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A systematic literature review of adopting eHealth in pharmaceutical care during COVID-19 pandemic: recommendations for strengthening pharmacy services

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Abstract

Objectives:

The study aimed to determine how eHealth was adopted in pharmaceutical care (PC), the outcome reported, and the contextual factors.

Method:

Following the Preferred Reporting Items for Systematic Review (PRISMA) guidelines, literature published till March 2022 reporting the application of eHealth in PC during the COVID-19 pandemic were identified from six databases and systematically analyzed.

Results:

Forty-three studies were included in this review. During the COVID-19 pandemic, hospital pharmacists, community pharmacists, and specialist pharmacists in 17 countries continued to educate, consult, monitor and manage the patients and the general public via phone calls, videoconferences, mobile applications, social media, websites, and/or enhanced interoperability of electronic medical records. Assuring the continuity of pharmacy care, reduced need for hospital visits, and improved work accuracy and efficiency were the benefits of eHealth mostly reported. Contextual factors affecting the adoption of eHealth were multifaceted prompting supporting actions at the levels of government, hospital/pharmacy, pharmacists and patients.

Conclusion:

This study revealed the wide adoption of eHealth in PC during the pandemic and the emerging evidence for its importance. Proper adoption of eHealth will help reshape the mode of pharmacy services to ensure continuity, quality and efficiency of care amid the challenges of the pandemic.

PROSPERO registration number: CRD42022299812

Strengths and limitations of this study:

- The review presents a logic model about eHealth in pharmaceutical care to inform an systematic approach towards adoption, implementation and evaluation.
- Adopting eHealth in pharmaceutical care during the COVID-19 pandemic not only supported tele-case-management, tele-consultation and tele-monitoring but also aided in the provision of emotional support.
- The most common benefits of eHealth in pharmaceutical care were reduced need for physical contact, continuity of care and improved efficiency.
- Our search strategy might not have captured all experiences of eHealth in pharmaceutical care embedded as part of an inter-professional program.

Introduction

Being an integral part of the health system, pharmaceutical system is charged with an important goal of ensuring the equitable access to pharmaceutical products and their quality use based on scientifically sound evidence and supported by pharmaceutical care (PC).[1] PC is defined as "*the responsible provision of drug therapy for the purpose of achieving definite outcomes that improve a patient's quality of life*".[2] By providing PC, pharmacists help to reduce drug-related problems, assuring rational drug use, supporting clinical management, and promoting healthy lifestyles.[3,4]

Since the onset of the COVID-19 pandemic, the delivery of PC has been inevitably disrupted by major public health measures compromising the provision of medicines and care. Nevertheless, pharmacists are expected not only to ensure the continuity of care but also to adapt PC to the new needs during the challenging time.[5] As such, eHealth has been increasingly adopted to support PC to overcome geographic barriers and enhance health outcome.[6]

According to the World Health Organization, eHealth is defined as "*the cost-effective and secure use of information and communication technology (ICT) through online in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge, and research*".[7] Reportedly, integrating eHealth into PC is beneficial to patient self-management and drug adherence, clinical disease management and health promotion.[3, 8-10] During the COVID-19 pandemic, as a result of public health measures resulting in reduced accessibility to hospitals or pharmacies, the traditional mode of in-person care delivery would no longer suffix. eHealth has, thus, been widely considered as an instrument for setting up a more innovative, efficient and resilient PC service model.[11]

There is a growing research interests in examining the interface between PC and eHealth. Some studies focused on evaluating particular PC-eHealth programs. Spanakis et al. evaluated a personalized eHealth platform that addressed key features of PC and found that eHealth could be used as a tool to allow pharmacists provide personalized PC services to optimize pharmacotherapy.[12] Other studies might focus on the application of PC-eHealth in the management of particular diseases. The study by Jeminiwa *et al* demonstrated the effectiveness of eHealth in improving adherence to inhaled corticosteroids among patients with persistent asthma.[13] Kilova et al. addressed the prospects for ICT in providing pharmaceutical care and how eHealth related technologies had aided in the promotion of patient care during the outbreak of the epidemic.[14, 15]

Another review by Ghina et al. primarily explored the eHealth services which could be used as an immediate alternative to PC for chronically-ill patients during an epidemic.[16]

At present, there is little systematic research about the "know-how" of integrating eHealth services and tools in PC to perform certain interventions or achieve predefined outcomes amid the challenges of the COVID-19 pandemic. This reviews aims to determine how eHealth was adopted in PC, the outcome reported and the contextual factors identified. The study findings are expected to be useful for informing the optimization of eHealth in PC whenever needed in future public health events.

