



Internet of Things Enabled Nursing Education and Care: A Global Scoping Review of Evidence, Implementation Challenges, and Policy Implications

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ABSTRACT

Purpose: To outline, evaluate, and integrate empirical and review literature provided by the requester on IoT, other smart-health technologies, and the digital policies influencing nursing education, clinical practice, and population health. **Methods:** Five-stage Arksey & O'Malley scoping review with Mattos, Levacs Refinements and PRISMA-ScR reporting. 16 full-text PDFs spanning publication years 2014-2024. Inclusion criteria: English, peer-reviewed, IoT, "Internet +" or other digital-transition technologies; relevance to nursing curricula, nursing services, and healthcare delivery or health-enabling smart cities. **Results:** Sixteen eligible records were identified: four quantitative primary studies, three cross-sectional surveys, one RCT, two engineering/architecture papers, two systematic reviews, one scoping review protocol, one narrative review, one meta-review of IoT definitions, one Macro-policy analysis of digital broadband policies, and one commentary, "Healthy Smart City." Geographic publication clustering identified East Asia (7) and Europe (3). Substantial repetitive benefits included enhanced psychomotor competence, high intention to adopt IoT in practice, real-time decision support, and macro-level public health improvements. Barriers focused on interoperability, privacy, expense, and gaps in digital readiness. **Conclusions:** Learning and service outcomes from IoT-enabled pedagogies and care systems are positive, but practical evaluation and equity-focused implementation science are lacking. For increased adoption, cross-national reimbursement frameworks, revised curricula, and multi-disciplinary standards frameworks are essential.

KEYWORDS

IoT (Internet of Things), Smart Nursing Education, Smart Health Technologies, Digital Transformation in Health

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1. BACKGROUND

Over the past decade, health technologies have undergone significant transformations due to the integration of low-cost sensors, wireless connectivity, and cloud analytics (Habibzadeh et al., 2020). IoT

in healthcare encompasses networks of instrumented objects, such as wearables, bed sensors, and medication dispensers, that collect and disseminate data automatically with minimal human input, providing continuous situational awareness

in real-time throughout clinical, community, and policy domains (Farahani et al., 2020). In this context, the Healthy Cities initiative by the World Health Organization now considers these cyber-physical systems to be relevant tools for environmental sustainability and a means to prevent non-communicable diseases (Bachmann et al., 2022). With formal education, bedside practice, public health mobilization, and advocacy, IoT in nursing offers both encouraging innovative possibilities and overwhelming disruptive difficulties. Nursing is a highly information-based discipline that requires prompt evaluation, pattern detection, and swift action (Fan, 2022). Embedding sensors into everyday clinical artifacts enhances nurses' perceptual abilities, in which "always-on" biometric streams augment professional judgment (Jayaraman et al., 2017). Demonstrated the practicality of a privacy-preserving IoT architecture in bandwidth-limited hospital units by resourcefully implementing mutual authentication in sub-millisecond intervals on resource-constrained devices, thereby proving sub-millisecond mutual authentication.

At the system level study, described a five-layer medical-IoT architecture for monitoring strokes in the elderly,

incorporating wearables, intelligent gateways, and cloud-based consulting into a forward-looking surveillance system. Such frameworks enable a shift in practice from episodic charting to continuous, predictive monitoring, which responds to worldwide calls for managing chronic illness while rationalizing nursing deployment and staffing. With clinical implementations, the IoT educational footprint has burgeoned (Park et al., 2017). A systematic review of pedagogical approaches in computer-aided nursing from 20 countries reported a sharp post-COVID increase of smart glasses-, augmented reality-, and sensor-based simulation studies, most demonstrating better knowledge or skill outcomes compared to traditional teaching (Dicheva et al., 2023). To enrich this macro perspective, A study with randomized 60 vocational college students from China to an "Internet +" fundamentals course with RFID-enabled skills stations: those in the experimental arm outperformed controls on several measures of psychomotor precision and self-directed learning. These findings align with constructivist theory, which posits that experiencing context-rich, feedback-rich environments accelerates deep learning and competency transfer (Liu et al., 2025).

From a practical standpoint, human readiness must meet technical promise. In Korea, survey data showed that nursing students' perceived usefulness and ease of use collectively accounted for 67% of the IoT adoption intention (Kang et al., 2019). Similarly, a study conducted across 17 Iraqi universities found that remote lecture attendance through smartphones was nearly universal; however, students expressed concerns about having limited exposure to IoT-related devices and low bandwidth when using specialized devices. (Hasan Al-Taai et al., 2023). Similarly, it was noted that 76% of Indonesian nurses self-assess their IoT knowledge level as “low,” despite acknowledging its potential clinical applications. A digital readiness gap is exposed in the findings: the enthusiasm is palpable, yet the IoT literacy, data ethics, and troubleshooting competencies required for foundational curricula and CPD frameworks are lacking.

