



## Review article

# Information and communication technology-based interventions for chronic diseases consultation: Scoping review

Pietro Randine<sup>a,\*</sup>, Aakash Sharma<sup>a</sup>, Gunnar Hartvigsen<sup>a,b</sup>, Håvard D. Johansen<sup>a</sup>, Eirik Årsand<sup>a</sup>

<sup>a</sup> Department of Computer Science, Faculty of Science and Technology, UiT The Arctic University of Norway, Tromsø, Norway

<sup>b</sup> Department of Health and Nursing Science, Faculty of Health and Sport Sciences, University of Agder, Norway

## ARTICLE INFO

## Keywords:

Chronic disease  
Consultation  
ICT  
eHealth  
mHealth  
Telehealth  
Sensors  
Wearable devices  
Security  
Privacy

## ABSTRACT

**Background:** Medical consultations are often critical meetings between patients and health personnel to provide treatment, health-management advice, and exchange of information, especially for people living with chronic diseases. The adoption of patient-operated Information and Communication Technologies (ICTs) allows the patients to actively participate in their consultation and treatment.

The consultation can be divided into three different phases: before, during, and after the meeting. The difference is identified by the activities in preparation (before), the meeting, conducted either physically or in other forms of non-face-to-face interaction (during), and the follow-up activities after the meeting (after).

Consultations can be supported by various ICT-based interventions, often referred to as eHealth, mHealth, telehealth, or telemedicine. Nevertheless, the use of ICTs in healthcare settings is often accompanied by security and privacy challenges due to the sensitive nature of health information and the regulatory requirements associated with storing and processing sensitive information.

**Objective:** This scoping review aims to map the existing knowledge and identify gaps in research about ICT-based interventions for chronic diseases consultations. The review objective is guided by three research questions: (1) which ICTs are used by people with chronic diseases, health personnel, and others before, during, and after consultations; (2) which type of information is managed by these ICTs; and (3) how are security and privacy issues addressed?

**Methods:** We performed a literature search in ACM, IEEE, PubMed, Scopus, and Web of Science and included primary studies published between January 2015 and June 2020 that used ICT before, during, and/or after a consultation for chronic diseases. This review presents and discusses the findings from the included publications structured around the three research questions.

**Results:** Twenty-four studies met the inclusion criteria. Only five studies reported the use of ICTs in all three phases: before, during, and after consultations. The main ICTs identified were smartphone applications, web-based portals, cloud-based infrastructures, and electronic health record systems.

Different devices like sensors and wearable devices were used in 23 studies to gather diverse information.

Regarding the type of information managed by these ICTs, we identified nine categories: physiological data, treatment information, medical history, consultation media like images or videos, laboratory results, reminders, lifestyle parameters, symptoms, and patient identification. Security issues were addressed in 20 studies, while only eight of the included studies addressed privacy issues.

**Conclusions:** This scoping review highlights the potential for a new model of consultation for patients with chronic diseases. Furthermore, it emphasizes the possibilities for consultations besides physical and remote meetings.

**Abbreviations:** COVID-19, coronavirus disease; EHR, electronic health record; FHIR, Fast Healthcare Interoperability Resources; GDPR, General Data Protection Regulation; HIPAA, Health Insurance Portability and Accountability Act; ICD-11, International Classification of Diseases version 11; ICT, information and communication technology; ICTs, information and communication technologies; IoT, Internet of Things; PHR, personal health record; PRISMA-ScR, PRISMA extension for Scoping review; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROMs, patient-reported outcome measures; SMS, short messaging service; SSL, Secure Sockets Layer; WHO, World Health Organization.

\* Corresponding author.

E-mail address: [pietro.randine@uit.no](mailto:pietro.randine@uit.no) (P. Randine).

<https://doi.org/10.1016/j.ijmedinf.2022.104784>

Received 2 November 2021; Received in revised form 8 April 2022; Accepted 24 April 2022

Available online 29 April 2022

1386-5056/© 2022 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

The scoping review also revealed a narrow focus on security and privacy. Security issues were more likely to be mentioned in the included publications, although with limited details. Future research should focus more on security and privacy due to the increasing amount of sensitive information gathered and used for consultations.

## 1. Introduction

### 1.1. Chronic diseases consultation

Chronic diseases include non-communicable diseases like diabetes, heart diseases, depression, and communicable diseases like AIDS and Tuberculosis. Long-term management, possibly lifelong, ongoing medical attention, and symptoms management characterize chronic diseases [1]. Being diagnosed with a chronic disease represents a life-long change in patients' lives, which and potentially affects others such as parents, spouses, and informal caregivers [2,3].

Patients with chronic diseases require self-management, namely coping with their conditions in their daily lives [4], including various activities such as medication routine, physical or occupational therapy, diet, and exercise [5]. Supporting patients to self-manage is essential to limit the burden of many chronic diseases [6], and therefore self-management of diseases is often discussed during medical consultations. A medical consultation is a two-way interaction between a patient and the health personnel, where better communication leads to better clinical outcomes [7]. These consultations are periodical [8] and an opportunity to clarify patients' understanding of the disease [9] and the different self-management activities to perform [5].

Chronic diseases are often complex, and consultations with health personnel based on missing, incomplete, or inaccurate information may result in a lower quality of care and a higher risk of medical errors [10]. For example, written information shared during or after the consultations is perceived as difficult to access by patients with impaired reading ability. Consequently, patients might not get the information and advice they need [11]. Furthermore, patients' lack of information and inadequate follow-up can lead to depression and unhealthy lifestyle changes [12].

### 1.2. Information and communication Technology-based interventions

Chronic disease consultations can be based on interventions supported by various Information and Communication Technologies (ICTs), like eHealth [13], mHealth [14], and telemedicine [15]. Smartphone applications, commercial wearable devices, or the Internet of Things (IoT) also offer patients the opportunity to track, register, and view their self-gathered/reported information [16]. Such tools highlight a potential information flow from patients to health personnel [17] that should be explored.

Including self-gathered data in the medical consultation is possible, however the information collected and processed from wearable sensors and IoT devices introduces additional security and privacy challenges [18–21]. Multiple security and privacy analyses highlighted smartphone applications' vulnerabilities due to lack of encryption, user profiling or poor standards of privacy policies [22–24]. The sensitive nature of health information requires health systems to guarantee secure storage, access, and processing of personal identifiable information [25] before potentially including them in the medical consultation. Furthermore, few studies do primarily focus on evaluating privacy and security [26].

