The Determinants of Digital Quality and Safety Education for Nurses (QSEN); A Systematic Review

Alahmadi Abdulhadi Mohammednasser M[1*], Nurul Azmir[2], Farra Aidah Jumuddin[3]

[1]School of Medicine, Lincoln University College, Malaysia, a.hadi-2@hotmail.com

[2]School of Medicine, Lincoln University College, Malaysia, dr.nurulazmir@lincoln.edu.my

[3]School of Medicine, Lincoln University College, Malaysia, farraaidah@lincoln.edu.my

[*]Corresponding Author's E-mail: a.hadi-2@hotmail.com

-675

Abstract: *The rapid advancement of digital technologies has transformed nursing education and expanded the ways nurses and nursing students develop quality and safety competencies. Digital learning, e-learning, virtual simulation, informatics-based education, and other technology-supported approaches are increasingly used to prepare nurses for safe, patient-centered, evidence-based, and high-quality care. Quality and Safety Education for Nurses (QSEN) provides a competency-based framework that emphasizes patient-centered care, teamwork and collaboration, evidence-based practice, quality improvement, safety, and informatics. However, the determinants influencing digital QSEN education remain dispersed across nursing education, informatics, patient safety, quality improvement, and digital learning literature. Therefore, this systematic review aimed to identify and synthesize the determinants of digital QSEN education among nurses and nursing students. Relevant studies addressing QSEN competencies, digital nursing education, e-learning, virtual simulation, informatics competence, patient safety education, teamwork, adverse event reporting, quality improvement, and digital self-efficacy were reviewed. A total of 30 studies were included and organized using a literature review matrix. The findings were synthesized narratively into educational, individual, clinical, organizational, and technological determinants. The review revealed that effective digital QSEN education is shaped by competency-based curriculum design, active digital learning strategies, informatics competence, digital health literacy, technology readiness, clinical relevance, leadership support, patient safety culture, and organizational readiness. Clarifying these determinants supports stronger digital nursing education and guides future research, curriculum development, and clinical practice planning.*

Keywords: Digital nursing education; QSEN; patient safety; nursing informatics; quality improvement; systematic review.

1. Introduction

Quality and Safety Education for Nurses (QSEN) has become an essential framework for preparing nurses to provide safe, effective, patient-centered, and evidence-based care in increasingly complex healthcare systems. The QSEN framework emphasizes six major competencies: patient-centered care, teamwork and collaboration, evidence-based practice, quality improvement, safety, and informatics. These competencies are important because nurses are expected to reduce preventable harm,

participate in quality improvement, use evidence in clinical decisions, communicate effectively with healthcare teams, and apply informatics in care delivery. The expansion of QSEN scholarship shows that quality and safety education has become a central concern in nursing education, clinical practice, professional development, and leadership. However, the literature also indicates that QSEN has not been equally developed across all practice areas, countries, or outcome-based research contexts. The bibliometric analysis of QSEN literature indicated that while QSEN publications have grown over time, stronger global collaboration and more focus on practice outcomes are still warranted (Sherwood et al., 2023). There is also an inkling from the nursing student perspective that some QSEN competencies are more apparent than others as students often report being better prepared to carry out patient Centered care when they graduate compared to quality improvement (Cengiz & Yoder, 2020). In graduate nursing education, a similar concern can be seen in the use of QSEN competencies rather than outcome data from projects assessing clinical practice (Ferro & Yoder, 2024).

The emergence of digital health, along with general trends in healthcare that are highly accelerated, present a new venue for QSEN education. Nursing education increasingly uses online learning, e-learning, digital educational resources, virtual simulation, augmented reality, electronic health record training, mobile applications, and clinical decision-support systems. These methods offer opportunities for increasing learning opportunities, assist in flexible training, and allow for the practice of high stakes safety skills in an environment acceptable to not put patients at risk. Validated digital resources for teaching health and safety among the health care workforce (Antoniolli et al., 2021). Rogers & Fyvie (2024) similarly optimized online educational experiences with the aim of improving nursing students' information literacy, evidence appraisal and ethical use of information. Active e-learning augmented one evidence-based nursing education course to leverage formative feedback from structured online discussions through student engagement with purposeful pedagogical practice and critical appraisals (Song & Park, 2021). Other nursing education methods include virtual reality simulation to support the clinical judgment and QSEN competency development (Shah et al., 2021). Similarly, virtual reality and augmented reality applications have been shown to improve patient safety learning, clinical competence, engagement, and practical skill development in nursing and healthcare education (Oh & Kim, 2023). Augmented reality can also connect theoretical knowledge with practical learning through immersive and interactive environments (Lampropoulos et al., 2025).