Methods

Study design

The protocol for this systematic literature review was developed in accordance with the Preferred Reporting Items for Systematic Review (PRISMA) guidelines[17] and had been registered in The International prospective register of systematic reviews (PROSPERO) with the reference number: CRD42022299812 (available from https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022299812). Literature was searched in six databases including PubMed, Scopus, Medline, Web of Science, Science Direct and China National Knowledge Infrastructure (CNKI).

Search strategy

A research question was developed using the population, intervention, comparison, outcome and time frame (PICOT) framework, which specified the pharmacist population, either practiced alone or as a member of an inter-professional team, providing pharmaceutical interventions with eHealth to patients during the COVID-19 pandemic.[18] Three major concepts and their Medical Subject Headings (MeSH) terms and corresponding phrases identified in related literature were used to formulate the search terms: "pharmaceutical care", "eHealth", and "COVID-19 pandemic". A detailed description of the search strategies for each chosen database is provided in Appendix. Additionally, the reference lists and citations of included articles were examined to identify further papers for inclusion.

Eligibility criteria

Studies which reported the use of eHealth in any aspects of PC during the COVID-19 pandemic, published between December 2019 (when cases of COVID-19 infection were first reported) and

March 2022, written in English or Chinese, and published in peer-reviewed journals were included. Opinion articles, conference abstracts, correspondence, letters, and editorials were excluded.

Study selection, data extraction and presentation

Two of the authors (ZC and PT) independently conducted the literature search, applied the inclusion and exclusion criteria, removed duplicates, and screened the studies based on the titles and abstracts. After initial screening, full texts of studies were obtained and analysed to ensure eligibility for inclusion in the Excel data extraction table. ZC and PT then extracted the data into an Excel table informed by the logic model[19] with the key components of goals, input, activities, output and contextual factors. Narrative synthesis was undertaken to summarize and report the findings. Any divergences during the literature search and data extraction process were resolved through discussion and subject to confirmation by two other authors (HH and COLU).

Patient and public involvement

No patient or public was involved.

Results

Study characteristics

As shown in Figure 1, 781 articles were retrieved initially. After removing duplicates (n = 795), and screening by the title and abstract (n = 565) and full text (n = 230), 43 articles were included in this review.[20-62] Among the included studies were 25 observational studies (including 13 cross-sectional studies[36-39, 43-48, 54, 59, 60], 5 case series[34, 35, 49-51], 5 retrospective study[40, 41, 52, 53, 55], 1 prospective study[61] and 1 interview study[42]) and 18 descriptive studies[20-33, 56-58, 62]. The general characteristics of the included studies are summarized in Appendix. The majority of the studies reported about the use of eHealth by hospital pharmacists[20, 21, 23, 25, 29-31, 33-35, 37-41, 43, 46-49, 52-55, 58, 59, 61], followed by community pharmacists[28, 35, 45, 46, 50, 51, 54, 60, 62]. Patients with chronic diseases[27, 31, 32, 34, 37, 39, 40, 43, 44, 48, 52, 54, 57, 60-62] were the primary targets populations of PC-eHealth interventions, followed by patients with COVID-19[26, 34, 42, 46, 49-51, 58] and cancer patients[27, 31, 37, 40]. The purpose of adopting eHealth, the eHealth tools used, the interventions provided by pharmacists with eHealth, and the intervention output are illustrated in Appendix.

Purposes of adopting eHealth in PC during the COVID-19 pandemic

Considering the lack of official definition or categorization framework of eHealth applied to PC, the purposes of adopting eHealth in the present study were informed by the current literature[8, 63-65]

and thus categorized into: (1) tele-education (educating patients about how to take medicines and adverse drug effects, n=17)[20, 22, 24, 25, 29, 31-33, 37-39, 42, 47, 48, 56, 57, 62]; (2) tele-consultation (addressing patients' enquiries about drug-related problems, n=28)[20, 21, 23, 25-28, 30-33, 35-38, 44, 45, 49-51, 53, 56-62]; (3) tele-monitoring (monitor the patients' use of medications in real time, n=27)[20, 21, 23, 25-27, 29-33, 35, 36, 38, 39, 41, 44-46, 48-51, 53-55, 57]; (4) tele-case-management (continuously manage the patient's medication regimen according to the patient's conditions, n=30)[22, 23, 26, 27, 29, 30, 32-34, 37-42, 44, 46, 48-54, 56-61]; and (5) tele-mentoring (the use of eHealth by other healthcare workers to seek advice from pharmacists, n=19).[21, 25, 28, 30, 31, 33, 34, 38-40, 42-44, 47, 48, 53, 57, 59, 62] It is noteworthy that all but 5 studies[22, 24, 46, 52, 56] reported the use of eHealth for multiple purposes.

