



# **The influence of digital technologies on nursing work in emergency, intensive and critical care**

## **A literature review**

Mariela Mihaylova

Bachelor's thesis

December 2024

Health and Welfare

Bachelor's Degree Programme in Nursing

**Mihaylova Mariela**

**The influence of digital technologies on nursing work in emergency, intensive and critical care**

Jyväskylä: JAMK University of Applied Sciences, December 2024, 31 pages

Health and Welfare, Degree Programme in Nursing, Bachelor's Thesis

Permission for web publication: Yes

Language of publication: English

### **Abstract**

The presence of digital technologies in nursing has grown rapidly in recent years. Artificial intelligence, robotics, Internet of Things, digital health records are some of the most common digital tools used in nursing and healthcare in general. Even though digitalization in nursing has become more popular, nursing profession is perceived and meant to be patient-centered profession, based on personalized care, empathy and professionalism of healthcare workers. Digital technology is being implemented to improve nursing work, but not to replace human care. Intensive, critical and emergency care are the most versatile nursing settings, where nurses can benefit from using various digital technology to enhance the efficiency of their work.

The aim of the literature review was to explore the influence of digital technologies on nursing work in intensive, critical and emergency care. The articles were selected by performing a combined search in CINAHL Ultimate and Medline via EBSCO. A total of 110 articles were initially identified, out of which five were selected for the literature review. The data analysis process revealed two main categories – positive influence and negative influence of digital technologies on nursing work in intensive, critical and emergency care.

In conclusion, the results revealed that using digital technologies in nursing has pros and cons, depending on the interface of the used applications, simplicity in navigation, overall technological and digital literacy and openness in nurses, as well as their attitude and interest in trying and learning to use innovations in their work. Overall, digital technologies seem to make nursing work more timely and financially efficient, but sometimes it might cause difficulties and misunderstandings.

### **Keywords/tags (subjects)**

Digital technologies, nursing work, intensive care, critical care, acute care, urgent care

### **Miscellaneous (Confidential information)**

None

## Contents

<b>1</b>	<b>Introduction</b> .....	<b>3</b>
<b>2</b>	<b>Background</b> .....	<b>4</b>
2.1	Digital technology in healthcare .....	4
2.2	Intensive, critical and emergency care .....	6
2.3	Use of digital technology in emergency, critical care and intensive care .....	7
2.3.1	Use of digital technology in emergency .....	7
2.3.2	Use of digital technology in critical care.....	8
2.3.3	Use of digital technology in intensive care.....	9
<b>3</b>	<b>Aim, purpose and research question</b> .....	<b>10</b>
<b>4</b>	<b>Methods</b> .....	<b>10</b>
4.1	Literature Review.....	10
4.2	Article selection process .....	11
4.3	Method of analysis .....	14
<b>5</b>	<b>Results</b> .....	<b>16</b>
5.1	Positive influence of digital technologies on nursing work .....	16
5.1.1	Direct positive impact.....	16
5.1.2	Indirect positive impact.....	18
5.2	Negative influence of digital technologies on nursing work.....	19
5.2.1	Direct negative impact .....	19
5.2.2	Indirect negative impact.....	20
<b>6</b>	<b>Discussion</b> .....	<b>21</b>
<b>7</b>	<b>Ethical considerations</b> .....	<b>24</b>
	<b>References</b> .....	<b>25</b>
	<b>Appendices</b> .....	<b>28</b>
	Appendix 1. Articles included in the literature review .....	28

## Figures

Figure 1.	An example of digital technology in healthcare in the form of IoT. ....	5
Figure 2.	Classical vs. data science triage. ....	8
Figure 3.	A concept of digitalized intensive care unit.....	9
Figure 4.	Article selection process .....	14

**Tables**

Table 1. Pico's table .....	11
Table 2. Inclusion and exclusion criteria.....	12
Table 3. Databases and keywords .....	13
Table 4. Example of data analysis process.....	15
Table 5. Main categories and subcategories .....	16

# 1 Introduction

Nowadays digital technology has entered pretty much every professional field, including nursing. The presence of artificial intelligence and robotics is expanded, as it is supposed to resolve or at least to diminish the effect of nursing shortage globally. Reliance on telehealth, virtual and remote guidance and care, healthcare platforms and electronic health data has increased, especially since the Covid-19 pandemic. Even with digital technology entering nursing rapidly, nursing profession is considered as one of the least respondent to the technological advancement and digital usage. To align to the future of digitalization, nurses are expected to take advantage of the benefits and opportunities of digital culture, but also to face the challenges of it and to increase their knowledge, skills and openness to using various digital technologies in nursing. (Booth et al., 2021)

Even though various digital technologies are present and continue being introduced into the nursing field, they are not supposed to be a replacement for human care. Nursing is a humane profession; it is certainly one of the professions that require the most human-to-human interactions and closeness. Digital and other technologies are meant to assist the nurses and enhance their work, rather than to be a substitute for it. Technological implementation in nursing can be worthwhile only if technology helps to optimize the clinical results, while nursing is preserved as patient-centered profession based on close human interactions and empathy. (Meissen et al., 2022.)

In the context of technology and healthcare, this thesis is intended to explore the influence of digital technologies on nursing work in some of the most vibrant and versatile healthcare settings where human lives are saved daily - intensive, critical and emergency care, and where the use of various devices and electronic platforms is meant to maximize the effectiveness and efficiency of nursing. The focus is generally on digital technologies use in intensive, critical and emergency care and their influence on nursing work.

## 2 Background

### 2.1 Digital technology in healthcare

Digital health technology ranges from medical software, applications and databases to artificial intelligence. Digital health technologies have the potential to improve the whole patient care process – from diagnosing to disease treatment and providing accurate healthcare. The span of digital technologies ranges from health and wellness applications to electronic medical devices for treatment of various conditions, as well as all medical records and databases. (FDA, 2020.) The concept of patient care is transformed in the digital age. For example, chat robots and questionnaires often replace personal communication with patients and their families. This is one of the many examples of changes in providing healthcare. Considering the increasing popularity of digital healthcare, the nursing profession is being reinvented to adapt to the newest concepts and technology developments. (Booth et al., 2021.)

In most cases the terms “information technology” and “digital technology” can be used for the same entity, even though there is a difference. Information technology is the term used for hardware, for devices, for example: phones, computers, computer networks, corporate email servers, wearable devices, key cards and anything internet of things (IoT). Digital technology is the term for the practical implementation and usage of such devices, for example: websites, applications, search engines, emailing, etc. (Primary Goal, n.d.)

