Health Information Technology and Telemedicine in Covid-19 Management: A Systematic Review

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Abstract

Aim: This study aims to conduct a review of information technologies and telemedicine services during Covid-19 pandemic in order to identify the main challenges on the way, and provide recommendations.

Method: A systematic review of medical informatics and telemedicine application in the 2019n-CoV period was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) method. The original papers or proceedings in English language containing the keywords were considered eligible for this study. 323 studies from the seven databases searched (PubMed, Web of Science, Science Direct, Scopus, Google Scholar, IEEE Xplore Library, and Springer Link) were imported to a project in Covidence.com and checked for duplications. After the reviewers screened their titles and abstracts, each potentially relevant study (n=107) was assessed in full text by one reviewer. As a result, 37 papers entered the study. The selected papers were then thoroughly checked by the reviewers for the desired data.

Results: The included studies were reviewed to extract the following information: types of technologies used in each paper, challenges and limitations faced around the world (both developed and developing countries). It also provided recommendations made by reviewed studies as solutions to the mentioned challenges.

Conclusion: This review unveils that there are few suitable policies and strategies simplifying technology use in managing crisis like pandemics even in countries that do not lack infrastructures or equipment. This study can present a starting point as it identifies the most utilized technologies and existing limitations on the way and offers practical recommendations to conquer them.

Keywords: Information Technology; Medical Informatics; Telemedicine; Covid-19 Health

By the last day of December 2019, a cluster of cases of etiologically unknown pneumonia was identified in Wuhan City, China. Later, in January 2020, the cause of these cases was claimed to be a new type of coronavirus given the term severe acute respiratory syndrome coronavirus-2(SARS-CoV-2) by World Health Organization (WHO) (1, 2). Coronaviruses have also been the source of severe acute respiratory syndrome (SARS-CoV) and the Middle East respiratory syndrome (MERS-CoV) (3). Considering the clinical characteristics of 2019-nCoV, which range from asymptomatic infections to serious respiratory problems, are similar.(4).

Although the novel coronavirus disease's overall mortality rate appeared to be lower than the other two, it has shown a higher transmission rate than that of SARS-CoV and MERS-CoV (5). Another tremendously challenging feature of the 2019-nCoV is its incubation's ability to last up to 14 days from infection to symptoms surfacing (5).

Infecting 1.7 million individuals within four months (6), Covid-19 had already been acknowledged as public health emergency of international concern by WHO (7). As of May 12, 2020, Covid-19 had grown into a pandemic involving 187 countries/regions worldwide (8). Oddly, different parts of the world infected with the 2019-nCoV had been facing varying degrees of its symptoms (9). Consequently, a single solution could not work for every region involved, and there needed to be innovative strategies tailored to each situation. While in-person care had always been the priority when it came to diseases and epidemics, this new virus and its impeccably unusual characteristics required a new approach to reduce human contact and increase availability at the same time. As a result, healthcare organizations and society moved toward technology and telemedicine (10).

The intensive need to collect and analyze timely and accurate data on a national scale to manage and control the current pandemic has been emphasized from various perspectives. Accessing such data would depend on improving existing health information technologies and legal infrastructures (11). Since health information technology (HIT)-based interventions tend to have the potential to better manage the procedures associated with patients from entry to discharge (13), it seems reasonable to consider them a starting point.

Several forms of information technology and related areas have been used in various aspects of the current pandemic. Artificial intelligence (AI) and deep learning enhance quick detection and diagnosis of Covid-19 alongside simplifying drugs discovery processes. A few examples of the remarkable contributions made by health information technologies in the fight against the Covid-19 are the Internet of Things (IoT), which offers platforms for monitoring epidemics, big data models of virus activity or prevalence (using location-based services data), and smartphone technology alone or as a subset of telemedicine (10, 12).

In this paper, the authors systematically reviewed the papers regarding the use of health information technology alongside telemedicine in the current pandemic to provide an overview of health informatics as existing solutions and limitations and challenges on the way. Moreover, according to reviewed papers, several convenient and applicable suggestions are expressed as probable answers to the current pandemic's increasing demands.