Informatics and digital competence are especially important determinants of digital QSEN education because nurses increasingly work in technology-supported clinical environments. Nurses must use electronic health records, digital documentation systems, clinical decision-support tools, health information systems, and digital communication platforms to support safe and high-quality care. Nursing informatics competence includes the knowledge, skills, and attitudes needed to use health information technologies effectively in education and clinical practice. A scoping review showed that nursing informatics competencies are relevant for nursing students, entry-level nurses, generalist nurses, and specialized nursing roles (Kleib et al., 2021). Education and training on electronic health record systems also require blended and workflow-based strategies, including e-learning, peer coaching, simulation, and clinical integration (Ting et al., 2021). Nursing informatics around quality and safety is not only educational content area, but a patient safety issue as well since this has been associated with improved safety outcomes in critical care settings including reduced medication errors and adherence to care processes (Shi et al., 2025). Nurses' digital health literacy and technology readiness also determine their competencies to use digital education products effectively and apply them in practice. Educational level, professional role, digital habits and attitudes toward technology affect nurses' digital health literacy (Comparcini et al., 2025). The readiness of nurse academics for technology is also important since confidence and engagement with technology on the part of

educators can affect how well online and digital learning is delivered to students (Browning et al., 2023).

Though digital QSEN education is increasingly being utilized, the considerations that inform QSEN education in a digital context are dispersed within literature on multiple topics, including: QSEN competency development, patient safety education, e-learning, adult learning theory and online nursing education, informatics and digital literacy for graduates of nursing programs, virtual simulation for nursing students, quality improvement methods in professional practice settings, interprofessional education and structures to support reporting of adverse events while fostering just culture. Research has also shown that online education can affect nursing students' knowledge, attitudes and skills in patient safety (Cho et al., 2022). The impact of e-learning has also enhanced the patient safety culture among emergency nurses (Najafi Ghezeljeh et al., 2021). It has been shown that quality improvement education for healthcare learners delivered digitally and online improves knowledge, attitudes, systems thinking self-efficacy (Reese et al., 2021). When learning activities are designed to address shared clinical problems, interprofessional digital and simulation-based learning can support teamwork, collaboration and patient safety in health professional students (Wong et al., 2022). Digital QSEN education should also teach principles of just culture and adverse event reporting, as nurses must be prepared to report their errors, communicate openly about them, and take part in system-level safety improvement (Glarcher & Vaismoradi, 2025). Thus, the aim of this systematic review is to identify and synthesize determinants of digital Quality and Safety Education for Nurses. The educational, individual, clinical, organizational and technological determinants that shape the design, implementation and outcomes of digital QSEN education for nurses are the focus of this review.

2. Methodology

This systematic review was designed to identify, classify, and synthesize the determinants of digital Quality and Safety Education for Nurses (QSEN). A systematic review approach was appropriate because the literature on digital QSEN education is distributed across several related areas, including QSEN competencies, patient safety education, nursing informatics, e-learning, virtual simulation, augmented reality, evidence-based practice, quality improvement, interprofessional education, adverse event reporting, and digital self-efficacy. A transparent and reproducible process of identification, screening, eligibility assessment and inclusion was followed. Previous QSEN reviews have examined the body of evidence on QSEN competencies, nursing students' perceptions, graduate nursing education and digital health systems through the lens of systematic, scoping or bibliometric approaches so structuring this review by specific integrative review method seems appropriate (Cengiz & Yoder, 2020). Similar review methods have also been employed to summarize evidence pertaining to QSEN publication rates and the application of QSEN competencies among graduate nurses (Sherwood et al., 2023). Similar reviews have also been conducted to highlight the relevance of related scopes such as nursing informatics competencies and digital clinical decision-making, which are key components of digital QSEN education (Kleib et al., 2021).

The search was conducted using databases commonly used in nursing and health sciences research, including PubMed, CINAHL, Scopus, Web of Science, ScienceDirect, and Google Scholar. The search strategy focused on peer-reviewed studies that addressed digital education, QSEN competencies, patient safety, informatics, and related quality and safety learning outcomes in nursing. The main search concepts included "Quality and Safety Education for Nurses," "QSEN," "digital education," "e-learning," "online learning," "virtual simulation," "augmented reality," "nursing

informatics," "digital health literacy," "patient safety education," "quality improvement education," "interprofessional education," "adverse event reporting," and "digital self-efficacy." The search was optimized to include studies involving nurses, nursing students, nurse educators and other members of the healthcare workforce in which results had applicability for quality and safety education within nursing. Key word searches for methodologies with regard to QSEN competencies, nursing informatics, electronic health record training and evidence-based nursing education have previously been used (Ting et al., 2021). Because these technologies are finding their way into nursing education for patient safety, clinical competence, teamwork, and evidence- based practice, studies on virtual reality, augmented reality, online learning, and digital platforms were also utilized in the search (Oh & Kim, 2023).

Eligibility criteria were established to ensure that the included studies were relevant to the purpose of the review. Studies were included if they focused on QSEN competencies, digital nursing education, patient safety education, nursing informatics, digital competence, evidence-based practice, quality improvement, teamwork, clinical decision-making, medication safety, adverse event reporting, just culture, or technology readiness among nurses or nursing students. Empirical studies, systematic reviews, scoping reviews, integrative reviews, bibliometric analyses, methodological studies, and educational intervention studies were considered eligible when they contributed evidence to the determinants of digital QSEN education. Studies were excluded if they were not related to nursing education or nursing practice, did not address digital or quality and safety education concepts (e.g., information security), lacked relevance to QSEN-related competencies, or offered insufficient information on educational determinants of implementation success or outcomes. This method allowed the review to capture direct QSEN studies and related digital education studies that add to the pool of knowledge on how technologies support learning in which QSEN competencies will be developed.