Different legislations in different regions govern data collection and storage, such as the General Data Protection Regulation (GDPR) in the European Union and European Economic Area (EEA) [27], and the Health Insurance Portability and Accountability Act (HIPAA) in the United States of America (USA). These regulations have been introduced partly because smartphones and wearables are now collecting massive amounts of sensitive information. They provide organizations with guidelines on storing, accessing, and processing sensitive information

such as health data. They are also interconnected because GDPR is European Union legislation that has consequences outside the EEA, including the USA.

### 1.3. Objective

This scoping review aims to map the existing knowledge and identify gaps in research about the use of ICT-based interventions for chronic diseases consultation.

We will operationalize the consultation into three different phases: before, during, and after. Before a consultation includes all the activities performed by ICT prior to the meeting. During a consultation comprises all the activities conducted in a physical meeting or in non-face-to-face interaction via ICT. After a consultation includes all the activities performed using ICT as a follow-up of the medical consultation.

The following research questions were formulated to guide the scoping review:

- RQ1. Which ICTs are used by people with chronic diseases, health personnel, and others, before, during, and after consultations?
- RQ2. Which type of information is managed by these ICTs?
- RQ3. How are security and privacy issues addressed in these ICTs?

## 2. Materials and methods

### 2.1. Study design

We chose to perform a scoping review to summarize findings from the literature and identify knowledge gaps [28,29]. A scoping review enables us to discuss the publications regardless of their quality [29,30]. Consequently, the confidence in the evidence and risk of bias of the included articles were not performed.

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping review (PRISMA-ScR) guidelines [31] to verify the structure and content of this scoping review. The checklist for the reported items can be found in Appendix A, and the protocol for the scoping review is registered in Open Science Framework [32]. Considering the rapid evolution of technologies and the fact that GDPR was adopted in 2016 [27], we considered studies published in the last five years (2015–2020) and before the coronavirus disease (COVID-19) pandemic.

### 2.2. Data sources and search strategy

We identified relevant published literature by searching in ACM, IEEE, PubMed, Scopus, and Web of Science. We performed a single data search in June 2020 for studies in English published from January 2015. The search strategy utilized in the scoping review is available in Appendix B.

### 2.3. Inclusion and exclusion criteria

Peer-reviewed articles were included if a primary study used ICT before, during, and/or after a consultation for chronic diseases. Quantitative, qualitative, and mixed-method studies were included to cover all the different adoptions of ICT.

Articles were excluded if they did not include a chronic condition, consultation, and ICT. Additionally, articles were excluded if they used ICT but focused only on the COVID-19 pandemic or on an individual evaluation, for example, medical evaluation, qualitative evaluation, cost

analysis, or machine learning evaluation. Other exclusion criteria were articles published before 2015, not written in the English language, or not a primary study (e.g., reviews, essays).

2.4. Eligibility and data collection procedure

We proceeded by removing the identified duplicates from the identified publications. Afterward, two passes were done to assess the eligibility of the articles. For the first pass, all titles and abstracts were examined by two independent reviewers (PR and AS). Conflicts were resolved by a third reviewer (EÅ). For the second pass, full texts of the selected articles were extracted and analyzed to confirm their eligibility. Two reviewers (PR and AS) then independently extracted and recorded the data from these articles in an Excel spreadsheet standardized for this review. Incongruences in the extracted data were discussed among all authors.

2.5. Strategy for data synthesis

We synthesized the findings from the included publications, structured around the three research questions. Due to the heterogeneity of

the included publications, a large variety of data emerged. We categorized and grouped each intervention by whether real patients used the ICT or not. We cataloged for each chronic condition (e.g., chronic headache, diabetes, hypertension, chronic skin complications) and the corresponding human system (e.g., nervous system, endocrine system, cardiovascular system, skin) based on WHO International Classification of Diseases version 11 (ICD-11) [33]. To address the first research question, information on the specific ICT or devices used, who used it, and when in the consultation it was used (before, during, after) were extracted. To address the second research question, we categorized the type of information managed by these ICTs, and the mode of recording information: automatic versus manual reporting.

Finally, to analyze security and privacy for the included publications, we categorized and grouped each intervention based on the global regions (i.e., Europe, Asia, Oceania, North America, South America, and Africa) and how security and privacy issues were addressed in these studies.