Tool(s) involved in the PC-eHealth service models

Phone calls alone in the form of a hotline or as a combination with videoconference, social media and television, mobile applications, websites, and/or wearable devices were mostly employed to enable PC-eHealth service mode in the included studies.[20, 23, 25, 27, 32, 35, 36, 39-43, 45, 49, 50, 55-57, 59-62]

Videoconference was often used to allow face-to-face interactions and observations of body language and facial expressions between the pharmacists and the patients.[23, 25, 29, 31-35, 39, 40, 42, 45-47, 50, 51, 57, 59]

Social media (e.g. Twitter[24] and Facebook[34]) , online networking services (e.g. Doximity[33, 41, 53]), mobile applications (e.g. WeChat[26, 38, 44, 58], Skype[29], Facetime[29], PetalMD[34], Cisco Jabber 12.6[33], Google voice[41, 53], WhatsApp[49, 61], short messages services[49, 59], Signal[53] and others[35, 46, 48, 56]), and wearable devices[25] had also been integrated into the PC-eHealth service models. Other communication means such as television[24], email[30, 34, 41], fax[30], and radio[48, 58] were also employed.

Some studies reported about the website monitoring applications developed by hospitals or pharmacies in response to the societal and patient needs during the pandemic. Examples were the SPHCC Patient Care (an online platform formed by 6 licensed internet hospitals allowing pharmacists continue to care for patients with COVID-19 online)[26], the CCSS (a website monitoring application formed by a primary health care center network for assuring medication supply)[28], the Cloud SYSUCC (a website monitoring application developed by a university cancer center to enable pharmacists continuously manage cancer patients) [37], the VigiLanz (a clinical surveillance platform supported pharmacists to readily communicate with other healthcare providers and participate in daily patient care routine)[25], the Virtual–Venipuncture INR (an IT support that

allowed pharmacists monitor the INR of patients receiving anticoagulants during the pandemic)[52], and several others[30, 35, 36, 44, 50, 58, 61]. A number of PC-eHealth service models was also pertained with an integration of the electronic medical record (EMR) system.[21, 22, 30, 31, 37, 42, 47, 57]

Interventions provided by pharmacists with eHealth

The services provided at the interface of PC-eHealth were multifaceted and could be categorized into one of 9 interventions (Table 1). Apart from the core components of PC such as (1) consultation, (2) medication order evaluation and dispensing, (3) patient monitoring for adverse drug events, (4) comprehensive follow-up and continuous assessment, (5) medication review and management, and (6) medication education, pharmacists had reportedly extended their services towards caring for patients' mental well-being (intervention 7), facilitating collaboration with the healthcare team with information sharing (intervention 8), and public health measures (intervention 9) during the pandemic. In comparison, community pharmacists were more inclined to use eHealth in providing emotional support to their patients and the public to ease their anxiety about the pandemic development, while hospital pharmacists utilized eHealth to carry out various PC interventions.

Table 1: Interventions provided by pharmacists at the interface of PC-eHealth during the COVID-19 pandemic

Interventions	Description
Core components of PC	
(1) Consultation	Address patients' enquires related to medications as well as the COVID-19 pandemic[20, 21, 25-30, 33, 35-38, 43-45, 48, 50, 51, 55-60, 62]
(2) Medication order evaluation and dispensing	Evaluate, process and dispense electronic prescriptions[22, 25, 26, 30, 32, 33, 37, 40-42, 49-51, 53, 57, 59, 62]
(3) Patient monitoring for adverse drug events	Monitor the drug reaction of patient after taking the medication[20, 23, 26, 29, 36, 40, 46, 48, 55, 57, 62]
(4) Comprehensive follow-up and continuous assessment	Conduct follow-up physical and psychological assessments of the patients[20, 26, 27, 29, 36, 39, 41, 52, 53, 55, 60, 61]
(5) Medication review and management	Conduct individualized review and management of medications for patients with[20, 27-30, 32, 34, 35, 37, 39, 41, 42, 47-51, 53, 54, 57, 61, 62]
(6) Medication education	Offer instructions about the administration of medications[20, 28, 30, 34, 35, 37, 39, 40, 43-45, 48, 49, 54, 57, 58, 62]
Extended components of PC during the COVID-19 pandemic	
(7) Emotional support	Provide support to patients to alleviate their concerns about their diseases[23, 35, 48, 62]
(8) COVID-19 information sharing	Sharing of information about the patients or their medications with other members of the healthcare team[22, 24, 27, 31, 35, 37, 39, 42, 45, 47, 48, 53, 58, 60]
(9) Infectious disease surveillance	Detect any signs of possible infection with COVID-19 among patients while delivering pharmacy services remotely[25, 60]