Method

- Search strategy

A systematic search was carried out in databases PubMed, Web of Science, Science Direct, Scopus, Google Scholar, IEEE Xplore library, and SpringerLink using keywords "Covid-19" and "health information technology" and their synonyms identified by mesh. Searching the databases was done on April 17, 2020. While the search results were exported in an XML file on the same day, decisions were made in the next three days. Appendix 1 presents the search strategy and the number of studies extracted from each database.

- Study selection and eligibility criteria

The search results' references were imported to Covidence (14) in XML format. After the

duplicate's elimination, titles and abstracts were reviewed for eligibility criteria by two authors independently. The full texts were downloaded where inclusion was in doubt. The remaining studies were then independently reviewed by authors to be selected according to the inclusion criteria. In case of disagreement, the reviewers would have a discussion to come to a conclusion. During the screening stage, Covidence online tool was used. The present systematic review was conducted based on the PRISMA checklist to ensure the inclusion of relevant papers (13).

- **Inclusion criteria**

1: They were original papers and proceedings, 2: Studies were written in English. 3: Papers contained the mentioned keywords in either their title or abstract.

- **Exclusion criteria**

1) Papers with full text were written in languages other than English; 2) Studies focused on pneumonia not Covid-19 or other types of coronavirus; 3)They were commentaries, letters to editor, systematic reviews, and meta-analysis 4: Papers lacked practical solutions and only described the situation; 5) Full texts were not available.

First of all, the eligible papers' publication sources were checked to determine which rank of journals had been concentrating the most on the subject. This was because it has been the focal point for the past few months. The figure below demonstrates the result.

- **Data items**

One of the reviewers independently investigated the included studies and extracted the following data items: study's type, design, setting (country), outcomes, population and sample size (if there were any), used tools, technologies used in the study, recommendations, limitations and challenges, and each paper's journal ranking. These data were organized in an excel file which was checked by the second reviewer, and then, finalized. This information was then visualized in figures and tables using qualitative synthesis to provide a comprehensive view for the readers.

- **Risk of bias assessment**

Joanna Briggs Institute (JBI) checklist was used to assess the quality of extracted papers. JBI's critical appraisal tools can assess the quality of a wide range of published papers, including systematic reviews, case controls, case reports, cohorts, randomized controlled trials, and qualitative studies. This research aims to assess the methodological quality of investigations and determine how a study has addressed the possibility of bias in its design, implementation, and analysis. JBI's critical appraisal checklist was used for qualitative studies. This checklist has ten questions which are represented in the following order:

1. Is there congruity between the stated theoretical perspective and the research methodology?
2. Is there congruity between the research methodology and the research question or objectives?
3. Is there congruity between the research methodology and the methods used to collect data?
4. Is there congruity between the research methodology and the representation and analysis of data?
5. Is there congruity between the research methodology and the interpretation of results?
6. Is there a statement locating the researcher culturally or theoretically?
7. Is the researcher's influence on the research, and vice versa, addressed?
8. Are participants, and their voices, adequately

represented?

9. Is the research ethical according to the current criteria, or the recent studies, and is there evidence of ethical approval by an appropriate body?
10. Do the conclusions drawn in the research report flow from the analysis or interpretation of the data?

These questions can be answered with four options: 1: Yes, 2: No, 3: Unclear, and 4: Not applicable.

Each "yes" answer has one point, and if 70% of the questions were answered with "yes" in a study, the risk of bias was considered "low." If it was 50% -69%, the risk of bias was considered "moderate," and below 50% was considered "high risk." The checklist was completed by two authors (S.R and M.R). In case of conflict between the two authors, through discussion with the third author it was resolved (L.S).

