associated with improved patient access, reduced hospital readmissions, and lower documentation burdens through integrated digital communication platforms (Edelman et al., 2020; Beauséjour & Hagens, 2022). Wearables, particularly in monitoring vital signs, provide real-time data to EHR systems, thereby supporting continuous patient monitoring without requiring constant bedside presence (Hehman et al., 2023; Galiano et al., 2024). In Madinah's primary care networks, telehealth and mobile platforms have gained traction during and after the COVID-19 pandemic, helping bridge staff shortages and providing nurses with tools to maintain continuity of care for rural populations. Still, the adoption of these tools varies by care setting: tertiary hospitals report higher usability and uptake, whereas rural clinics face barriers of connectivity, training, and patient digital literacy (Lear et al., 2025; Tiase et al., 2023). This variation underscores the importance of context-sensitive integration strategies that align technology adoption with infrastructural readiness.

Interoperability systems and digital dashboards serve as unifying platforms that integrate diverse streams of nursing data to support workflow optimization. Dashboards synthesizing predictive analytics, staffing variability, and real-time allocation metrics have demonstrated significant efficiency gains by allowing managers and frontline nurses to monitor workload distribution at a glance (Marbouh et al., 2023; Tsang et al., 2021). Interoperability also addresses duplication reduction by ensuring data can flow seamlessly across systems, eliminating manual re-entry and reducing potential error rates (Akbal & Doğan, 2025; Cachata et al., 2024). In practice, however, interoperability remains one of the most significant challenges, with studies reporting that fragmented digital infrastructures can paradoxically increase workload due to duplicated inputs and inconsistent system outputs (Mohammadnejad et al., 2023). For Saudi hospitals, including those in Madinah, this issue is particularly pressing: while digital health strategies emphasize interoperability, system fragmentation across public and private providers complicates the implementation of unified dashboards. As summarized in Table 2, technological integration factors cluster into health information systems, CDSS/AI, mobile and remote technologies, and digital dashboards, each shaping NCE and WFO in distinct ways. Ultimately, the literature highlights that integration is not simply about deploying tools but ensuring alignment with clinical workflows, nurse training, and infrastructural realities to achieve meaningful gains (Allen et al., 2023; Neumann et al., 2024).

Table 2: Key Technological Integration Factors Influencing Nursing Care Efficiency and Workflow Optimization

Category	Factors Identified in Literature
Health Information Systems	EHR usability, interoperability, duplication reduction, audit-log analytics, documentation burden management (Redley et al., 2020; Strudwick et al., 2023; Congdon et al., 2020).
Clinical Decision Support & AI	AI decision support, predictive analytics, error detection, acuity-based staffing, predictive scheduling, real-time workload allocation (AL Enezi et al., 2024; Jacobsen et al., 2024; Song et al., 2024; Wang et al., 2025).

Category	Factors Identified in Literature
Mobile & Remote Technologies	Telehealth delivery, mobile apps, wearable monitoring, virtual nursing models, digital content management (Edelman et al., 2020; Thomas, 2024; Hehman et al., 2023; Galiano et al., 2024).
Digital Dashboards & Integration Tools	Real-time digital dashboards, staffing variability monitoring, nurse turnover indicators, workload distribution insights (Marbouh et al., 2023; Lear et al., 2025; Peutere et al., 2024).

3.2. Workload Management (WLM)

Workload management has emerged as a central determinant of nursing care efficiency, with acuity-based staffing, predictive scheduling, real-time allocation, and digital dashboards consistently identified as pivotal mechanisms for balancing workload demands. Acuity-based staffing models and predictive scheduling tools have been shown to enhance fairness and transparency in workload distribution, thereby mitigating burnout and turnover risks (Lear et al., 2025; Jacobsen et al., 2024; Song et al., 2024). Real-time allocation systems further strengthen workforce resilience by dynamically matching nurse availability with patient acuity, reducing missed care and optimizing direct patient contact hours (Wang et al., 2025; Bruyneel et al., 2025). Digital dashboards contribute by providing actionable insights into staffing variability, patient acuity levels, and task allocation, enabling managers and frontline nurses to anticipate demand fluctuations and implement timely adjustments (Marbouh et al., 2023; Lee et al., 2025; Galiano et al., 2024). Collectively, these tools contribute to greater standardization of processes, improved patient safety, and enhanced efficiency in healthcare delivery. Nevertheless, the literature also identifies challenges in the adoption of workload management systems. Studies report resistance among staff due to perceptions of inequity in predictive models, concerns regarding reduced autonomy in decision-making, and tensions between algorithmic outputs and professional judgment (Allen et al., 2023; Hunstein & Fiebig, 2024; Keach et al., 2025). Furthermore, when such systems are poorly integrated into clinical practice, they may inadvertently exacerbate workload imbalances by shifting documentation and coordination responsibilities onto nurses, thereby undermining their intended efficiency gains (Redley et al., 2020; Congdon et al., 2020). Evidence suggests that workload management strategies are most effective when they are implemented transparently, co-designed with nursing staff, and supported by continuous feedback mechanisms that allow for contextual adjustment and alignment with professional practice (Neumann & Purdy, 2023; Tsang et al., 2021).