Output of PC-eHealth interventions

The impact of adoption eHealth in PC during the pandemic was mainly in reducing the need for physical contact or visits to the hospital/clinic for minimizing the risks of infection and transmission[20, 21, 25, 26, 28, 30, 32, 33, 38, 43, 45, 48, 52-54, 58, 60, 62] as well as allowing the continuous monitoring of the patients in the absence of in-person interactions[21, 23, 26, 27, 29-31, 39-43, 45-47, 49, 51, 56, 57]. Some studies reported an improvement in the efficiency of PC due to the use of eHealth[25, 34, 38, 44, 50, 57, 58, 61] and patient satisfaction about the PC-eHealth services they received was also reported[28, 29, 32, 36, 37, 44, 46, 54, 59]. Other benefits of adopting eHealth in PC during the pandemic included the dissemination of reliable information[24], reduced abuse of over-the-counter medicines[35], facilitating transition of care between hospitals[22] and communications within the healthcare team and with patients and caregivers[25]. However, there was one study that reported a negative impact on the quality of PC after eHealth was integrated.[55]

Input relevant to establishing PC-eHealth service model

To aid in the establishment and development of pharmaceutical care using eHealth throughout the epidemic, key input at the levels of government, hospital and pharmacies, pharmacist professional organizations and pharmacists has been identified.

At the government level, legislation that defines the services of PC-eHealth and the liability for such services, safeguards data protection and promotes database interoperability was commonly discussed in the included studies.[31, 50, 57, 59, 61] Initiatives to upgrade remote information technology and outpatient clinic systems might be launched by the government[33, 35]. Continuous supervision and evaluation of PC-eHealth interventions by the government had been suggested[28, 57], which might require special department or taskforce to lead and faciliate the adoption and implmentation of eHealth in PC and other healthcare services alike.[50, 61] It was also important for the government to provide reliable and up-to-date information about the COVID-19 pandemic to be disseminated via the PC-eHealth platform.[50]

For the hospitals or pharmacies, efficient and appropriate communication mechanisms were considered the utmost important to control the spread of the pandemic, which was why many of them had established networks across different healthcare settings and developed their own eHealth applications.[26,37, 55] Hospitals and pharmacies not only developed new eHealth systems on their own, but also promoted the use of the systems to other hospitals or pharmacies through training,

empowering their interconnections to optimize their patient coverage.[22, 54] Staff had been asked to sign codes of conduct to protect patient confidentialiaty.[33]

Pharmacist professional organizations were expected to define PC-eHealth services[41, 47], offer advice to pharmacists about making eHealth plans and provide guidelines for PC-eHealth service provision[25, 43, 52, 53, 62], and support pharmacists with funding[47] and human resources[44] to establish the PC-eHealth infrastructure. At the pharmacist level, communication and collaboration among pharmacists from different sectors to care for complicated patients[20,29, 34], self-motivation to learn about the PC-eHealth guidelines[25], training and supervision by more experienced pharmacists[29, 38, 60] , participation in the eHealth multidisciplinary working group[43] and closer collaboration with other healthcare providers and other key stakeholders [51] were considered important factors.

Contextual factors affecting the adoption of eHealth in PC during the pandemic

Contextual factors affecting the adoption of eHealth in PC during the COVID-19 pandemic had been described in terms of challenges and enablers in the included studies. Challenges might arise at the levels of pharmacists, government, patients, and eHealth tool suppliers. For pharmacists, the shift from face-to-face towards eHealth service model resulting in long working hours had inevitably created conflicts between personal and professional lives[34]. Other issues such as unfamiliarity with the eHealth systems[22, 27], limitations of assessments due to a lack of in-person interactions[32, 35, 62] or eye contact[31], difficulty in obtaining consent from the patients to receive PC-eHealth service[31, 33], lack of control over the entire PC-eHealth process[28,62] were also discussed. Some pharmacists just did not have the motivation to adopt eHealth.[34, 56]

For government, evaluation of PC-eHealth services in order to inform a reasonable remuneration system[41,47, 56] and development of a robust legal framework, policies, and procedures to guide the use of eHealth in PC lagged behind.[47, 56] From the perspectives of the healthcare institutes, whether it be hospital or community pharmacies, a lack of electronic patient records[50, 51], a lack of funding to set up a teleworking envirnoment[45] and a lack of communication infrastructure readily in place for timely scaling up during the pandemic[34] were cited as the biggest challenges.

