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Digital technologies in nursing: An umbrella review

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ABSTRACT

Background: Digital technologies promise to reduce nurses' workload and increase quality of care. However, considering the plethora of single and review studies published to date, maintaining a comprehensive overview of digital technologies' impact on nursing and effectively utilizing available evidence is challenging.
Objective: This review aims (i) to map published reviews on digital nursing technologies, based on their aims and the specific technologies investigated, to synthesize evidence on how these technologies' uses is associated with (ii) nurses' work-related and organizational factors, professional behavior, and health and work safety and (iii) ethically relevant outcomes for people in need of care.
Design: Preregistered overview of reviews (PROSPERO-ID: CRD42023389751).
Setting(s): We searched for systematic reviews in eight databases, five key journals, and reference lists of included reviews published in English until May 21, 2024.
Methods: We used the AMSTAR 2 checklist to assess the methodological quality of included reviews reporting associations with nursing outcomes. The extracted data were analyzed by their frequency and narratively synthesized.
Results: We identified 213 reviews on digital technologies' uses in the nursing sector. Most of these focused on information and communication technologies. The most frequently reported research objectives encompass technology usage and/or general experiences with it and technology-related consequences for care recipients. Regarding work-related and organizational factors, beneficial impacts were found for the execution of nursing tasks, information management and job control. Depending on the technology type, reviews reported mixed effects for documentation activities, communication/collaboration and mainly negative effects on nurses' workload. Concerning occupational safety and health-related and further nurse outcomes, reviews reported mostly positive effects on nurses' job satisfaction and professional competence. Adverse effects related to mental and physical strain, such as increased frustration, fatigue, and burnout. Regarding ethically relevant outcomes, robotic and telecare technologies had the most reported findings. Most evidence concerned effects on the principles of beneficence/non-maleficence and respect for autonomy.
Conclusions: Digital nursing technologies' legitimacy hinges on their impact on patient outcomes and nurses' work, safety, and health. This review identifies a diverse array of these technologies, with both positive and negative effects. However, due to narrative limitations, meta-analysis was impractical. Future research should quantitatively assess the effects of various digital nursing technologies on work, safety, health, and ethical outcomes.
Tweetable abstract: Research on digital tech in nursing lacks focus on key work factors, occupational health and ethical outcomes. #NursingTech #ResearchGaps

What is already known

- Digital technologies are increasingly being introduced in the healthcare sector and will influence nurses' work and health.
- Numerous single studies and reviews analyze digital technologies in nursing.
- Given the plethora of studies published to date, maintaining a comprehensive overview of digital technologies' impact on nursing and effectively utilizing available evidence is challenging.

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What this paper adds

- Mapping of published reviews on digital nursing technologies, based on their aims and the specific technologies investigated.
- Synthesis of evidence on how the usage of various digital technologies is associated with nurses' work-related and organizational factors as well as related individual outcomes.
- Synthesis of evidence on how the usage of various digital technologies is associated with ethically relevant outcomes for people in need of care.

1. Background

Amid healthcare challenges like workforce shortages and aging populations, digital technologies offer the chance to enhance job demands for healthcare professionals and elevate care quality (European Union, 2021; WHO, 2016a). Consequently, diverse scientific fields, including engineering, medicine, nursing, psychology, philosophy, and sociology have seen a surge in studies on digital healthcare technologies in recent years.

The interdisciplinary nature and diverse scope of the present research landscape render navigation complex and challenging. Furthermore, the vast majority of studies and reviews investigating the potential utility of digital technologies in healthcare seem to focus on physician or patient outcomes. However, professional nurses account for approximately 59 % of the world's healthcare workforce (WHO, 2020) and are considered key users of digital technologies (Rouleau et al., 2017; WHO, 2019). Nevertheless, numerous single studies and reviews also analyze digital technologies in nursing. Given the plethora of studies published to date, maintaining a comprehensive overview of digital technologies' impact on nursing and effectively utilizing available evidence is challenging.

Digital nursing technologies encompass a broad spectrum of tools designed to support nursing practice. Unlike non-digital technologies, they typically enable data processing and often allow tasks to be performed more efficiently, remotely, and with greater accuracy. Examples include electronic health records (for streamlining patient documentation), telecare systems (for remote patient monitoring), robots (to assist with routine tasks), and decision support systems (to aid clinical decision-making). A more detailed overview can be found in Huter et al. (2020).

As work tools, digital technologies can influence work demands and organizational structures, thereby affecting employee stress, safety and health (Parker and Grote, 2022). For example, a review by Wisner et al. (2019) showed that while the use of electronic health records can improve interprofessional communication, they may also increase nurses' cognitive load. Early identification of these changes is crucial to optimize benefits and prevent potential harm to employees and patients. In fact, decent work constitutes an overarching goal in the digital world (Deshpande et al., 2021; United Nations, 2015), and according to the International Occupational Safety and Health Convention (C155; ILO, 1981) it is mandatory to ensure that digitalized workplaces, including working tools, equipment, and processes are safe and do not bear work-related health risks. However, to the best of our knowledge, no systematic overview has yet considered the impact of *various* digital nursing technologies on work-related and organizational factors, occupational safety or health-related outcomes. Several overviews of reviews have examined digital nursing technologies, focusing on specific technologies such as telehealth applications (Spelten et al., 2021; McLean et al., 2013; Zhang et al., 2023). They found, for example, that telehealth technologies can improve the accuracy of nursing care and provide a cost-effective solution, particularly in the care of the elderly. An overview of reviews by Huter et al. (2020) examined various digital technologies but focused solely on effectiveness outcomes. The review found that various digital nursing technologies have the potential to improve efficiency through improved patient safety, streamlined documentation and improved workflows.

Given the large number of relevant reviews, we chose to conduct an umbrella review to map, aggregate and synthesize findings from multiple systematic reviews. This approach enables us to offer a thorough overview of the topic across different settings and interventions. Additionally, we aimed to identify potential evidence gaps to help direct future systematic reviews and prioritize research efforts.

In addition, ethical aspects must be considered when developing digital technologies in the nursing sector. Nurses regularly make complex decisions involving multiple perspectives and individual care situations, often with significant moral consequences (Rainer et al., 2018). The risk of neglecting patient interests and repercussions in care processes is independent of digital technologies but can increase with their use, particularly for technologies that affect human relationships (Schlicht and Räker, 2023). Such technologies have the potential to alter the dynamics between nurses and patients, fundamentally challenging and/or transforming "traditional cultures of caring ethics" (Ramvi et al., 2023, p. 1124). This concerns, for example, tendencies toward risky and unsafe work behaviors, changing power dynamics and opportunities for empathic interaction between nurses and care-recipients. To ensure ethical alignment, information on the association of digital technologies with ethically relevant outcomes for people in need of care is needed (Brey, 2009). However, to our knowledge, no review has yet synthesized evidence on this issue for various digital nursing technologies' usage.

Against this background, the present overview of reviews aims to (i) map existing reviews on digital nursing technologies, based on their aims and the specific technologies investigated, and synthesize evidence on how these technologies' use is associated with (ii) work-related and organizational factors, professional behavior, health- and safety-related outcomes among nurses (including midwives, see American Nurses Association, 2023), as well as (iii) ethically relevant outcomes for people in need of care. Based on this, we draw conclusions regarding the implications for future research and practice.

2. Methods

Our methodological approach followed the recommendations of Higgins et al. (2023), McCrae et al. (2015), and Smith et al. (2011). The review board included five scientists with methodological expertise, long-lasting expertise in the healthcare sector, and comprehensive knowledge on the digitalization of in-person-related tasks. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (ID: CRD42023389751; https://www.crd.york.ac.uk/prospero).

2.1. Research questions

Our review addresses the following questions:

Q1. How many reviews empirically investigating the use of digital technologies in the nursing sector have been published since 2010, which digital technologies were investigated, and which research objectives were stated by the authors?
Q2. What associations between digital technologies' use and work-related or organizational factors, occupational safety and health, and distal nurse outcomes are reported in these reviews?
Q3. What associations between digital technologies' use and ethically relevant outcomes for people in need of care are reported in these reviews?

2.2. Inclusion criteria

Reviews were included if they (a) were systematic reviews (with or without meta-analysis), that is, those reporting clearly stated objectives, a reproducible methodology, eligibility criteria for reviews, databases, and the number of included studies; (b) were written in English; (c) investigated a specified digital technology; (d) investigated a technology that is typically used in the nursing context (and/or, at least half of the included single studies had to address nurses within the population(s) under research); (e) were published between January 01, 2010 and May 21, 2024; and (f) were published in a peer-reviewed journal.

2.3. Search strategy

We conducted a systematic search in the electronic databases Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Library, EBSCOhost (including PsycINFO, PsycArticles, and Psyndex), Excerpta Medica database (Embase) (excluding PubMed/ MEDLINE), ProQuest, PubMed, Scopus, and Web of Science on April 13., 2022. The search was updated on May 21, 2024. Additionally, we manually searched five key journals in the field of nursing studies (International Journal of Nursing Studies, International Journal of Mental Health Nursing, Journal of Nursing Management, Intensive and Critical Care Nursing, and Worldviews on Evidence-Based Nursing). We also checked the reference lists of included reviews to reduce the risk of missing relevant reviews.

The keywords for each of these databases are listed in Supplementary material S1. The search terms were based on the PICOS scheme, excluding the comparison and outcome components, as we aimed to be inclusive and provide a broad overview of technologies used in or developed for the nursing sector. To develop the search string, we analyzed and integrated search strings used in other published reviews related to digital technologies in healthcare, as well as available MeSH terms. The search terms were discussed with experts for safety and health in a digitalized world of work from the German FIOSH and experienced librarians.

The bibliographic software package EndNote (version X9.3.3) was used to manage all articles analyzed in the research process (both included and excluded reviews).