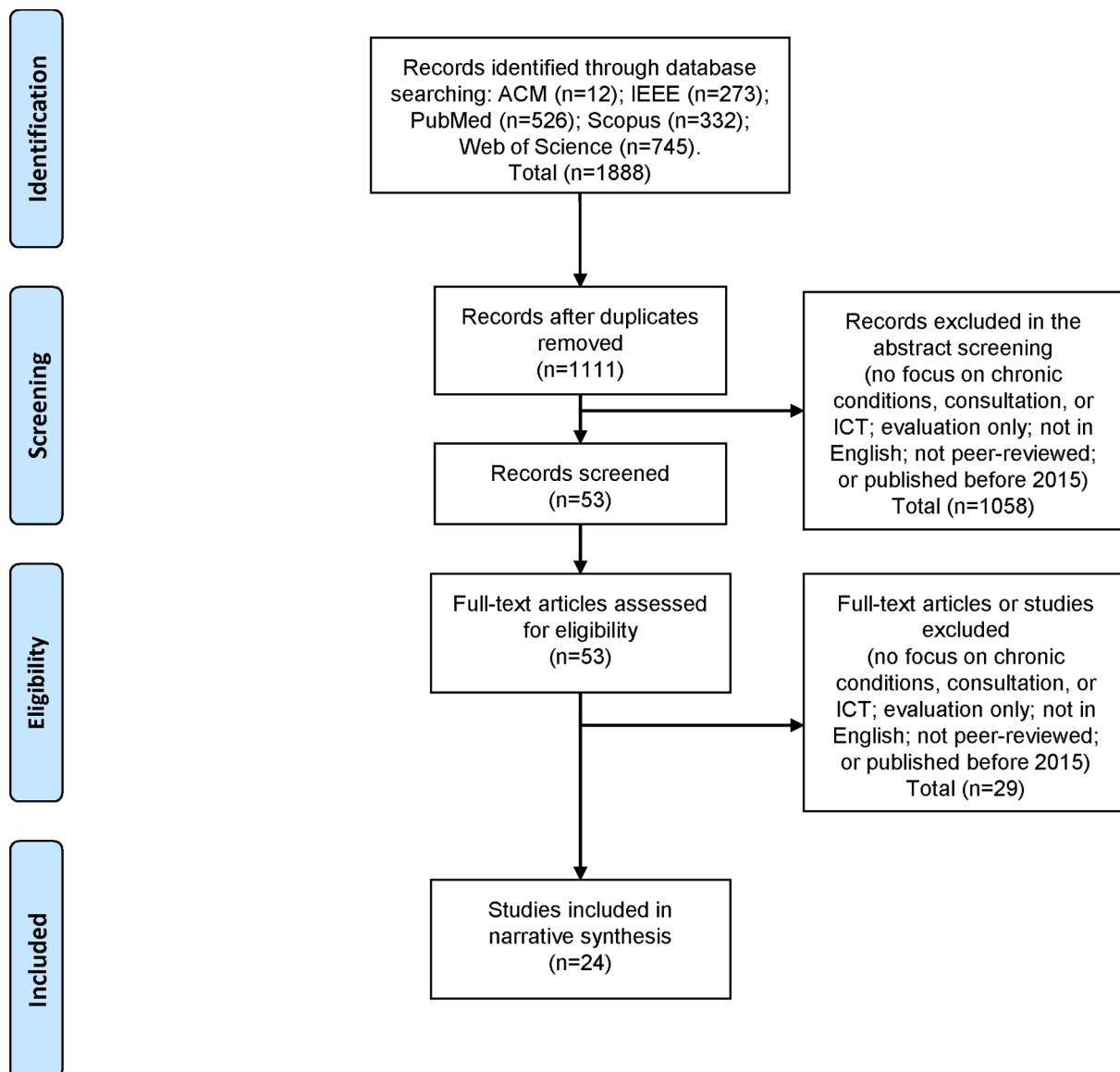


Fig. 1. PRISMA flow diagram of the performed scoping review.

### 3. Results

#### 3.1. Identified and included studies

The search performed in the five databases resulted in 1888 articles in total. After removing duplicates, 1111 articles were included in the screening process. In the abstract screening, we excluded 1058 articles based on the inclusion and exclusion criteria. In total, 53 articles were eligible for full-text screening. Among these, 29 full-text articles were excluded. Finally, a total of 24 articles [34–57] were included in the scoping review and the PRISMA flow diagram in Fig. 1 summarizes the process.

#### 3.2. Intervention and targeted chronic condition

The 24 included studies were conducted across the globe and distributed as follows: 12 in Europe [34,36–39,41,46,49,53–55,57], five in North America [35,42,45,48,50], two in South America [47,51], two in Asia [40,43], two in Oceania [44,56] and one in Africa [52].

Most of the studies (18/24) included real patients [35,36,38–44,48–51,53–57]. The remaining (6/24) only described the potential use of the developed technologies and how patients may be involved [34,37,45–47,52]. The chronic conditions and the corresponding human system based on ICD-11 for the 24 included studies are reported in Appendix C.

#### 3.3. Icts identified (RQ1)

This section presents the ICTs identified, who was using them, and when they were used in the consultation (before, during, and/or after).

Each study typically used one or more ICTs in their interventions. The most used ICTs were smartphone applications (17/24) [34,36–38,40–42,44–46,49,50,52–56] and web-based portals (16/24) [34–37,39,40,42,44,45,47,48,51,53,54,56,57].

The smartphone applications were made for both Android and iOS in seven studies [36,38,40,41,44,49,56]. In two studies, the smartphone applications were supported by three mobile operating systems: Android, iOS, and Windows Phone [42,55]. The remaining applications targeted only one operating system, either Android (7/24) [34,37,45,46,52–54] or iOS (1/24) [50].

Furthermore, we identified (7/24) cloud-based infrastructures [42,44,46,48,52,54,55], which were: a Fitbit cloud server and a cloud-based communication platform to send and receive text messages [42], a cloud-based database server to host patient data [44], a cloud-based platform to host and process information coming from IoT devices [46], a commercial third-party cloud-based caregiver portal [48], an undefined cloud-based infrastructure to host and analyze patients' sensors data [52], a wearable sensor third-party cloud [54], and a commercial cloud platform to host patients' smartphone and sensors data [55].

The remaining identified ICTs were: Electronic Health Record (EHR) systems (6/24) [37,40,41,47,53,57], video conferencing tools [39,40], decision support systems [39,40], short message service (SMS) [40,52], one ICT-enabled Kiosk [43] and a personal health record (PHR) system (1/24) [47].

Lastly, the devices used for collecting information were smartphones in 17 of the studies [34,36–38,40–42,44–46,48,49,52–56] and tablets in four studies [39,50,51,57]. The devices used to record symptoms, lifestyle parameters, and physiological data include: blood pressure monitors [35,40,41,46,48], pulse oximeters [35,39,46,48], weight scales [35,40,41,48], glucometers [35,38,46], ECG monitors [40,41], and oxygen saturation sensors [40,53]. Other devices were: Wristbands [35,42], an accelerometer [53], an unspecified Bluetooth device [52], an ICT-kiosk embedded with both a blood pressure monitor and scales for height and weight [43] and an unspecified qualified medical Bluetooth device [37].

#### 3.3.1. Use of ICT by patients, health personnel, and others

Both patients and health personnel were ICT users in all 24 studies. Physicians [34,36,40–42,44,47,50,51] and nurses [35,39,41,43,44,48,54] were the most involved health personnel, in nine and seven studies, respectively. Other individuals involved in using the ICTs were researchers [51,55] and family members [40,55]. In particular, there were functions allowing patients to invite their families to participate in self-management of chronic heart failure [40] and for notification regarding the activities of a patient with Parkinson's disease [55].

#### 3.4. Information managed by identified ICTs (RQ2)

We identified nine categories of information that are gathered, stored, retrieved, processed, analyzed, or transmitted by ICTs. The information was grouped as follows: identification, medical history, laboratory results, treatment, reminders, consultation media, physiological data, lifestyle parameters, and symptoms. The relationship between the defined categories and each study is presented in Fig. 2.