The shift to virtual care caused by the pandemic has become the norm for digitally mediated nurse-patient interactions. In a discrete choice experiment involving 395 older Chinese adults, a 70% insurance reimbursement rate emerged as the most significant incentive for adopting “Internet + Nursing” home-visit services, with average

willingness to pay reaching ¥203 (~US \$28) per month (Li et al., 2016). Find a parallel implementation study focusing on the enthusiasm for technology and the lack of sustainable uptake due to financing models (Liu et al., 2025). At the end of the spectrum, as seen in China's broadband expansion significantly increased household use of clean energy, demonstrating how macro-infrastructure policy can alter social determinants of health and, consequently, nursing workloads. The IoT world remains promising but is marred by proprietary protocols, unclear terminology, and inconsistent regulation. A study cataloged 34 distinct academic definitions of IoT clustering, persistent hurdles such as interoperability, privacy, energy efficiency, and usability into seven grand challenge categories (Motta et al., 2019). A scoping review protocol suggests that platform fragmentation is a significant barrier to adoption among undergraduates, highlighting the need for unified ontologies and evaluation frameworks (Jang & Song, 2022).

The neglect of security protocols narratively reviewed, has persisted, eroding student trust due to weak data-governance practices and breaching confidentiality norms at the heart of the education culture

(Meylani, 2024). IoT is being layered into metropolitan administration beyond the classroom and hospital wards. Pollution monitoring systems, Geographic Information System (GIS) dashboards, and citizen feedback loops are combined to address environmental public health challenges and encourage physical activity within city infrastructure (Kamel Boulos & Al-Shorbaji, 2014). These advantages within the nursing domain will translate to fewer respiratory admissions, shorter hospital stays, and expanded community health promotion roles. Realizing these gains, however, depends on nurses supporting equity in public health communications, Advocacy, and technologically mediated public health debate. Post-pandemic teaching instruments, student perceptions, and cybersecurity frameworks have all been reviewed separately; none have attempted to bridge education, bedside care, and policy through a unified evidentiary basis (Dicheva et al., 2023; Kang et al., 2019; Chiang et al., 2018). Most empirical work from the East Asia cluster poses contextual generalizability issues. In this context, the current scoping review aims to pursue three interrelated objectives: IoT-focused nursing scholarly articles within the 2014- to 2024- time frame; Cross-empirical results and

conceptual outcomes from didactic, clinical, and macrosystem policy levels; and Address the identified gaps, oversights in methods, and priority issues for multi-disciplinary research.

This review aims to provide stakeholders with a comprehensive yet detailed guide on leveraging IoT innovation within the context of equity, privacy, and professional boundaries, integrating sixteen diverse studies ranging from a randomized controlled trial to a smart-city commentary. Section 2 outlines our scoping review Arksey O'Malleys and Levacs Refinements and PRISMA-ScR reporting (Arksey & O'Malley, 2005; Mattos et al., 2023). Section 3 provides a synthesis with thematic analysis. Section 4 critiques the effectiveness of pedagogy, workforce readiness, cybersecurity, economic drivers, and policy intersections. Section 5 proposes responsive strategies, and Section 6 identifies delimiting factors and future research directions. With this explanatory framework, we aim to engage curriculum developers, clinical executives, and policymakers concerned with the rapidly changing nexus of nursing and IoT.