2.4. Study selection

Fig. 1 shows the flowchart of our literature search (following the PRISMA 2009 flow diagram of Moher et al., 2009). From the 10.107 records initially found, we excluded 3.725 duplicates, leaving 6.382 records for title and abstract screening. Initially, 50 references were selected and screened by all authors. This was followed by a discussion of criteria for inclusion and exclusion due to moderate agreement ($\kappa = 0.49$, 68 %). Another set of 50 references was then screened by pairs of authors, with subsequent discussion. At this stage, the interrater agreement was 84 %, i. e., there was 'sufficient/good' agreement between the raters with Fleiss' kappa statistic $\kappa = 0.70$ (Fleiss, 1971). Each author continued to screen a

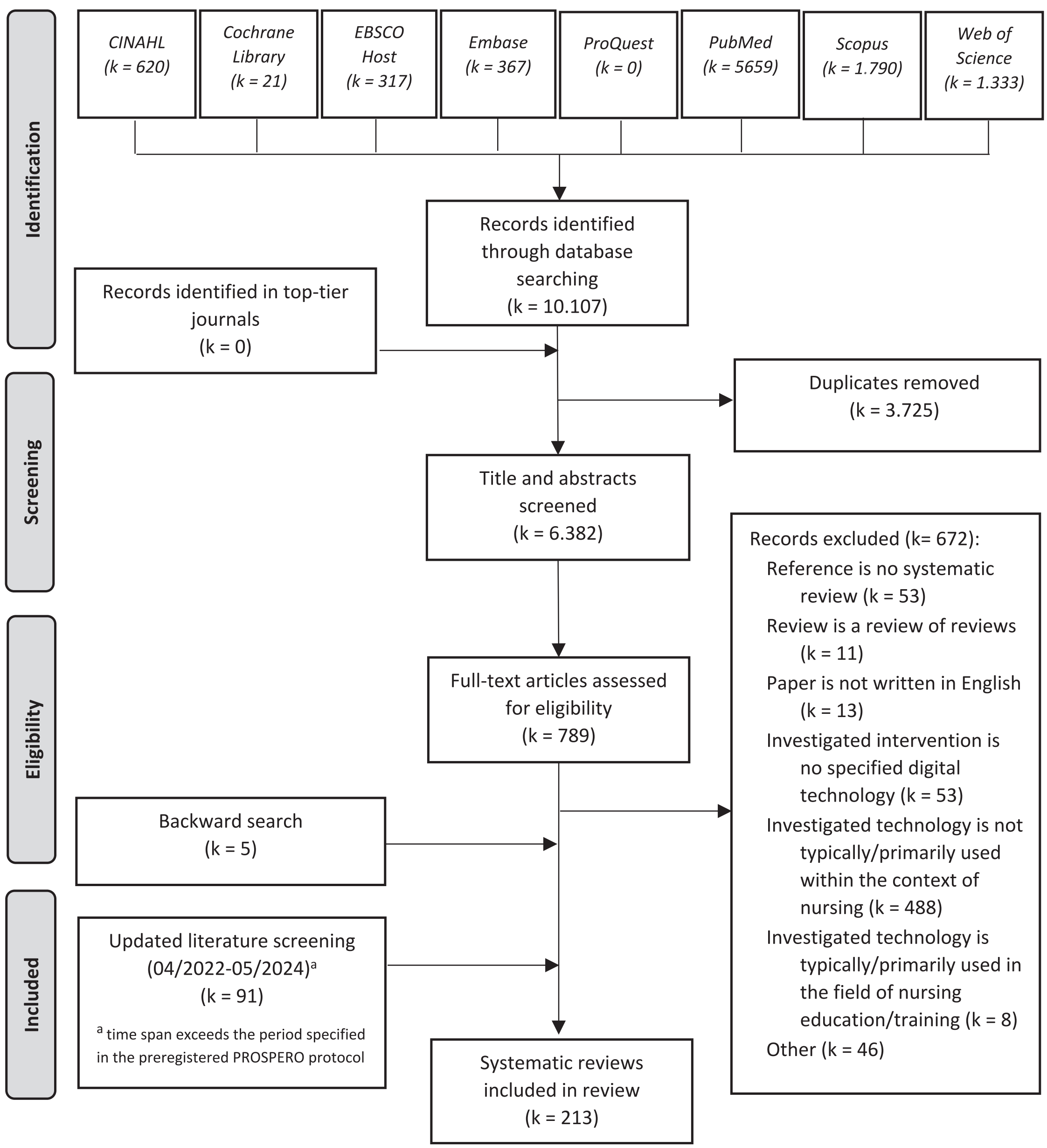

Fig. 1. PRISMA Flow Diagram illustrating the systematic search and review selection process.

set of the references by applying the eligibility criteria.

After the exclusion of 5.593 publications, all authors (LS, UR, MM, JW, LT) reviewed a set of the 789 full-text articles independently. We excluded 672 articles (see Supplementary material S2) that did not meet the inclusion criteria using the web-app Rayyan (Ouzzani et al., 2016), resulting in 117 included reviews. As a result of the literature update, 91 reviews were added. After screening the reference lists of the included reviews, we identified five additional reviews. The final sample comprised 213 reviews.

2.5. Data extraction and quality assessment

The reviews were coded for data extraction using IBM SPSS Statistics 29.0. We developed a standardized data charting form to extract relevant data from the selected papers. Before starting data collection, the entire team reviewed the form. In addition, three authors conducted a pilot test on 20 studies to confirm the accuracy of the form. The extracted data included information on the digital technology investigated, the reviews' objective(s), investigated work-related and organizational factors, occupational safety and health-related outcomes and related distal nurse outcomes, and ethically relevant outcomes for people in need of care. We also extracted information regarding the number of studies included and the healthcare settings investigated (in/outpatient long-term care and short-term care) (see Supplementary material S3).

We used the technology categories developed by Huter et al. (2020) to classify digital nursing technologies. Two reviewers (LS, UR) iteratively developed all other categories during parallel coding in order to answer our research questions. In case of a disagreement, results were discussed between both to achieve consensus. The extracted data were analyzed by their frequency and narratively synthesized. The outcome data associated with the use of digital technologies were classified into four categories: impairments, inconsistent findings, no effect, and improvements. We did not statistically aggregate effect sizes because most of the included references that were analyzed for answering Q2 and Q3 (111 out of 118) were qualitative reviews. Due to the high heterogeneity among the included meta-analyses, a meaningful statistical summary was impractical. Specifically, one meta-analysis investigated telecare technology (Flodgren et al., 2015), two investigated robotic technology (Abbott et al., 2019; Yen et al., 2024), two investigated monitoring/sensor applications (Areia et al., 2021; Cortes et al., 2021) and two investigated multiple technologies (Zhang et al., 2023; Tian et al., 2024). Consequently, reported associations reflect qualitatively described relationships.

We used the critical items 2, 4, 7, 9, 11, 13, and 15 of the AMSTAR 2 checklist to assess the reviews' methodological quality (i.e., for Q2 and Q3). Overall confidence was rated as "high", "moderate," "low," or "critically low" (Shea et al., 2017).

3. Results

3.1. Number and characteristics of identified review (Q1)

3.1.1. Methodological quality of the reviews

Regarding review quality (see Supplementary material S4), 101 out of 118 reviews answering Q2 and Q3 (86%) received a rating of *critically low* quality, i.e., they had at least two critical weaknesses. Eighteen reviews were evaluated as *low quality*, i.e., they had at least one critical weakness.

3.1.2. Digital technologies

Table 1 lists the number of reviews for each technology category. More than half of the reviews (k = 118; 55 %) focused on information and communication technologies. Most of these were telecare technologies (k = 43; 20 %), followed by electronic health/medical records (k = 37; 17 %), computerized decision support systems (k = 21; 10 %; in the following referred to as "decision support systems"), health institution information systems (k = 7; 3 %), communication support systems, and apps (both ks = 5; 2 %). The second largest category comprised robotic technology, which was investigated in 38 reviews (18 %). Moreover, six reviews (3 %) analyzed monitoring/sensor applications, five virtual and augmented reality technology (2 %) and three (1 %) assistive devices. The remaining reviews examined other technologies (k = 12; 6 %) or multiple technologies (k = 31; 15 %).

Table 1
Number of reviews differentiated for digital technologies and reported associations with nursing outcomes.

Digital technology	Reviews investigating digital technologies (Q1)	Reviews reporting associations with work-related/ organizational factors or safety and health-related outcomes (Q2)	Reviews reporting associations with ethically relevant patient outcomes (Q3)
	k (%)	k (%)	k (%)
Information and communication technologies	118 (55.1)	59 (56.7)	17 (40.5)
Health institution information systems	7 (3.3)	5 (4.8)	1 (2.4)
Electronic health/medical records	37 (17.4)	24 (23.1)	1 (2.4)
Computerized decision support systems	21 (9.9)	8 (7.7)	3 (7.1)
Telecare technologies	43 (20.2)	18 (17.3)	8 (19.1)
Communication support systems	5 (2.3)	1 (1.0)	2 (4.8)
App(s)	5 (2.3)	3 (2.9)	2 (4.8)
Robotic technologies	38 (17.8)	20 (19.2)	14 (33.3)
Monitoring/sensor applications	6 (2.8)	5 (4.8)	1 (2.4)
Assistive devices	3 (1.4)	1 (1.0)	0 (0.0)
Virtual/augmented reality	5 (2.3)	1 (1.0)	1 (2.4)
Other	12 (5.6)	7 (6.7)	0 (0.0)
Multiple technologies	31 (14.6)	11 (10.6)	9 (21.4)
Total (%)	213/213 (100)	104/213 (100)	42/213 (100)

Note. k = total number of reviews. Only one technology category could be selected per review, Q: research question.
Note that the following included reviews only refer to Q1: *Aarskog et al., 2019; *Andtfolk et al., 2022; *Arruum et al., 2022; *Bail et al., 2022; *Barbosa Ide et al., 2016; *Bernabei et al., 2013; *Blythe et al., 2022; *Borum, 2018; *Bright and Doody, 2023; *Brown et al., 2023; *Burnazovic et al., 2024; *Castro et al., 2023; *Charalambous et al., 2024; *Choi et al., 2023; *Conte et al., 2023; *de Diego et al., 2024; *de Leo et al., 2023; *Dendere et al., 2021; *Dionisi et al., 2019; *Domingos et al., 2017; *dos Santos et al., 2023; *Felding et al., 2023; *Fenton et al., 2023; *Fernandes et al., 2024; *Finley et al., 2021; *Fithriyyah and Aulawi, 2022; *Galiano et al., 2024; *Gillam et al., 2021; *Gondim et al., 2022; *Guardado et al., 2024; *Hamade et al., 2019; *Harada et al., 2023; *Head et al., 2017; *Hogan-Murphy et al., 2015; *Holloway et al., 2024; *Hsu and Kao, 2023; *Huryk, 2010; *Hwang et al., 2022; *Hwang and Chang, 2023; *Islam et al., 2021; *Jedwab et al., 2023; *Kachouie et al., 2014; *Kamei et al., 2013; *Kang et al., 2020; *Kappes et al., 2023; *Kausch et al., 2021; *Khairunisa and Triharini, 2023; *Khong et al., 2015; *Kruse et al., 2015; *Kulpa et al., 2021; *Li et al., 2024; *Linda et al., 2024; *Long et al., 2017; *Ma et al., 2023; *MacDonald et al., 2023; *Manietta et al., 2022; *Mathijssen et al., 2023; *McCarthy et al., 2019; *Meissner and Schnepp, 2014; *Mieronkoski et al., 2017; *Miller et al., 2021; *Moerman et al., 2019; *Molinari-Ulate et al., 2023; *Mun et al., 2023; *Nagel and Penner, 2016; *O'Connor et al., 2022a, 2024; *Ozkaynak et al., 2017; *Papadopoulos et al., 2020; *Piaggio et al., 2023; *Piazza and Drury, 2023; *Poitras et al., 2024; *Qi et al., 2023; *Ragno et al., 2023; *Raymond et al., 2022; *Redondo-Sáenz et al., 2023; *Rezende et al., 2023; *Ruksakulpiwat et al., 2024; *Servaty et al., 2020; *Sexton et al., 2022; *Shamsabadi et al., 2023; *Shishehgar et al., 2018; *Sivakanthan et al., 2021; *Stolic et al., 2023; *Strudwick and Hall, 2015; *Taşçi et al., 2024; *Tay Hui et al., 2012; *Thompson et al., 2023; *Toffaha et al., 2023; *Toffoletto and Tello, 2020; *Udsen et al., 2014; *Uslu and Buldukoglu, 2016; *Wan et al., 2024; *Wen et al., 2024; *Yunara et al., 2023

3.1.3. Research objectives

Numerous reviews aimed to investigate the relationships between digital technologies' use and the safety and health of people in need of care (k = 48; 23 %), while only a small proportion (k = 14; 7 %) considered this in relation to nurses. Twenty-seven reviews (13 %) sought to investigate technology implementation processes, and 46 reviews (22 %) assessed the impact on economic aspects. The impact of the investigated technologies on nurses' working practices was analyzed in 36 reviews (17 %). A relatively small proportion of reviews (k = 22; 10 %) addressed care quality, including ethical aspects. Approximately a fourth of the included reviews (k = 56; 26 %) aimed to examine technology usage and/or general experience with it. Approximately a firth (k = 43; 20 %) explored stakeholders' technology acceptance of and/or attitudes toward a digital health technology. 27 reviews (13 %) sought to identify digital technologies suitable for supporting specific nursing activities.