An example of digital technologies is IoT (Internet of Things) in healthcare. In the technology field the abbreviation IoT is widely used for the term Internet of Things, and the term “data” is used to refer to information. IoT is a network of connected devices that accumulate and exchange data. Every device that collects or sends information in a network of devices is IoT device. In healthcare it is the network of the devices and applications used, for example, in the ward. Computer and mobile applications that work with the data received from the devices are also part of the IoT in the ward. (SBR Technologies, 2021)

IoT in healthcare is shown in Figure 1 as an example of multiple connected healthcare devices collecting and exchanging data – monitoring vital signs, activity, nutrition, medications. It features hardware, applications, wearable devices, telehealth devices, etc. (SBR Technologies, 2021)



Figure 1. An example of digital technology in healthcare in the form of IoT. (SBR Technologies, 2021)

Another example is electronic health records, which are a huge improvement in healthcare industry, hence they replace the paper archives. Healthcare professionals have direct access to patients' history of treatments, underlying diseases and other important health factors. Moreover, patients have access to their own healthcare records and thus have a better understanding of own conditions and treatments. Also, remote monitoring and telemedicine are used widely in any healthcare settings. (FutureLearn, 2021)

In Finland, healthcare technology and nursing technology is continuously trending. Some of the latest trends are: telehealth and remote monitoring and counselling, electronic health records, AI, robotics, wearable smart devices, virtual reality, data analytics and blockchain for securing the data, 3D printing, numerous healthcare applications, smart hospitals. The evolution of nursing technology in Finland shapes the healthcare field in the country and makes it one of the most advanced globally. (Nursing.fi, 2023)

Digital healthcare has become an important and essential asset in healthcare. However, there are some challenges to be considered. Some disadvantaged groups, such as elderly, or other people who cannot learn, use or afford the usage of digital services, cannot benefit from them, thus those disadvantaged groups often happen to be isolated from access to digital healthcare services. Another challenge is cybersecurity. The more popular digital health services become, the more vulnerable those platforms are for cyberattacks. This matter is concerning because those platforms contain private and sensitive data about patients and care plans. Also, developing and maintenance of digital platforms is costly. (European Parliament, 2021)

## **2.2 Intensive, critical and emergency care**

ICU is an abbreviation for intensive care unit. Patients in ICU usually are on 24-hour life support. Patients in ICU have a life-threatening acute condition. ICU nurses are specialized in working in such units. Normally one nurse in ICU cares for a maximum of two patients at a time. (Healthline, 2021.) Critical care unit (CCU) basically means the same as ICU in various hospitals. In other hospitals CCU is a unit for more specific intensive care, such as cardiac care, neuro, medical and surgical care. Intensive care and critical care units provide 24-hour monitoring for patients with life-threatening conditions. Nurses are trained in critical care and usually nurse to patient ratio is very low, as patients in these units require constant monitoring and care. When the patients are stabilized and no longer need constant monitoring, they usually are transferred to another ward to continue the recovery treatment. (Healthline, 2021)

ICU and CCU nurses must be capable of recognizing the changes in a patient's condition and to react promptly, because a critically ill patient's condition can deteriorate in a very short time. Communication skills are also very important, as ICU and CCU nurses provide important information about a patient's condition to physicians, other healthcare team members and family members. Many patients in intensive and critical care are on life support, therefore nurses in these units must possess a strong understanding of the respiratory and cardiovascular systems and anatomy and physiology overall. Other important skills are knowledge of medications and the ability to administer medications in various routes. (Malinowski, 2024)

National Care for Health Statistics of the US Government (2022) describes emergency department as hospital outpatient unit for unscheduled visits of patients whose conditions require immediate

treatment. Emergency nurses are specialized and trained in triage (recognizing the severity of the condition and how long the patient can wait to receive treatment), and they are the first responders. Emergency nurses must be skilled in quick assessment and making the right decision under stressful situations. (WGU, 2024.) In addition to triage, emergency department nurses must be capable to take and evaluate vital signs, to administer medications in various routes, to provide wound care and assist the doctors in stabilizing the patient, intubation and minor surgical procedures, to monitor the patient (Electronic Medical Certification, 2024).

## **2.3 Use of digital technology in emergency, critical care and intensive care**

### **2.3.1 Use of digital technology in emergency**

Evolving from paper documentation to electronic health records provides the possibility to extract and use data to predict possible complications and outcomes. It is experimented in triage, when data science tools can be a fast and accurate asset to explore the previous algorithms. Variables that are used in data science tools are the vital signs and symptoms, as well as previous data about the outcomes of similar situations and treatments. Data mining applications can be used for fast decisions when timing is critical. Of course, the human factor, such as the competence of the staff is the most important, but such digital data tools are a supporting asset in critical decisions. (Nan, n. d.)

The difference between classic triage and triage based on data science is described in Figure 2. In classic triage, the nurse evaluates the vital signs and biochemical parameters and assesses the severity index. In data science triage, clinical data modelling is used to assess the severity index, based on similarities with previous cases. (Defilippo et al., 2024.)

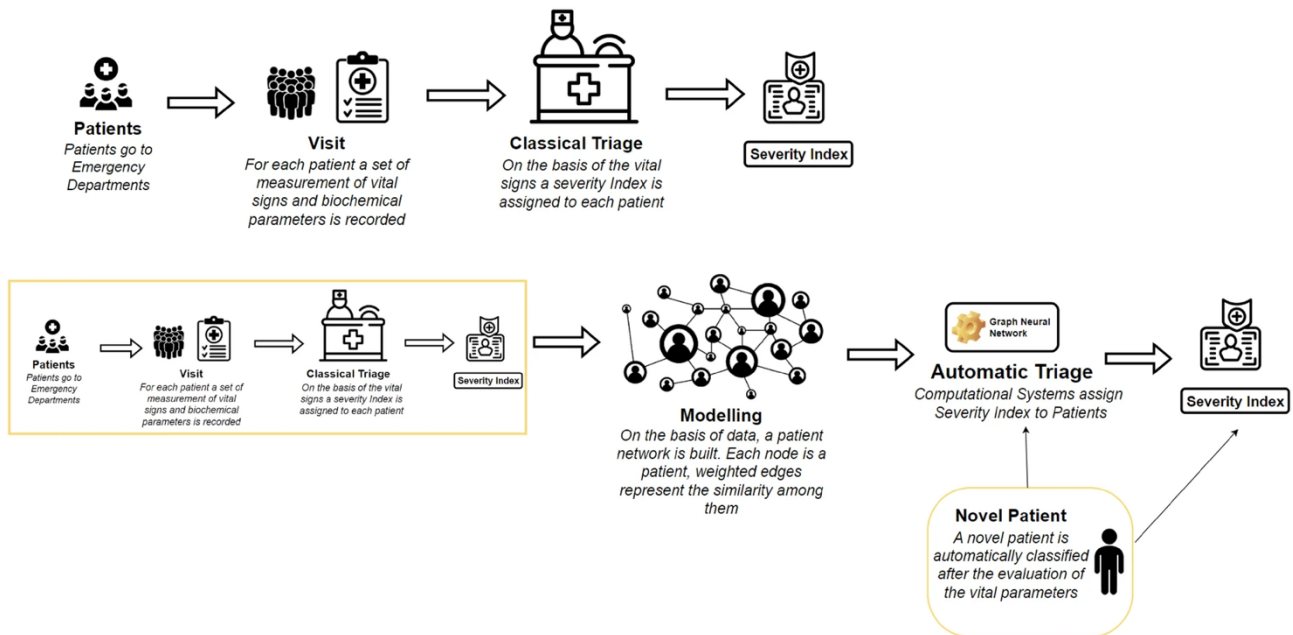


Figure 2. Classical vs. data science triage. (Defilippo et al., 2024)