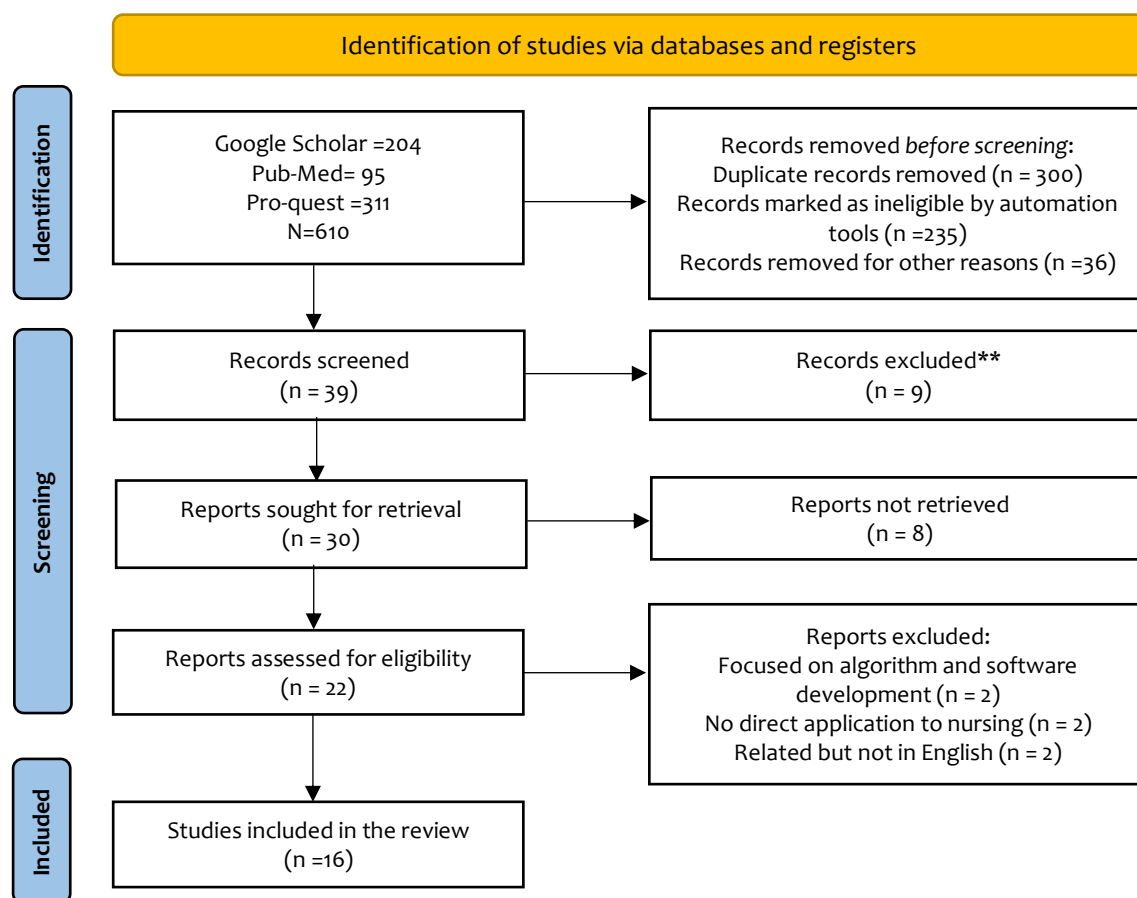
2. METHODS

The review followed the structure of (Arksey & O'Malley, 2005) of five steps:

identifying the question, identifying studies, selecting, charting data, collating/ summarizing, and adding stakeholder consultation per Levac’s extension. Reporting aligns with PRISMA-ScR sampling frame (n = 16) (Tricco et al., 2018). No external database searching was undertaken by design. Studies had to 1) be scholarly papers published by peer-reviewed journals; 2) deal with IoT, “Internet +”, computer-aided, or broadband digital-transition technologies; 3) focus on nursing education, nursing services, or health-

system/smart city interdisciplinary work in the broader milieu. Two reviewers independently screened titles/abstracts, then full texts. All discussions resolved discrepancies. Sixteen papers met all criteria; the Researcher captured author, year, country, aim, design, sample, technology, outcomes, and limitations. A profile of descriptive statistics was generated, followed by analysis through inductive thematic coding. Convergent themes shaped the narrative discussion.

Figure 1. Prisma Diagram



The PRISMA flow diagram (Figure 1) outlines the selection process for IoT studies relevant to nursing care, from database search to final inclusion. Regarding identification, searches of three electronic sources— Google Scholar (204 records), PubMed (95 records), and ProQuest (311 records)—resulted in a total of 610 unique citations. Before the screening process, quality control preemptively eliminated 571 citations, which included 300 duplicates, 235 flagged as irrelevant by automated relevance checks, and 36 discarded for various other reasons, such as incomplete bibliographic information or non-research formats. Of these, 39 records were left to be examined at the title and abstract screening stage. Title and abstract screening reduced the pool by nine papers removed from the review question, bringing the total to 30 full-text reports “reports sought for retrieval.” None of these eight reports was obtainable despite extensive contact with the libraries and authors. This reduced the complete set of available documents to 22 unreviewed articles awaiting eligibility assessment. Eligibility appraisal removed six reports for defined reasons, including weakness in the method or topic, such as two that focused predominantly on the application of IoT in clinical practice to algorithm or software

products, two that discussed IoT in non-nursing health disciplines, and two that were authored in foreign languages without accessible, reliable translations. As a result, 16 observed studies met all the relevant criteria and were included in the qualitative synthesis. The diagram clearly illustrates a four-step funnel – identification, screening, eligibility, and inclusion – which systematically reduces the initial set of 610 citations to 16 studies that have been meticulously cited. Each phase, where decisions are made, shows marked cuts, enhancing transparency and reproducibility, and demonstrates that nearly 97% of the harvested records were discarded in the previously discussed steps. The decision to exclude records stems from the requirement that any literature reviewed must be directly relevant and methodologically sound. Additionally, the evaluation of selection bias, the thoroughness of the literature search, and the ability to replicate these steps within the review’s methodology for IoT adoption in nursing, as demonstrated by numeric counts at each step, is a testament to the methodology’s integrity.

3. RESULTS

Table 1 shows the Summary of articles from 2014 to 2024; sixteen articles were published that fall under the inclusion criteria of this study. Publication hit a high after 2020 (10/16, 63 %). Most publications came from East Asia, Iraq, Turkey, Brazil, the United Kingdom, Jordan, and the United States. The research originated from China (4), Korea (2), Taiwan (1), and Indonesia (1); and was contributed to by foreign countries: Iraq (1), Turkey (1), Brazil (1), UK (1), Jordan (1), Global (2) Australia (1) and the USA (1). The study contexts were grouped as follows: (a) Nursing education (7/16, 44%), (b) Clinical-care architecture or patient-service design (4/16, 25%), (c) Workforce of perception surveys (3/16, 19%), and (d) Policy or conceptual analyses (2/16, 12%) . The empirical aspects of the research included a parallel RCT of an “Internet +” class in conjunction with a fundamentals course. (Wang et al., 2023), one discrete-choice experiment (Liu et al., 2025), and three readiness cross-sectional surveys with students or nurses (Kang, et al., 2021; Hassan Al-Taai et al., 2023; Taryudi et al., 2022). Two papers offered an engineering or security assessment of IoT architecture. (Chiang et al., 2018; Li et al., 2016) . On the secondary evidence side, we found two systematic

reviews. (Dicheva et al., 2023; Motta et al., 2019), a scoping-review protocol (Jang & Song, 2022), and a narrative review of smart-learning environments (Meylani, 2024) Other articles offered a disaster-simulation view (Laplante & Laplante, 2016; Yan et al., 2023), a healthy-city commentary (Kamel Boulos & Al-Shorbaji, 2014) And a macroeconomic policy analysis of China’s broadband initiative. In seven studies addressing the education domain, pedagogies that integrate IoT-enhanced learning outperformed those without IoT enhancements (Al-Rawashdeh et al., 2024; Varela-Aldás et al., 2025).