3.1.4. Care setting

The studies included in the reviews were mostly conducted in short-term care settings (e.g., hospitals) (k = 69; 32 %), followed by inpatient long-term care settings (e.g., nursing homes) (k = 35; 16 %). Only 14 reviews (7 %) included studies conducted in long-term outpatient (i.e., home care) settings. Of the reviews, 53 (25 %) focused on mixed settings and 31 (15 %) made no specification regarding the setting(s).

3.2. Associations between digital technologies, work-related or organizational factors, and occupational safety and health-related outcomes (Q2)

The reported associations between the use of digital technologies and work-related or organizational factors, as well as occupational safety and health-related and distal nurse outcomes, covered a wide range of aspects. Owing to the multitude of outcomes, we built upon the classifications by Huter et al. (2020) and Parker and Grote (2022) and coded data into two main categories: (a) *work characteristics*, encompassing work-related and organizational factors (e.g., nurses' work behavior, job demands, and communication/collaboration) potentially affecting nurses' safety and health and (b) *proximal indicators* reflecting nurses' occupational safety and health-related outcomes, specifically (mental and physical health, occupational safety) and distal outcomes (e.g., nurses' job-related competence and job-related attitudes, nurse–patient relationship).

3.2.1. Work-related and organizational factors

We found 95 systematic reviews reporting associations between digital technologies' use and work-related and organizational factors. Across the various technologies, the included reviews indicated more favorable effects than adverse ones (see Supplementary material S5-Fig. 1). Specifically, decision support systems and electronic health records showed more positive than negative effects, whereas for monitoring/sensor applications it was the opposite. Overall, most reported associations were for electronic health/medical records, followed by telecare systems.

The work-related and organizational factors examined covered aspects such as *nurses' work behavior* (i.e., general nursing activities or more specific documentation activities), *quantitative demands* (i.e., workload, time savings, staffing, and workflow), *cognitive demands* (i.e., cognitive load and information management), *communication/collaboration*, and *job control*. They represent important aspects of work design that must be considered when digital technology is integrated into work systems (Parker and Grote, 2022). Moreover, we also found several moderating variables.

Table 2 shows the associations between digital technologies and nurses' work-related and organizational factors. Most findings were available for associations to aspects of working time (k = 37 reviews on "time savings"), nurses' workload (k = 32) and communication and collaboration (k = 29). Twenty-four reviews reported on aspects of nursing activities in general and workflow, respectively, 23 on information management and 16 on nursing documentation activities. Evidence for associations with cognitive load (k = 5), nurses' job control (k = 6), and staffing (k = 4) was scarce.

3.2.1.1. Nurses' work behavior. Many reviews reported that digital technologies support *nursing activities*. For example, Abdellatif et al. (2021), Harmon et al. (2012), and Mebrahtu et al. (2021) consistently reported an increase in clinical work standardization associated with the use of decision support systems. Two reviews found that robotic technologies could assist nurses in performing routine tasks (Dino et al., 2022; Ghafurian et al., 2021).

3.2.1.2. Quantitative demands. Most reviews reported negative or inconsistent findings regarding the association between digital technologies' use and nurses' *workload*. Additionally, some reviews had contradictory results. Areia et al. (2021), Cortes et al. (2021), and Davis et al. (2014) found an increased workload associated with the use of monitoring/sensor applications. Radhakrishnan et al. (2016), Scerri et al. (2021), Young et al. (2011) and Wahyuni et al. (2023) reported similar effects for telecare technologies, especially for home care nurses. In contrast, two reviews examining electronic health/medical records (Kelley et al., 2011; Nguyen et al., 2021) reported an increased chance for improvement associated with the technology use, while Tolentino and Gephart (2020) reported an increase in nurse workload during the implementation phase (decreasing over time). Regarding the use of robotic technologies, Kangasniemi et al. (2019) and Loveys et al. (2022) found a positive impact on nurseś workload, Ohneberg et al. (2023) and Ghafurian et al. (2021) report inconsistent results whereas Budak et al. (2021) found an increased workload for nurses.

Improvements in documentation time spent (*time savings*) have been reported particularly for the use of electronic health and medical records (da Costa and da Costa Linch, 2020; de Sousa et al., 2012; Fuller et al., 2018; Hovde et al., 2015; Park et al., 2024). da Costa and da Costa Linch (2020) found that this reduction in time spent documenting increased the time spent communicating within the team. However, three reviews (Forde-Johnston et al., 2023; Harmon et al., 2020; Kelley et al., 2011) reported increased documentation time associated with the implementation of this technology, resulting in decreased time for patient care. Moreover, four reviews reported inconsistent effects of electronic health/medical records on time savings, such as an initial increase in documentation time, but a decrease with frequent use (Jedwab et al., 2019; Kruse et al., 2017; Mohsin-Shaikh et al., 2019; Saraswasta and Hariyati, 2018).

Regarding the effects on *staffing*, available evidence is scarce. Dino et al. (2022) found that robotic technologies could reduce the need for manpower in intensive care units. Xyrichis et al. (2021) reported mixed effects for telecare technologies. While some results indicated the suitability of these technologies for overcoming challenges associated with staff shortages at night, on weekends, and in rural hospitals others suggested potential negative effects on overall staffing levels.

Associations between digital technologies and nurses' *workflow* are mainly found for electronic health/medical records. The included systematic reviews reported both adverse and desirable effects. On the one hand, four reviews found improved workflows for nurses using such technology (Collins et al., 2011; Fuller et al., 2018; Hardiker et al., 2019; Park et al., 2024), and de Sousa et al. (2012) reported that nurses were more involved in intensive care processes. Similarly, Shiells et al. (2019) found indications of improvements in staff alignment. On the other hand, five reviews reported disrupted workflows, partly due to technical difficulties (da Costa and da Costa Linch, 2020; Fraczkowski et al., 2020; Gephart et al., 2015; Kelley et al., 2011; Tolentino and Gephart, 2020).

3.2.1.3. Cognitive demands. Although findings on the impact of digital

Table 2
Synthesis of evidence from systematic reviews (k = 95) for associations between digital technologies and nurses' work-related and organizational factors.

Digital technology	Findings from systematic reviews (with direction of impact in brackets)
Nursing activities (general)	
ICT HIS (k = 3)	(−) new staff roles without compensation (Ko et al., 2018) (0) no changes in time spent (Kruse et al., 2021; Waneka and Spetz, 2010)
EHR/EMR (k = 3)	(0) no changes in individualized patient care (Stevenson et al., 2010) (+) more standardized care and prevention of complications (Hovde et al., 2015) (+/−) mixed results regarding documentation comprehensiveness (Hants et al., 2023)
CDSS (k = 3)	(+) clinical work standardization (e. g. less deviations from protocols or reduction of cognitive bias) (Abdellatif et al., 2021; Harmon et al., 2012; Mebrahtu et al., 2021)
Telecare technologies (k = 5)	(−) extra responsibility, rather than an efficient aid tool (Brewster et al., 2014); tasks changes: monitoring and responding to tele-homecare data, installing devices, training patients, resolving technical difficulties (Radhakrishnan et al., 2016) (+) reduced need to travel (Penny et al., 2018); increased communication and interaction with patients (Radhakrishnan et al., 2016); expansion of traditional roles was perceived as motivating and challenging (Tan et al., 2021)
Communication support systems	[Not reported]
App(s)	[Not reported]
Robotic technologies (k = 6)	(+/−) helpful for reminders, alarms and monitoring, but not for core nurse activities (Papadopoulos et al., 2018) (0) new tasks, including preparation and continuous monitoring of robotic technology (Celik et al., 2022; Martins et al., 2019; Scerri et al., 2021) (+) can assist nurses in the performance of routine tasks (in patients' home) (Dino et al., 2022; Ghafurian et al., 2021)
Monitoring/sensor applications	[not reported]
Assistive devices (k = 1)	(+) sensors offer nurses' telecare and remote work (Behera et al., 2021)
Virtual−/augmented reality	[not reported]
Other (k = 2)	(0) changes in the nurses' role and work tasks (internet) (Ahmad et al., 2018) (+) less space required and less waste (drug distribution systems) (Ahtiainen et al., 2020)
Multiple technologies (k = 2)	(+) simplification of work tasks (ICT) (Fagerstrom et al., 2017); support for patient education (Saab et al., 2021)
Nursing activities (documentation)	
ICT HIS (k = 4)	Quality: (+/−) (Ko et al., 2018) but also (+) improvements (Kruse et al., 2021; Waneka and Spetz, 2010) Time: (+/−) (Moore et al., 2020; Waneka and Spetz, 2010)
EHR/EMR (k = 5)	Quality: (+) improvements (da Costa and da Costa Linch, 2020) Time: (−) increased time spent on documentation (Forde-Johnston et al., 2023); (+/−) (Jedwab et al., 2019; Kelley et al., 2011); (+) reduction (Shiells et al., 2019)
CDSS	[Not reported]
Telecare technologies (k = 1)	(+) enhanced accuracy in information assessment and documentation (Gagnon et al., 2024)
Communication support systems	[not reported]
App(s) (k = 1)	(+) more consistent documentation (Glanville et al., 2023)
Robotic technologies	[Not reported]
Monitoring/sensor applications	[Not reported]
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other (k = 2)	(−) more documentation discrepancies (drug distribution systems) (Ahtiainen et al., 2020) (+) more accurate patient data assessment (speech recognition technology) (Joseph et al., 2020)
Multiple technologies (k = 3)	Quality: (+) improvements (O'Connor et al., 2022b); (−) high effort (Telecare) (Huter et al., 2020) Time: (−) increase in documentation time (Coffetti et al., 2023; HIS systems: Huter et al., 2020)
Workload	
ICT HIS (k = 1)	(−) increased workload for senior nurses and those responsible for consultation preparation (Shelley et al., 2024)
EHR/EMR (k = 4)	(+/−) increased during implementation (decrease with time) (Tolentino and Gephart, 2020) (0) changes (Stevenson et al., 2010) (+) reduction (Kelley et al., 2011; Nguyen et al., 2021)
CDSS (k = 3)	(+) reduction (Abdellatif et al., 2021) (+/−) (Sariköse and Şenol Çelik, 2024) (0) no changes (Dunn Lopez et al., 2017)
Telecare technologies (k = 9)	(−) increased workload (Radhakrishnan et al., 2016; Tan et al., 2021; Wahyuni et al., 2023; Young et al., 2011), due to increased time spent on interaction (Golden et al., 2024), frequent task switching, interruptions, and collaboration with technicians (McNamara, 2024), burdensome alerts and reminders (Lundereng et al., 2023) (0/−) inconsistent reported association (Koivunen and Saranto, 2018; Valk-Draad and Bohnet-Joschko, 2022)
Communication support systems	[Not reported]
App(s) (k = 2)	(−) increased problems with life-domain balance because of messages during off-job time (de Jong et al., 2020) (+) reduction (regenerating function by allowing leisure activities during breaks) (Fiorinelli et al., 2021)
Robotic technologies (k = 5)	(−) increased (PARO system (robotic animal)) (Budak et al., 2021) (+/−) (Ohneberg et al., 2023), distracted residents and reduced wandering behavior (Ghafurian et al., 2021) (+) reduction (Kangasniemi et al., 2019; Loveys et al., 2022)
Monitoring/sensor applications (k = 4)	(−) adverse consequences of alarms and technology use for burden of care and workload (Areia et al., 2021; Cortes et al., 2021; Davis et al., 2014) (+/−) improved alarm efficacy vs. need to deal with frequent device errors (Mileski et al., 2019)
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other (k = 1)	(+/−) changes depending on system (drug distribution systems) (Ahtiainen et al., 2020)
Multiple technologies (k = 4)	(−) increased (HIS system) (Huter et al., 2020), feelings of time pressure and increased workload during implementation (Coffetti et al., 2023) (+/−) inconsistent findings (HIS, apps, virtual−/augmented reality, assistive devices) (Mohammadnejad et al., 2023); (+) reduction (e.g., walking distances, use of robots for lifting