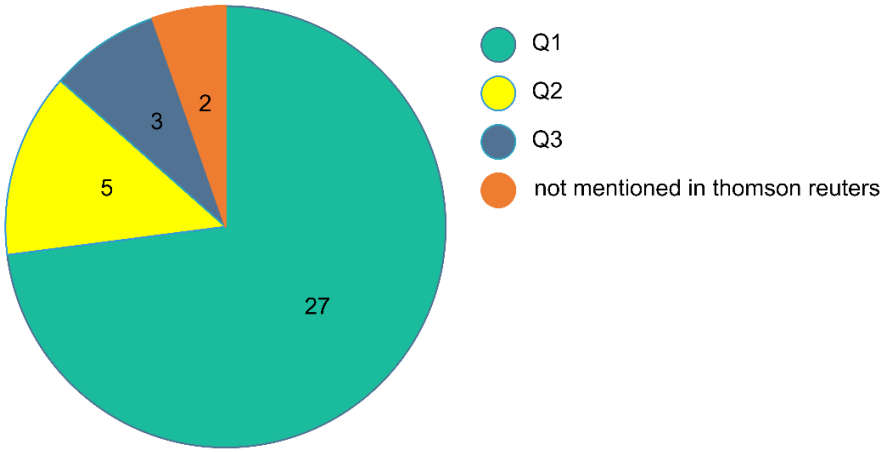

Figure 1: Included papers' journal ranking

Results

The initial search yielded 323 studies. 72 of them were removed as duplicates; leaving 251 studies whose title and abstract were screened based on the eligibility criteria. 144 papers were found to be irrelevant. The remaining 107 studies were screened according to the exclusion criteria which eliminated 70 papers from the study. At last, 37 papers were chosen for the investigation. The flow of screening papers based on the PRISMA method is illustrated in Figure 2.

- Concept of information technology and their use in health-related situations

As new technologies are being continuously designed and adopted in health services for a long time now, it is safe to assume that it is a familiar topic for most people nowadays (14).Accordingly, HIT is defined as applying any form of technology (including computers, smartphones, etc.) in healthcare settings. It is intertwined with concepts like medical informatics, and information and communication technologies (15). health information management (HIM), health information system (HIS), telehealth, telemedicine, mobile health (M-health), electronic health (E-health), and virtual care are some other examples of how comprehensive and extensive these are in healthcare system.

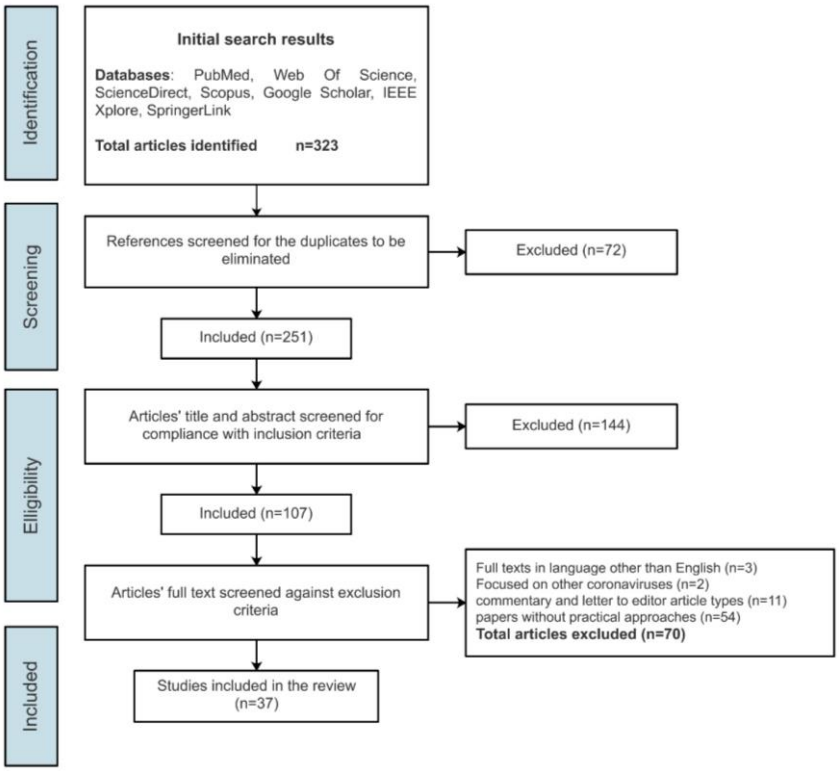

Figure 2: The PRISMA diagram for the records search and study selection

- Most used technologies/approaches regarding selected studies

After the data extraction step, the need to visualize the obtained information became a necessity. One of the most focused items in the full-text review and data extraction stages was the field of technology or approach stated in the study. To keep the figure brief and clean, the authors grouped similar technologies. The Table below the Figure clarifies the series mentioned in Figure 3.