In the subsequent paragraphs, we provide additional details of some of the identified categories.

Identification included demographic characteristics [51,57], patient profiles [34] or phone number [42]. Medical history included clinical diagnosis [40], medical records [52], EHR and PHR information [47], comorbidities [51,57], mental health history [56], clinical records [55], patient history [49] and health status [55,57].

Treatment referred to medications [40,44,51,57], therapy [46], treatment advice [45], care plans [52] and treatment without further explanation [36]. Consultation media included videos [39,40,50], images [45,47,49] or messages [46] shared during a consultation. The physiological data and lifestyle parameters were strongly related to the chronic condition and the devices used in the interventions. The former included a large variety of information, with blood pressure, weight, and oxygen saturation being the most recurring ones. The latter included daily activities such as exercise [56], nutrition [55], and physical activity tracking [37].

We excluded payment information from Fig. 2, which was registered in only one study [47].

#### 3.4.1. Mode of recording information: automatic versus manual reporting

Except for one study [47], the 23 studies included devices for collecting information. We identified 15 studies with ICTs that required manual input to gather information [34,36,38–40,43–46,49,51,53,55–57]. Among these, smartphone applications were the most common ICTs [38,40,44,46,49,53,55]. Web-based portals were used to register information in two studies [36,57], while in three studies, smartphone applications were used together with web-based portals [34,45,56]. Other manual collection methods involved an Android tablet [51], a tablet with an unspecified operating system [39], and an ICT-kiosk [43].

We identified 14 studies [35,37–39,41–43,46,48,52–56] that used wearable devices or sensors to gather information automatically. We found two exceptions where the data collected from devices had to be manually transferred to the system. In one study [40], the patients manually recorded the psychological information (e.g., systolic pressure, pulse, weight) gathered from devices. In the other study [44], patients used personal devices to record their treatment parameters and medications and have to manually reported their values via a smartphone application.

#### 3.5. Security and privacy in the identified ICTs (RQ3)

##### 3.5.1. Security

Twenty studies of the included 24 [34–40,42,44–50,52,54–57] addressed at least one security issue. The remaining four studies did not mention security as an aspect of their system [41,43,51,53], even though they involved real patients. Two of these were based in Europe [41,53], one in South America [51], and one in Asia [43].

Ref	Identification	Medical history	Laboratory results	Treatment	Reminders	Consultation media	Physiological data	Lifestyle parameters	Symptoms	Before, During, After
[40]	X	X	X	X	X	X	X			Before + During + After
[45]				X	X	X				
[55]		X		X	X			X		
[56]		X			X					
[57]	X	X	X	X					X	
[37]							X	X		Before + During
[39]						X	X		X	
[47]		X				X				
[52]		X		X			X			
[36]			X	X	X					Before + After
[38]							X			
[44]				X						
[54]							X	X		
[46]				X		X	X			During + After
[34]	X								X	Before
[35]								X		
[41]							X			
[48]							X		X	
[43]			X				X			During
[49]		X					X			
[50]							X			
[51]	X	X	X	X			X			
[42]							X			After
[53]							X	X	X	

Fig. 2. Information categories identified in the 24 studies.

One study [52] mentioned the importance of security in mobile healthcare. Four studies [35,49,54,57] discussed compliance with regional regulations without providing any details. Two studies relied on a third party’s assurance of security [34,50]. The former [34] relied on the guarantees of secure data hosting in a trusted data center. The latter [50] relied on Apple FaceTime’s security guarantees.

Password-based authentication was used by seven studies [34,37,40,42,46,47,56] to avoid unauthorized access. Encryption for data transmission is recommended for sensitive data, and many of the reviewed studies mentioned the usage of Secure Sockets Layer (SSL) for security. We found eight studies [36–40,44,48,55] that used SSL to secure their system against unwanted access to the data during transmission. In terms of secure storage, only one study [36] mentioned using encrypted storage of data.

### 3.5.2. Privacy

Only eight studies [34–36,42,47,49,54,57] addressed privacy issues. Many of these stated their compliance with certain regulations such as HIPPA or GDPR without providing any details. Three of the eight studies [35,42,54] claimed to be compliant with HIPPA, one study [57] with GDPR, and one study [49] with privacy norms in Norway.

One study [47] mentioned validating their care model using an expert institutional team, which involved getting legal advice to evaluate possible privacy risks. However, they did not mention if there were any findings. Only two studies [34,36] mentioned design choices that

mitigated the privacy risks associated with the patients’ data. Both studies avoided storing any patient identifying information to ensure privacy.

## 4. Discussion

### 4.1. Principal findings

We identified 24 studies that used various ICTs to support consultations for chronic diseases. Only five studies [40,45,55–57] used ICTs to support all three phases: before, during, and after consultations. We found significant heterogeneity among the ICTs used and chronic diseases. However, smartphone applications and web-based portals were the most used ICTs regardless of the chronic disease. This finding is consistent with the high relevance of smartphone applications for eHealth research, reported by WHO [58]. Overall, the identified ICTs were used mainly by patients and health personnel, predominantly physicians and nurses. Others, such as family members, were participants in only two studies [40,55].

Further, we investigated the types of information managed by these ICTs, including the devices used and the manner of reporting the information. We identified nine categories of information, and physiological data were the most managed information. We found that the ICT-based interventions spanning across all three phases (before, during, and after) were the most complete in terms of information [40,45,55–57]

and allowed a continuous follow-up of patients via reminders and treatment information. Moreover, the devices for gathering information were widespread among patients and widely adopted in the included studies (23/24).

ICTs for chronic disease consultation have potential privacy risks associated with handling health information. They must guarantee that the sensitive information is handled carefully in terms of security and privacy. Many (20/24) of the studies mentioned at least one security issue. However, the focus on privacy issues was found to be limited. Only eight studies mentioned privacy issues.

#### 4.2. ICTs and new information

The traditional ICT-based interventions were teleconsultations,

which replaced physical meetings and diversified health personnel practice [59]. In this scoping review, the scope of these interventions was diverse and broad. Fig. 3 displays how the primary ICTs were distributed among the different interventions and consultation phases.