Data were extracted using a structured literature review matrix. The extraction process focused on author and year, QSEN or patient safety competencies, digital education method, informatics or digital competence, evidence-based practice or quality improvement, teamwork or interprofessional learning, clinical practice outcomes, and technology readiness or self-efficacy. A checkmark was used only when a concept was explicitly mentioned in the study, while blank cells indicated that the concept was not clearly reported. This matrix approach helped classify the 30 included studies according to their contribution to the review topic and supported the thematic synthesis of determinants. The final matrix showed that the included studies covered multiple dimensions of digital QSEN education, including QSEN competency development, digital education methods, informatics competence, evidence-based practice, quality improvement, teamwork, clinical outcomes, and technology readiness. This classification was then used to guide the results section and to organize the main determinant categories.

The synthesis was conducted narratively because the included studies varied in design, population, educational method, outcome measures, and review type. Quantitative pooling was not appropriate because the studies included systematic reviews, scoping reviews, cross-sectional studies, quasi-experimental studies, randomized trials, methodological studies, and educational evaluations. Instead, the evidence was grouped into recurring determinant categories: educational determinants, individual determinants, clinical determinants, organizational determinants, and technological determinants. This narrative synthesis approach was suitable because previous studies in this field also show heterogeneity in learning methods and outcomes, especially across e-learning, simulation, informatics, patient safety education, and quality improvement education (Song & Park, 2021). The final synthesis aimed to clarify how these determinant categories influence the design, implementation, and outcomes of digital QSEN education for nurses.

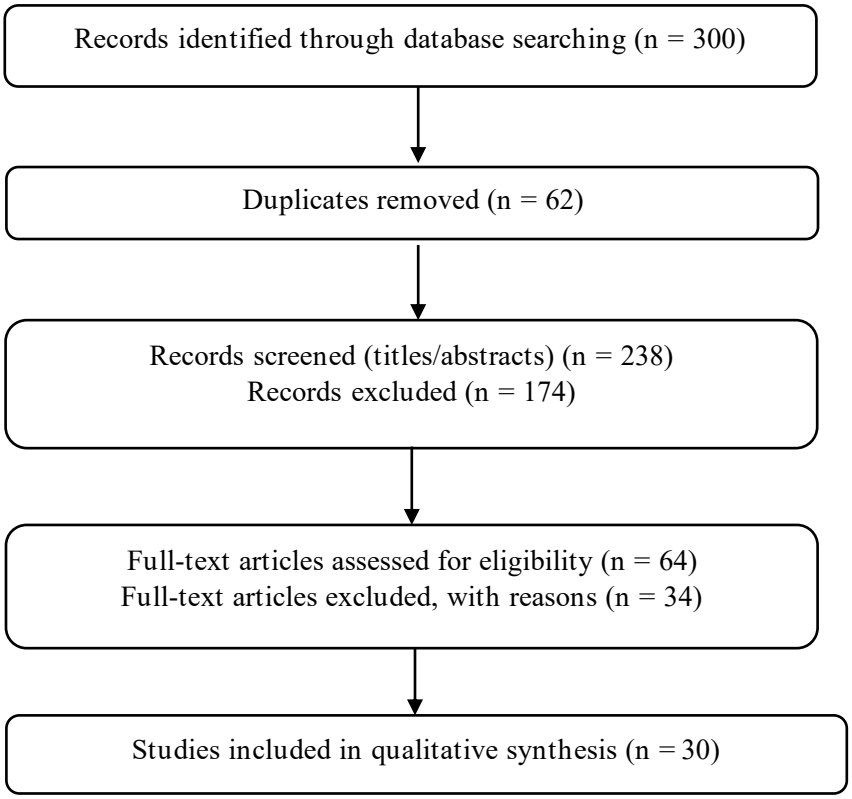

Figure 1. PRISMA 2020 Flow Diagram

3. Results

3.1 Study Selection and Characteristics

The final review included 30 studies that addressed the determinants of digital Quality and Safety Education for Nurses (QSEN) across nursing education, clinical practice, digital learning, informatics, patient safety, quality improvement, teamwork, and technology readiness. The included literature consisted of systematic reviews, scoping reviews, bibliometric analyses, integrative reviews, cross-sectional studies, quasi-experimental studies, randomized controlled trials, methodological validation studies, and educational intervention evaluations. This variation shows that digital QSEN education is not limited to one research tradition but is shaped by evidence from nursing education, clinical training, professional development, digital health, and patient safety science. The studies also differed in population focus, including nursing students, junior nurses, registered nurses, nurse academics, healthcare leaders, and interprofessional healthcare learners. This diversity strengthens the review because digital QSEN education requires attention to both learners and educators, as well as the organizational and clinical systems in which nurses use digital technologies.