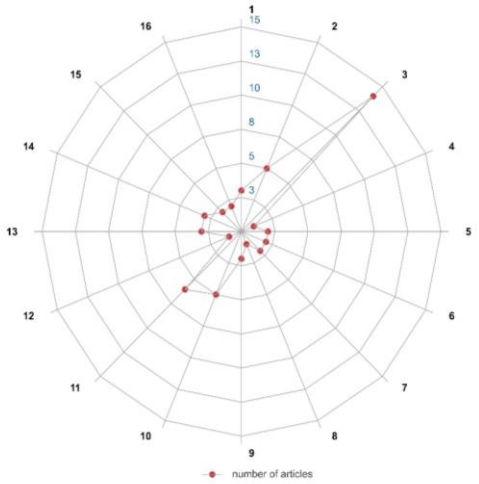

Figure 3: Number of papers per technology

Table 1: Types of applied approaches/technologies in included papers

Row	Types of approaches used
1	Online survey
2	Health information (technology) services/information technology/information and communication technology (ICT)
3	Telemedicine, virtual care, telehealth, teleconsultation, teleconference, telecommunication, telepsychiatry, tele education, teletelepathology
4	Data mining
5	Deep learning
6	Artificial intelligence
7	GIS technologies
8	Big data
9	Health QR code
10	M-health (example: contact tracing through smartphone applications)
11	Incidence prediction, epidemic prevention/control, epidemiological databases
12	Online monitoring/guidance
13	Medical records/ electronic health records
14	E-health technologies
15	Network (including neural network and mobile network 5G)
16	Decision making

As shown in figure 3, most studies focused on telemedicine applications including telepsychiatry, teleconsultation, telehealth, etc. It implies that the world has already accepted, implemented, and evaluated the telemedicine family. Many studies elaborated on the epidemiological aspect of the disease, for example, on systems for estimating and predicting the prevalence, or spotting areas most likely to get involved or already involved and in the danger zone. Accordingly, in a pandemic like this, not only should we prioritize which care to deliver to patients, but we also have to stay updated regarding the situation worldwide.

- Limitations and challenges

Although the effectiveness of telemedicine and technologies in simplifying pandemic management is crystal clear, there are many obstacles on the way. Almost every paper included in this study made at least one point about how helpful information systems or telemedicine are in the current situation. Some of them also declared several challenges they were facing and solutions to overcome them.

The figure below indicates the limitation identified regarding using any form of telemedicine or information technology in varied phases of Covid-19 management. In table 2, recommendations for the development and implementation of systems based on new technologies have been provided by researchers.

- Risk of bias within studies

Twenty-seven studies in this review were evaluated with a low risk of bias. Six citations were addressed with a moderate risk of bias (16-21) and four with a high risk of bias(24-22 ,10) . The question “Is there a statement locating the researcher culturally or theoretically?” was not applicable in our included examinations because the studies were not experimental.