Even though most of the studies used smartphone applications, half supported only one mobile operating system (e.g., Android, iOS). The reason for this is likely due to the additional cost of developing and maintaining native applications for each mobile platform. From a technical perspective, hybrid smartphone application frameworks can be used in most cases to reduce the cost of cross-platform support [60], and we found this approach used in one study [36]. Additionally, studies have shown that the restriction to a unique mobile operating system may impose limitations on patient recruitment and difficulties in generalizing findings [61–63], which generally compromises the adoption of

Ref	Smartphone apps	Web-based portal	Cloud infrastructure	EHR	Before, During, After
[40]	X	X		X	Before + During + After
[45]	X	X			
[55]	X		X		
[56]	X	X			
[57]		X		X	
[37]	X	X		X	Before + During
[39]		X			
[47]		X		X	
[52]	X		X		
[36]	X	X			Before + After
[38]	X				
[44]	X	X	X		
[54]	X	X	X		
[46]	X		X		During + After
[34]	X	X			Before
[35]		X			
[41]	X			X	
[48]		X	X		
[43]					During
[49]	X				
[50]	X				
[51]		X			
[42]	X	X	X		After
[53]	X	X		X	

Fig. 3. Main ICTs used in the interventions.

these interventions in regular practice.

Regarding the use of these ICTs, we have expanded the search to other actors, those who could use them to support the patient's chronic disease management. There is evidence that patients find sharing information with their family or guardians to be positive [64–66], within certain limits. For example, some chronic conditions such as HIV [36] or mental illness [56] are often seen a stigma or very personal, in which case patients would like to keep their information confidential, as identified in previous reviews [58,67]. Excluding the mentioned studies [36,56], this scoping review found only two studies that involved family members [40,55]. This limited participation of others may represent a limitation in the current ICT-based interventions. Future studies should consider the possibility of including others in the use of ICT for chronic disease consultation, and address the technology-related challenges [68,69].

In considering the information managed by these ICTs, we found an information flow from sensors and wearables into the medical consultations. In this scoping review, we found a significant preference and use of automatically reported information via sensors. Automatically collecting information could alleviate the health personnel and patients' concerns about data entry errors. These errors can lead to wrong treatment and guidance, especially when an ICT uses treatment and screening algorithms [67]. However, the limited number of EHR systems identified in the review could be motivated by the challenges in integrating physiological data, lifestyle parameters, and/or symptoms recorded via different patient devices or wearables with EHR systems. Future studies should investigate this kind of integration, and the potential for use in medical consultation. There is little research validating wearable activities monitors [70,71]. Interoperability standards, such as Fast Healthcare Interoperability Resources (FHIR) [71], were mentioned in only one study [37], although the use of standardization when dealing with sensor data is found to be beneficial for reducing such risks [72].

#### 4.3. Security and privacy challenges

ICTs have introduced new information and possibilities relevant for chronic diseases consultations. In multiple studies [73–75], researchers have argued that ICTs must identify and address security and privacy issues in the healthcare system. Lack of transparency in ICTs about security and privacy safeguards makes it difficult to ascertain to what extent a patient's data is stored and processed in a compliant manner. Moreover, failing to protect a patient's data can result in legal fines [76] and may lead to the non-adoption of new technologies [77].

This scoping review also highlights the need to address the existing privacy and security challenges for chronic disease consultation via new studies. Some ICT interventions relied on third-party systems such as secure cloud-based storage, secure hosting, and secure applications for security guarantees. Even if it is technically possible to rely on third-party systems, researchers must also consider the legal issues around using such solutions. Public cloud services may be restricted by laws that do not allow hosting sensitive medical data outside a country's physical boundaries. For example, only one out of the 12 included European studies described their systems compliance with the GDPR [57]. As shown by previous studies, these interventions often do not become regular clinical practice due to security and privacy issues [77,78].

#### 4.4. Limitations

Due to the type of review, the publications were included and discussed regardless of their quality.

The search strategy included publications within a short period (2015–2020) because of the rapid development of technologies. The grey literature was not explored, and our search was limited to peer-reviewed research only in English. The search strategy also excluded articles related to the COVID-19 pandemic because we wanted to investigate the consultations outside the unexpected COVID-19 context.

Lastly, we encountered taxonomy problems since this review includes both quantitative and qualitative studies with heterogeneous information. We decided to first use the authors' definitions when extracting the data and then grouped the information under new or modified definitions. This process might limit the specificity of the presented results. However, it provides a snapshot of recent ICTs used in consultations.

## 5. Conclusions

This scoping review can serve as a starting point for researchers interested in exploring consultations that are not merely physical or remote meetings (during) but are expanded to include a preparation (before) and a follow-up (after) phase. We discovered a few examples of continuous consultation (before, during, after) and involvement of others such as family members or informal caregivers.

ICT currently supports this new way of doing consultations where patients can gather health information automatically via sensors or manually via mobile devices, before and/or after the consultations. However, the use of sensors and wearable devices produced by third-party companies makes it exceptionally relevant to design secure systems and protect individuals' privacy.

Our scoping review revealed a narrow focus on security and privacy. Security issues were more likely to be mentioned in the included publications than privacy issues, although, with limited details. Future research should emphasize security and privacy due to the increasing amount of sensitive information gathered outside health care settings to be potentially used in consultations.

Lastly, we have chosen to discard all the literature focusing on the COVID-19 pandemic. As we have seen during the pandemic, restricted access to primary and secondary care has forced health sector to seek alternatives, compared to a normal situation – which has increased the use of ICTs. In the coming years, future studies should verify if the COVID-19 pandemic has permanently affected the way of performing a consultation or not.

## Funding

The publication charges for this article have been funded by a grant from the publication fund of UiT The Arctic University of Norway. The work has been funded in part by the Research Council of Norway project number 263248.

## Acknowledgements

We would like to thank Dillys Larbi for her assistance in reviewing the document and her role as an “internal reviewer”. Furthermore, we thank Katja Pauline Czerwinska for her feedback on the document figures.

## Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijmedinf.2022.104784>.

## References

- [1] S. Bernell, S.W. Howard, Use your words carefully: what is a chronic disease? *Front. Public Health* 4 (2016) 159.
- [2] C.M. Martin, Chronic disease and illness care: adding principles of family medicine to address ongoing health system redesign, *Can. Fam. Physician* 53 (2007) 2086–2091.
- [3] M. Von Korff, J. Gruman, J. Schaefer, S.J. Curry, E.H. Wagner, Collaborative management of chronic illness, *Am. Coll. Physicians* (1997).
- [4] W.R. Miller, S. Lasiter, R.B. Ellis, J.M. Buelow, Chronic disease self-management: a hybrid concept analysis, *Nurs. Outlook* 63 (2015) 154–161.
- [5] D.E. Warburton, C.W. Nicol, S.S. Bredin, Health benefits of physical activity: the evidence, *CMAJ* 174 (2006) 801–809.