Patients' digital health literacy[30, 31, 45,31, 48, 56, 57] and cultural acceptance[31, 36, 37] might vary and unfamiliarity with new PC-eHealth systems might collectively discourage them from taking up PC-eHealth services. Moreover, a lack of access to high-tech devices[36] and a lack of willingness to accept eHealth services[31, 48, 57] might also be a barrier to patients' acceptance of PC-eHealth

services. For some patients who had already receiving PC-eHealth interventions, a lack of adherence to the services could negatively impact on the outcome of eHealth service model. [28]

For the PC-eHealth tool suppliers, some of the biggest challenges experienced during the COVID-19 pandemic included the unstable network connectivity[21, 49], inadequate interoperability of systems provided by different providers[21], a lack of standardized platform and technical support within and across the care settings[33], errors in digital systems[43], cyber security considerations[27, 42], and the lack of complete patient data for sharing.[22] Operational networks not in time[44, 49]

To support the adoption of eHealth in PC for better management of patients during the pandemic, several enablers had been suggested. These included new forms of supervision to regulate and standardize pharmacists' interventions provided through PC-eHealth model[33,34, 37], strategies for appropriate resource assessment and allocation, workflow modification and infrastructure maintenance[23, 44, 55, 56], follow-up evaluation of the performance and reliability of the pharmacists[34], continuous and stable IT support[22, 58], and research to develop the evidence about the effectiveness and societal implications of PC-eHealth during pandemic[46, 54].

Discussion

Significant use of eHealth in PC during the COVID-19 pandemic

This review revealed that it was common for pharmacists to adopt eHealth to ensure the continuity of PC amid the threat of COVID-19 pandemic and the challenges pertained with public health measures. This is in alignment with the overall development trend in PC for different care settings.[66] During the pandemic, the most commonly reported purposes of using eHealth in PC were tele-case-management, tele-consultation and tele-monitoring, often with the use of phone calls in combination with videoconference, social media and television, mobile applications, websites, and/or wearable devices. Specific to the needs during the pandemic, PC-eHealth was often employed to provide emotional support and to dissimilate pandemic-related information. The benefits of adopting eHealth, as reported in previous public health incidents[67], were widely recognised and mostly observed in terms of reduced need for physical contact, continuity of care and improved PC efficiency.

The logic model to guide the planning of eHealth adoption in PC

Integrating eHealth into PC was suggested as early as 20 years ago.[68]Since then, many studies had been carried out to investigate different PC-eHealth practice models designed for different patient groups.[69-72] However, up to date, the integration of eHealth into PC has not been generalized nor standardized, and a systematic approach to advancing the quality and coverage of PC with eHealth is still lacking. The COVID-19 pandemic has disturbed the traditional mode of healthcare delivery which has expectedly accelerated the uptake and scaling-up of eHealth.[73] However, as far as PC is concerned, the attempts made so far are rather extemporaneous as evident by the vast variety of tools, purposes of care and interventions identified in this study. In order to systematically and graphically present the blueprint of "know-how", a logic model of establishing PC-eHealth during a pandemic has been built based on the study findings, detailing the goals to be achieved, the input and activities taken place, the output produced, and the contextual factors involved (Figure 2). This may serve as a framework for guiding and reinforcing the adoption of eHealth in PC to meet the challenges of COVID-19 pandemic or other public health incident alike.