RCT reported higher self-directed learning scores and gained self-reported learning of five psychomotor skills ($d = 0.79$) in the intervention arm. In the 20-nation review, smart devices, such as smart glasses and sensor-rich manikins, enhanced learning for 82% of primary study participants. Surveys showed high ($> 4/5$) behavioral intention among students and faculty, with perceived usefulness as the primary reason for adoption. Indonesian bedside nurses overwhelmingly self-assess their IoT knowledge as “low” (76%), indicating a curriculum gap. These two engineering papers provided solutions for secure, low-latency architectures: in Chiang et al (2018)’s

SHA-3 scheme, mutual authentication was completed in 6.3 ms, and real-time vitals, along with expert consultation for stroke preventative care, were delivered from Li et al (2021)'s five-layer platform. The disaster-simulation perspective suggested RFID victim tracking to improve triage accuracy. In IoT-enabled nursing, the home visit DCE revealed that patient uptake centered on economic incentives: a 70% reimbursement rate by insurers was most beneficial, while the average willingness-to-pay statistic was above ¥203/month. Inductive coding

produced eight recurring themes: (1) attributable learning-outcome gains or achievement benchmarks; (2) user preparedness and digital-literacy gaps; (3) secure and scalable architectures; (4) real-time decision support for clinically autonomous actions; (5) privacy, anonymity, and politics of the ungovernable interdependence hump; (6) policy and economically-defined incentives; (7) smart cities' healthcare interdependencies, and (8) standardization and conceptual precision.

Table 1. Summary of data (Continue to page 52)

#	Author (Year)	Nation / Setting	Aim & Design	Sample	Tech / Policy	Key Findings
1	Dicheva et al. 2023	20-country review	Mixed-methods SLR of post-COVID nursing pedagogies	78 studies	VR/AR, smart glasses, AI chatbots	Tech-enhanced learning improves knowledge and skills
2	Wang et al. 2023	China	Parallel RCT of "Internet +" fundamentals	60 students	Hybrid LMS & OSCE station sensors	Improves psychomotor scores, self-learning
3	Kang et al. 2021	Korea	Cross-sectional survey	348 students	IoT in health	Recognition and usefulness $r = .37$; usefulness and intention $r = .67$
4	Hasan Al-Taai et al. 2023	Iraq	Descriptive survey	194 faculty/students	Smartphones & IoT	97% use smartphones for teaching
5	Taryudi et al. 2022	Indonesia	Cross-sectional survey	350 nurses	Future IoT	76% low IoT knowledge; 50% foresee major impact
6	Jang & Song 2022	Korea	Scoping-review protocol	-	IoT platform tech	Identifies platform fragmentation

7	Meylani et al. 2024	Turkey	Narrative review	-	Wearables, smartboards	Gamification improves engagement with associated privacy risks
8	Chiang et al. 2018	Taiwan	Engineering security eval.	Prototype	SHA-3 smart bio-objects	6.3 MS authentication latency
9	Li et al. 2021	China	IoT architecture design	-	Five-layer Medical IoT	Real-time vitals; expert consult
10	Laplante et al. 2018	USA	Perspective	Disaster simulation	RFID tags	IoT could enhance triage tracking
11	Motta et al. 2019	Brazil	Meta-review	15 SLRs	IoT concept	34 definitions; 7 challenge areas
12	Liu et al. 2024	China	Discrete-choice experiment	395 older pts	“Internet +” nursing	70 % insurance reimbursement drives uptake
13	Yan et al. 2023	China	Quasi-natural DID	37 146 hh	Broadband China policy	Digital transition increases clean energy adoption in middle regions
14	Kamel Boulos & Al-Shorbaji 2014	Global	Healthy-city commentary	-	Smart-city IoT	Urban IoT can underpin healthier cities
15	Khafid et al. 2024	Indonesia	Scoping review	-	IoT in nursing curricula	Outlines PRISMA-ScR approach
16	Al Qarni et al. 2024	Saudi Arabia	Conceptual review	-	Smart classrooms, RFID	Lists 10 educational IoT applications

Table 2 (thematic matrix) associates each theme with its corresponding studies. Only one RCT and one Discrete Choice Experiment (DCE) achieved high methodological rigor, and none of the studies provided longitudinal follow-up over six months. There were no analyses of cost-effectiveness, and no equity-centered implementation research was conducted. Furthermore, the West and low-resource

areas remain underrepresented in East Asia, which adversely impacts generalizability. The integration of IoT into educational and clinical settings holds promise for academic and clinical outcomes; however, issues such as inadequate IoT security, system interoperability, and workforce readiness pose risks that require strategic research and policy interventions.