- [6] G. Roglic, WHO Global report on diabetes: a summary, *Int. J. Noncommunicable Dis.* 1 (1) (2016) 3.
- [7] L. Gask, T. Usherwood, The consultation, *BMJ* 324 (2002) 1567–1569.
- [8] L. Gask, Role of specialists in common chronic diseases, *BMJ* 330 (2005) 651–653.
- [9] World Health Organization, General principles of good chronic care: integrated management of adolescent and adult illness, WHO, 2003.
- [10] J.S. Ancker, H.O. Witteman, B. Hafeez, T. Provencher, M. Van de Graaf, E. Wei, The invisible work of personal health information management among people with multiple chronic conditions: qualitative interview study among patients and providers, *J. Med. Internet Res.* 17 (2015), e137.
- [11] B.P. Janssen, N. Mitra, A. Shah, F. Wan, D. Grande, Using digital technology to engage and communicate with patients: a survey of patient attitudes, *J. Gen. Intern. Med.* 31 (2016) 85–92.
- [12] L. Gholizadeh, P.M. Davidson, M. Heydari, Y. Salamonsen, Heart disease and depression: is culture a factor? *J. Transcult. Nurs.* 25 (3) (2014) 290–295.
- [13] G. Eysenbach, What is e-health? *J. Med. Internet Res.* 3 (2) (2001) e20.
- [14] M. Kay, J. Santos, M. Takane, mHealth: new horizons for health through mobile technologies, *World Health Organization*, 64 (2011) 66–71.
- [15] W.H. Organization, Telemedicine: opportunities and developments in member states. Report on the second global survey on eHealth, World Health Organization, 2010.
- [16] H.D. Johansen, D. Johansen, T. Kupka, M.A. Riegler, P. Halvorsen, Scalable Infrastructure for Efficient Real-Time Sports Analytics, Companion Publication of the 2020 International Conference on Multimodal Interaction, 2020, pp. 230–234.
- [17] C. Dinh-Le, R. Chuang, S. Chokshi, D. Mann, Wearable health technology and electronic health record integration: scoping review and future directions, *JMIR mHealth uHealth* 7 (9) (2019) e12861.
- [18] S. Al-Janabi, I. Al-Shourbaji, M. Shojafar, S. Shamshirband, Survey of main challenges (security and privacy) in wireless body area networks for healthcare applications, *Egypt. Inf. J.* 18 (2017) 113–122.
- [19] G. Marques, R. Pitarna, N.M. Garcia, N. Pombro, Internet of Things architectures, technologies, applications, challenges, and future directions for enhanced living environments and healthcare systems: a review, *Electronics* 8 (2019) 1081.
- [20] R.H. Weber, Internet of Things-New security and privacy challenges, *Comput. Law Security Rev.* 26 (2010) 23–30.
- [21] A. Sharma, K.P. Czerwinska, L. Brenna, D. Johansen, H.D. Johansen, Privacy perceptions and concerns in image-based dietary assessment systems: questionnaire-based study, *JMIR Human Factors* 7 (4) (2020) e19085.
- [22] T. Alessa, M.S. Hawley, E.S. Hock, L. de Witte, Smartphone apps to support self-management of hypertension: review and content analysis, *JMIR mHealth uHealth* 7 (5) (2019) e13645.
- [23] P. Bondaronek, G. Alkhalidi, A. Slee, F.L. Hamilton, E. Murray, Quality of publicly available physical activity apps: review and content analysis, *JMIR mHealth uHealth* 6 (3) (2018) e53.
- [24] A. Papageorgiou, M. Strigkos, E. Politou, E. Alepis, A. Solanas, C. Patsakis, Security and privacy analysis of mobile health applications: the alarming state of practice, *IEEE Access* 6 (2018) 9390–9403.
- [25] J.G. Hodge Jr, L.O. Gostin, P.D. Jacobson, Legal issues concerning electronic health information: privacy, quality, and liability, *JAMA* 282 (1999) 1466–1471.
- [26] D. Larbi, P. Randine, E. Arsand, K. Antypas, M. Bradway, E. Gabarron, Methods and evaluation criteria for apps and digital interventions for diabetes self-management: systematic review, *J. Med. Internet Res.* 22 (7) (2020) e18480.
- [27] G.D.P. Regulation, Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46, *Official J. Eur. Union (OJ)* 59 (2016) 294.
- [28] H. Arksey, L. O'Malley, Scoping studies: towards a methodological framework, *Int. J. Soc. Res. Methodol.* 8 (1) (2005) 19–32.
- [29] M.D. Peters, C.M. Godfrey, H. Khalil, P. McInerney, D. Parker, C.B. Soares, Guidance for conducting systematic scoping reviews, *Int. J. Evidence-based Healthcare* 13 (2015) 141–146.
- [30] Z. Munn, M.D. Peters, C. Stern, C. Tufanaru, A. McArthur, E. Aromataris, Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach, *BMC Med. Res. Methodol.* 18 (2018) 143.
- [31] A.C. Tricco, E. Lillie, W. Zarin, K.K. O'Brien, H. Colquhoun, D. Levac, D. Moher, M. D.J. Peters, T. Horsley, L. Weeks, S. Hempel, E.A. Akl, C. Chang, J. McGowan, L. Stewart, L. Hartling, A. Aldcroft, M.G. Wilson, C. Garrity, S. Lewin, C. M. Godfrey, M.T. Macdonald, E.V. Langlois, K. Soares-Weiser, J.o. Moriarty, T. Clifford, Ö. Tunçalp, S.E. Straus, PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation, *Ann. Intern. Med.* 169 (7) (2018) 467–473.
- [32] P. Randine, A. Sharma, G. Hartvigsen, H.D. Johansen, Å. E. Use of Information and Communication Technology Before, During, and After a Consultation for Chronic Diseases: Scoping Review Protocol, 2020.
- [33] W.H. Organization, ICD-11 for mortality and morbidity statistics, Retrieved June, 22 (2018) 2018.
- [34] A.J. Aljaaf, D. Al-Jumeily, A.J. Hussain, T. Baker, M. Alloghani, J. Mustafina, H-diary: mobile application for headache diary and remote patient monitoring, in: 2018 11th International Conference on Developments in eSystems Engineering (DeSE), IEEE, 2018, pp. 18–22.
- [35] E. Chang, A. Iukuridze, M. Echevarria, J.B. Teh, D. Chanson, B. Ky, E.J. Chow, R. Nakamura, L. Lindenfeld, S.H. Armenian, Feasibility and acceptability of using a telehealth platform to monitor cardiovascular risk factors in hematopoietic cell transplantation survivors at risk for cardiovascular disease, *Biol. Blood Marrow Transplant.* 26 (6) (2020) 1233–1237.