The heterogeneity of eHealth tools used in PC

The heterogeneity of eHealth tools employed in the PC-eHealth during the COVID-19 pandemic are associated with both benefits and concerns for both the patients and the pharmacists. Prior to the pandemic, the utilization of telemedicine was mainly to allow pharmacists to extend the reach of their interventions chronic disease management and telephone was the most common communication method.[8] With the additional use of videoconference, mobile applications, website application, social media and wearable devices as reported in this study, real-time interactions and data collection is now possible to achieve more personalized PC support.[74] Nevertheless, the capacity to operate different eHealth tools could be challenging to some patients.[75] and the hybrid mode of service provision would easily overwhelm a lot of pharmacists.[76]

Furthermore, the vast amount of personalized data generated from multiple sources and shared dynamically entails a new level of concerns over privacy and cybersecurity.[77] In the absence of a legal or regulatory framework, the practice of PC via different eHealth tools might lead to ethical and legal issues and subject pharmacists to liability consequences should any adverse events happen to the patients.[78] A lack of standardized design of PC-eHealth pose great challenges to scaling up and interoperability preventing a timely and thorough transformation of service mode whenever needed.[79] This is especially relevant during a pandemic when immediate actions are called for and healthcare resource allocation is particularly uncertain. To this end, it would be the priority of action

for the regulatory bodies and pharmacist professional organizations to provide clear guidance on how to appropriately adopt eHealth in PC.

Moving forward

For the efficiency use of healthcare resources particularly in the context of a pandemic, eHealth adoption and implementation in PC requires adequate planning and continuous evaluation of cost-effectiveness.[80] Indeed, any eHealth interventions in the healthcare sector should be adequately planned, piloted and progressively scaled up to ensure the expected deliverables. Other preparation should be carried out simultaneously. As eHealth continues to transform PC, strategies to help patients and pharmacists enhance digital literacy and build the knowledge of technology should take place to improve engagement and receptivity towards technological integration.[81]

For the PC-eHealth currently in operation, more efforts should be made to quantify the clinical and economic benefits for the patients or the public, and the long-term outcomes. [82, 83] In order to secure resources to support PC-eHealth, a fine balance needs to be established between evidence-based integration of e-Health and constructive experimentation of PC.[84] Synthesizing the evidence is important for informing the future directions and implications for policy and practice.

Limitations of this review

It is possible that our search strategy did not capture all examples of PC-eHealth experiences during the pandemic if they were embedded as part of an inter-professional program, depending on how pharmacists were referenced in the text of available publications. The logic model developed in this study provided an overall landscape of all the factors relevant to the adoption of eHealth in PC during the pandemic but was not able to establish any causal chains among the components. Future research is warranted to confirm the interretionship among each factor in order to better future planning, monitoring and evaluation.

Conclusion

This study revealed the wide adoption of eHealth in PC during the pandemic and the emerging evidence for its importance. As the momentum of adopting eHealth in PC yielded during the COVID-19 pandemic will continue to drive further innovative development, an orchestrated, transdisciplinary approach adapted to different local contexts is needed to achieve the benefits of

PC-eHealth. Future research should be directed to substantiate the assessment of eHealth in reshaping the mode of pharmacy service in terms of not only the continuity, but also the quality and efficiency of care amid the challenges of any pandemic.

Author's Contributions

Zhi Feng Cen: Conceptualization, Methodology, Validation, Investigation, Writing - Original Draft.

Pou Kuan TANG: Validation, Writing - Review & Editing.

Hao HU: Conceptualization, Methodology, Review & Editing

Afonso Miguel CAVACO: Review & Editing

Luoxin ZENG: Review & Editing

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Competing interests

None declared.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication

Not applicable.

Ethics approval

Not applicable.