The characteristics of the included studies indicate that QSEN and patient safety competencies were strongly represented across the review. QSEN competence was explored in a few of our studies and more specifically bibliometric evidence on QSEN scholarship, nursing students' perceptions of QSEN competencies; graduate nurses' use of QSEN competencies; & junior nurse knowledge attitudes and skills related to the effect of nurses participating in QSEN programs (Sherwood et al., 2023). Other studies were based on related safety outcomes, which comprised of patient safety culture, medication safety, adverse event reporting and just culture, in addition to the design of patient

safety management systems, which also represents a critical area for investigation that was included in this work as well (Najafi Ghezeljeh et al., 2021). Digital education approaches were also well represented, such as e-learning, online modules, mobile learning, virtual reality/augmented reality, serious games, flipped learning، and digital educational resources (Oh & Kim ، 2023)). The final significant area was Informatics and digital competence, which included studies on nursing informatics competencies, electronic health record education in undergraduates, eHealth literacy skills and digital self-efficacy.

Table 1 summarizes the 30 included studies using a literature review matrix. The matrix uses a fixed column set to classify each study according to whether it explicitly addressed QSEN or patient safety competencies, digital education methods, informatics or digital competence, evidence-based practice or quality improvement, teamwork or interprofessional learning, clinical practice outcomes, and technology readiness or self-efficacy. A checkmark was used only when the concept was explicitly present in the study, while blank cells indicate that the concept was not clearly reported. This approach allowed the review to identify the dominant themes across the included literature without adding subjective comments inside the table. The matrix shows that the strongest areas of concentration were QSEN or patient safety competencies, digital education methods, informatics or digital competence, and clinical practice outcomes. It also shows that teamwork or interprofessional learning and technology readiness or self-efficacy were less frequently represented, although they remain important determinants of digital QSEN education.

Table 1. Literature Review Matrix

No	Author(s) & Year	QSEN / Patient Safety Competencies	Digital Education Method	Informatics / Digital Competence	Evidence-Based Practice / Quality Improvement	Teamwork / Interprofessional Learning	Clinical Practice Outcomes	Technology Readiness / Self-Efficacy
1	Sherwood et al. (2023)	✓			✓		✓	
2	Cengiz & Yoder (2020)	✓			✓			
3	Ferro & Yoder (2024)	✓			✓		✓	
4	Antoniolli et al. (2021)		✓					
5	Rogers & Fyvie (2024)		✓	✓	✓			
6	Song & Park (2021)		✓		✓			
7	AlRatrout et al. (2025)	✓			✓		✓	
8	Shah et al. (2021)	✓	✓		✓		✓	✓
9	Wittenberg et al. (2025)	✓	✓				✓	
10	Altmiller & Pepe (2022)	✓	✓		✓		✓	✓
11	Oh & Kim (2023)	✓	✓				✓	

No	Author(s) & Year	QSEN / Patient Safety Competencies	Digital Education Method	Informatics / Digital Competence	Evidence-Based Practice / Quality Improvement	Teamwork / Interprofessional Learning	Clinical Practice Outcomes	Technology Readiness / Self-Efficacy
12	Lampropoulos et al. (2025)	✓	✓			✓	✓	
13	Kleib et al. (2021)			✓				
14	Shi et al. (2025)	✓		✓			✓	
15	Ting et al. (2021)		✓	✓			✓	
16	Comparcini et al. (2025)			✓			✓	✓
17	Browning et al. (2023)		✓					✓
18	Laakkonen et al. (2024)			✓			✓	✓
19	Loutfy et al. (2026)		✓	✓			✓	✓
20	Cho et al. (2022)	✓	✓				✓	
21	Najafi Ghezeljeh et al. (2021)	✓	✓				✓	
22	Reese et al. (2021)		✓		✓	✓	✓	✓
23	Chao et al. (2022)		✓		✓		✓	
24	Wong et al. (2022)		✓			✓	✓	
25	Jiang et al. (2024)	✓				✓	✓	
26	Hants et al. (2023)			✓			✓	
27	Hills et al. (2022)	✓					✓	
28	Zhao et al. (2025)	✓	✓		✓		✓	
29	Glarcher & Vaismoradi (2025)	✓			✓	✓	✓	
30	Conte et al. (2025)			✓			✓	✓

3.2 Determinants of Digital QSEN Education

The results demonstrate that digital QSEN education is influenced by five interdependent factors: educational design, digital learning methods, informatics competence, learner characteristics and organizational support. QSEN competencies were incorporated into curricula, online modules, simulation activities, instruction focused on evidence-based practice and training in quality improvement as educational determinants. Multiple studies ascertained that QSEN-related learning is reinforced when it is based on competency, designed in structured courses, and linked to objective measures of knowledge, skill, and attitude. Yet, evidence also shows that QSEN competencies are not always integrated equally throughout nursing curricula, with patient centered care seemingly more

apparent than quality improvement or informatics (Cengiz & Yoder, 2020). Graduate nursing education also showed variation in the use of QSEN competencies, particularly in relation to clinical application and outcome measurement (Ferro & Yoder, 2024). Digital education methods, including e-learning, online modules, flipped learning, mobile learning, virtual reality, augmented reality, and serious games, appeared as major determinants because they influenced how learners interacted with quality and safety content (Song & Park, 2021). Virtual and augmented reality were especially important because they allowed learners to practice clinical judgment, patient safety, teamwork, and practical skills in immersive environments without exposing patients to risk (Oh & Kim, 2023).