- [36] P. Chausa, F.J. Gárate, C. Cáceres, E. Wallitt, J. Whetham, E.J. Gómez, E. Consortium, EmERGE Platform: A New mHealth Solution for People Living with HIV, Mediterranean Conference on Medical and Biological Engineering and Computing, Springer, 2019, pp. 832–838.
- [37] M. Donati, A. Celli, A. Ruiu, S. Saponara, L. Fanucci, A telemedicine service platform exploiting BT/BLE wearable sensors for remote monitoring of chronic patients, in: 2018 7th International Conference on Modern Circuits and Systems Technologies (MOCAST), IEEE, 2018, pp. 1–4.
- [38] S. Franc, G. Charpentier, Devices to support treatment decisions in type 1 diabetes: The Diabeo system, *Technological Advances in the Treatment of Type 1 Diabetes*, Karger Publishers, 2015, pp. 210–225.
- [39] M. Gerdes, F. Gallefoss, R.W. Fensli, The EU project “United4Health”: results and experiences from automatic health status assessment in a Norwegian telemedicine trial system, *J. Telemed. Telecare* 25 (2019) 46–53.
- [40] X. Guo, X. Gu, J. Jiang, H. Li, R. Duan, Y. Zhang, L. Sun, Z. Bao, J. Shen, F. Chen, A hospital-community-family-based telehealth program for patients with chronic heart failure: single-arm, prospective feasibility study, *JMIR mHealth uHealth* 7 (12) (2019) e13229.
- [41] D. Kauw, M.A. Koole, M.M. Winter, D.A. Dohmen, I.I. Tulevski, S. Blok, G. A. Somsen, M.P. Schijven, J.W. Vriend, D. Robbers-Visser, Advantages of mobile health in the management of adult patients with congenital heart disease, *Int. J. Med. Inf.* 132 (2019), 104011.
- [42] S. Kitsiou, M. Thomas, G.E. Marai, N. Maglaveras, G. Kondos, R. Arena, B. Gerber, Development of an innovative mHealth platform for remote physical activity monitoring and health coaching of cardiac rehabilitation patients, in: 2017 IEEE EMBS International Conference on Biomedical & Health Informatics (BHI), IEEE, 2017, pp. 133–136.
- [43] G. Ng, N. Tan, J. Bahadin, E. Shum, S.W. Tan, Development of an automated healthcare kiosk for the management of chronic disease patients in the primary care setting, *J. Med. Syst.* 40 (2016) 1–11.
- [44] M.A. Nidcao, J. Kim, T. Baldacchino, Y.H. Jung, M. Mikaheal, A. Patekar, K. Sud, ‘My Home Hemo’-app-a new telehealth tool for remote monitoring of patients on home haemodialysis, *Renal Soc. Australasia J.* 12 (2016) 41–47.
- [45] B. Parmanto, G. Pramana, X.Y. Daihua, A.D. Fairman, B.E. Dicianno, Development of mHealth system for supporting self-management and remote consultation of skincare, *BMC Med. Inf. Decis. Making* 15 (2015) 1–8.
- [46] E. Patti, M. Donatelli, E. Macii, A. Acquaviva, IoT software infrastructure for remote monitoring of patients with chronic metabolic disorders, in: 2018 IEEE 6th International Conference on Future Internet of Things and Cloud (FiCloud), IEEE, 2018, pp. 311–317.
- [47] F. Plazzotta, J.A. Sommer, S.N.M. Fossier, D.R. Luna, Asynchronous dermatology teleconsultations using a personal health record, *MIE* (2018) 690–694.
- [48] S.J. Rhoads, C.I. Serrano, C.E. Lynch, S.T. Ounpraseuth, C.H. Gauss, N. Payakachat, C.L. Lowery, H. Eswaran, Exploring implementation of m-health monitoring in postpartum women with hypertension, *Telemed. e-Health* 23 (2017) 833–841.
- [49] S.M.H. Rizvi, T. Schopf, A. Sangha, K. Ulvin, P. Gjersvik, E.J.F. Houwink, Tele dermatology in Norway using a mobile phone app, *Plos One* 15 (4) (2020) e0232131.
- [50] K. Shem, S.J. Sechrist, E. Loomis, L. Isaac, SciPad: effective implementation of telemedicine using iPads with individuals with spinal cord injuries, a case series, *Front. Med.* 4 (2017) 58.
- [51] D.V. Silveira, M.S. Marcolino, E.L. Machado, C.G. Ferreira, M.B.M. Alkmim, E. S. Resende, B.C. Carvalho, A.P. Antunes, A.L.P. Ribeiro, Development and evaluation of a mobile decision support system for hypertension management in the primary care setting in Brazil: mixed-methods field study on usability, feasibility, and utility, *JMIR mHealth uHealth* 7 (2019), e9869.
- [52] L.S. Tapsoba, F. Guinko, H.B. Sta, A mobile cloud-based application for renal insufficiency patient monitoring, in: 2018 International Conference on Smart Communications and Networking (SmartNets), IEEE, 2018, pp. 1–7.
- [53] J. Timmerman, M. Dekker-van Weering, M. Stuiver, W.G. Groen, M. Wouters, T. Tönis, H. Hermens, M. Vollenbroek-Hutten, Ambulant monitoring and web-accessible home-based exercise program during outpatient follow-up for resected lung cancer survivors: actual use and feasibility in clinical practice, *J. Cancer Surviv.* 11 (2017) 720–731.
- [54] R.P.B. Tonino, K. Larimer, O. Eissen, M.R. Schipperus, Remote patient monitoring in adults receiving transfusion or infusion for hematological disorders using the VitalPatch and accelerateIQ monitoring system: quantitative feasibility study, *JMIR Human Factors* 6 (4) (2019) e15103.
- [55] K.M. Tsiouris, D. Gatsios, G. Rigas, D. Mijlkovic, B.K. Seljak, M. Bohanec, M. T. Arredondo, A. Antonini, S. Konitsiotis, D.D. Koutsouris, PD\_Manager: an mHealth platform for Parkinson’s disease patient management, *Healthcare Technol. Lett.* 4 (2017) 102–108.
- [56] M. Varnfield, K. Rajesh, C. Redd, S. Gibson, L. Gwillim, S. Polkinghorne, Health-e minds: a participatory personalised and gamified mHealth platform to support healthy living behaviours for people with mental illness, in: 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), IEEE, 2019, pp. 6943–6947.
- [57] C. Webers, E. Beckers, A. Boonen, Y. van Eijk-Hustings, H. Vonkeman, M. Van De Laar, A. Van Tubergen, Development, usability and acceptability of an integrated eHealth system for spondyloarthritis in the Netherlands (SpA-Net), *RMD Open* 5 (2019), e000860.
- [58] World Health Organization, WHO Guideline: Recommendations on Digital Interventions for Health System Strengthening: Web Supplement 2: Summary of Findings and GRADE Tables, WHO, 2019.