Data availability statement

No data are available

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1. Berenguer B, La Casa C, de la Matta MJ, et al. Pharmaceutical care: past, present and future. *Curr Pharm Des* 2004; 10: 3931-3946. 2004/12/08. DOI: 10.2174/1381612043382521.
2. Hepler CD and Strand LM. Opportunities and responsibilities in pharmaceutical care. *Am J Hosp Pharm* 1990; 47: 533-543. 1990/03/01.
3. Pande S, Hiller JE, Nkansah N, et al. The effect of pharmacist-provided non-dispensing services on patient outcomes, health service utilisation and costs in low- and middle-income countries. *Cochrane Database Syst Rev* 2013: Cd010398. 2013/03/02. DOI: 10.1002/14651858.Cd010398.
4. Wilke D, Schiek S, Bertsche T, et al. Verwendung von Routinedaten der gesetzlichen Krankenkasse in einer Pilotstudie zur Evaluation pharmazeutischer Interventionen im Krankenhaus. *Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen* 2017; 121: 21-28. DOI: https://doi.org/10.1016/j.zefq.2017.03.004.
5. Ghibu S, Juncan AM, Rus LL, et al. The Particularities of Pharmaceutical Care in Improving Public Health Service during the COVID-19 Pandemic. *Int J Environ Res Public Health* 2021; 18 2021/09/29. DOI: 10.3390/ijerph18189776.
6. (2010) WHO. Telemedicine – Opportunities and developments in member states. *Report on the second global survey on eHealth* 2010; Vol. 2. (2010).
7. Organization WH. 58th World Health Assembly. *Geneva,Switzerland: World Health Organization* 2005; WHA 58.28.
8. Niznik JD, He H and Kane-Gill SL. Impact of clinical pharmacist services delivered via telemedicine in the outpatient or ambulatory care setting: A systematic review. *Research in Social and Administrative Pharmacy* 2018; 14: 707-717. DOI: https://doi.org/10.1016/j.sapharm.2017.10.011.
9. Littauer SL, Dixon DL, Mishra VK, et al. Pharmacists providing care in the outpatient setting through telemedicine models: a narrative review. *Pharm Pract (Granada)* 2017; 15: 1134. 2018/01/11. DOI: 10.18549/PharmPract.2017.04.1134.
10. Nkansah N, Mostovetsky O, Yu C, et al. Effect of outpatient pharmacists' non-dispensing roles on patient outcomes and prescribing patterns. *Cochrane Database Syst Rev* 2010; 2010: Cd000336. 2010/07/09. DOI: 10.1002/14651858.CD000336.pub2.
11. George PP, Molina JA, Cheah J, et al. The evolving role of the community pharmacist in chronic disease management - a literature review. *Ann Acad Med Singap* 2010; 39: 861-867. 2010/12/18.
12. Spanakis M, Sfakianakis S, Kallergis G, et al. PharmActa: Personalized pharmaceutical care eHealth platform for patients and pharmacists. *J Biomed Inform* 2019; 100: 103336. 2019/11/07. DOI: 10.1016/j.jbi.2019.103336.
13. Jeminiwa R, Hohmann L, Qian J, et al. Impact of eHealth on medication adherence among patients with asthma: A systematic review and meta-analysis. *Respir Med* 2019; 149: 59-68. 2019/02/26. DOI: 10.1016/j.rmed.2019.02.011.
14. Kilova K, Mihaylova A and Peikova L. Opportunities of information communication technologies for providing pharmaceutical care in the COVID-19 pandemic. *Pharmacia* 2021; 68: 9-14. Article. DOI: 10.3897/pharmacia.68.e56987.
15. Kow CS and Hasan SS. Pharmacist-patient communication amid COVID-19 pandemic: A review of available options and potential impact. *British Journal of Pharmacy* 2021; 6. DOI: 10.5920/bjpharm.836.
16. Ghina Nadhifah Iftinan NW, Keri Lestari Telepharmacy: A Potential Alternative Approach for Diabetic Patients During the COVID-19 Pandemic. *Journal of Multidisciplinary Healthcare* 2021.
17. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; 372: n71. DOI: 10.1136/bmj.n71.
18. Fandino W. Formulating a good research question: Pearls and pitfalls. *Indian J Anaesth* 2019; 63: 611-616. DOI: 10.4103/ija.IJA_198_19.
19. Moltó-Puigmartí C, Vonk R, van Ommeren G, et al. A logic model for pharmaceutical care. *J Health Serv Res Policy* 2018; 23: 148-157. 2018/05/23. DOI: 10.1177/1355819618768343.
20. Abdallah I, Eltahir A, Fernyhough L, et al. The experience of Hamad General Hospital collaborative anticoagulation clinic in Qatar during the COVID-19 pandemic. *J Thromb Thrombolysis* 2020: 1-7. 2020/10/06. DOI: 10.1007/s11239-020-02276-4.
21. Allison A, Shahan J, Goodner J, et al. Providing essential clinical pharmacy services during a pandemic: Virtual video rounding and precepting. *Am J Health Syst Pharm* 2021 2021/05/15. DOI: 10.1093/ajhp/zxab208.