Table 2: Provided recommendations by authors in included papers

Studies by:	Recommendations
Amparore et al (22), Chick et al (16), Gonzales-Zamora et al (25), Zhou et al(26)	Increased use of telemedicine, simulation, and smart learning educational programs, including video conferencing, micro-video teaching techniques, and telemonitoring of surgical procedures, may be the solution for education's sake. For instance, organizations involved in surgery should make surgical video libraries freely accessible.
Cai et al(27)	A united system with big data integration and information exchange is required to overcome the obstacles in health institutions, predict information hazards, and reduce medical resources' consumption to manage situations such as the current one.
Torous et al(28), Hong et al(29)	The correct use of telehealth services and their expansion should be a priority.
Cuan-Baltazar et al (30), Hernández-García et al (31)	For everyone to access reliable and quality information regarding Covid-19 during this crisis, WHO and governments should highlight valid sources like public health organizations'websites.
Doshi et al (17), Humphreys et al (32), Perez-Alba et al (33), Yasaka et al (34), calton et al(35)	Laying the groundwork for the required information-based technologies as well as virtual care programs such as inpatient video visits (or telephone visits if needed), active health surveillance models, or advanced technology-based contact tracing applications.
Luciani et al (36), Reeves et al (21)	The availability of EHRs and expert staff is pivotal in supporting healthcare delivery and should be improved to meet their fullest potential.
Ayyoubzadeh et al (37), Boulos and Graghty(38)	Future research should consider collecting information from various sources including social media, mass media, environmental factors, people contacting Covid-19 centers, or utilizing a combination of systems and technologies such as GIS technologies and drones to help pandemic management on a larger scale.
Calton et al(35), Hollander and Carr(19), Leite et al(20), Ohannessian et al(39), Okereafor et al(40), Serper et al(23)	Using the current situation as a catalyst in identifying challenges, implementing and adopting telemedicine by resolving issues like payment structures, inter-state licensing, or hospital credentialing. Encouraging policymakers to take advantage of reported experiences to expand e-Health services or to generate more specified tools like Big Data Health Intelligence with analytics tools even apart from the Covid-19 pandemic.
Ferretti et al(24), Gibson and Rush(18), Xu et al(41), Zamberg et al(42)	Further modeling is required for application-based approaches such as digital contact tracing or machine learning, especially in the case of data production since real-time detailed data is a vital factor in public health decision makings. Future studies should also cover clinical outcomes and the total impact of M-health interventions.
Gong et al(43), Huang et al(44)	For internet hospitals to reach their fullest potential, the authors suggest an endeavor is needed to recruit more specialists, design more standardized guidelines, and optimize online services and applications. On the patient side, self-management skills improvement and quarantine monitoring for confirmed or suspected cases is a necessity.
Lin et al(45)	A unified approach incorporating human services, healthcare systems, and public health, might enhance resiliency for the sake of future events preparation.