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Table 2 (*continued*)

Digital technology	Findings from systematic reviews (with direction of impact in brackets)
	patients) (Huter et al., 2020), decreased pressure (Zhou et al., 2023)
Time savings	
ICT HIS (k = 1)	(+) improved (fewer phone calls and visits) (Shelley et al., 2024)
EHR/EMR (k = 12)	(−) less patient care time due to increased time spent on documentation (Forde-Johnston et al., 2023; Harmon et al., 2020; Kelley et al., 2011) (+/−) (Jedwab et al., 2019; Kruse et al., 2017; Mohsin-Shaikh et al., 2019), initial increase in documentation time, but decrease with frequent use (Saraswasta and Hariyati, 2018) (+) improved (da Costa and da Costa Linch, 2020; de Sousa et al., 2012; Fuller et al., 2018; Hovde et al., 2015; Park et al., 2024)
CDSS (k = 2)	(+) improved (Abdellatif et al., 2021; Sariköse and Şenol Çelik, 2024)
Telecare technologies (k = 3)	(+) improved (e.g., reduced clinical time, patient waiting times) (Gagnon et al., 2024; Gordon et al., 2022; Koivunen and Saranto, 2018) (0) no effects on hospital transfers (Gordon et al., 2022)
Communication support systems	[Not reported]
App(s) (k = 3)	(+) improved (e.g., for information search) (de Jong et al., 2020; Fiorinelli et al., 2021; Glanville et al., 2023)
Robotic technologies (k = 3)	(+/−) (Haubold et al., 2020) (+) time for data collection and drug administration (Kangasniemi et al., 2019; Maalouf et al., 2018)
Monitoring/sensor applications (k = 2)	(−) lead nurses require more time for data management with risks for inadequate staffing (Davis et al., 2014) (+) improved time management (Omotunde and Wagg, 2023)
Assistive devices (k = 1)	(+) reduction of time for non-care tasks (e.g., traveling) (Behera et al., 2021)
Virtual-/augmented reality (k = 1)	(+) improved (Wuller et al., 2019)
Other (k = 6)	(+/−) (drug distribution systems) (Ahtiainen et al., 2020) (0) unplanned overtime hours [which was expected to be reduced] (digital workforce management systems) (Tuominen et al., 2018) (+) improved (automated pharmacy systems: Batson et al., 2021; speech recognition technology: Joseph et al., 2020; medication dispensing and administration technology: Zheng et al., 2021); reduction of time for scheduling, including plans and shift exchanges (automated scheduling and rostering systems) (O'Connell et al., 2024)
Multiple technologies (k = 3)	(−) system errors perceived as waste of time (ICT) (Fagerstrom et al., 2017) (+) improved (Fagerstrom et al., 2017), improved for data management and documentation (EHR/EMR) (Huter et al., 2020), better time management (Saab et al., 2021)
Staffing	
ICT HIS (k = 4)	(0) no effects on staff replacement and turnover (Ko et al., 2018)
EHR/EMR	[Not reported]
CDSS	[Not reported]
Telecare technologies (k = 1)	(+/−) possibility to overcome challenges associated with staff shortages during nights and weekends as well as in rural hospitals but also concerns about potential negative effect on overall staffing levels (Xyrichis et al., 2021)
Communication support systems	[Not reported]
App(s)	[Not reported]
Robotic technologies (k = 1)	(+) less need for manpower in ICU by providing robot support to healthcare providers (Dino et al., 2022)
Monitoring/sensor applications	[Not reported]
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other (k = 1)	(+) reduced turnover rate (digital workforce management systems) (Tuominen et al., 2018)
Multiple technologies	[Not reported]
Workflow	
ICT HIS (k = 2)	(+/−) inconsistent for time-related fade-out (Ko et al., 2018) (+) improvements (Waneka and Spetz, 2010)
EHR/EMR (k = 12)	(−) impaired (da Costa and da Costa Linch, 2020), more difficulties due to technical problems (Fraczkowski et al., 2020; Gephart et al., 2015; Kelley et al., 2011; Tolentino and Gephart, 2020) (+/−) (Mohsin-Shaikh et al., 2019) (+) improved (Collins et al., 2011; Fuller et al., 2018; Hardiker et al., 2019; Park et al., 2024), better inclusion of nurses in intensive care processes (de Sousa et al., 2012), better staff coordination (Shiells et al., 2019)
CDSS	[Not reported]
Telecare technologies (k = 3)	(+/−) (Golden et al., 2024; Ramnath et al., 2014) (+) uninterrupted periods of rest, fewer interruptions (Young et al., 2011)
Communication support systems (k = 1)	(+/−) nurses expressed concerns with the adjustment of the web camera, but postintervention most nurses experience communication to be convenient and user friendly (Epstein et al., 2017)
App(s) (k = 3)	(−) perception of smartphone as possible distractor (cause of distraction, loss of attention and medical errors) (de Jong et al., 2020; Fiorinelli et al., 2021) (+) improved (Glanville et al., 2023), increased efficiency of nurses' workflow (due to the possibility of more direct communication with physicians) (de Jong et al., 2020)
Robotic technologies (k = 2)	(−) interruption through frequent alarms (David et al., 2022) (+/−) (Haubold et al., 2020)
Monitoring/sensor applications	[Not reported]
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other	[Not reported]
Multiple technologies (k = 1)	(−) more distractions (Saab et al., 2021)
Cognitive load	
ICT HIS	[not reported]
EHR/EMR (k = 4)	(−) increased (Gephart et al., 2015; Wisner et al., 2019), cognitive overload related to, e.g., alert fatigue and navigating the HER (Harmon et al., 2020) (0/−) low technology satisfaction: increased cognitive failures (Park et al., 2024); (+) better and less mentally demanding clinical decision-making (Harmon et al., 2020)
CDSS (k = 1)	(0) no changes (Akbar et al., 2021)
Telecare technologies	[Not reported]
Communication support systems	[Not reported]
App(s)	[Not reported]
Robotic technologies	[Not reported]
Monitoring/sensor applications (k = 1)	(−) increased (Mileski et al., 2019)

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Table 2 (*continued*)

Digital technology	Findings from systematic reviews (with direction of impact in brackets)
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other	[Not reported]
Multiple technologies	[Not reported]
Information management	
ICT HIS (k = 1)	(+) enhanced information use for care planning (Shelley et al., 2024)
EHR/EMR (k = 10)	(−) maintaining information overview as risk (Wisner et al., 2019) (0) no changes (Kelley et al., 2011) (+) decrease of information loss, interruptions and omission errors (Collins et al., 2011) and better access to patient information (de Sousa et al., 2012; Fuller et al., 2018; Gephart et al., 2015; Harmon et al., 2020; Kruse et al., 2017; Park et al., 2024; Saraswasta and Hariyati, 2020)
CDSS (k = 2)	(+) technology generated information helpful for patient discharge planning (Araujo et al., 2020) (−) inappropriate presentation of alerts leads to information loss (due to distractions) (*Miller et al., 2015)
Telecare technologies (k = 4)	(−) concerns about missing important patient information (Lundereng et al., 2023) (+) increased access to information (Gagnon et al., 2024; Koivunen and Saranto, 2018), improved decision making (Penny et al., 2018)
Communication support systems	[Not reported]
App(s) (k = 1)	(+) flexible access to patient data (Fiorinelli et al., 2021)
Robotic technologies	[Not reported]
Monitoring/sensor applications	[Not reported]
Assistive devices	[Not reported]
Virtual-/augmented reality (k = 1)	(−) risk of missed patient information (i.e., relevant symptoms) as the focus is directed away from the patient (Wuller et al., 2019) (+) easy information retrieval, observation from different perspectives (Wuller et al., 2019)
Other	[not reported]
Multiple technologies (k = 4)	(+) better information access (Saab et al., 2021; Huter et al., 2020; Zhou et al., 2023); support for information management and clinical decision making (ICT) (Tahsin et al., 2023)
Communication and collaboration	
ICT HIS (k = 1)	(+) improved, also teamwork (Ko et al., 2018)
EHR/EMR (k = 7)	(−) reduction in face-to face communication (Shiells et al., 2019); impaired interaction among clinicians (Park et al., 2024) (+/−) inconsistent for interprofessional communication (de Sousa et al., 2012; Jedwab et al., 2019; Mohsin-Shaikh et al., 2019; Wisner et al., 2019) (+) communication among staff and between shifts (Hovde et al., 2015)
CDSS (k = 3)	(+/−) inconsistent effects regarding team interaction (Sariköse and Şenol Çelik, 2024) (0) no changes in nursing culture (Abdellatif et al., 2021) (+) enhanced teamwork (between health care professionals) and communication (Abdellatif et al., 2021); increased ability to communicate with the multidisciplinary team (Harmon et al., 2012), better role distribution between nurses and physicians (Abdellatif et al., 2021)
Telecare technologies (k = 6)	(−) conflicting recommendations from ICU and teleclinicians (Young et al., 2011), role conflicts because of changed responsibility in decision making (between nursing staff in care homes and external healthcare providers) (Tan et al., 2021) (+/−) interprofessional (Radhakrishnan et al., 2016) (+) improved (interdisciplinary) communication (Gagnon et al., 2024; Penny et al., 2018) and cooperation between internal and external teams (Valk-Draad and Bohnet-Joschko, 2022)
Communication support systems	[not reported]
App(s) (k = 3)	(−) decreased interdisciplinary communication and nurse performance through use of mobile devices for personal use during work hours (Fiorinelli et al., 2021), organizational policies/regulation and organizational support low or problematic (de Jong et al., 2020) (+) improved between staff (de Jong et al., 2020; Fiorinelli et al., 2021; Glanville et al., 2023)
Robotic technologies (k = 2)	(−) poor communication, i.e., limited nonverbal cues and direct eye contact, between surgeon, who is physically separated, and the team (robot assisted surgery) (Moloney et al., 2023) (0) changes in communication style requiring more interaction and increased cooperation (Lee et al., 2024)
Monitoring/sensor applications	[Not reported]
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other	[Not reported]
Multiple technologies (k = 7)	(+) improved (interprofessional/ interdisciplinary) communication (Coffetti et al., 2023; Huter et al., 2020; O'Connor et al., 2022b; Saab et al., 2021), better colleague collaboration and information exchange (ICT) (Fagerstrom et al., 2017; Tahsin et al., 2023), also between health and social workers (Yutong et al., 2023)
Job control	
ICT HIS	[Not reported]
EHR/EMR	[Not reported]
CDSS	[Not reported]
Telecare technologies (k = 3)	(+) improved autonomy (Young et al., 2011), improved ability to work independent and flexible (e.g., working times, workplace, remote opportunities) (Koivunen and Saranto, 2018; Golden et al., 2024)
Communication support systems	[Not reported]
App(s)	[Not reported]
Robotic technologies	[Not reported]
Monitoring/sensor applications (k = 1)	(+) more responsibility (i.e., task delegation) and autonomy (Davis et al., 2014)
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other (k = 1)	(+) improved (automated scheduling and rostering systems) (O'Connell et al., 2024)
Multiple technologies (k = 1)	(−) loss of autonomy and control (ICT) (Fagerstrom et al., 2017)
Moderating variables	
ICT HIS (k = 1)	Work experience: novice nurses experience a greater impact on their workload compared to senior nurses (Shelley et al., 2024)
EHR/EMR (k = 7)	Less open culture and bottom-up communication as hindrances (Tolentino and Gephart, 2020) problems if no training and participation was applied during system implementation (Gephart et al., 2015); organizational culture and the given fit of nurses – with the use of technology adapted –