3.3. Workflow Optimization as a Mediator

Workflow optimization serves as a critical mediating mechanism through which technology integration and workload management translate into improved nursing care efficiency. Technological enablers such as electronic health records, audit-log analytics, and artificial intelligence–driven decision support systems enhance workflow by reducing duplication, improving handover quality, and standardizing processes. These improvements not only free nurses' time for direct patient care but also reduce error rates and documentation turnaround, thereby contributing to more efficient care delivery (Redley et al., 2020; AL Enezi et al., 2024; Strudwick et al., 2023). Similarly, workload management strategies such as predictive scheduling, acuity-based staffing, and digital dashboards enhance workflow by reducing variability in task

allocation, improving resource visibility, and facilitating coordination across shifts (Lear et al., 2025; Song et al., 2024; Tsang et al., 2021; Curtis et al., 2025). Although some studies report direct effects of technology integration on nursing efficiency, such as improvements in patient access through telehealth or the expansion of workforce capacity via virtual nursing, these outcomes are primarily mediated by workflow-related gains such as improved communication, reduced travel requirements, and standardized documentation processes (Edelman et al., 2020; Thomas, 2024; Beauséjour & Hagens, 2022). Conversely, poorly designed or inadequately integrated systems have been found to disrupt workflows, leading to increased cognitive burden, documentation overload, and resistance to adoption, which in turn erode potential efficiency benefits (Congdon et al., 2020; Tiase et al., 2023). Taken together, the evidence strongly supports the conceptualization of workflow optimization as a mediating construct that links both technological innovations and workload management practices to measurable improvements in nursing care efficiency (Neumann & Purdy, 2023; Jacobsen et al., 2024).

4. Discussion

This systematic literature review synthesized findings from 51 peer-reviewed studies to examine how technological integration and workload management shape NCE through the mediating role of WFO. The review indicates that both digital health innovations and structured workload allocation mechanisms interact in complex ways to influence documentation burden, staffing equity, direct-care time, and job satisfaction. These findings are situated within health systems frameworks that emphasize not only the structural introduction of technologies but also the organizational processes required to translate them into outcomes. The results highlight that efficiency improvements are rarely direct effects of technology or staffing interventions alone; rather, they emerge through optimized workflows that reduce duplication, standardize processes, and balance nursing workload.

4.1. Principal Findings

The evidence consistently demonstrates that interoperable electronic health records, decision support tools, and audit-log analytics may reduce duplication, streamline documentation, and improve handover quality (Redley et al., 2020; Strudwick et al., 2023). Similarly, acuity-based staffing models, predictive scheduling, and digital dashboards appear to strengthen workload equity, thereby mitigating turnover and burnout risks (Lear et al., 2025; Song et al., 2024). Importantly, workflow optimization emerges as the key mediator linking these structural interventions to improved efficiency, suggesting that the success of TI and WLM depends less on the presence of tools themselves and more on how they reshape processes. At the same time, studies caution that poorly integrated systems may inadvertently exacerbate workload pressures or reduce professional autonomy (Congdon et al., 2020; Allen et al., 2023). These findings underscore that efficiency gains must be understood as conditional on training, leadership commitment, and organizational readiness.

4.2. Strengths and Limitations

The review benefited from a comprehensive search strategy, adherence to PRISMA guidelines, and inclusion of diverse study designs across multiple care contexts. This breadth strengthens confidence that the findings capture both global evidence and Saudi-specific developments relevant to Vision 2030 reforms. Nonetheless, certain limitations may have shaped the synthesis. The heterogeneity of study outcomes, ranging from documentation turnaround to nurse turnover, complicated the aggregation of results. Differences in study design, data quality, and reporting standards also mean that conclusions should be interpreted cautiously. Moreover, logistical barriers such as the exclusion of non-English language and grey literature may have limited the scope of perspectives included. These constraints do not weaken the overall contribution but should be recognized as shaping the contours of available evidence.