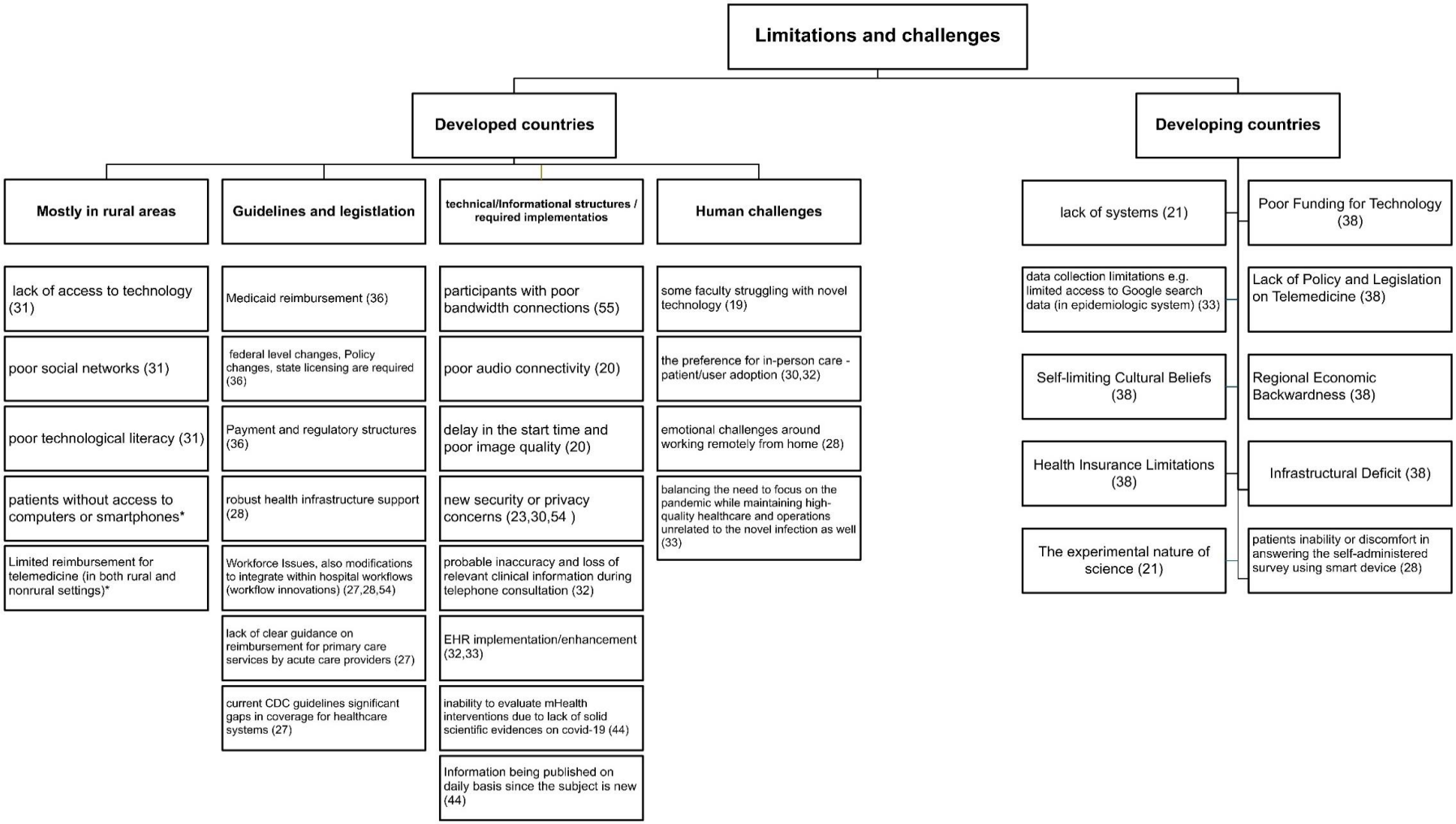

Figure 4: Limitations and considerable challenges

Discussion

This systematic review assessed the landscape of technologies for Covid-19 pandemic. Specifically, it identified the most available health-based technologies performed by different regions, their challenges and limitations that need to be overcome. Most importantly, this research provided an overview to get the whole idea about what is lacked in the current pandemic.

The concept of HIT covers a wide range of subtopics, from patients' increasing data getting harder to manage through traditional methods to emerging systems and technologies to simplify human beings' workload. Before the current pandemic, numerous studies had been conducted on different aspects of the combination of medical care and information technologies. An example would be working on EHRs (as a foundation for health information systems and technologies) and their vital role in the health care system. In a paper published by Harle and Menachemi in 2012, EHRs were considered an important step toward HIT systems. This paper explored EHR and its direct impact on patient's safety, efficiency, effectiveness, patient-centeredness, equity, and timeliness as a shred of evidence for governments to have policies designed toward its implementation and application(46). Zhao et al. studied the relationship between telehealth and hospital performance. They concluded that telehealth services not only could improve the care efficacy, but also could play a significant role in the hospital's overall performance (47). In 2015, Seyed-Abdul et al. listed some strategic perspectives based on accomplishments of HIT adoption in Taiwan for over 17 years. This research aims to indicate how beneficial it is to adopt large-scale HIT systems and how it supports universal healthcare delivery (48).

The paragraphs above were only a few examples of the existence of these topics years ago. The point is that currently, they are not optional or recommended but obligatory and essential. The urge to find out how to use the amount of information or facilities with the highest efficiency, or how to help individuals from long distance, is what is different from before. Although many reviews exist regarding telemedicine or information technologies combined with healthcare systems, the nature of recent projects and the number of practical steps taken toward both legislation and utilization area cannot be the same. That is one of the reasons for carrying out this review.

As a response to extreme circumstances like the present-day outbreak which has restricted patients' presence in healthcare centers, the world has turned to depend on technology as an ally in fighting against the Covid-19 pandemic (20). Studies included in our review covered a good variety of different successful approaches (figure 2). GIS systems as supports for epidemiological management (18, 49), mHealth applications in contact tracing (27, 34, 42), telehealth services in hospitals or clinics (43, 50-53), etc were addressed. Few studies declared innovative combinations such as dashboards based on modern GIS technologies and web-based tools to access improved data sharing and real-time information to support critical decision-making (49, 54). Most studies have stated that there are many federal and physical barriers on the way. Yet quick prioritization and good planning alongside patients and providers' collaboration is the key.

As briefly mentioned in the results section, a part of extracted data in this review was challenges and limitations. An important part of adopting and applying something is to identify its limitations. Considering the sensitivity of the healthcare system topic, one could imagine how different the challenges would be in different countries/states/organizations.