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Table 2 (*continued*)

Digital technology	Findings from systematic reviews (with direction of impact in brackets)
	workflow and -practices with organizational policies and structures (Fraczkowski et al., 2020; Fuller et al., 2018; Hardiker et al., 2019; Shiells et al., 2019; Tolentino and Gephart, 2020); authentic leadership and technical support as drivers of success (Tolentino and Gephart, 2020)
CDSS (k = 1)	Technology usage is influenced by organizational factors (leadership, culture, structure, training, resources, support, champions) and patient factors (patient complexity) (Piscotty and Kalisch, 2014)
Telecare technologies (k = 3)	Involvement of staff during implementation is beneficial for acceptance (Brewster et al., 2014); potential barriers for efficient implementation: bad sound and video quality, missing technical support and missing staff training, implementation requires time and practice, interruptions, poor communication, inaccurate information (Penny et al., 2018; Ramnath et al., 2014)
Communication support systems	[Not reported]
App(s)	[Not reported]
Robotic technologies (k = 3)	Implementation preparation, fit to patient needs, time for other tasks, preparation time, easy handling (Haubold et al., 2020); on-side peer-training is more effective for learning than off-side (Moloney et al., 2023); prevention of nurse interruptions (e.g., due to technical failures or additional nursing tasks) is linked to workflow advantages (Ohneberg et al., 2023)
Monitoring/sensor applications (k = 1)	High alarm sensitivity increases adverse effects (Mileski et al., 2019)
Assistive devices	[Not reported]
Virtual-/augmented reality	[Not reported]
Other (k = 1)	Centralized vs. hybrid system (drug distribution systems) (Ahtiainen et al., 2020)
Multiple technologies (k = 2)	Organizational factors (e.g., care-IT collaboration, nurse involvement during implementation, management support, change readiness in teams) and person factors (e.g., valence of ICT experiences, ICT skills, age, gender) (Coffetti et al., 2023); demand-side factors (e.g., low confidence and trust), technical factors (e.g., low infrastructure) and systemic factors (e.g., inadequate legislative framework) (Yutong et al., 2023)

Note. k = total number of reviews. (−): impairment, (+/−): inconsistent finding, (0) no effect, (+) improvement; ICT: information and communication technologies, HIS: health institution information system, EHR/EMR: electronic health/medical record, CDSS: computerized decision support system.

technologies on nurses' *cognitive load* are generally scarce, three reviews (Gephart et al., 2015; Harmon et al., 2020; Wisner et al., 2019) on electronic health/medical records found evidence of an association with increased cognitive overload.

In contrast, eight reviews identified improvements in nurses' *information management* associated with the use of such technology. For instance, Harmon et al. (2020) reported an overall improvement in clinical decision making and Collins et al. (2011) reported reductions in information loss. Six reviews (de Sousa et al., 2012; Fuller et al., 2018; Gephart et al., 2015; Harmon et al., 2020; Kruse et al., 2017; Park et al., 2024; Saraswasta and Hariyati, 2020) found indications of an improved access to patient information associated with electronic health/medical records.

3.2.1.4. Communication/collaboration. Regarding work-related *communication and collaboration* among nurses and other health professionals, systematic reviews have mainly provided evidence of positive or inconsistent effects. For example, Abdellatif et al. (2021) and Harmon et al. (2012) found a positive impact of decision support systems on teamwork among healthcare professionals and on communication opportunities within multidisciplinary teams. Four reviews found inconsistent effects of electronic health and medical records on interprofessional communication (de Sousa et al., 2012; Jedwab et al., 2019; Mohsin-Shaikh et al., 2019; Wisner et al., 2019).

3.2.1.5. Job control. Regarding nurses' perceived *job control*, three reviews reported positive effects of telecare technologies, such as managing to work more independently and flexibly (Koivunen and Saranto, 2018).

3.2.1.6. Moderating variables. Finally, the reviews identified several *moderating variables* that shaped the association between the use of digital technology and related outcomes. These factors include *facilitators* such as the training and involvement of healthcare staff during technology implementation (Brewster et al., 2014; Gephart et al., 2015), organizational culture, and alignment of nurses' workflows and work practices with organizational policies and structures when using technology (Fraczkowski et al., 2020; Fuller et al., 2018; Hardiker et al., 2019; Shiells et al., 2019; Tolentino and Gephart, 2020). In contrast, lack of staff training and inaccurate information were identified as potential *barriers* to efficient technology implementation (Penny et al., 2018; Ramnath et al., 2014).

3.2.2. Safety, health and distal nurse outcomes

We found 58 systematic reviews reporting associations between digital technologies and occupational safety and health-related outcomes or more distal nurse outcomes, such as job attitudes or changes in professional competence, which are potentially related to health and safety. The highest overall number of reported associations was for telecare systems and electronic health/medical records, followed by robotic and multiple technologies, and decision support system use (see Supplementary material S6-Fig. 2). Across all technologies, the included reviews reported more positive than negative outcomes. Mainly positive findings were identified for robotic technologies, and more negative findings for electronic health/medical records.

Table 3 summarizes the associations among the included systematic reviews on digital technologies, occupational safety, and health-related as well as distal nurse outcomes. Across all technologies, there was most evidence for effects on the nurse–patient relationship (k = 33), followed by effects on nurses' physical and mental health (k = 21), professional competence (k = 19) job attitudes (k = 18) and nurse occupational safety (k = 7).

3.2.2.1. Safety and health-related outcomes. The impact of digital technologies, particularly electronic health and medical records and monitoring and sensor applications, on *nurses' physical and mental health* has been largely perceived as negative. For electronic health/medical records use, Hardiker et al. (2019), da Costa and da Costa Linch (2020) and Nguyen et al. (2021) found associations with feelings of frustration, with adverse emotional reactions, and burnout when compared to the use of paper charts. Regarding the use of monitoring/sensor technologies the included reviews reported increased fatigue owing to false alarms (Cortes et al., 2021) and increased noise exposure (Mileski et al., 2019). Telecare technologies have been reported as both positively and negatively related to nurses' health. While Koivunen and Saranto (2018) reported a reduction in nurses' stress experiences, Young et al. (2011) found both, studies reporting less stress, as well as an increase in physical stress and boredom. Tan et al. (2021) reported negative affective reactions owing to changes in task execution through telecare technologies and Golden et al. (2024) identified feelings of anxiety related to a (perceived) lack of evidence of improved maternal outcomes compared to face-to-face prenatal care.

Reviews addressing how technologies influence *occupational safety* were rare, with limited evidence regarding robotic technology. The reviews found address nurse hygiene and injury risks associated with robots performing nursing activities such as feeding (Papadopoulos et al., 2018). In contrast, one review (Kangasniemi et al., 2019) reported a reduction in the potential radiation exposure associated with the use of an automated injection system.

3.2.2.2. Distal nurse outcomes. Regarding *nurses' professional competence*, the reviews included in this study predominantly reported mostly positive effects. In their review of 35 studies, Mebrahtu et al. (2021) found positive effects of decision support systems on nurses' professional knowledge. However, a review by Akbar et al. (2021) suggested an improvement in decision competence shortly after the implementation of a decision support system, and a decrease over time. Three reviews reported improvements in knowledge and skills, as well as learning opportunities associated with the use of telecare technologies (Gagnon et al., 2024; Koivunen and Saranto, 2018; Tan et al., 2021). Further, improved patient symptom assessment was found for telecare (Lundereng et al., 2023), increased computer literacy skills for apps (Glanville et al., 2023) and professional development for robotic technologies (Celik et al., 2022).

Many reviews have reported beneficial effects of digital technologies on nurses' *job-related attitudes*. Abdellatif et al. (2021) reported increased professional commitment among nurses and Mebrahtu et al. (2021) and Sariköse and Şenol Çelik (2024) reported increased overall satisfaction associated with the use of decision support systems. Similarly, robotic technologies have been reported to increase nurses' satisfaction (Kangasniemi et al., 2019) and make nursing tasks more attractive (Moloney et al., 2023; Papadopoulos et al., 2018).

Regarding the effects on *nurse–patient relationship*, reviews indicated more positive than negative effects. For instance, "robopets" (i.e., pet- or animal-like robots) have been reported to act as a communicative "icebreaker" between staff and residents (Abbott et al., 2019), to reduce patient strain and negative emotions, leading to improved social interactions (Ghafurian et al., 2021; Scerri et al., 2021) and to enable better social connections with patients (Dino et al., 2022). However, Papadopoulos et al. (2018) identified concerns regarding potential disruptions to social connections with patients. Regarding telecare technologies, three reviews (Koivunen and Saranto, 2018; Lundereng et al., 2023; Radhakrishnan et al., 2016) concluded that such technologies can improve patient–nurse/staff interactions, whereas three other reviews reported adverse effects (Brewster et al., 2014; Gagnon et al., 2024; Joo, 2022). Regarding the use of electronic health/medical records, three reviews reported improved communication and/or more time for nurse–patient interaction (Hovde et al., 2015; Saraswasta and Hariyati, 2020, 2018), while Forde-Johnston et al. (2023), Park et al. (2024) and Shiells et al. (2019), and reported impaired communication.

3.3. Associations between digital technologies and ethically relevant outcomes for people in need of care (Q3)

We identified 42 systematic reviews reporting associations between digital technologies and a broad range of ethically relevant outcomes for people in need of care (see Table 4). Given the diverse array of outcomes, we built categories based on the *four principles of biomedical ethics* (Beauchamp and Childress, 2019), a framework for ethical assessment within the domain of healthcare practices. Accordingly, we classified the data into three categories of principles: (a) *beneficence*, encompassing norms, dispositions, and actions aimed at promoting the well-being of patients alongside *nonmaleficence*, which stresses the duty to abstain from causing harm to patients, (b) *respect for autonomy*, highlighting the obligation to honor autonomous actions, disclose information, and foster capacities for autonomous choice, and (c) *justice* emphasizing the obligation to equitably distribute benefits, risks, and costs, particularly in conditions of limited resources.