### 2.3.2 Use of digital technology in critical care

Murillo-Cabezas et al. (2020) describe using digital healthcare technologies in a critical care unit during the Covid-19 pandemic. Large amount of patients' data is used to evaluate and predict the outcome of the infection, as well as the possible complications. This way medical professionals can create the best possible treatment plan for the patient. However, collecting and evaluating a large amount of data is impossible without computer applications, particularly aimed for assessment of disease progression. Such applications have been used, especially since the pandemic.

Acquiring large amount of data from laboratory and radiology results and clinical measurements with minimal manual interventions, using electronic rather than paper documentation, and implementation of online counseling rather than face to face, have been used to decrease the spread of the virus and contaminations (Cummins & Schuller, 2020). Nursing staff seem more exhausted during pandemics and crisis situations, because nurses often remain to work overtime, or they care for many patients. The consequence of such overload is more errors. Data science and artificial intelligence tools and applications can be used in arranging and prioritizing tasks; thus it can reduce the number of errors. (Kiranne et al., 2021.)

### 2.3.3 Use of digital technology in intensive care

Anderson et al. (2018) explain a concept of a smart intensive care unit, which according to the authors is digitally and technologically equipped intensive care unit with a full range of healthcare technologies for the benefits of patients and healthcare team – from bedside to communication channels and exchanging information between the stakeholders involved in the patient care. The concept defined by the authors features certain techniques: observation and management of all the alarm systems and devices (ventilators, infusion pumps, etc.) through a single virtual platform; smart devices for medication calculation and dosing; data integration, research and analysis for prediction of possible clinical abnormalities, which are invisible in traditional monitoring; environmental monitoring and control (for example light, temperature, air) through smart devices that transmit the information of any occurring environmental abnormality to the providers, free wi-fi access for all the patients and guests in the hospital ward; telemedicine and robotics for diagnostics, treatment and communication.

A model of digitalized intensive care unit, described in Figure 3, features sensors algorithm and electronic device monitoring the patient's vital signs in real time and sending alerts to the monitoring center of the intensive care unit. Healthcare professionals (doctors and nurses) access and evaluate the data, provide the right treatment for the patient and monitor the effectiveness of the treatment or the medication. (Acme Digital, 2024)

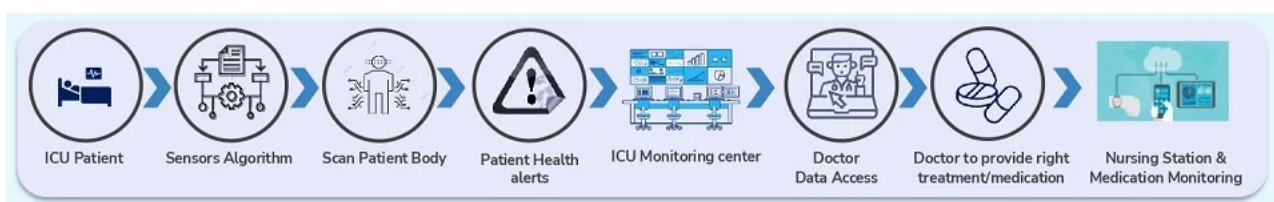


Figure 3. A concept of digitalized intensive care unit. (Acme Digital, 2024.)

### **3 Aim, purpose and research question**

The aim of this thesis is to obtain information about the influence of digital technologies on nursing work in emergency, intensive and critical care settings. The purpose of the thesis is to use the obtained information in analyzing the effect of digital technologies on nursing in emergency, intensive and critical care, which can potentially be used by researchers and developers for the advancement and innovation of digital health technology.

The research question of the thesis is: What is the influence of digital technologies on nursing work in emergency, intensive and critical care settings?

## **4 Methods**

### **4.1 Literature Review**

Literature review is often used research method in health sciences, especially in academic theses on bachelor's and master's level. Literature review is a synthesis and analysis of published and reviewed scientific articles, describing a certain clinical subject. Literature review starts with defining a research question, defining a span of the researched population and conditions, and then searching and selecting official articles according to the selection criteria. When the number of articles is enough for outlining the findings and discussing them, then the next step is analysis of the data the selected articles provide. (Popenoe et al., 2021.) While empirical research studies use data obtained from direct experiments, observations, interviews, etc., literature reviews are meant to outline and analyze empirical researches and other studies on the topic of interest (CSU, 2024).

First detail of writing a literature review is creating a list of key words related to the research question. All the concepts and their synonyms can be used to search for applicable literature in relevant databases. Then the search results can be narrowed down, and the literature can be evaluated and carefully selected. The next step is to outline the themes, patterns, conflicts and contradictions, gaps. Then literature can be outlined chronologically, thematically or

methodologically, depending on the research. The final step is writing and summarizing the literature review. (McCombes, 2024)

This literature review follows the steps of creating a list of the keywords, setting specific criteria (articles in English language, peer-reviewed, and not older than five years), searching for applicable articles in two medical databases, narrowing down the search results to the ones that can answer the research question, identifying patterns and conflicts and thematically outlining the results, while shaping the answers of the research question. At the end of the literature review the results are summarized and discussed, answers of the research questions are provided and possible developments in the field are suggested. Further details of these steps are described in the next sections.

## 4.2 Article selection process

Table 1 is described as PICO's table, which has been created to help choosing the keywords for the article search.

Table 1. Pico's table

Population	Nurses
Interest	Use of digital technology
Context	Intensive, critical and emergency care
Studies	Peer-reviewed, in English, published 2019-2024

In November 2024 a search for relevant articles according to the keywords has been executed, considering the inclusion and exclusion criteria listed in Table 2.