Informatics and digital competence also emerged as central determinants because digital QSEN education depends on nurses' ability to use health technologies effectively in learning and practice. Nursing informatics competencies were repeatedly linked to safe documentation, electronic health records, clinical decision-making, and patient safety outcomes (Kleib et al., 2021). Training on electronic health record systems further showed the importance of blended, workflow-based education that includes e-learning, peer coaching, simulation, and clinical relevance (Ting et al., 2021). Individual determinants included digital health literacy, technology readiness, digital self-efficacy, educational level, professional role, and attitudes toward technology. Nurses with stronger digital health literacy and more positive digital attitudes were better positioned to engage with technology-supported education and clinical practice (Comparcini et al., 2025). Another important aspect was technology readiness among nurse academics because educators have a crucial role in shaping the nature of digital learning as their confidence and willingness to use technology impact delivery (Browning et al., 2023). Organizational determinants were leadership support, engagement of staff, positive safety culture, digital resource access and error-related reporting feedback and learning systems. These organizational conditions are essential because digital QSEN education is most effective when learning is supported by a culture of safety, transparency, and continuous improvement (Glarcher & Vaismoradi, 2025).

3.3 Outcomes Associated with Digital QSEN Education

The studies included in this review indicated digital QSEN education as a favorable learning and competency outcome (e.g., knowledge, attitudes, skills, confidence, information literacy, evidence-based practice competence competency and patient safety competency) among nursing students. Educational programs with a focus on Quality and Safety Education for Nurses (QSEN) enhanced junior nurses' cognitive, technical and interpersonal competencies relevant to quality and safety, demonstrating that coordinated education improves novice nurses' preparedness for safe performance of nursing practice (AlRatrout et al., 2025). Digital patient safety online education also had a positive impact on nursing students' knowledge, attitudes and skills, indicating that synchronous digital education is a valid alternative for the development of patient safety competences (Cho et al., 2022). These findings show that digital QSEN education can strengthen multiple QSEN-related learning outcomes when the educational method is aligned with the intended competency.

Digital QSEN education was also associated with clinical, behavioral, and practice-related outcomes. E-learning improved patient safety culture among emergency nurses, indicating that digital education can influence safety-related attitudes in clinical settings (Najafi Ghezeljeh et al., 2021). Nursing informatics was linked to patient safety outcomes in critical care, including reduced medication errors, improved screening practices, better care bundle compliance, and prevention of adverse events (Shi et al., 2025). Digital training platforms also improved adverse event reporting awareness, intention, and behavior among nurses, showing that technology-supported education can influence reporting practices and quality improvement behaviors (Zhao et al., 2025). Interprofessional digital

and simulation-based learning facilitated teamwork, communication, and collaborative problem-solving which are identified as key domains for safe care delivery (Wong et al., 2022). However, the results also revealed that many studies centered only on short-term outcomes such as knowledge, confidence, satisfaction and perceived competence; even fewer studies reported long term impacts on patient outcomes or sustained behavior change or organizational change. The observed gap also indicates that studies of QSEN education via digital methods in the future will need improved designs and longer follow-up periods, as well as standardized outcome measures, in order to ascertain whether such educational experiences yield persistent gains in aspects of nursing aimed at enhancing patient safety.

4. Discussion

4.1 Interplay of Educational, Individual, Clinical, and Organizational Antecedents

The findings of this systematic review show that digital QSEN education is shaped by the interaction of educational, individual, clinical, and organizational antecedents rather than by a single factor. Educational antecedents include curriculum design, competency-based learning, active e-learning, digital simulation, evidence-based practice activities, and quality improvement training. These antecedents are key as just exposure to digital tools alone will not lead to deep learning unless they can be demonstrated to connect with defined QSEN outcomes linked to structured learning objectives. Prior evidence suggests that the nursing curriculum may not provide even coverage for QSEN competencies with quality improvement more often receiving less focus than patient-centered care (Cengiz & Yoder, 2020). This imbalance indicates that digital QSEN education may need to be explicitly organized around all quality and safety competencies without a simpler emphasis on general awareness of safety. This goal can be supported by active e- learning and online learning experiences comprising discussion, interaction, critical appraisal, and applied learning tasks (Song & Park 2021). Similarly, virtual reality and augmented reality can strengthen safety education when they are aligned with clinical judgment, patient safety management, and practical skill development (Oh & Kim, 2023). Therefore, the educational value of digital QSEN depends on how well digital methods are integrated with competency-based nursing education.