Table 2. Result of Thematic Analysis

Theme	Description	Supporting Studies
1. Learning-Outcome Gains	IoT-enhanced blended or simulation courses improve psychomotor accuracy, autonomy, and satisfaction.	1, 2,15
2. Student & Workforce Readiness	High intention to adopt IoT but variable knowledge; curriculum gaps noted.	3, 4, 5,16
3. Secure & Scalable Architectures	Lightweight cryptography and layered designs enable privacy-preserving, low-latency care.	8, 9
4. Real-time Clinical Decision Support	Continuous vitals, home-visit scheduling, and triage tracking support safer care.	8, 9, 10
5. Implementation Barriers	Interoperability, privacy, reimbursement, and methodological rigor limit uptake.	6, 7, 11
6. Economic & Policy Incentives	Insurance coverage and broadband infrastructure drive patient and population adoption.	12, 13
7. Smart-City & Environmental Health Nexus	City-scale IoT contributes to healthier living conditions and indirectly affects nursing workload.	14
8. Conceptual Clarity & Standards	Meta-review synthesizes definitions; standards needed for nursing-specific IoT.	11

4. DISCUSSION

The scoping review includes a list of 16 peer-reviewed studies, creating a more polycentric and interdisciplinary discourse on nursing education, clinical care, and health policy concerning IoT technologies. Randomized and quasi-experimental studies demonstrate robust learning gains from integrating IoT in foundational skills training (Liu et al., 2025). RCT found significant effects on psychomotor accuracy ($d \approx 0.8$) when replacing paper checklists with RFID-enabled stations, a result corroborated by Zhang et al. (2022), engineering field test of an IoT teaching-management system that improved laboratory utilization rates and

feedback loop responsiveness, aligning results from Mastour et al. (2025), when pilot testing an IoT learning platform in medical education reporting problem-solving scores and satisfaction levels significantly accelerated by the intervention, despite the short duration of four weeks. Constructivist perspectives support these findings by emphasizing the importance of multisensory, richly contextual feedback in skill mastery; the participants were learners in highly simplified clinical data environments. Where are the trials? Varela-Aldás et al. (2025) documented their engagement with hands-on IoT acceptance, exposing participants to learning

opportunities, directly suggesting “learning-by-using” strengthens the intention to use technology, but their design lacked a non-intervention comparator. Thus, future studies should focus on multi-site cluster RCTs that integrate long-term evaluation of cognitive, retention, and practice-transition measures, as well as safety outcomes. Surveys from six different countries indicate a pervasive gap in readiness. The willingness of South Korean undergraduates to embrace Internet of Things (IoT) technologies is almost entirely mediated by their perceptions of its usefulness and user-friendliness (Kang, 2021), these results were echoed in Turkish health professional students, who were optimistic but lacked knowledge of the operational details (Bodur et al., 2019). Nurses working at a tertiary care hospital in China viewed IoT-enabled infusion pumps and location inspirations as valuable for alleviating workloads., However, concerns about alarm fatigue and privacy intrusiveness were significant (Kang et al., 2019). Addressing this gap requires a course redesign that combines data ethics critical reflection with hands-on exercises in sensor calibration and dashboard customization. Maston et al.'s (2025) proposed interventions indicate that peer-mentored sandboxes may facilitate active

confidence more effectively than top-down workshops designed vertically (Skiba, 2013, 2014) on “the connected age” underscore the need for wearable tech to be contextualized within clinical settings to be meaningful rather than when commanded. These findings suggest that pedagogy should shift from mere sensitization efforts to active, participatory co-design, where nurses influence and IoT can enhance care delivery in nursing. Existing technical case studies affirm, albeit with reservations, that lightweight cryptography can safeguard patient data on resource-constrained devices (Chiang et al., 2018; Almutairi & Sheldon, 2025), as addressed in Motta et al. (2019) meta-review, which lists privacy and interoperability among seven grand challenges that impede scale-up). A more recent proposal adds cloud-edge hybrids integrating bedside analytics performed at the bedside with federated learning to mitigate data-sovereignty conflicts (Martinez-Millana et al., 2020). Further elaborate on the home-hub concept aimed at informal caregiving by designing clinical portals to receive encrypted streams. The study by Mieronkoski et al. (2017), express that big-data analytics will amplify the value of IoT only if governance transforms terabytes of information into actionable

insights. A scoping review published before the pandemic had already cautioned that, in the absence of vendor-agnostic data frameworks, IoT at the bedside risks creating new silos instead of eliminating existing ones (Mieronkoski et al., 2017). Therefore, action is needed in two ways: (a) nursing informatics professional organizations need to collaborate with accrediting bodies to define basic standards for interoperability, and (b) healthcare organizations need to adopt green-IT policies to reduce the environmental impact associated with the proliferation of devices. The identified literature gap is the lack of discussion, which overlooks the consideration of financial incentives as singularly critical. Highlight a discrete-choice experiment conducted on 395 older Chinese adults, where a 70% insurance reimbursement increase led to a threefold increase in willingness to accept IoT-enabled home-visit nursing (Li et al., 2016). Cost-sensitivity is also noted (Laplante et al., 2018; Laplante & Laplante, 2016) frameworks. In China, the Broadband initiative has already demonstrated that investment in infrastructure can influence health behaviors, such as the use of cleaner energy, which in turn shifts the demand for nursing services (Zhao et al., 2023).