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Article with free access to the full text	Articles without free access to the full text
Articles in English language	Articles in other languages
Articles published during 2019-2024	Articles published earlier than 2019
Peer-reviewed articles	Articles that are not peer-reviewed
Articles relevant to the research question	Articles not relevant to the research question
Empirical research articles	Literature review articles

The article search has been carried out in two databases – CINAHL Ultimate and Medline as combined search via EBSCO. EBSCO is one of the major providers of research databases, e-books, e-journals and library technologies for universities, schools, governments, libraries, medical and healthcare institutions and other institutions worldwide (EBSCO, 2024). The keywords used in the search are (digital technology or digital technologies) AND (nurs\* or nurses or nursing) AND (emergency care or acute care or urgent care or intensive care or critical care). Table 3 is a referral to databases and keywords used in the article search.

Table 3. Databases and keywords

Database	Keywords
CINAHL Ultimate and Medline combined search	(digital technology or digital technologies) AND (nurs* or nurses or nursing) AND (emergency care or acute care or urgent care or intensive care or critical care)

A total of 110 articles were initially identified in the combined search that has been carried out in CINAHL Ultimate and Medline via EBSCO. After reviewing the titles, a total of 93 articles were excluded. From the remaining 17 articles, abstract review filtered out 4. Then 8 articles were excluded from the remaining 13, due to not having access to the full text (6) and not being relevant to the research question (2). A total of five articles are used in this literature review. The full list of the reviewed articles and their brief description is provided in Appendix 1. The article selection process is described below in Figure 4.

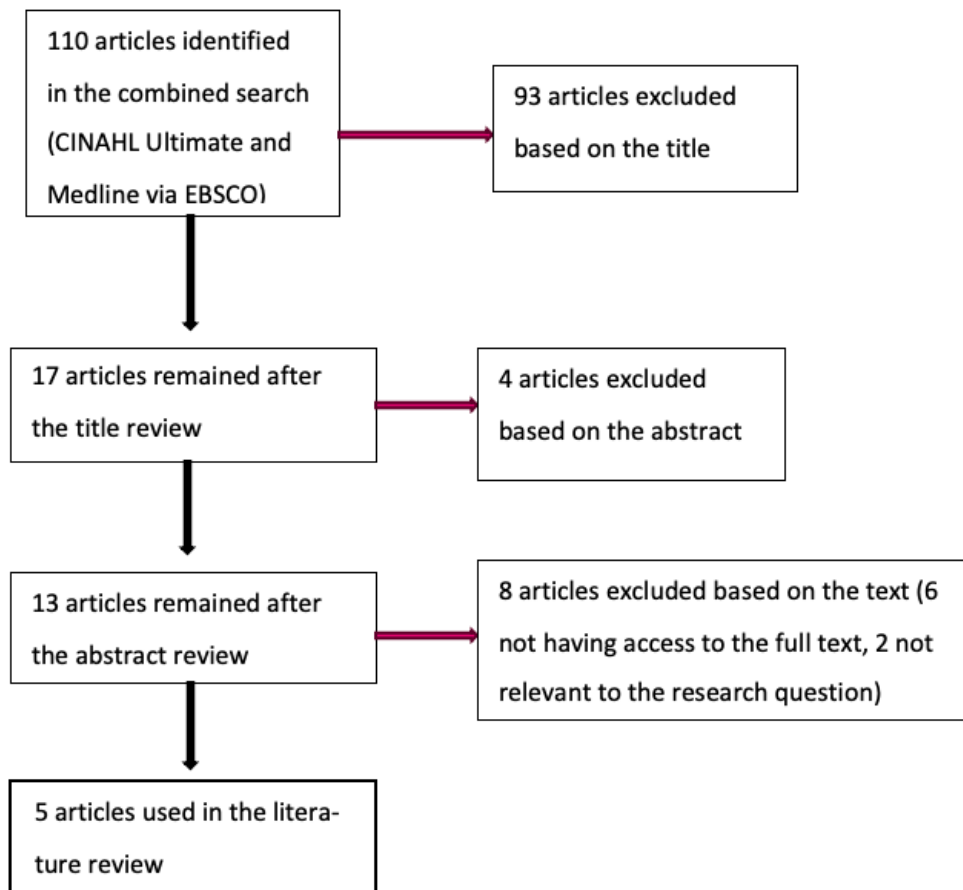


Figure 4. Article selection process

### 4.3 Method of analysis

Content analysis can be used in quantitative and qualitative way. In the recent years, a broader scope of research analysis has been defined under the umbrella of content analysis. Usually the content analysis consists of two level of analysis: statistical analysis of the terms, and the second level is interpretation of the underlying topics and conflicts. There are deductive and inductive approaches in implementing content analysis. In deductive approach the categories and sub-categories are pre-determined, and the raw material is used to prove the existing theories. In inductive approach there are no pre-determined topics and categories, but rather they are emerging from the raw material. (Seuring & Gold, 2012.) In this literature review is used inductive content analysis. Articles are read thoroughly, topics and conflicts are identified based on repetitive terms or terms with similar meanings and they are grouped in categories and sub-categories. There is no pre-existing theory to prove, but rather it emerges as an answer to the

research question. The table 4 below provides an example of the data analysis process – data coding and emerging of categories and sub-categories.

Table 4. Example of data analysis process

Raw Data	Simplified phrase	Subcategory	Main category
Camera observation has helped the nurses to adjust their care better to the patients' needs, thus they could visit the patient more or less frequently depending on the needs. (Kollerup et al., 2021)	Camera observation has made the patient visits more need-based.	Direct positive influence	Positive influence
Knowing that the patient is safe brings confidence and comfort to the nurses. (Kollerup et al., 2021)	Digital technology brings sense of confidence and comfort to the nurses.	Indirect positive influence	Positive influence
Nurses feel uncomfortable thinking about where to place the institutional mobile phone while caring for other patients. (Kollerup et al., 2021)	Pondering the place of institutional devices (mobile phone).	Direct negative influence	Negative influence
Nurses concerned about the patients' and visitors' privacy, as sometimes the patient's face or the relatives can be seen on the camera. (Kollerup et al., 2021)	Concern related to privacy of patients and visitors when cameras in use.	Indirect negative influence	Negative influence
Electronic health records are easier to revise than manually written health records, thus interpretation of documentation and nursing care is improved. (Yilmazturk, 2023)	Digital technology brings more clarity in nursing work.	Direct positive influence	Positive influence
Learning satisfaction among ICU nurses is increased with using mobile learning technology and e-learning system. (Lee & Chang, 2024)	Using mobile learning technology has increased the learning satisfaction of ICU nurses.	Indirect positive influence	Positive influence
Discomfort caused by internet connection issues. (Lee & Chang, 2024)	Internet connection issues bring discomfort.	Direct negative influence	Negative influence
Fast-tracked introduction of the electronic diary caused confusion and resistance. (Haakma et al., 2022)	Discomfort caused by fast-tracked introduction of electronic diary.	Indirect negative influence	Negative influence

## 5 Results

Data analysis revealed two main categories with two subcategories each. The two main categories are: positive influence and negative influence of digital technologies on nursing work in ICU, critical care and emergency care. Each of these categories consists of two subcategories: direct and indirect impact. Direct impact means the impact digital technology has on nursing tasks directly, how does it affect nursing tasks. Indirect impact means what feelings and attitudes digital technologies evoke in nurses, how does it affect their nursing identity and their desire to perform their nursing work. Table 5 visualizes the two main categories and their subcategories.