Overall, the reviews reported more impairments or inconsistent findings than improvements in ethically relevant outcomes for people needing care. Robotic technologies and telecare technologies had the highest overall number of reported findings, followed by telecare systems (Supplementary material S7-Fig. 3). Considering associations with individual ethical principles, the most evidence was found for effects on beneficence/non-maleficence (k = 32), followed by respect for autonomy (k = 21). Few reviews reported associations with the principle of justice (k = 6).

3.3.1. Beneficence/nonmaleficence

The impact of digital technologies, particularly robotic technologies, on the realization of the principles of *beneficence/nonmaleficence* has been perceived as beneficial in some cases and potentially harmful in others.

Regarding assistive social robots, three reviews (Ghafurian et al., 2021; Haltaufderheide et al., 2023; Yen et al., 2024) found a positive association with care recipients' quality of life and Loveys et al. (2022) an increased perception of social support. However, two reviews (Persson et al., 2021; Moloney et al., 2023) found indications of potential risks to patient safety, inter alia in the context of robotic surgery. Additionally, Abbott et al. (2019) and Scerri et al. (2021) reported that robopets might evoke feelings of infantilization. Four reviews (Abbott et al., 2019; Bemelmans et al., 2012; David et al., 2022; Scerri et al., 2021) found inconsistent effects, such as a lower level of perceived loneliness as well as concerns about the perceived personal space of living in home care facilities. Moreover, reviews examining telecare technologies reported that such could negatively affect nurses' ethical responsibility for care-recipients (Brewster et al., 2014), or also lead to an increased emphasis on physical issues, as interpersonal matters can be challenging to address over the phone (Schuessler and Glarcher, 2024). However, the reviews also noted benefits, such as an enhanced sense of safety during the SARS-CoV-2 pandemic (Joo, 2022).

3.3.2. Respect for autonomy

Regarding the effects on the principle of *respect for autonomy* the reviews reported both positive and negative effects, primarily in relation to telecare as well as robotic technologies. Lundereng et al. (2023) reported an improvement in shared decision-making and Schuessler and Glarcher (2024) more timely information for patients associated with the use of telecare technologies. In contrast, three reviews Penny et al. (2018) reported a reduction in patient privacy linked to these technologies. Meal robots were reported to contribute to more patient autonomy (Persson et al., 2021) and gaze-controlled wheelchairs increased independence for patients with amyotrophic lateral sclerosis (Dino et al., 2022; Vandemeulebroucke et al., 2021). However, perceptions of assistive social robots' (SAR) impact on patient privacy were inconsistent (Ghafurian et al., 2021; Vandemeulebroucke et al., 2021), and the use of telepresence robots was considered to negatively impact patient privacy, due to "the possibilities of witnessing residents' personal and private situations, overhearing workers' conversations, and recording [of] videos by remote users" (Hung et al., 2022, p. 15).

3.3.3. Justice

Regarding the principle of *justice*, reviews indicated positive effects associated with the use of telecare technologies and negative effects associated with decision support systems, particularly triage systems. Telecare technologies have been reported to promote health equity by reducing health disparities among vulnerable populations (Joo, 2022; Martin et al., 2023) and to enable the priorization of patients based on individual needs through the use of patient-generated data (Lundereng et al., 2023). For decision support systems, Komariah et al. (2021) reported ageism in relation to care service recommendations, and Penny et al. (2018) reported language discrimination, i.e., patients with higher language proficiency were more likely to receive advice with a higher

Table 3
Synthesis of evidence from reviews (k = 58) for associations between digital technologies and occupational safety and health and distal nurse outcomes.

Digital technology		Physical and mental health	Occupational safety	Professional competence	Job-related attitudes	Nurse–patient relationship
ICT	HIS (k = 1)	[Not reported]	[Not reported]	(+) technology serves as a supportive learning tool, especially for novice nurses (Shelley et al., 2024)	(+/−) regarding job satisfaction (Ko et al., 2018)	(+) improved communication between (Shelley et al., 2024)
	EHR/EMR (k = 13)	(−) adverse emotional reactions (da Costa and da Costa Linch, 2020), frustration (Hardiker et al., 2019) and burnout (Nguyen et al., 2021) (0/−) low technology satisfaction (causing workflow interferences): increased burnout, stress, and frustration (Park et al., 2024) (+) less stress experience (Fuller et al., 2018)	[Not reported]	(−) fear that nurses would become deskilled (Stevenson et al., 2010) (+) development and improvement of clinical reasoning and judgment skills (de Sousa et al., 2012)	(0/−) low technology satisfaction: increased job dissatisfaction and higher intent to leave (Park et al., 2024) (+) better job satisfaction (Weinschreider et al., 2022)	(−) impaired communication/interaction (Shiells et al., 2019; Park et al., 2024), less face-to-face communication (more attention to computer screen than patient); more automatic and bureaucratic communication patterns (Forde-Johnston et al., 2023) (+) improved communication (Hovde et al., 2015; Saraswasta and Hariyati, 2020); more time for nurse–patient interaction (Saraswasta and Hariyati, 2018)
	CDSS (k = 5)	(−) more fatigue (Abdellatif et al., 2021)	[Not reported]	(+/−) improvement of decision-making ability after implementation, decrease with time (Akbar et al., 2021) (+/0) inconsistent effects regarding professional knowledge (Araujo et al., 2020) (0) no changes (Abdellatif et al., 2021) (+) improvements in professional knowledge (Mebrahtu et al., 2021)	(+) higher nurse satisfaction (Mebrahtu et al., 2021; Sariköse and Şenol Çelik, 2024), higher professional commitment (Abdellatif et al., 2021)	(+) better nurse–patient communication (Abdellatif et al., 2021)
	Telecare technologies (k = 9)	(−) increase of physical stress and boredom (Young et al., 2011); negative affective reactions due to changes in task execution (Tan et al., 2021); feelings of anxiety related to (perceived) lack of evidence of improved maternal outcomes (Golden et al., 2024) (+) less stress experiences (Koivunen and Saranto, 2018; Young et al., 2011); reduced infection anxiety (Joo, 2022)	(+) better team safety and team safety climate (Young et al., 2011); reduced infection risk during SARS-CoV-2 pandemic (Golden et al., 2024; Joo, 2022)	(+) improvements in knowledge and skills (Koivunen and Saranto, 2018) and learning opportunities (Gagnon et al., 2024; Tan et al., 2021); enhanced symptom assessments (Lundereng et al., 2023)	(−) fear of changes (Koivunen and Saranto, 2018) and belief that technology affects job role and might induce (ethical) role conflicts (Brewster et al., 2014) (+) better job satisfaction (Brewster et al., 2014; Koivunen and Saranto, 2018)	(−) adverse effects such as decreased interactivity, conflicting changes (Brewster et al., 2014; Gagnon et al., 2024); less empathy, reduced information exchange, and fewer problems presented (Joo, 2022) (+/−) (Golden et al., 2024) (+) improved patient–nurse communication and relationships (Koivunen and Saranto, 2018; Lundereng et al., 2023; Radhakrishnan et al., 2016)
	Communication support systems (k = 1)	[Not reported]	[Not reported]	[Not reported]	[not reported]	(+) better interaction with families (Epstein et al., 2017)
	App(s) (k = 3)	(−) more distractions and loss of attention (Fiorinelli et al., 2021) (+) better recovery opportunities during breaks and routine work (Fiorinelli et al., 2021)	(−) safety concerns reported (Fiorinelli et al., 2021) but also (+) improved personal safety (e. g. walking to vehicles at night) (de Jong et al., 2020)	(0) no changes in clinical decision-making competence and self-efficacy (Glanville et al. (2023) (+) increased computer literacy skills (Glanville et al., 2023)	(+) higher job satisfaction (Fiorinelli et al., 2021)	(+) better communication with patients (de Jong et al., 2020)
Robotic technologies (k = 8)		(−) annoyance from technical errors (Ghafurian et al., 2021); stress from lack of understanding, fear of harming patients, and missing guidelines (Moloney et al., 2023)	(−) concerns about nurses' hygiene and injury risks (Papadopoulos et al., 2018) (+) reduction of radiation dose (device used for radioactive material) (Kangasniemi et al., 2019)	(+) opportunity for professional development (Celik et al., 2022)	(+) increased nurse satisfaction (Kangasniemi et al., 2019); potential to make the job more attractive (Papadopoulos et al., 2018); pride in working with cutting-edge technology within surgical teams (Moloney et al., 2023)	(−) concerns about social connections to patient (Papadopoulos et al., 2018); decreasing frequency of patient-caregiver-interactions (Ghafurian et al., 2021) (+) better social connections to patients (Dino et al., 2022) and more time for patients (Kangasniemi et al., 2019); technology as

(continued on next page)

Table 3 (*continued*)

Digital technology	Physical and mental health	Occupational safety	Professional competence	Job-related attitudes	Nurse–patient relationship
					communicative "icebreaker" between staff and residents (Abbott et al., 2019); improved social interactions (Scerri et al., 2021)
Monitoring/sensor applications (k = 4)	(−) fatigue due to false alarms (Cortes et al., 2021); increased noise load (Mileski et al., 2019)	[Not reported]	[Not reported]	[Not reported]	(−) potential of reduced nurse–patient interaction (Omotunde and Wagg, 2023) and of lower care quality due to fewer face-to-face patient visits (Davis et al., 2014) (+) alarms increase chance of more interactions (Mileski et al., 2019)
Assistive devices (k = 1)	[not reported]	(+) sensors used to offer telecare and remote work can reduce nurses' infection risks (Behera et al., 2021)	[Not reported]	[Not reported]	[not reported]
Virtual-/augmented reality (k = 1)	[not reported]	[Not reported]	[Not reported]	[Not reported]	(−) more challenging communication with the patient (Wuller et al., 2019)
Other (k = 4)	(+) less stress for nurses with positive attitudes toward internet (internet: Ahmad et al., 2018); less absence rates, fatigue/need for recovery, and better/ longer sleep (automated scheduling and rostering systems) (O'Connell et al., 2024) (+/0) positive vs. no effect on work-life balance (O'Connell et al., 2024)	[Not reported]	(+) better information exchange and access to evidence-based information and knowledge (internet) (Ahmad et al., 2018)	(+) higher job satisfaction (digital workforce management systems: Tuominen et al., 2018; automated scheduling and rostering systems: O'Connell et al., 2024), especially for nurses with positive attitudes toward internet (internet: Ahmad et al., 2018)	(+) more time for nurse–patient interaction (internet: Ahmad et al., 2018; speech recognition technology: Joseph et al., 2020)
Multiple technologies (k = 8)	(+) reduced stress (due to simplification of work-related tasks) (ICT); increased sense of professional security (CDSS) (Fagerstrom et al., 2017); improved well-being (Huter et al., 2020) (−) feeling of stress because of additional documentation time (Coffetti et al., 2023)	[Not reported]	(−) technology can hamper critical reflection and judgments (Fagerstrom et al., 2017) (+) technology as a learning tool (Saab et al., 2021) and for strengthening professional development (Fagerstrom et al., 2017); potential to improve nursing training and education (Martinez-Ortigosa et al., 2023); enhanced decision-making quality (O'Connor et al., 2022b; Jayousi et al., 2024)	(−) fear of being replaced (O'Connor et al., 2022b; Jayousi et al., 2024)	(−) EHR/EMR: reduced time for patient interactions (Huter et al., 2020) (+/−) ICT: facilitation of patient participation but also ICT as relationship threat (Fagerstrom et al., 2017) (+) better partnership (Jayousi et al., 2024); enhanced interaction (ICT) (Tahsin et al., 2023)

Note. k = total number of reviews. (−): increased risk for impairment, (+/−): inconsistent finding, (0) no effect, (+) increased chance of improvement; ICT: information and communication technologies, HIS: health institution information system, EHR/EMR: electronic health/medical record, CDSS: computerized decision support system.

urgency level.