Equity implications are of paramount importance. Research conducted within Iraq and Indonesia highlights widespread smartphone ownership, yet low bandwidth availability, and sparse access to quality sensors. Al-Rawashdeh et al. (2024), introduced a behavioral-intention framework for smart-health uptake, including socio-economic factors and organizational facilitators. Policies aimed at subsidizing devices for rural clinics and low-income families may prove equally crucial in ensuring that technological advancements in the Internet of Things (IoT) health innovation technology do not widen but instead narrow health inequalities. The IoT paradigm extends far beyond hospitals. Postulated the healthy city concept, envisioning urban sensor grids that monitor air quality and traffic and alert for disasters. This is a vision that many cities are now implementing (Kamel Boulos & Al-Shorbaji, 2014). A geological-disaster monitoring system illustrates how real-time environmental data streams can shape nursing curricula focused on disaster preparedness (Li et al., 2016; Liu et al., 2025). Laplante et al. (2018), further advance the discourse by stating that empathetic caring healthcare systems must be reconceived as distributed cyber-physical ecosystems

where learning and adaptation occur cyclically among nurses, sensors, and healthcare decision-makers. Such perspectives reinforce connections between public health and nursing while expanding opportunities for nurse advocacy in city planning discussions. There is still a lack of diverse methodologies; however, gaps must be filled. There is a surge in new articles, but half seem to be conceptual or commentary pieces, with little longitudinal evaluation research (Pal & Jadidi, 2021).

To date, no research has combined cost-effectiveness with equity-weighted results. This is crucial if IoT is to be scaled up in a responsible manner. Similarly, none of the included trials assessed ecological factors, such as e-waste, which is a glaring omission in light of the sustainability need. Therefore, future work should adopt mixed-methods stepped-wedge designs to measure clinical efficacy, user experience, environmental expense, and ROI in various socio-economic settings. Lastly, the integration of big data remains largely visionary. A prototype geriatric teaching resource recommender system is shown, but end-to-end analytics that cycle bedside data into adaptive pedagogy remain on the drawing board (Al-Rawashed et al., 2024; Fan, 2022). Fulfilling this will require cross-

disciplinary coalitions that join nursing faculties with data scientists, ethnographers, and government digital innovation departments.

Educational, Practice, and Policy Implications

- 1) **Interdisciplinary Curriculum:** Include IoT competencies such as calibrating sensors and data stewardship within informatics, as well as implementing high-fidelity IoT simulation for psychomotor skills training in IoT.
- 2) **Sustained Professional Development:** Include sessions focused on the practicality of IoT-enabled instantaneous dashboards and their interpretation.
- 3) **Payment Framework:** DCE (The Discrete Choice Experiments) emphasized incorporating IoT nursing services into national insurance pay structures to mitigate disparities in access to IoT services.
- 4) **Scale Interrelation:** Nursing groups are encouraged to interact with IEEE-P2413 (Standard for an Architectural Framework for the Internet of Things (IoT) and ISO/TC 215 (Health Informatics/Security) in establishing domain ontologies.

5) Research Priorities. Conduct multi-site RCTs, equity-focused implementation studies, and macro-micro modeling that connect smart-city IoT with nursing outcomes.

Limitations

The diverse methodologies prevented any form of quantitative synthesis. Additionally, some of the included literature (for example, broadband policy at the macro level) only tangentially relates to nursing and lacks direct relevance to nursing.

5. CONCLUSION

This scoping review synthesized evidence from 16 peer-reviewed studies and two conceptual papers published between 2014 and 2024 to categorize the impact of Internet of Things (IoT) technologies on nursing education, clinical practice, and policy. The collective findings of IoT-enhanced pedagogies, including radio-frequency identification (RFID) and sensor-rich simulation pedagogies, consistently outperform traditional methods in psychomotor skill accuracy, knowledge retention, and learner independence. Secure, low-latency architectures that enable proactive disease management with real-time monitoring of vital signs on

resource-constrained devices illustrate the technical feasibility of IoT in clinical contexts. Economic assessments reveal reimbursement policy as the primary driver, while broader policy analysis highlights national broadband infrastructure as applicable, albeit indirectly supportive of changes in health unit workload. While these findings are informative, the evidence base remains weak, as only one randomized controlled trial and one discrete choice experiment have met rigorous standards, and longitudinal outcome and cost-effectiveness equity assessments are largely absent. Principally, gaps in digital readiness, privacy governance, and interoperability hinder progress for students and practicing nurses. Additionally, the East Asia focus of primary studies raises concerns about regional applicability in lower-resource or Western contexts. Three synergistic steps are necessary to realize the promise of IoT in healthcare. First, nursing education and professional development should incorporate IoT competencies, such as data ethics and troubleshooting IoT system issues, rather than making these skills optional in workshops. Second, professional associations should partner with a standards organization to develop interoperability and security guidelines that support nursing

workflows. Third, healthcare policymakers need to revise reimbursement models and digital inclusion initiatives to prevent the acceleration of existing health inequities. IoT enables highly effective care and data-driven learning experiences but requires responsible financing, thorough impact assessment, and strong governance for broad adoption. Closing these gaps enables the nursing profession to take the lead in the next evolution of digital healthcare, rather than being left behind.

CONFLICT OF INTEREST

The author declares no conflicts of interest regarding the publication.

AUTHOR CONTRIBUTION

GFDV – Conception, Design, Screening and selection, Quality checks, analysis and interpretation, Drafting, and review of the manuscript.

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REFERENCES

Almutairi, M., & Sheldon, F. T. (2025). IoT–Cloud Integration Security: A Survey of Challenges, Solutions, and Directions.