Table 5. Main categories and subcategories

Positive influence of digital technologies on nursing work	<ul style="list-style-type: none"> <li>• Direct positive impact – how digital technologies affect positively nursing tasks</li> <li>• Indirect positive impact – what positive, good feelings and attitudes in nurses are evoked by digital technologies</li> </ul>
Negative influence of digital technologies on nursing work	<ul style="list-style-type: none"> <li>• Direct negative impact – how digital technologies affect negatively nursing tasks</li> <li>• Indirect negative impact – what negative, bad feelings and attitudes in nurses are evoked by digital technologies</li> </ul>

### 5.1 Positive influence of digital technologies on nursing work

#### 5.1.1 Direct positive impact

Direct positive impact is the positive impact digital technologies have directly on nursing tasks, on the work nurses perform during their shifts. It means that digital technologies improve the efficiency, effectiveness and quality of nursing work. Articles used in this literature review focus on various types of digital technologies, however each one of the researched digital technologies has some kind of direct positive impact on nursing work.

Kollerup et al. (2021) studied the camera-assisted nursing observation of restless acute care patients in an acute care ward. The restless patients have been mainly elderly ones with dementia or delirium. Mental health and suicidal patients have been excluded from the study. The authors suggest that this type of digital technology has improved the efficiency of nursing work, as camera-assisted nursing observation has adjusted the nursing care based on patient's needs. Nurses knew better when the patients needed nursing care or nursing interventions, thus they visit the patients more or less frequently, depending on patients' needs. Kollerup et al. (2021) have also found that adverse events, such as removal of peripheral venous cannulas, oxygen masks and urinary catheters, patient falls, etc., have been prevented or their duration has been shortened in time. For example, when a patient has removed their peripheral intravenous catheter, the nurse has noticed this situation on the camera and has fixed it on time, so the patient hasn't remained without treatment for a longer time and only a small amount of the medication has been spilled. Sometimes semi-conscious patients have moved away from the bed without moving the intravenous line with them, which also has resulted in removal of the intravenous catheter. Nurses have had the possibility to observe their behavior continuously on the camera and have realized that sitting up in the bed has been a sign that the patient wanted to visit the bathroom, so they knew to visit and assist the patient.

Yilmazturk et al. (2023) have carried out a quantitative analysis of the effect of digitalization of nursing forms in intensive care units on time and cost. The time used to fill up electronic forms has been compared to the time used to fill paper forms. The filling time of an electronic form has been significantly shorter than the filling time of a paper form. The results have revealed that 41.67% of the time has been saved when filling up electronic forms. Also, filling up electronic forms has saved a total of 97.560 paper sheets for the time of the research, which makes USD 801.3 in savings, including saving of the printing toner as well. Saving time and money directly affects nursing work and the work conditions in the ward and in the hospital. Yilmazturk et al. (2023) suggest, that also nursing errors due to fatigue are reduced when using electronic forms, compared to when using paper forms. Another idea of the authors is that it is easier to read and revise electronic forms than manually written ones, which improves the understanding and interpretation of the health records, thus it brings more clarity in nursing work.

Rozenes et al. (2023) have developed and tested a smart personalization of monitoring systems thresholds to reduce the alarm fatigue in healthcare teams. The smart personalization has been tried and tested in intensive care units and emergency departments in various hospitals in Israel. A smart IoMT (Internet of Medical Things) sensor has been attached, and the device has grouped and segregated the data and compared it to previously recorded alarms. The settings of the sensor could be adjusted by the nursing and medical teams considering the specifications of the monitoring. There have been alerts automatically forwarded to the medical team or nursing team respectively, alerts that have been a subject of decision-making process and forwarded to either of both healthcare teams, and alerts marked as false alarms. Rozenes et al. (2023) have found that reducing the number of false alarms has reduced the workload of medical and nursing staff. It has also improved the collaboration between medical and nursing teams, as less false alarms have been forwarded and exchanged between the teams.

### **5.1.2 Indirect positive impact**

Indirect positive impact means the good, positive feelings, emotions and attitudes in nurses provoked by the introduction and use of digital technology. It is indirect impact, because while it might not directly affect the nursing work performance, yet it influences and affects the quality of it, as it might be correlated to reducing the levels of stress, saving time and energy and other positive factors that can lead to positive outcomes in nursing work.

Camera-assisted nursing observation of restless patients that has been studied by Kollerup et al. (2021) has evoked feelings of comfort and confidence in nurses when they know that their patients are safe. Nurses know that they have control over their patients' situations. Comfort and confidence and the sense of control are the opposite of stress and insecurity, which can be obstacles to providing good care. Nurses who have experienced stress-relief from knowing and controlling the patient's situation have been positive that they are able to provide good nursing care.

Nursing knowledge and nursing skills are constantly developed in all healthcare settings. Nurses update their knowledge and skills by completing various courses throughout their career. Lee & Chang (2024) have studied how online learning has affected nursing satisfaction among intensive care unit nurses. The researchers suggest that nurses' learning satisfaction has highly depended on their openness and acceptance of using information technology. Nurses who participated in the

study have voluntarily agreed to use e-mobile learning platform, considering the range of their digital literacy. The researchers Lee & Cheng (2024) have found, using quantitative analysis of measuring nursing satisfaction, that using e-learning system and mobile learning technology has brought learning satisfaction in most ICU nurses. The nurses in the study have been happy and interested to use digital learning technology for pursuing their courses, as long as the learning platforms have been easy to navigate and if the offered courses have been useful for their professional development.

During the second wave of Covid-19, innovative methods have been introduced in healthcare to minimize unnecessary hospital visits by patients and by other visitors. Haakma et al. (2022) have studied the implementation of experimental diary intervention in an intensive care unit. The diary has been a mobile application to send short updates to patients' relatives about the patients' condition and anything important concerning the patients. This way the relatives' visits would have been minimized during the pandemic. Some of the respondent ICU nurses have been positive about the introduction and the usage of the diary and all respondents have admitted its usefulness. The respondents have been convinced of the added value of this electronic diary intervention, as it has improved the collaboration between nurses and patients' relatives. The nurses have felt satisfaction in being able to facilitate such a collaboration and have felt the appreciation and trust from patients' relatives. All of this has brought positive feelings amongst the nurses.