4. Discussion

4.1. Summary of evidence

In this systematic review, we synthesized the findings from 213 systematic reviews focusing on digital nursing technologies. More than half the reviews examined information and communication technologies, particularly by telecare technologies and electronic health/medical records, followed decision-support systems. After information and communication technologies robotics was the most investigated technology. The most frequently reported research objectives encompassed technology usage and/or general experiences with it, followed by technology-related consequences for the safety and health of care recipients and the impact on economic aspects.

Although not explicitly stated as a research question in most reviews, almost half of the reviews included findings on the impact of digital technologies on *work-related and organizational factors*. This was especially true for electronic health/medical records, telecare, and robotic technologies. Overall, the results within each technology category were mixed; that is, reviews reported impairments, inconsistent findings, no effects, and improvements. Technology type and particular work-related or organizational factors are pivotal in explaining such inconsistencies. Chances of improvement in work design were particularly reported for decision support systems and electronic health records, whereas monitoring/sensor applications were more often associated with adverse consequences such as increased fatigue.

Across all technology categories, we found cumulative evidence that technology use has (mainly) beneficial effects on the execution of

Table 4
Synthesis of evidence from reviews (k = 42) reporting associations between digital technologies and ethically relevant patient outcomes.

Digital technology		Beneficence, nonmaleficence	Respect for autonomy	Justice
ICT	HIS (k = 1)		(+) increased patient autonomy (Shelley et al., 2024)	[Not reported]
	EHR/EMR (k = 1)	(−) risks for patient safety (Fraczkowski et al., 2020)	[Not reported]	[Not reported]
	CDSS (k = 3)	(−) situational adaptability to individual needs (pain assessment tools) (Harmon et al., 2012)	[Not reported]	(−) indications of ageism (Islam et al., 2021) and speech discrimination (Sexton et al., 2022)
	Telecare (k = 8)	(−) (perceived) decrease of ethical responsibility of caregivers for care-recipients (Brewster et al., 2014); increased focus on physical issues due to difficulties in discussing interpersonal matters over the phone (Schuessler and Glarcher, 2024); risks for patient safety due to potential miscommunication and misinterpretation (Martin et al., 2023) (0/+) inconsistent findings regarding general quality of life (Flodgren et al., 2015; Komariah et al., 2021) (+/−) inconsistent effects on assessment of visible social cues such as patients' living situation (Lundereng et al., 2023) (+) disease-specific quality of life (Flodgren et al., 2015); increased sense of safety during SARS-CoV-2 pandemic (Joo, 2022)	(−) decreased patient privacy (Penny et al., 2018) (+/−) inconsistent findings (Martin et al., 2023) (+) increased patient autonomy (Komariah et al., 2021) and shared decision-making (Lundereng et al., 2023); improved and more timely information for patients (Schuessler and Glarcher, 2024)	(+) potential to promote health equity (Joo, 2022; Martin et al., 2023); priorization of patients based on individual patient needs (Lundereng et al., 2023)
	Communication Support Systems (k = 2)	(+) quality of life (e.g., perception of decreased social isolation and loneliness) during SARS-CoV-2 pandemic (Beogo et al., 2023) and of persons with dementia (e.g., confidence, self-esteem) (Hung et al., 2021)	(−) privacy concerns (touchscreen tablets) (Hung et al., 2021)	[Not reported]
	App(s) (k = 2)	[Not reported]	(−) decreased patient privacy (de Jong et al., 2020[a]; Fiorinelli et al., 2021)	[Not reported]
Robotic technologies (k = 14)		(−) patient safety concerns (robotic surgery: Moloney et al., 2023; Persson et al., 2021); infection concerns (robopets) (Budak et al., 2021); risk of infantilisation (robopets) (Abbott et al., 2019[a]; Scerri et al., 2021[a]) (+/−) inconsistent regarding quality of life (e.g., perception of decreased loneliness but also of personal space) (robopets) (Abbott et al., 2019[a]; Bemelmans et al., 2012[a]; Budak et al., 2021; David et al., 2022[a]; Scerri et al., 2021[a]) (+) assistive social robots: increased quality of life (e.g., perceived loneliness, wellbeing) (Ghafurian et al., 2021[a]; Haltaufderheide et al., 2023[a]; Yen et al., 2024) and increased perceptions of social support (Loveys et al., 2022[a])	(−) decreased patient privacy (Hung et al., 2022) (0/−) inconstistent regarding patient privacy (Ghafurian et al., 2021[a]; Vandemeulebroucke et al., 2021[a]) (+) (Persson et al., 2021); increased perception of independence (Dino et al., 2022[a]; Vandemeulebroucke et al., 2021[a])	[Not reported]
Monitoring/sensor applications (k = 1)		(+) increased quality of life (e.g., wellbeing, social participation) (Omotunde and Wagg, 2023)	(+) increased perception of independence (Omotunde and Wagg, 2023)	[Not reported]
Assistive devices		[Not reported]	[Not reported]	[Not reported]
Virtual/augmented reality (k = 1)		(+/−) inconsistent regarding quality of life (mixed findings regarding loneliness but also improvement of wellbeing) (Li et al., 2022)	[Not reported]	[Not reported]
Other		[Not reported]	[Not reported]	[Not reported]
Multiple technologies (k = 9)		(−) discouragement of independent thought (ICT) (Fagerstrom et al., 2017); less comprehensive assessment of patient well-being (O'Connor et al., 2022b[a]) and individual needs (Ramvi et al., 2023); decreased quality of life (Zhang et al., 2024) (+/−) loss of nonverbal clues but easier information sharing with nurses (telecare) (Ramvi et al., 2023) (0) no effect on quality of life (monitoring/sensor applications: Huter et al., 2020; ICT: Tian et al., 2024) (+) increased quality of life (Zhou et al., 2023[a]); reduced perceived loneliness and enhanced wellbeing (robotic technology) Huter et al., 2020[a]); enhanced social interactions (virtual/augmented reality) and improved patient safety (Jayousi et al., 2024) as well as sense of security (monitoring/sensor applications) (Huter et al., 2020)	(−) decreased patient privacy (O'Connor et al., 2022b[a]; monitoring/sensor applications: Alves et al., 2023; HIS: Jayousi et al., 2024) (0) no effect on perceived autonomy (monitoring/sensor applications) (Huter et al., 2020) (+) decrease in information-asymmetry between patients and nurses (Zhou et al., 2023[a]); more reciprocal, collaborative relationships between nurses and patients (Ramvi et al., 2023)	[Not reported] (+) potential to reduce inequalities (ICT) (Jayousi et al., 2024)

Note. k = total number of reviews. (−): impairment, (+/−): inconsistent finding, (0) no effect, (+) improvement; ICT: information and communication technologies, HIS: health institution information system, EHR/EMR: electronic health/medical record, CDSS: computerized decision support system.

[a] Finding refers to an artificial intelligence-assisted technology.

nursing activities in general (e.g., standardization of workflows, routine task support), information management, and job control, and it often results in time savings. Depending on the technology type, reviews reported mixed effects with regard to documentation activities, communication/collaboration and nurses' workflow and predominantly negative or inconsistent effects on nurses' workload, particularly for telecare and monitoring/sensor applications.

Safety and health-related or distal nurse outcomes were investigated in 58 of the 213 reviews. Again, the findings varied within each technology category. Improvements were particularly reported for robotic technologies, whereas evidence for the use of electronic health and medical records was comparatively critical across the outcomes.

Job attitudes, especially job satisfaction, seem to be positively affected by digital technologies. We also found that digital technology might promote nurses' professional competence. In contrast to such protective effects, several reviews have reported that the use of digital nursing technologies can translate into detrimental mental and physical strain effects, such as increased frustration, fatigue, and burnout.

Approximately one-fifth of the included reviews reported associations between digital nursing technologies and *ethically relevant outcomes for people in need of care.* Most of the reviews addressed aspects related to principles of beneficence/non-maleficence and patient autonomy, whereas patient outcomes related to the principle of justice were less often investigated. Notably, we found the highest number of reported findings for robotic technologies. Overall, we found ethically adverse or inconsistent effects more often than positive or null effects.

4.2. Availability and quality of systematic reviews

Our literature search confirmed that the current database on nursing technology is complex (Huter et al., 2020). The included reviews primarily focused on information and communication technologies and robotic systems. In contrast, monitoring/sensor applications, assistive devices, and virtual/augmented reality have been examined significantly less frequently.

These differences may be attributed to the uneven distribution of digital technologies in the nursing sector. However, to the best of our knowledge, no representative statistics show the dissemination of these technologies in nursing practice. Therefore, whether the available reviews address the requirements of nursing practice with regard to the technologies under study is unclear.

Furthermore, the quantity of evidence, (i.e., the number of included single studies) differs among the reviews and the digital technologies they investigate. For example, for electronic health/medical records the scope of included studies within the reviews is broad, from four single studies (Gephart et al., 2015) to 120 studies (Jedwab et al., 2019). In contrast, in the five reviews investigating communication support systems, the range of the included single studies was between four (Beogo et al., 2023) and 18 (Ju et al., 2021; see also Supplemental material S3).

An analysis of the research objectives of each review revealed that the focus is primarily on the relationship between the use of digital technologies and patient health and safety, on economic aspects or on technology usage and/or general experiences with it. Other important consequences of introducing digital technologies into the nursing work system, such as work design, work organization, nurses' safety and health, and potentially associated ethical dilemmas, have rarely been considered in the reviews so far. However, the World Health Organization (2016a, 2020) and the Socha-Dietrich (2021) advocate for concerted efforts to alleviate the burden on healthcare workers and harness the potential of digital technologies as essential components of future-proof healthcare systems. Therefore, systematic reviews that directly address work and health-related consequences for nurses, using digital technologies, are needed.

Regarding the *methodological quality* of the integrated reviews, all received a low or critically low quality rating, according to the AMSTAR 2 checklist, a quality assessment tool commonly used in overviews of reviews. Consistent with de Santis et al. (2023), we discovered difficulties in applying the checklist. First, the authors of AMSTAR 2 have pointed out that aggregating item ratings into overall scores is not recommended (Shea et al., 2017). Rather, researchers should adopt quality ratings based on specific questions and data. Following these suggestions in our review limits the comparability when applying the AMSTAR 2 checklist across studies and the practicability of the tools. Second, the reviews predominantly considered descriptive studies, with more robust quasi-experimental designs or randomized controlled trials being exceptions. Against this background, the AMSTAR 2 checklist is strict. After careful consideration, we decided to include all reviews in the synthesis of evidence but to make the quality assessment transparent.

4.3. Work-related and organizational factors

We identified a variety of work-related and organizational factors, whereby job demands, time savings and social aspects were most frequently addressed across the reviews.