Nevertheless, countries with the same groupings (developed countries and developing countries) tend to have more common

limitations than the other group. Having categorized limitations into two big groups as in Figure 3, it should be easier for each region to spot its problem and think of solutions. To the authors' knowledge, no study has been performed precisely on the limitations of telemedicine or technology implementation. Strategies for mitigating these challenges can also be valuable topics to expand on in future research. The majority of the reviewed studies recommended some points toward improvements, or general tips for better care or management. Ferretti et al.'s study on quantifying SARS-CoV-2 transmission suggested epidemic control with digital contact tracing. It implied that an application-based intervention based on further modeling with improved sensitivity (of testing in the early infection stage) and intelligent social distancing via digital contact tracing could be more powerful than what their analysis demonstrated (24).

In a study regarding Internet hospitals' contribution to prevent and control Covid-19 in china published by Gong et al., several recommendations were listed as extra efforts that must be done to make better use of Internet hospitals. The items were: recruiting more doctors, especially psychologists and pediatricians, to join online services, improving the usability of the Internet hospital applications, strengthening the propaganda to expand user base, plus a more standardized consultation service guideline. They also offered methods to increase the online services during the pandemic and improve Internet hospitals' positive influences on the public as future studies (43).

The present study has a number of strengths. To begin with, it is not only looking for the problems, but also gathers recommended solutions. There are many challenges and limitations in adopting technology-based methods in a short time. They could vary from government's lack of legislations to the lack of physical facilities. Different countries struggle with different types or levels of these issues. Grouping these challenges and limitations to different kinds of countries is strength of this research. It allows readers from different regions (either developed or developing country) to relate to the problems and solutions.

As for the current study's limitations, authors can refer to the exclusion of non-English papers. There were a number of studies whose full text was available in languages other than English. It would be a good idea to use multi lingual teams in future reviews in order to include papers in other languages as well.

Technology-based approaches are dominating in-person methods in the field of health care. This study is a small step toward creating an overview of a new challenge called the Covid-19 pandemic as a catalyst for this dominance. It was also to emphasize the role HIT has and could have in future.

Many countries are currently dealing with the situation made by the new coronavirus. However, the required infrastructures, cost or the knowledge to use these technologies vary in different parts of the world. Therefore, the authors recommend that the future researchers focus on each regional challenge specifically to find tailored and optimal solutions.

Conclusion

HIT and telemedicine, which have been auxiliary solutions for better provision of healthcare for years, have emerged as the best way to survive the current situation created by Covid-19 pandemic. Many studies and reviews have pinpointed the advantages of using technology when it comes to disease management. However, spotting its challenges and considering probable solutions by involved organizations tend to be less expressed. Since the benefits of technology outweigh its challenges and limitations, health centers must

develop the infrastructure to implement and optimally use technology. Policymakers and managers in the Ministry of Health and Medical Education worldwide are also strongly recommended to provide appropriate policies and strategies to facilitate and expedite their implementation process. This study presents a useful starting point for policymakers and healthcare providers to establish or improve health informatics structures best suited for fighting Covid-19. It also reflects that the scope of using telemedicine or HIT in situations like pandemics is wide-ranged and requires more systematic reviews to keep track of their advances and remaining obstacles.

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Appendix 1: Search strategies for per database