## **5.2 Negative influence of digital technologies on nursing work**

### **5.2.1 Direct negative impact**

Direct negative impact is the negative impact of digital technology directly on the performance of nursing tasks. It means that nursing performance could be hindered or challenged by uncomfortable situations, or the quality of nursing care could be decreased due to difficulties and issues related to using digital technology.

One of the most common issues about using digital technology is related to internet connection. Connection outage or slow connection can be crucial in the performance of nursing work. This problem has been mentioned by Lee & Chang (2024) in their study of nursing satisfaction related to using mobile e-learning platforms. The authors did not discuss the internet connection issue in

detail, but its negative impact on any task dependent on internet (in that case using e-learning platform by ICU nurses) is obvious.

Another example of direct negative impact of digital technologies is provided by Kollerup et al. (2021) in their study about camera-assisted nursing observation of restless patients in an acute unit. Because the camera observation application has been installed on the institutional mobile phone for nurses to be able to observe the restless patients continuously, one nurse has expressed discomfort pondering where to place the institutional mobile phone while caring for other patients. Another nurse has encountered uncomfortable situations when having to explain to some patients and visitors that she was not using her personal mobile phone during work shift, but rather the institutional one, with the task of observing particular patients.

### **5.2.2 Indirect negative impact**

Indirect negative impact means the bad, negative attitudes and feelings the nurses experience, caused by using digital technology, which may affect the performance of nursing work. Feelings of discomfort and negative attitudes influence the desire of nurses to do their job, the quality of their work and their identity as nurses. Therefore, indirect negative impact also affects nursing work.

Unfortunately, digital technology does not always bring the desired outcome and even might bring a sense of guilt in nurses. Such an example is described in the work of Kollerup et al. (2021) about camera-assisted nursing observation of restless patients in an acute ward. Despite the continuous camera observation, sometimes nurses have not managed to react on time, to reach the patient on time and to prevent adverse events. Nurses have often blamed themselves if adverse situations occur, like a patient falling or detaching their catheters. Besides that, in the same study many nurses have claimed that camera observation cannot replace the presence of a caregiver who can comfort the patient. Moreover, nurses have expressed their concern that patients' privacy is not always respected. Even though the camera has been placed in a box that could be closed when there were visitors around or during delicate situations, such as basic care, the nurses have noticed visitors' or patients' faces on the camera. This has been the opposite of their pledge to respect the patients. The authors Kollerup et al. (2021) also suggest, based on their questionnaire results, that less experienced nurses tend to be less open towards the introduction of camera observation experiment.

Another example of experiencing feelings of discomfort, apathy and resistance among nurses is mentioned in the work of Haakma et al. (2022). The fast-tracked implementation of electronic diary to connect to patients' relatives during Covid-19 pandemic has been met with negative attitude by some nurses. They have complained about being overloaded with new information and tasks. Additionally, some of the nurses in the study have not been satisfied with the layout and user-friendliness of the application, as they found it difficult to navigate, to log in and log out and to compose short messages.

## 6 Discussion

This literature review has revealed two main directions of influences of digital technologies on nursing work in intensive, critical and emergency care – positive impact of digital technology on nursing work and negative impact of digital technology on nursing work. The studies of Kollerup et al. (2021), Haakma et al. (2022), Lee & Chang (2024) have revealed both sides of the influence of digital technologies on nursing, while the studies of Yilmazturk et al. (2023) and Rozenes et al. (2023) have revealed and discussed only the positive impact of digital technology on nursing work in intensive and critical care. The authors of the studies have disclosed the positive and negative influence on nursing work as direct and indirect. Direct way affects directly the tasks nurses perform during their shifts. Indirect way implies on nursing work through the attitude of nurses, their nursing identity and desire to perform their tasks using digital technology.

The results seem trustworthy and genuine, even though one of the studies used in the literature review, the study of Rozenes et al. (2023) has pointed out only positive impact of the described digital technology on nursing work due to testing and advertising the authors' own invention – the digital technology tool that could reduce the number of false alarms in patient monitoring. The authors described how reducing the number of false alarms has benefited the work of healthcare professionals, however they failed to address the possibility of errors, such as an alarm that might be marked as a false one by the digital tool and ignored by the healthcare teams, when a nursing or medical intervention might be required or needed. Therefore, this particular study can be considered a biased one. The rest of the studies used in the literature review seem authentic and neutral.

The other study that has pointed out only the positive impact of digital technology on nursing work in intensive and critical care is the work of Yilmazturk et al. (2023). The authors claim that introduction of electronic health records as a replacement of paper documentation reduces the workload of nurses, saves time, enhances the quality of nursing work, makes it easier to read and interpret electronic forms, and is financially more viable. Another study that confirms the time and cost efficiency, as well as the improved quality of patient care with using electronic health records, is a literature review of Kamau (2015). The author suggests that nurses can provide better patient care when they have enough time and resources to prepare and organize their work. Using electronic health records to access patient's data and for documenting and charting is timely and financially efficient, therefore it can enhance and improve the nursing work in the units.

Most of the researchers have revealed both sides of using digital technology in nursing work – the positive side that increases the efficiency and effectiveness of nursing, and the negative one that creates burdens for nurses to perform their tasks as desired. Both sides of using digital technology in nursing are discussed also in the work of Knop et al. (2024), who have studied the impact of digital technology on the professional identity of nurses. According to Knop et al. (2024), nurses tend to associate their digital literacy with their professional skills, as technological skills allow them to express their power at the workplace. However, the authors also include the possibility for nurses to become dependent on technology, to be possibly controlled by the institutional departments responsible for the IT support and to allow dehumanization of nursing care. What the authors mean about dehumanization is relying on technology to perform measurements that can be done with bodily contact (such as relying on the heart rate monitor rather than measuring the heart rate manually when needed). Besides dehumanization of nursing care, Knop et al. (2024) bring up the decrease of nurses' psychosocial skills as a result of it.

The idea that technology cannot replace the human attendance is discussed in the work of Kollerup et al. (2021). In the study it is briefly mentioned that less experienced nurses tended to be less accepting of implementing camera observation of restless patients. On the other hand, the work of Haakma et al. (2022) about implementation and use of patient electronic diary as a tool for communicating with patients' relatives, demonstrated the opposite – in the times of pandemic, when unnecessary visits should be avoided, digital technology is a great replacement of face-to-

face interactions. Utilizing digital technology might not be as powerful as face-to-face communication and interactions, but at certain periods during the pandemic it has been the preferable and best possible option.