4.3. Interpretation with Previous Literature

The findings are well aligned with Donabedian's framework, which posits that structures (technologies and staffing models) must act through processes (workflows) to yield better outcomes. Similarly, socio-technical systems theory reinforces the idea that efficiency improvements are realized only when technological tools and human factors are jointly optimized. This review therefore supports earlier research showing that predictive dashboards and scheduling tools improve outcomes when they are co-designed with nurses and embedded within routine workflows (Jacobsen et al., 2024; Wang et al., 2025). By contrast, earlier studies that reported minimal or even negative impacts of EHR adoption may reflect systems with poor interoperability or inadequate usability (Congdon et al., 2020), whereas more recent evidence demonstrates stronger efficiency gains when EHRs are integrated with audit-log analytics and structured documentation processes (Redley et al., 2020).

The results can also be interpreted through job demand–resources (JD-R) and job demand–control–support (JDCS) models. These frameworks suggest that high job demands without sufficient resources contribute to stress and burnout, while resources such as predictive scheduling, digital dashboards, and telehealth platforms buffer demand and enhance performance (Bruyneel et al., 2025; Edelman et al., 2020). At the same time, the review reveals tensions between algorithmic decision-making and professional judgment. While AI-enabled scheduling may improve equity, some nurses perceive it as a constraint on autonomy, echoing concerns in the literature that efficiency must not be pursued at the cost of professional discretion (Allen et al., 2023). This suggests that implementation strategies should not only focus on technical accuracy but also on alignment with professional practice and cultural context.

4.4. Implications

From a practice perspective, health systems should prioritize nurse-inclusive design, interoperability standards, and the transparent implementation of predictive scheduling and acuity-based staffing. Embedding structured handover protocols, investing in digital literacy, and supporting dashboard use for real-time workload monitoring could further strengthen efficiency gains. Policy implications are equally significant: within the Saudi Vision 2030 framework, standardizing workflow pathways across health clusters, mandating usability and interoperability

metrics, and ensuring leadership accountability for digital adoption may be critical steps. For research, the review points to the need for robust designs that explicitly test WFO-mediated models, report standardized outcome metrics, and examine adoption barriers in context-specific environments such as the Madinah Health Cluster.

4.5. Future Research Agenda

Future research should employ longitudinal and stepped-wedge designs to evaluate bundles of technological and workload management interventions, with explicit measurement of WFO as a mediator. Mixed-methods studies could provide deeper insights into staff perceptions, resistance, and the contextual factors shaping adoption. Standardization of NCE and WFO metrics would allow greater comparability and enable meta-analyses across studies. In Saudi Arabia, multi-site investigations across different hospital clusters may be particularly valuable to assess how national digital health reforms are operationalized locally. Such efforts may contribute not only to advancing academic knowledge but also to shaping policy and practice in alignment with Vision 2030 goals for digital transformation and healthcare excellence.

5. Conclusion

This review demonstrates that technological integration and workload management, when considered as complementary structural levers, improve nursing care efficiency primarily through their effects on workflow optimization. Electronic records, decision support, telehealth, virtual nursing, dashboards, and audit analytics do not generate efficiency by virtue of their presence; rather, they enable standardized handovers, reduce duplication, illuminate real-time workload, and stabilize task flow when they are embedded in redesigned processes. Likewise, acuity-based staffing, predictive scheduling, and dynamic allocation reduce volatility and perceived unfairness only when their outputs are visible, explainable, and aligned with professional judgment. The central theoretical contribution is a mediation thesis: workflow optimization transmits and conditions the effects of both technology and workload strategies on efficiency outcomes such as documentation turnaround, direct-care time, safety events, and staff experience. Boundary conditions matter. Interoperability, usability, nurse co-design, and digital literacy appear to be necessary for benefits to materialize, while leadership commitment and data governance sustain gains and mitigate risks such as alert fatigue, perceived loss of autonomy, or inequitable assignment patterns.

For systems pursuing transformation, the actionable implication is that digital investment should be inseparable from workload governance and process redesign. Health organizations can translate this synthesis into practice by adopting a co-design approach with nurses, mandating interoperability and usability criteria, validating acuity tools against local case-mix, and deploying dashboards that couple predictive signals with clear escalation rules. In policy terms, Vision 2030 ambitions will be most credibly realized when national and cluster-level leaders standardize workflow pathways, define measurable usability and interoperability targets, and tie executive accountability to equitable staffing and prudent use of AI. Future evaluations in the Madinah Health Cluster should prioritize robust, prospective designs that track workflow endpoints

alongside efficiency metrics and staff outcomes, enabling continuous learning and course correction. The one-page takeaway is straightforward: co-designed, interoperable, acuity-aware systems that foreground workflow optimization can and should deliver measurable improvements in nursing care efficiency turning digital health from a promise into a repeatable operating capability aligned with national transformation goals.

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