Electronics, 14(7), 1394. <https://doi.org/10.3390/electronics14071394>

Al-Rawashdeh, M., Keikhosrokiani, P., Belaton, B., Alawida, M., & Zwiri, A. (2024). Effective factors for the adoption of IoT applications in nursing care: A theoretical framework for smart healthcare. *Journal of Building Engineering*, 89, 109012. <https://doi.org/10.1016/j.jobee.2024.109012>

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, 8(1), 19–32. <https://doi.org/10.1080/1364557032000119616>

Alqarni, T. M., Hamadneh, B. M., & Jdaitawi, M. T. (2024). Perceived usefulness of Internet of Things (IOT) in the quality of life of special needs and elderly individuals in Saudi Arabia. *Heliyon*, 10(3), e25122. <https://doi.org/10.1016/j.heliyon.2024.e25122>

Bachmann, N., Tripathi, S., Brunner, M., & Jodlbauer, H. (2022). The Contribution of Data-Driven Technologies in Achieving the Sustainable

- Development Goals. Sustainability, 14(5), 2497. <https://doi.org/10.3390/su14052497>
- Bodur, G., Gumus, S., & Gursoy, N. G. (2019). Perceptions of Turkish health professional students toward the effects of the internet of things (IOT) technology in the future. Nurse Education Today, 79, 98–104. <https://doi.org/10.1016/j.nedt.2019.05.007>
- Chiang, C.-F., Hsu, F.-M., & Yeh, K.-H. (2018). Robust IoT-based nursing-care support system with smart bio-objects. BioMedical Engineering OnLine, 17(S2), 154. <https://doi.org/10.1186/s12938-018-0582-5>
- Dicheva, N. K., Rehman, I. U., Anwar, A., Nasralla, M. M., Husamaldin, L., & Aleshaiker, S. (2023). Digital Transformation in Nursing Education: A Systematic Review on Computer-Aided Nursing Education Pedagogies, Recent Advancements and Outlook on the Post-COVID-19 Era. IEEE Access, 11, 135659–135695. <https://doi.org/10.1109/ACCESS.2023.3337669>
- Fan, F. (2022). An Inquiry-Based Teaching Model for Nursing Professional Courses Based on Data Mining and Few-Shot Learning Technology. Computational Intelligence and Neuroscience, 2022, 1–9. <https://doi.org/10.1155/2022/9441375>
- Farahani, B., Firouzi, F., & Chakrabarty, K. (2020). Healthcare IoT. In Intelligent Internet of Things (pp. 515–545). Springer International Publishing. https://doi.org/10.1007/978-3-030-30367-9_11
- Habibzadeh, H., Dinesh, K., Rajabi Shishvan, O., Boggio-Dandry, A., Sharma, G., & Soyata, T. (2020). A Survey of Healthcare Internet of Things (HIoT): A Clinical Perspective. IEEE Internet of Things Journal, 7(1), 53–71. <https://doi.org/10.1109/JIOT.2019.2946359>
- Jang, A., & Song, C. (2022). Internet of things platform technology used in undergraduate nursing student education: a scoping review protocol. BMJ Open, 12(4), e058556. <https://doi.org/10.1136/bmjopen-2021-058556>
- Jayaraman, P. P., Yang, X., Yavari, A., Georgakopoulos, D., & Yi, X. (2017).

- Privacy preserving Internet of Things: From privacy techniques to a blueprint architecture and efficient implementation. *Future Generation Computer Systems*, 76, 540–549. <https://doi.org/10.1016/J.FUTURE.2017.03.001>
- Kamel Boulos, M. N., & Al-Shorbaji, N. M. (2014). On the Internet of Things, smart cities and the WHO Healthy Cities. *International Journal of Health Geographics*, 13(1), 10. <https://doi.org/10.1186/1476-072X-13-10>
- Khafid, M., Bramantoro, T., Hariyani, N., Setyowati, D., Palupi, R., Ariawantara, P. A. F., Pratamawari, D. N. P., Pindobilowo, P., & Mohd Nor, N. A. (2024). The Use of Internet of Things (IoT) Technology to Promote Children's Oral Health: A Scoping Review. *European journal of dentistry*, 18(3), 703–711. <https://doi.org/10.1055/s-0043-1776116>
- Kang, J. Y., Kong, Y. W., Kim, E. B., Kim, E. A., Park, S. J., Park, J., Seong, J. Y., Son, C. E., Lee, B. M., & Kim, Y. M. (2021). Relationships among nursing students' recognition, perceived usefulness, and intention to accept IoT. *Korean Journal of Food & Health Convergence*, 7(1).
- Kang, S., Baek, H., Jung, E., Hwang, H., & Yoo, S. (2019). Survey on the demand for adoption of Internet of Things (IoT)-based services in hospitals: Investigation of nurses' perception in a tertiary university hospital. *Applied Nursing Research*, 47, 18–23. <https://doi.org/10.1016/j.apnr.2019.03.005>
- Laplante, P. A., Kassab, M., Laplante, N. L., & Voas, J. M. (2018). Building Caring Healthcare Systems in the Internet of Things. *IEEE Systems Journal*, 12(3), 3030–3037. <https://doi.org/10.1109/JSYST.2017.2662602>
- Laplante, P. A., & Laplante, N. (2016). The Internet of Things in Healthcare: Potential Applications and Challenges. *IT Professional*, 18(3), 2–4. <https://doi.org/10.1109/MITP.2016.42>
- Li, Y., Yu, W., Yang, B., & Liu, C. (2016). A comparison of the caring behaviours of nursing students and registered nurses: implications for nursing education. *Journal of Clinical Nursing*,