The research of Lee & Chang (2024) has focused on e-learning and mobile learning applications as a tool for professional development of ICU nurses. The authors acknowledge the positive outcome of the e-learning experience among the ICU nurses who participated in the analysis, as well as their motivation and interest towards it. Similar results have been revealed by Rezayi et al. (2022), who have conducted a literature review about effects of technology-based educational tools on learning outcomes of ICU nurses and nursing students. The writers have concluded that nursing students enhance their learning performance through simulation-based e-learning and using mobile applications, as it improves their attitude and interest in studying, and thus their knowledge and skills. The same is valid for the ICU nurses who use e-learning methods for their professional development – the outcomes are improved skills, performance, confidence, knowledge. According to the authors, ICU nurses must be more technologically educated and knowledgeable than their colleagues in other departments, because they monitor, chart, administer medications, respond to signals and while doing their tasks they use more equipment. Besides that, their patients are often intubated or ventilated, so the ICU nurses must know the “ins and outs” of any technological equipment introduced and used in the ward (Rezayi et al., 2022).

The results seem reliable, despite the limited sources used in this literature review. The same results might be applicable for nurses working in other departments, rather than intensive, critical and emergency care. However, like Rezayi et al. (2022) suggest, nurses working in these departments are expected to be one step ahead in their openness to accepting the implementation of new digital tools and getting used to operating with them, compared to their peers. For example, as Haakma et al. (2022) and Lee & Chang (2024) claim, some nurses have not been accepting and have even been resistant to use newly introduced and experimental digital tools. Therefore, user experience in using digital devices and simplicity of navigation the platforms and applications is very important for digital tools to be accepted and nurses to be trained to use them. Possible further research to define what characteristics of digital technology tools (devices and applications) might establish it as user-friendly, useful and desirable in nursing work would be applicable as a continuation of this study.

## 7 Ethical considerations

Ethical considerations in literature review concern mainly the authors of the materials used, and the readers of the thesis. The most important ethical consideration in literature review is to cite others' work correctly and to avoid plagiarism. Additionally, only peer-reviewed articles are used, to provide relevant information and findings and not to mislead the readers with unproven and non-evidence-based information. (Kara, 2021.) To enhance the clarity for the reader, a table with descriptions of the selected articles and the reason for them being selected for the review is added (see Appendix 1). Citates and references are double-checked before submitting the work, to avoid unintentional plagiarism and to respect the work of the authors.

A common limitation of a literature review is the limited availability of relevant articles concerning the clinical issue of the work and considering all the selection criteria. Moreover, quite often there is overall limited research on the defined problem. (Dudovskiy, 2022.) The limitation that has been encountered in this work is that some articles that could have been a good option to be used, did not have access to the full text in the databases. For example, accessible materials focused on the influence of digital technology on nursing work in triage could not be found in the databases used in this review. Thus, the used articles used might not have been the best possible ones for the study, but overall, the information used provided relevant answers to the research question.

## References

Acme Digital. (2024). Electronic Intensive Care Unit – EICU. <https://www.acmeconsulting.in/electronic-intensive-care-unit.html>

Anderson, D. C., Jackson, A. A., & Halpern, N. A. (2018). Informatics for the Modern Intensive Care Unit. *Critical care nursing quarterly*, 41(1), 60–67. <https://doi.org/10.1097/CNQ.0000000000000186>

Bernstein, C. (2021). Definition digital health (digital healthcare). <https://searchhealthit.techtarget.com/definition/digital-health-digital-healthcare>

Booth, R. G., Strudwick, G., McBride, S., O'Connor, S., Lopez, A. L. S. (2021). How the nursing profession should adapt for a digital future. *BMJ* 2021;373: n1190. <https://doi.org/10.1136/bmj.n1190>

California State University. (2024). Secondary Education: Empirical and Review Articles. Pollak Library. <https://libraryguides.fullerton.edu/c.php?g=190194&p=3774340>

Cummins, N., Schuller, B.W. (2020). Five Crucial Challenges in Digital Health. *Front. Digit. Health*. <https://pmc.ncbi.nlm.nih.gov/articles/PMC8521883/>

Defilippo, A., Veltri, P., Lió, P., Guzzi, P. H. Leveraging graph neural networks for supporting automatic triage of patients. *Sci Rep* 14, 12548 (2024). <https://doi.org/10.1038/s41598-024-63376-2>

Dudovskiy, J. (2022). Research limitations. *Business Research Methodology*. <https://research-methodology.net/research-methods/research-limitations>

EBSCO. (2024). About EBSCO. <https://www.ebsco.com/about>

Electronic Medical Certification. (2024). 7 Key Responsibilities of an Emergency Room Nurse. <https://emedcert.com/blog/key-responsibilities-of-an-emergency-room-nurse>

European Parliament. (2021). The rise of digital health technologies during the pandemic. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690548/EPRS\\_BRI\(2021\)690548\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690548/EPRS_BRI(2021)690548_EN.pdf)

FDA US Food & Drug Administration. (2020). What is Digital Health. <https://www.fda.gov/medical-devices/digital-health-center-excellence/what-digital-health>

FutureLearn. (2021). The future of healthcare technology: How is medicine changing. <https://www.futurelearn.com/info/blog/future-of-healthcare-technology>

Haakma, T., Tieben, R., Sleven, B., Buise, M., van Mol, M. (2022). Experiences of nurses with an innovative digital diary intervention in the intensive care unit: A qualitative exploration. *Intensive & Critical Care Nursing*, (70). <https://doi.org/10.1016/j.iccn.2022.103197>

Kamau, N. (2015). Electronic Health Documentation and Its Impact on Nurses Routine Practices. <https://www.theseus.fi/bitstream/handle/10024/104801/Nancy%20Kamau%20PDF.pdf>

Kara, H. (2021). Ethics and Your Literature Review. Methodspace. <https://www.methods-space.com/blog/125795-2>

Kirrane, M. D., Shrapnel, S., Ramanan, M., Clement, P., Fraser, J. F., Laupland, K. B., Sullivan, C. M., & Shekar, K. (2021). Intensive care digital health response to emerging infectious disease outbreaks such as COVID-19. *Anaesthesia and Intensive Care*, 49(2), 105–111. <https://doi.org/10.1177/0310057X20975777>

Knop, M., Mueller, M., Kaiser, S., Rester, C. (2024). The impact of digital technology use on nurses' professional identity and relations of power: a literature review. <https://onlinelibrary.wiley.com/doi/10.1111/jan.16178>

Kollerup, M.G., Tolstrup, G., Laursen, B. S. (2021). Camera-assisted nursing observation of restless patients in an acute care setting, a multi-method feasibility study. <https://research.ebsco.com/c/xfqt5t/viewer/pdf/ptmxxqa3o5>

Lee, S.-Y., Chang, C.-Y. (2024). Factors influencing nurses' satisfaction to online learning approach: a cross ICU analysis. <https://research.ebsco.com/c/xfqt5t/viewer/pdf/4isyn7acgf>

Malinowski, S. (2024). What does an intensive care nurse do and is it stressful?. American Military University. <https://www.amu.apus.edu/area-of-study/nursing/resources/what-does-an-intensive-care-nurse-do/>