- [59] M. O’Cathail, M.A. Sivanandan, C. Diver, P. Patel, J. Christian, The use of patient-facing teleconsultations in the national health service: scoping review, *JMIR Med. Informatics* 8 (3) (2020) e15380.
- [60] M. Martinez, S. Lecomte, Towards the quality improvement of cross-platform mobile applications, in: 2017 IEEE/ACM 4th International Conference on Mobile Software Engineering and Systems (MOBILESoft), IEEE, 2017, pp. 184–188.
- [61] R. Whear, J. Thompson-Coon, M. Rogers, R.A. Abbott, L. Anderson, O. Ukoumunne, J. Matthews, V.A. Goodwin, S. Briscoe, M. Perry, K. Stein, Patient-initiated appointment systems for adults with chronic conditions in secondary care, *Cochrane Database Syst. Rev.* 2020 (4) (2020).
- [62] A.T. Burge, N.S. Cox, M.J. Abramson, A.E. Holland, Interventions for promoting physical activity in people with chronic obstructive pulmonary disease (COPD), *Cochrane Database Syst. Rev.* (2020).
- [63] M.J. Palmer, S. Barnard, P. Perel, C. Free, Mobile phone-based interventions for improving adherence to medication prescribed for the primary prevention of cardiovascular disease in adults, *Cochrane Database Syst. Rev.* (2018).
- [64] C.L. Gilliss, W. Pan, L.L. Davis, Family involvement in adult chronic disease care: reviewing the systematic reviews, *J. Fam. Nurs.* 25 (1) (2019) 3–27.
- [65] K.J. O’Leary, M.E. Lohman, E. Culver, A. Killarney, G. Randy Smith Jr., D.M. Liebovitz, The effect of tablet computers with a mobile patient portal application on hospitalized patients’ knowledge and activation, *J. Am. Med. Inf. Assoc.* 23 (2016) 159–165.
- [66] L. Wilcox, J. Woollen, J. Prey, S. Restaino, S. Bakken, S. Feiner, A. Sackeim, D. K. Vawdrey, Interactive tools for inpatient medication tracking: a multi-phase study with cardiothoracic surgery patients, *J. Am. Med. Inform. Assoc.* 23 (2016) 144–158.
- [67] W.A. Odendaal, J.A. Watkins, N. Leon, J. Goudge, F. Griffiths, M. Tomlinson, K. Daniels, Health workers’ perceptions and experiences of using mHealth technologies to deliver primary healthcare services: a qualitative evidence synthesis, *Cochrane Database Syst. Rev.* (2020).
- [68] A.Y.I. Hassan, Challenges and recommendations for the deployment of information and communication technology solutions for informal caregivers: scoping review, *JMIR Aging* 3 (2) (2020) e20310.
- [69] E. Park, H. Kim, A. Steinhoff, Health-related internet use by informal caregivers of children and adolescents: an integrative literature review, *J. Med. Internet Res.* 18 (3) (2016) e57.
- [70] S.M. Brooke, H.-S. An, S.-K. Kang, J.M. Noble, K.E. Berg, J.-M. Lee, Concurrent validity of wearable activity trackers under free-living conditions, *J. Strength Cond. Res.* 31 (2017) 1097–1106.
- [71] T. Loncar-Turukalo, E. Zdravevski, J.M. da Silva, I. Chouvarda, V. Trajkovik, Literature on wearable technology for connected health: scoping review of research trends, advances, and barriers, *J. Med. Internet Res.* 21 (2019), e14017.
- [72] D. Bender, K. Sartipi, HL7 FHIR: An Agile and RESTful approach to healthcare information exchange, in: Proceedings of the 26th IEEE International Symposium on Computer-based Medical Systems, IEEE, 2013, pp. 326–331.
- [73] T.M. Hale, J.C. Kvedar, Privacy and security concerns in telehealth, *AMA J. Ethics* 16 (2014) 981–985.
- [74] N.A. Azeez, C. Van der Vyver, Security and privacy issues in e-health cloud-based system: a comprehensive content analysis, *Egypt. Inf. J.* 20 (2019) 97–108.
- [75] D. Haluza, D. Jungwirth, ICT and the future of health care: aspects of health promotion, *Int. J. Med. Inf.* 84 (1) (2015) 48–57.
- [76] K.A. Houser, W.G. Voss, GDPR: The end of Google and Facebook or a new paradigm in data privacy, *Rich. J. Tech.* 25 (2018) 1.
- [77] E. Meinert, A. Alturkistani, D. Brindley, P. Knight, G. Wells, N. de Pennington, Weighing benefits and risks in aspects of security, privacy and adoption of technology in a value-based healthcare system, *BMC Med. Inf. Decis. Making* 18 (2018) 1–4.
- [78] G.A. Teixeira, M.M. da Silva, R. Pereira, The critical success factors of GDPR implementation: a systematic literature review, *Digital Policy, Regulation and Governance*, 2019.