-
- 25(21–22), 3317–3325. <https://doi.org/10.1111/jocn.13397>
- Liu, H., Wang, W., & Li, S. (2025). Spatio-temporal evolution and driving factors of the coupling and coordinated development of China's digital economy and older adult care services. *Frontiers in Public Health*, 13. <https://doi.org/10.3389/fpubh.2025.1490461>
- Martinez-Millana, A., Ibanez-Sanchez, G., & Traver, V. (2020). Cloud and Internet of Things Technologies for Supporting In-House Informal Caregivers: A Conceptual Architecture (pp. 1–28). https://doi.org/10.1007/978-3-030-30817-9_1
- Mastour, H., Khoshgoftar, Z., Ahmady, S., & Sohrabi, S. (2025). Implementing an Internet of Things-based learning platform into medical education: Addressing educational challenges with innovative solutions. *Medical Teacher*, 47(8), 1262–1265. <https://doi.org/10.1080/0142159X.2024.2445036>
- Mattos, S. M., Cestari, V. R. F., & Moreira, T. M. M. (2023). Scoping protocol review: PRISMA-ScR guide refinement. *Rev Enferm UFPI*, 12(1). <https://doi.org/10.26694/reufpi.v12i1.3062>
- Meylani, R. (2024). Transforming Education with the Internet of Things: A Journey into Smarter Learning Environments. *International Journal of Research in Education and Science*, 10(1), 161–178. <https://doi.org/10.46328/ijres.3362>
- Mieronkoski, R., Azimi, I., Rahmani, A. M., Aantaa, R., Terävä, V., Liljeberg, P., & Salanterä, S. (2017). The Internet of Things for basic nursing care: A scoping review. *International Journal of Nursing Studies*, 69, 78–90. <https://doi.org/10.1016/j.ijnurstu.2017.01.009>
- Motta, R. C., Silva, V., & Travassos, G. H. (2019). Towards a more in-depth understanding of the IoT Paradigm and its challenges. *Journal of Software Engineering Research and Development*, 7, 3. <https://doi.org/10.5753/jserd.2019.14>
- Pal, S., & Jadidi, Z. (2021). Protocol-Based and Hybrid Access Control for the IoT: Approaches and Research Opportunities. *Sensors*, 21(20), 6832. <https://doi.org/10.3390/s21206832>

- Park, S. J., Subramaniyam, M., Kim, S. E., Hong, S., Lee, J. H., Jo, C. M., & Seo, Y. (2017). Development of the Elderly Healthcare Monitoring System with IoT, 309–315. https://doi.org/10.1007/978-3-319-41652-6_29
- Skiba, D. J. (2013). The Internet of Things (IoT). *Nursing Education Perspectives*, 34(1), 63–64. <https://doi.org/10.5480/1536-5026-34.1.63>
- Skiba, D. J. (2014). The Connected Age and Wearable Technology. *Nursing Education Perspectives*, 35(5), 346–347. <https://doi.org/10.5480/1536-5026-35.5.346>
- Hassan Al-Taai, S. H., Kanber, H. A., & Mohammed Al-Dulaimi, W. A. (2023). The Importance of Using the Internet of Things in Education. *International Journal of Emerging Technologies in Learning (IJET)*, 18(01), 19–39. <https://doi.org/10.3991/ijet.v18i01.35999>
- Taryudi, T., Lindayani, L., Mutiar, A., & Purnama, H. (2022). Perceptions of Indonesian Nurses Toward the Application of the Internet of Things in the Future. *KnE Life Sciences*. <https://doi.org/10.18502/kls.v7i2.10398>
- Tricco, A. C., Lillie, E., Zarin, W., O’Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., ... Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*, 169(7), 467–473. <https://doi.org/10.7326/M18-0850>
- Varela-Aldás, J., Junta, C., Choque, E., & Palacios-Navarro, G. (2025). Influence of Higher Education on IoT Acceptance through Hands-On Learning. *TEM Journal*, 528–539. <https://doi.org/10.18421/TEM141-47>
- Wang, Q.-L., Liu, L.-L., Liu, C.-R., Zhu, Q.-S., Ren, Z.-Y., Gang, T.-T., Zhou, C.-Y., Li, Q.-P., Chen, X., & Han, B.-R. (2023). ‘Internet+’ comprehensive nursing training course in the post-epidemic era—an exploration of the mixed teaching mode: a randomized trial. *Frontiers in Medicine*, 10. <https://doi.org/10.3389/fmed.2023.1152732>
- Yan, J., Li, J., Li, X., & Liu, Y. (2023). Digital transition and the clean renewable

energy adoption in rural family:
evidence from Broadband China.
Frontiers in Ecology and Evolution, 11.
<https://doi.org/10.3389/fevo.2023.1241>
410

Zhang, J., Shields, L., Ma, B., Yin, Y., Wang, J.,
Zhang, R., & Hui, X. (2022). The clinical
learning environment, supervision and
future intention to work as a nurse in
nursing students: a cross-sectional and
descriptive study. *BMC Medical
Education*, 22(1), 548. [https://doi.org/
10.1186/s12909-022-03609-y](https://doi.org/10.1186/s12909-022-03609-y)

Zhao, J., Dong, K., & Taghizadeh-Hesary, F.
(2023). Is income inequality a
stumbling block to the global natural
gas market? *Energy Economics*, 118,
106520. [https://doi.org/10.1016/j.eneco.
2023.106520](https://doi.org/10.1016/j.eneco.2023.106520)