McCombes, S. (2024). How to Write a Literature Review. <https://www.scribbr.com/methodology/literature-review/>

Meissen, H., Gong, M. N., Wong, A. I., Zimmerman, J. J., Nadkarni, N., Kane-Gil, S. L., Amador-Castaneda, J., Bailey, H., Brown, S. M., DePriest, A. D., Eche, I. M., Narayan, M., Provencio, J. J., Seedeerstrom, N. O., Sevransky, J., Tremper, J., Aslakson, R. A. The Future of Critical Care: Optimizing Technologies and a Learning Healthcare System to Potentiate a More Humanistic Approach to Critical Care. <https://pmc.ncbi.nlm.nih.gov/articles/PMC8926065/>

Murillo-Cabezas, F., Vigil-Martín, E., Raimondi, N., & Pérez-Fernández, J. (2020). Covid-19 pandemic and digital transformation in critical care units [Pandemia de Covid-19 y transformación digital en Cuidados Intensivos]. *Medicina Intensiva*, 44(7), 457–458. <https://doi.org/10.1016/j.medicine.2020.04.004>

Nan, L. (n.d.) Artificial Intelligence and Data Science in Emergency Care. SingHealth Duke-NUS Academic Medical Centre. <https://www.scri.edu.sg/wp-content/uploads/2019/07/Artificial-Intelligence-and-Data-Science-in-Emergency-Care.pdf>

National Center for Health Statistics. (2022). Emergency department. [HTTPS://WWW.CDC.GOV/NCHS/HUS/SOURCES-DEFINITIONS/EMERGENCY-DEPARTMENT.HTM](https://www.cdc.gov/nchs/hus/sources-definitions/emergency-department.htm)

Nursing.fi. (2023). The Latest Trends in Nursing Technology in Finland. <https://nursing.fi/the-latest-trends-in-nursing-technology-in-finland/>

Popenoe, R., Langius-Eklöf, A., Stenwall, E., & Jervaeus, A. (2021). A practical guide to data analysis in general literature reviews. *Nordic Journal of Nursing Research*, 41(4), 175–186. <https://doi.org/10.1177/2057158521991949>

Primary Goal. (n.d.). What's The Difference Between IT and Digital? <https://primarygoal.ac.uk/blog/whats-the-difference-between-it-and-digital/>

Rezayi, S., Amanollahi, A., Shahmoradi, L., Rezaei, N., Katigari, M. R., Zolfaghari, M., Manafi, B. (2022). Effects of technology-based educational tools on nursing learning outcomes in intensive care units: a systematic review and meta-analysis. <https://pmc.ncbi.nlm.nih.gov/articles/PMC9719128/>

Rozenes, S., Fux, A., Kagan, I., Hellerman, M., Tadmor, B., Benis, A. (2023). Alert-Grouping: Smart Personalization of Monitoring System Thresholds to Help Healthcare Teams Struggle with Alarm Fatigue in Intensive Care. <https://research.ebsco.com/c/xfqt5t/viewer/pdf/w4k52f66y5>

SBR Technologies. (2021). Advantages Of The Internet of Things in Healthcare. <https://sbr-technologies.com/advantages-of-iot-in-healthcare/>

Seuring, S., Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. <https://doi.org/10.1108/13598541211258609>

WGU. (2024). What is an ER nurse?. <https://www.wgu.edu/career-guide/healthcare/er-nurse-career.html>

Yilmazturk, N., Kose, I., Cece, S. (2023). The effect of digitalization of nursing forms in ICUs on time and cost. <https://research.ebsco.com/c/xfqt5t/viewer/pdf/3sxum6r5j5>

## Appendices

### Appendix 1. Articles included in the literature review

Author, Year & Title of publication	Aim & Purpose	Participants	Data collection & analysis	Key findings	Country
Kollerup, M.G., Tolstrup, G., Laursen, B. S. (2021). Camera-assisted nursing observation of restless patients in an acute care setting, a multi-method feasibility study	To assess the implementation, functionality and applicability of camera-assisted observation of restless patients in the acute care unit.	<p>Eight registered nurses, chosen by the head nurse, have implemented the camera observation and have documented the experience. The same nurses have voluntarily participated in individual interviews. All the nurses and nursing assistants of the ward (n=70) have filled in a questionnaire form.</p> <p>The camera observation experiment has been initiated on 44 patients in the unit during a 6-month period. For 39 of them, the informed consent has been given by a relative.</p>	Written records, individual interviews, questionnaires. Numerical analysis for the nurses' records and questionnaires. Content analysis of the interviews.	The nurses have found the observation application and the use of equipment easy to use but have been overwhelmed by some uncomfortable situations and thoughts. The nurses have confirmed that the camera observation method has improved the patients' safety and their sense of being able to better control the situation.	Denmark
Yilmazturk, N., Kose, I., Cece, S. (2023). The effect of digitalization of nursing forms in ICUs on time and cost	To measure the effect of digitizing medical records kept in paper forms in ICUs on timesaving and paper consumption.	Two volunteer nurses from the ICU of the Istanbul University Hospital have measured the time it took to fill in the electronic forms.	Time calculation, comparison, future projection	One nurse per patient per day saved 56.82 min (3.95% per day). 28,353 adult intensive care beds in Turkey and an average occupancy rate of 68%. Based on the occupancy rate of 68%, the number of full beds is 19,280. When 56.82 min are saved per bed, 760.71 care days are saved...The estimated savings	Turkey

				13,040,804.8 US dollars per year.	
Lee, S.-Y., Chang, C.-Y. (2024). Factors influencing nurses' satisfaction to online learning approach: a cross ICU analysis	To evaluate nurses' satisfaction with using mobile learning technology in intensive care unit setting	212 ICU and critical care nurses	Questionnaires, quantitative analysis via statistical software	Nurses have found the mobile technology useful for their learning and have been satisfied with its usability	Taiwan
Haakma, T., Tieben, R., Sleven, B., Buise, M., van Mol, M. (2022). Experiences of nurses with an innovative digital diary intervention in the intensive care unit: A qualitative exploration	To explore the nurses' experience with the implementation of post-ICU diary	Fourteen ICU nurses from three hospitals	Focus group interviews, thematic analysis	Participants experienced obstacles, such as insufficient time and integration with their own work processes.	The Netherlands
Rozenes, S., Fux, A., Kagan, I., Hellerman, M., Tadmor, B., Benis, A. (2023). Alert-Grouping: Smart Personalization of Monitoring System Thresholds to Help Healthcare Teams Struggle with Alarm Fatigue in Intensive Care	Testing smart personalization of monitoring system threshold that would reduce the number of false alarms, thus help the work of healthcare teams	Medical and nursing teams in ED and ICU	Testing, system records, comparison	Reduction of false alarms and improving the work of nursing and medical teams	Israel