Individual antecedents also influence the effectiveness of digital QSEN education because nurses and nursing students vary in their digital health literacy, informatics competence, technology readiness, digital self-efficacy, and attitudes toward technology. These learner-related factors determine whether digital education is experienced as supportive, confusing, engaging, or burdensome. Digital health literacy has been shown to differ according to nurses' educational levels, professional roles, habits, and attitudes toward digital technologies (Comparcini et al., 2025). Nursing students' eHealth literacy and informatics competencies are also connected, which indicates that digital proficiency should be developed systematically within nursing curricula (Loutfy et al., 2026). Educators' technology readiness is equally important because nurse academics are responsible for designing, delivering, and evaluating digital learning experiences (Browning et al., 2023). When the digital content involves real-life safety situations such as clinical decision making, medication safety, adverse event reporting and teamwork with follow-up to patient care outcomes, these provide clinical antecedents that influence QSEN education digitally too. The digital health systems utilized can aid decision-making among nurses but incomplete integration of the nursing process may lead to restricted visibility of nursing work and limiting patient outcome evaluation (Hants et al., 2023). Organizational factors such as leadership support, safety culture, access to digital resources and staff engagement and blame-free reporting processes help in determining the possibility of translating the digital QSEN education from learning related needs to continuous practice improvement. Just culture is particularly important

because it encourages error reporting, open communication, and system-level learning rather than individual blame (Glarcher & Vaismoradi, 2025).

4.2 Policy, Practical, Educational, and Theoretical Implications

The findings have important policy implications for nursing education and healthcare organizations. Digital QSEN education should be supported by policies that require systematic integration of quality, safety, informatics, evidence-based practice, and digital competence into nursing curricula and continuing professional development. The increasing recognition of QSEN in competency-based nursing education shows the need for stronger institutional and national standards that ensure all nurses are prepared for safe, technology-supported care (Sherwood et al., 2023). Policy makers should also recognize that digital competence is not limited to technical skills; it is connected to patient safety, communication, documentation, clinical decision-making, and quality improvement. Therefore, policies should support access to digital platforms, simulation technologies, electronic health record training, and standardized assessment tools. Healthcare organizations should also invest in digital leadership because leaders influence digital implementation, staff development, and organizational readiness for technology-supported care (Laakkonen et al., 2024). Without policy-level support, digital QSEN education may remain fragmented, dependent on individual educators, and unevenly implemented across institutions.

In practice, the review suggests that digital QSEN education should be designed as a clinically relevant and outcomes-oriented process. Nurses need digital education that helps them apply quality and safety principles in real care situations, including medication safety, adverse event reporting, patient safety culture, and clinical decision-making. E-learning has shown positive effects on patient safety culture among emergency nurses, which supports its use in clinical professional development (Najafi Ghezeljeh et al., 2021). WeChat-based training also improved adverse event reporting awareness, intention, and behavior, showing that digital platforms can influence safety behaviors when they address practical barriers to reporting (Zhao et al., 2025). Educationally, nursing programs should use blended approaches that combine online learning, simulation, peer coaching, electronic health record training, and reflective activities. Training on electronic health record systems should be connected to nurses' clinical workflows rather than taught as an isolated technical skill (Ting et al., 2021). Theoretically, digital QSEN education can be understood as an integration of competency-based education, informatics competence, patient safety culture, and experiential learning. This means that digital QSEN education should not be treated only as online content delivery; instead, it should be viewed as a structured model for developing nurses' knowledge, skills, attitudes, confidence, and safety behaviors in technology-enabled healthcare environments.

4.3 Comparison with Existing Reviews, Limitations, and Future Research

The findings of this review are consistent with previous QSEN and digital nursing education reviews but extend them by integrating evidence across multiple related domains. Earlier QSEN reviews showed that QSEN scholarship has expanded, but gaps remain in global collaboration, practice impact, and outcome measurement (Sherwood et al., 2023). Reviews of nursing students' perceptions also showed that QSEN competencies are not equally represented, especially because quality improvement is often less visible in curricula (Cengiz & Yoder, 2020). This review lends weight to those findings but adds that when competency-based and clinically relevant, digital learning methods can help fill two important gaps. Similar results were noted in an informatics literature search that indicated nursing informatics competency is a requirement for safe documentation, digital communication, electronic health record usage and patient safety outcomes (Kleib et al., 2021).

Likewise, the evidence for virtual reality, augmented reality, serious games and digital flipped learning demonstrates that technology to support patient safety (for example), evidence-based practice, teamwork and clinical competence in health care is feasible only when thoughtfully designed and evaluated (Lampropoulos et al., 2025). By contrast, the many studies still addressing only short-term educational outcomes, which are placed over longer patient, organizational or behavioral outcomes.