Database	Search query	Number of articles
PubMed	("Health information system" OR "Information system" OR "Health information" OR "Health information technology" OR "Information technology" OR "Medical informatics" OR "Medical informatics application" OR "Informatics application" OR "Health informatics" OR "Clinical informatics" OR "Medical computer science" OR "Computer science" OR "Medical computer sciences" OR "Medical computer" OR "Information science" OR "Medical information sciences" OR "Telemedicine" OR "Mobile health" OR "mHealth" OR "eHealth" OR "Telehealth") AND ("Covid-19" OR "SARS-CoV-2 infection" OR "2019 novel coronavirus infection" OR "2019-nCoV infection" OR "coronavirus disease-19" OR "2019-nCoV disease" OR "COVID-19 virus infection" OR "2019-nCoV" OR "Wuhan coronavirus" OR "SARS-CoV-2" OR "2019 novel coronavirus" OR "COVID-19 virus" OR "coronavirus disease 2019 virus" OR "COVID19 virus" OR "Wuhan seafood market pneumonia virus") (Title/Abstract)	142
Web of Science	**ALL FIELDS:** (((telemedicine) OR (Health information system) OR (Health information technology) OR (Medical informatics)) AND ((Covid-19) OR (SARS-CoV-2 infection) OR (2019-nCoV infection) OR (coronavirus disease-19) OR (2019-nCoV disease)))	14
Science Direct	("telemedicine" OR "Health information system" OR "Health information technology" OR "Medical informatics") AND ("Covid-19" OR "SARS-CoV-2 infection" OR "2019-nCoV infection" OR "coronavirus disease-19" OR "2019-nCoV disease")	28
Scopus	TITLE-ABS-KEY(("Health information system" OR "Information system" OR "Health information" OR "Health information technology" OR "Information technology" OR "Health information" OR "Medical informatics" OR "Medical informatics application" OR "Informatics application" OR "Health informatics" OR "Clinical informatics" OR "Medical computer science" OR "Computer science" OR "Medical computer sciences" OR "Medical computer" OR "Information science" OR "Medical information sciences" OR "Telemedicine" OR "Mobile health" OR "mHealth" OR "eHealth" OR "Telehealth") AND ("Covid-19" OR "SARS-CoV-2 infection" OR "2019 novel coronavirus infection" OR "2019-nCoV infection" OR "coronavirus disease-19" OR "2019-nCoV disease" OR "COVID-19 virus infection" OR "2019-nCoV" OR "Wuhan coronavirus" OR "SARS-CoV-2" OR "2019 novel coronavirus" OR "COVID-19 virus" OR "coronavirus disease 2019 virus" OR "COVID19 virus" OR "Wuhan seafood market pneumonia virus"))	27
Google Scholar	("telemedicine" OR "Health information system" OR "Health information technology" OR "Medical informatics") AND ("Covid-19" OR "SARS-CoV-2 infection" OR "2019-nCoV infection" OR "coronavirus disease-19" OR "2019-nCoV disease") –By abstract	81
IEEE Xplore Library	(“Health information system” OR “Information system” OR “Health information” OR “Health information technology” OR “Information technology” OR “Health information” OR “Medical informatics” OR “Medical informatics application” OR “Informatics application” OR “Health informatics” OR “Clinical informatics” OR “Medical computer science” OR “Computer science” OR “Medical computer sciences” OR “Medical computer” OR “Information science” OR “Medical information sciences” OR “Telemedicine” OR “Mobile health” OR “mHealth” OR “eHealth” OR “Telehealth”) AND (“Covid-19” OR “SARS-CoV-2 infection” OR “2019 novel coronavirus infection” OR “2019-nCoV infection” OR “coronavirus disease-19” OR “2019-nCoV disease” OR “COVID-19 virus infection” OR “2019-nCoV” OR “Wuhan coronavirus” OR “SARS-CoV-2” OR “2019 novel coronavirus” OR “COVID-19 virus” OR “coronavirus disease 2019 virus” OR “COVID19 virus” OR “Wuhan seafood market pneumonia virus”) (2019-2020):	25

Database	Search query	Number of articles
SpringerLink	("Health information system" OR "Information system" OR "Health information" OR "Health information technology" OR "Information technology" OR "Health information" OR "Medical informatics" OR "Medical informatics application" OR "Informatics application" OR "Health informatics" OR "Clinical informatics" OR "Medical computer science" OR "Computer science" OR "Medical computer sciences" OR "Medical computer" OR "Information science" OR "Medical information sciences" OR "Telemedicine" OR "Mobile health" OR "mHealth" OR "eHealth" OR "Telehealth") AND ("Covid-19" OR "SARS-CoV-2 infection" OR "2019 novel coronavirus infection" OR "2019-nCoV infection" OR "coronavirus disease-19" OR "2019-nCoV disease" OR "COVID-19 virus infection" OR "2019-nCoV" OR "Wuhan coronavirus" OR "SARS-CoV-2" OR "2019 novel coronavirus" OR "COVID-19 virus" OR "coronavirus disease 2019 virus" OR "COVID19 virus" OR "Wuhan seafood market pneumonia virus")(Abstract)	6