While occupational health researchers have identified job control as an important job resource that shapes the workload of workers (Karasek, 1979; Karasek and Theorell, 1990; Parker and Grote, 2022), only six reviews have considered this factor in relation to digital technologies. We could not derive any findings regarding skill variety, skill use, or job feedback. Another essential aspect of work, particularly in the context of nursing, was insufficiently addressed in the reviews: the interactive dialogical demands inherent to the core characteristics of work in this sector. We identified technology-related effects on the nurse–patient relationship. However, from a work design perspective, it is imperative to consider not only the quality of the relationship but also the prevention of stress-related demands associated with interactive dialogical tasks (Zapf and Holz, 2006).

Notably, future reviews (and probably single studies) should analyze these currently less considered but important work-related factors (job control, skill variety and use, job feedback, and interactive-dialogical demands), as digital nursing technologies will only be successfully and sustainably implemented in nursing if they promote safe and healthy work, thereby contributing to a decent work environment. This imperative is aligned with the global strategy on human resources for health outlined in the World Health Organization (2016a).

Second, we considered the heterogeneous effects of digital nursing technologies on work-related and organizational factors within and between different digital technologies. Our findings indicate that certain technologies are frequently linked to work-related improvements (e.g., decision support systems), whereas others are more frequently associated with unfavorable effects (e.g., monitoring/sensor applications).

However, it is not only the technology that determines nurses' work tasks and work organization and, in turn, the potential risks for safety, health, and ethical behavior. It is also a matter of task-technology fit (Goodhue and Thompson, 1995), person-environment fit (Caplan, 1987), and implementation process characteristics (Parker and Grote, 2022).

Following the sociotechnical work design approach, the successful implementation of digital technologies in nursing should collaboratively optimize both the technical and social aspects of the work system (Parker et al., 2001; Parker and Grote, 2022). Different stakeholder groups (e.g., engineers, work design experts, healthcare management, nurses, and patient representatives) should be involved in a participatory approach during both phases of technology development and implementation to consider diverse knowledge and interests effectively.

4.4. Safety and health-related and further nurse outcomes

Considering safety and health-related outcomes, we found that current evidence mainly relates to the acute consequences of digital technology use, such as negative emotions, frustration, stress, boredom, and fatigue, which might develop from technology stressors, such as false alarms or distraction from other nursing tasks. Against the background of empirically proven typical health impairments in nursing (e.g., Fronteira and Ferrinho, 2011; Rosa et al., 2019) one might wonder why potential musculoskeletal complaints, emotional and physical exhaustion, and depressive symptoms were rarely considered in the investigation of technology-related effects on nurses' health. Therefore, future research should also consider middle- and long-term health consequences to assess whether digital technologies, alongside other known work stressors in nursing (e.g., shift work), pose potential risks for occupational illnesses.

Regarding the direction of the effects, as previously noted in relation to the influences on work system factors, we found that digital technology could affect nurses' health both positively and negatively. On the one hand, several reviews reported adverse technostrain effects that mirror acute strain reactions of employees in the initial weeks of technology implementation (Brod, 1984; Salanova et al., 2013). However, as discussed above, the question remains whether such effects become chronic, or under what circumstances nurses adapt. We also found some evidence that the nurse–patient relationship may be impaired and that nurses' job roles might change when implementing telecare technologies. On the other hand, many other reviews have reported beneficial effects for nurses associated with the use of digital technologies, such as reduced stress, improved recovery opportunities, increased job satisfaction, and improved professional competencies. Surprisingly, despite the frequently warned risk of deskilling associated with digital technologies, current data do not substantially support this concern. In sum, further research is necessary to precisely determine why and under what circumstances digital technologies affect nurse outcomes, and what role related changes in work and organizational characteristics play in this regard.

4.5. Ethically relevant outcomes for people in need of care

Regarding ethically relevant outcomes, the evidence related mainly to robotic technologies and, in recent years, to telecare technologies. Although scarce, there was also evidence of associations with other technologies, such as decision support or communication systems. In addition, many reviews addressing ethically relevant outcomes fell into the category of "multiple technologies".

A closer examination of the technologies for which ethical aspects were analyzed in the reviews reveals that they may directly impact human–human relationships and/or have unintended consequences associated with a dehumanization of care. Most evidence was found for effects on beneficence/nonmaleficence, which are principles that inherently build on the relationships and communication between nurses and care recipients. Only six reviews that addressed ethically relevant outcomes of technology use related to the principle of justice – which is particularly pertinent in situations requiring prioritization of nursing activities before interacting with patients.

While many studies have discussed the role of ethical aspects related to the implementation of digital nursing technologies in general (Ali et al., 2022; Ramvi et al., 2023) and specifically to the use of robots (e.g. Vandemeulebroucke et al., 2018; Gibelli et al., 2021), to our knowledge, the central role of robotic systems, particularly social and assistive robots, as well as telecare technologies has not yet been established in a comprehensive overview of empirical studies on various digital nursing technologies.

A considerable portion of the investigated (particularly robotic) technologies relies on algorithms driven by artificial intelligence (AI). AI systems can imitate human problem-solving, enabling them to aid or execute tasks that demand cognitive abilities (Parker and Grote, 2022). This underscores the necessity for the ethical design and implementation of digital nursing technologies within work systems (WHO, 2021; Bird et al., 2020). Furthermore, it prompts a closer examination of ethically significant outcomes linked to technologies that may be less prominent than robotic systems (which are still relatively uncommon, especially in Europe), yet possess the ability to mimic human problem-solving and impact human-human interaction, such as communication support systems or decision support systems.

Finally, our overview of reviews showed that published reviews reported a wide range of ethically relevant findings, considering the specificities of concrete application areas. However, the comparability of the findings was impaired by the lack of a common ethical framework – such as that used by Beauchamp and Childress (2019), or also those based on relational theories of health care and nursing (e.g., Noddings, 1984; Tronto, 1993) – explicitly used in the studies and, accordingly, by the inconsistencies in the terminology used to describe the findings.

4.6. Strengths and limitations of our systematic review of reviews

As a strength, this review has a thorough evidence-based approach to elucidating the influence of digital technologies on multiple aspects of nurses' work system design and related individual outcomes. These include work-related and organizational factors, health and safety, job attitudes, professional behavior and competence, and ethical considerations.

A key asset was the thorough development of the search string, which enhanced the robustness of the study methodology. Moreover, our review of reviews is based on a comprehensive literature search of eight international databases encompassing 14 years of research. We applied the dual control principle during screening and coding of retrieved reviews and, in accordance with recommendations by Smith et al. (2011), used the AMSTAR 2 tool for quality assessment of included reviews. However, because of the narrative nature of (most) the included reviews and due to the high heterogeneity of the included meta-analyses, it was not possible to aggregate (the) associations of interest in a meta-analytical manner. Such a meta-analysis would be desirable, as it would allow the comparison of risks and potentials of the technologies' introduction with those of other work factors on a common scale.

4.7. Implications for research, policy and practice

Nine million additional nurses and midwives are needed by 2030 to reach "Good Health and Well-being," which is one of the Sustainable Development Goals declared by the United Nations. To attract numerous people to this important profession in the near future, following the global strategy on human resources for health, the "uphold the personal, employment and professional rights of all health workers, including safe and decent working environments […]" is crucial (World Health Organization, 2016b, p 8).

The legitimacy of digital nursing technologies should be evaluated based on their influence on patient outcomes as well as their contribution to improving nurses' work and promoting their safety and health. Although our review offers initial insights, a significant amount of work remains to gain a thorough understanding of the impacts of these technologies. Future research should aim to quantitatively summarize the effects through meta-analyses and conduct high-quality studies investigating the impact of different digital nursing technologies on various aspects of work characteristics, safety, and health. The World Health Organization (WHO) emphasizes the importance of ensuring favorable working conditions, particularly in the nursing profession, which faces unique challenges. To this end, it is imperative to explore how digital technologies intersect with the interactive nature of nursing and how they influence work stressors and patient care. Discussions should also consider the potential exacerbation effects and the role of moderators in influencing technology outcomes.

Our overview of reviews shows a need for further investigation of ethically relevant outcomes associated with non-robotic technologies that may (nevertheless) affect human-human interaction. Moreover, we posit that establishing a unified framework for ethical considerations associated with the use of digital nursing technology could aid in identifying a broader spectrum of aspects. This, in turn, could facilitate the efficient translation of ethical principles into practical application.

Policy efforts should focus on optimizing the contributions of nursing practice, leveraging digital nursing technology opportunities, and incorporating nurses' perspectives into governance decisions. Technology impact assessments, such as those conducted through technology assessments, should be integrated into policy discussions to support decision-making. In addition, more attention should be paid to the need to include ethical aspects in the (further) development of methodological approaches for the assessment and evaluation of work-related risks in the care sector.

In practice, it is essential to involve stakeholders from the beginning of technology development and to foster collaborative and participative approaches to optimize the use of digital technologies. Empowering the health workforce to utilize the digital revolution fully is crucial; however, it is equally important to educate stakeholders on decent work design principles to ensure successful technology implementation. References to frameworks such as the European Commission's checklist for digital transformation can provide valuable guidance, although adaptation to specific contexts and incorporation of additional criteria are necessary. Overall, a concerted effort across the research, policy, and practice domains is needed to realize the full potential of digital nursing technologies while safeguarding the well-being of nurses and patients.

5. Conclusions

In this overview of 213 reviews of digital nursing technologies, we observed a diverse landscape of research focusing on various technological domains. Information and communication technologies, particularly electronic health/medical records, telecare technologies, and decision-support systems, were among the most investigated. While the predominant research objectives revolved around nurses' technology attitudes/acceptance and/or the impact of technology on the safety and health of care recipients or economic aspects, approximately half of the reviews also reported effects on work-related and/or organizational factors, and approximately a quarter on safety and health-related or distal nurse outcomes.

Although the findings varied among the different technology categories, certain trends became apparent. The use of digital nursing technology has shown beneficial effects on nursing activities, information management, and job control, and often resulted in time savings. The impact on documentation activities and communication/collaboration showed mixed results and that on nurses' workflow, as well as workload showed predominantly negative or inconsistent effects, with telecare and monitoring/sensor applications, particularly associated with an increase in workload. Safety- and health-related outcomes were explored in a subset of reviews that revealed both improvements and concerns across different technology types. Job attitudes and nurses' professional competencies tended to benefit from digital technologies, while physical and mental health did not. Review outcomes related to ethical considerations, although addressed in a smaller proportion of reviews, underscored the importance of the principles of beneficence/nonmaleficence as well as patients' autonomy, with robotic and telecare technologies attracting significant attention in this regard. Overall, adverse or inconsistent ethical effects were slightly more prevalent than positive or null effects.

This comprehensive review highlights the complexity of digital technology integration in nursing and underscores the need for nuanced research to better understand its multifaceted impact on nursing practices and patient care. Finally, digital nursing technologies are not the silver bullets in the struggle for a sustainable workforce. Multiple interventions at multiple levels are needed, including human-centered technology implementation.

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Amendments to the study protocol

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CRediT authorship contribution statement

Larissa Schlicht: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Johannes Wendsche:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marlen Melzer:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Letizia Tschetsche:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Ulrike Rösler:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Most information can be found in the supplements. Additional data, including the coding scheme and SPSS file underlying this study, are available upon request from the corresponding author.

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