This review has several limitations. First, the included studies varied in design, population, intervention type, outcome measures, and educational context, which limited the possibility of statistical synthesis. Second, the reviewed literature included systematic reviews, scoping reviews, cross-sectional studies, quasi-experimental studies, randomized trials, and educational evaluations, which means that the strength of evidence was not uniform across all determinant categories. Third, the studies mostly reported self-reported outcomes including confidence, perceived competence, satisfaction, attitudes and readiness. Only a few studies evaluated objective clinical outcomes or long-term changes in patient safety indicators. The field of digital QSEN education is rapidly evolving, and as such newer technologies (e.g., artificial intelligence, advanced simulation, adaptive learning, data-driven feedback) may not yet be present in the evidence base. Future studies should test the effectiveness, and long-term improvement in nursing practice and patient outcomes resulting from digital QSEN education by using more rigorous experimental or longitudinal designs. Future research is needed to develop standardized measures of digital QSEN competencies, inter-country and healthcare system comparisons of digital education models and analyses of the impact of organizational culture, leadership & resources on delivery. Additional investigation into the interplay of digital self-efficacy, digital health literacy and informatics competence with patient safety culture and clinical performance amongst nurses and nursing students must also be conducted (Conte et al., 2025).

5. Conclusion

This systematic review identified the main determinants of digital Quality and Safety Education for Nurses (QSEN) and showed that effective digital QSEN education depends on the interaction of educational, individual, clinical, organizational, and technological factors. The results suggest that digital epigean can support the development of competence for QSEN when it is congruently competency based, clinically relevant, and supported by appropriate digital resources. the study aimed to synthesize evidence on the effectiveness of e-learning and other digital blended learning courses in improving nurses' and nursing students' knowledge, attitudes, confidence, digital competence, patient safety awareness, and quality improvement readiness. Mixed methods systematic reviews were used for the study. However, these advantages are realized when digital learning is not treated as a cheap content-distribution channel, but rather as an organized educational approach tied to patient safety, informatics, evidence-based practice, teamwork and team formation among clinicians and continuous quality improvement.

Overall, the review highlights that digital QSEN education is essential for preparing nurses to work safely and effectively in modern healthcare environments. Nurses need not only quality and safety knowledge, but also the digital literacy, informatics competence, technology confidence, and clinical judgment required to apply these competencies in practice. The review also shows that organizational support, leadership, safety culture, and access to appropriate digital resources are necessary for translating digital learning into practice improvement. Although the evidence supports the value of digital QSEN education, more attention is needed to long-term outcomes, standardized competency

assessment, and measurable impacts on clinical practice and patient safety. Future digital QSEN education should therefore be designed as an integrated, outcomes-oriented approach that prepares nurses for safe, high-quality, and technology-enabled healthcare delivery.

References

AlRatrout, S., Abu Khader, I., ALBashtawy, M., Asia, M., Alkhawaldeh, A., & Bani Hani, S. (2025). The impact of The Quality and Safety Education (QSEN) program on the knowledge, skills, and attitudes of junior nurses. *PLoS One*, *20*(1), e0317448.

Altmiller, G., & Pepe, L. H. (2022). Influence of technology in supporting quality and safety in nursing education. *The Nursing Clinics of North America*, *57*(4), 551.

Antoniolli, S. A. C., Assenato, A. P. R., Araújo, B. R., Lagranha, V. E. D. C., Souza, L. M. D., & Paz, A. A. (2021). Construction and validation of digital education resources for the health and safety of workers. *Revista Gaúcha de Enfermagem*, *42*, e20200032.

Browning, M., Banik, B., Bourke, S., Abdelkader, A., Anish, L., & Muduwa, M. (2023). The impact of COVID 19 restrictions on Australian nurse academics attitudes to technology: A survey of technology readiness index 2.0. *Nurse Education in Practice*, *71*, 103719.

Cengiz, A., & Yoder, L. H. (2020). Assessing nursing students' perceptions of the QSEN competencies: A systematic review of the literature with implications for academic programs. *Worldviews on Evidence-Based Nursing*, *17*(4), 275-282.

Chao, W. Y., Huang, L. C., Hung, H. C., Hung, S. C., Chuang, T. F., Yeh, L. Y., & Tseng, H. C. (2022, July). Effectiveness of digital flipped learning evidence-based practice on nurses' knowledge, attitude, and practice: A quasi-experimental trial. In *Healthcare* (Vol. 10, No. 7, p. 1257). MDPI.

Cho, D. B., Lee, W., Kim, S. Y., & Choi, S. (2022). Effect of online education on the knowledge on, attitudes towards, and skills in patient safety for nursing students in Korea: a mixed-methods study. *Journal of educational evaluation for health professions*, *19*.

Comparcini, D., Simonetti, V., Tomietto, M., Pastore, F., Totaro, M., Ballerini, P., ... & Cicolini, G. (2025). The Relationship Between Nurses' Digital Health Literacy and Their Educational Levels, Professional Roles, and Digital Attitudes: A Cluster Analysis Based on a Cross-Sectional Study. *Journal of Clinical Nursing*, *34*(7), 2885-2897.

Conte, G., Arrigoni, C., Magon, A., De Angeli, G., Paglione, G., Baroni, I., ... & Caruso, R. (2025, September). Unlocking the Determinants of Digital and Technological Self-Efficacy: Insights from a Cross-Sectional Study Among Nurses and Nursing Students. In *Healthcare* (Vol. 13, No. 17, p. 2208). MDPI.

Ferro, A. L., & Yoder, L. H. (2024). A scoping review of graduate nurses' education and use of QSEN competencies. *Military Medicine*, *189*(Supplement_1), 45-50.

Glarcher, M., & Vaismoradi, M. (2025). Promoting just culture in nursing education: A systematic integrative review on enhancing patient safety. *Nurse education today*, *152*, 106776.

Hants, L., Bail, K., & Paterson, C. (2023). Clinical decision-making and the nursing process in digital health systems: an integrated systematic review. *Journal of clinical nursing*, *32*(19-20), 7010-7035.

Hills, M., Teoh, S. W. K., & Lebedevs, T. (2022). Evaluation of the effectiveness and staff acceptance of education strategies to improve medication safety. *Pharmacy Education*, *22*(1), 428-435.

Jiang, Y., Cai, Y., Zhang, X., & Wang, C. (2024). Interprofessional education interventions for healthcare professionals to improve patient safety: a scoping review. *Medical Education Online*, *29*(1), 2391631.

Kleib, M., Chauvette, A., Furlong, K., Nagle, L., Slater, L., & McCloskey, R. (2021). Approaches for defining and assessing nursing informatics competencies: a scoping review. *JBI evidence synthesis*, *19*(4), 794-841.

Laakkonen, N., Jarva, E., Hammarén, M., Kanste, O., Kääriäinen, M., Oikarinen, A., & Mikkonen, K. (2024). Digital competence among healthcare leaders: a mixed-methods systematic review. *Journal of Nursing Management*, *2024*(1), 8435248.

Lampropoulos, G., Fernández-Arias, P., Del Bosque, A., & Vergara, D. (2025). Augmented reality in health education: Transforming nursing, healthcare, and medical education and training. *Nursing Reports*, *15*(8), 289.

Loutfy, A., Elzeiny, A., Van Belkum, C., El-Monshed, A. H., Al-Helali, A., Rashed, A., ... & Marwan, S. (2026). Digital proficiency: a self-assessment of eHealth literacy and informatics competencies among nursing students. *Informatics for Health and Social Care*, 1-16.

Najafi Ghezeljeh, T., Karimpour, R., Omrani, S., Haghani, S., & Emami, A. (2021). The effects of e-learning on patient safety culture in emergency nurses. *Journal of Client-Centered Nursing Care*, *7*(3), 215-226.

Oh, J. W., & Kim, J. E. (2023). Effectiveness of a virtual reality application-based education programme on patient safety management for nursing students: A pre-test–post-test study. *Nursing Open*, *10*(12), 7622-7630.

Reese, D., Dolansky, M. A., Moore, S. M., Bolden, H., & Singh, M. K. (2021). Quality improvement education innovation: evaluation of Coursera MOOC 'Take the Lead on Healthcare Quality Improvement'. *Journal of Research in Nursing*, *26*(1-2), 62-78.

Rogers, T., & Fyvie, A. (2024). Using Nursing and Information Literacy Standards to Design an Online Learning Experience. *Journal of Nursing Education*, *63*(9), 638-642.

Shah, M., Siebert-Evenstone, A., Eagan, B., & Holthaus, R. (2021, May). Modeling educator use of virtual reality simulations in nursing education using epistemic network analysis. In *2021 7th International Conference of the Immersive Learning Research Network (iLRN)* (pp. 1-8). IEEE.

Sherwood, G., Jones, C. B., Conklin, J. L., & Dodd, A. (2023). Quality and safety education for nurses: A bibliometric analysis. *Journal of Nursing Scholarship*, *55*(5), 914-925.

Shi, Q., Wotherspoon, R., & Morphet, J. (2025). Nursing informatics and patient safety outcomes in critical care settings: A systematic review. *BMC nursing*, *24*(1), 546.

Song, C. E., & Park, H. (2021). Active learning in e-learning programs for evidence-based nursing in academic settings: A scoping review. *The Journal of Continuing Education in Nursing*, *52*(9), 407-412.

Ting, J., Garnett, A., & Donelle, L. (2021). Nursing education and training on electronic health record systems: an integrative review. *Nurse education in practice*, *55*, 103168.

Wittenberg, E., Goldsmith, J. V., Maffucci, J., Burt, L., Szwajnos, E., & Lee, H. G. (2025). Competency-based education for teaching the concept of communication. *Journal of Professional Nursing*.

Wong, J. Y. H., Ko, J., Nam, S., Kwok, T., Lam, S., Cheuk, J., ... & Wai, A. K. C. (2022). Virtual ER, a serious game for interprofessional education to enhance teamwork in medical and

nursing undergraduates: development and evaluation study. *JMIR Serious Games*, *10*(3), e35269.

Zhao, X., Zhao, L., Li, G., Yang, W., Wang, H., & Yang, Y. (2025). Reducing nurses' barriers to reporting adverse events using a wechat-based cognitive load training platform: an open-label, randomized controlled trial. *Risk Management and Healthcare Policy*, 947-961.