22. Cashman H, Mayson E, Kliman D, et al. An integrated electronic health record facilitates a safer and more efficient rural outreach haematology service. *Internal Medicine Journal* 2020. Article. DOI: 10.1111/imj.14973.
23. Do T, Luon S, Boothe K, et al. Advancing ambulatory pharmacy practice through a crisis: Objectives and strategies used in an ambulatory care action team's response to the COVID-19 pandemic. *Am J Health Syst Pharm* 2021 2021/01/24. DOI: 10.1093/ajhp/zxab014.
24. Goff DA, Ashiru-Oredope D, Cairns KA, et al. Global contributions of pharmacists during the COVID-19 pandemic. *JACCP Journal of the American College of Clinical Pharmacy* 2020; 3: 1480-1492. Article. DOI: 10.1002/jac5.1329.
25. Kjerengtroen S, Wilde SM, Fontaine GV, et al. COVID-19 preparedness: Clinical pharmacy services remote staffing in a quaternary, level I trauma and comprehensive stroke center. *American Journal of Health-System Pharmacy* 2020; 77: 1250-1256. Article. DOI: 10.1093/ajhp/zxaa132.
26. Liao Y, Ma C, Lau AH, et al. Role of pharmacists during the COVID-19 pandemic in China - Shanghai Experiences. *J Am Coll Clin Pharm* 2020 2020/08/25. DOI: 10.1002/jac5.1288.
27. Marchese M, Heintzman A, Pasetka M, et al. Development of a process map for the delivery of virtual clinical pharmacy services at Odette Cancer Centre during the COVID-19 pandemic. *J Oncol Pharm Pract* 2021; 27: 650-657. 2021/02/09. DOI: 10.1177/1078155221991202.
28. Margusino-Framiñán L, Illarro-Uranga A, Lorenzo-Lorenzo K, et al. Pharmaceutical care to hospital outpatients during the COVID-19 pandemic. Telepharmacy. *Farm Hosp* 2020; 44: 61-65. 2020/06/14. DOI: 10.7399/fh.11498.
29. Mohammad I, Berlie HD, Lipari M, et al. Ambulatory Care Practice in the COVID-19 Era: Redesigning Clinical Services and Experiential Learning. *J Am Coll Clin Pharm* 2020 2020/08/25. DOI: 10.1002/jac5.1276.
30. Reardon J, Yuen J, Lim T, et al. Provision of Virtual Outpatient Care during the COVID-19 Pandemic and Beyond: Enabling Factors and Experiences from the UBC Pharmacists Clinic. *Innov Pharm* 2020; 11 2021/05/20. DOI: 10.24926/iip.v11i4.3432.
31. Segal EM, Alwan L, Pitney C, et al. Establishing clinical pharmacist telehealth services during the COVID-19 pandemic. *American Journal of Health-System Pharmacy* 2020; 77: 1403-1408. Article. DOI: 10.1093/ajhp/zxaa184.
32. Warda N and Rotolo SM. Virtual medication tours with a pharmacist as part of a cystic fibrosis telehealth visit. *J Am Pharm Assoc (2003)* 2021 2021/05/02. DOI: 10.1016/j.japh.2021.04.005.
33. Yerram P, Thackray J, Modelevsky LR, et al. Outpatient clinical pharmacy practice in the face of COVID-19 at a cancer center in New York City. *J Oncol Pharm Pract* 2021; 27: 389-394. 2021/01/19. DOI: 10.1177/1078155220987625.
34. Adam JP, Khazaka M, Charikhi F, et al. Management of human resources of a pharmacy department during the
COVID-19 pandemic: Take-aways from the first wave. *Res Social Adm Pharm* 2021; 17: 1990-1996. 2020/11/16. DOI: 10.1016/j.sapharm.2020.10.014.
35. Al Mazrouei N, Ibrahim RM, Al Meslamani AZ, et al. Virtual pharmacist interventions on abuse of over-the-counter medications during COVID-19 versus traditional pharmacist interventions. *Journal of the American Pharmacists Association* 2021; 61: 331-339. Article. DOI: 10.1016/j.japh.2021.02.003.
36. Alhmoud EN, Abd El Samad OB, Elewa H, et al. Drive-up INR testing and phone-based consultations service during COVID-19 pandemic in a pharmacist-lead anticoagulation clinic in Qatar: Monitoring, clinical, resource utilization, and patient- oriented outcomes. *J Am Coll Clin Pharm* 2021 2021/07/07. DOI: 10.1002/jac5.1469.
37. Chen ZJ, Liang WT, Liu Q, et al. Use of a Remote Oncology Pharmacy Service Platform for Patients With Cancer During the COVID-19 Pandemic: Implementation and User Acceptance Evaluation. *J Med Internet Res* 2021; 23: e24619. 2021/01/05. DOI: 10.2196/24619.
38. Li H, Zheng S, Liu F, et al. Fighting against COVID-19: Innovative strategies for clinical pharmacists. *Res Social Adm Pharm* 2021; 17: 1813-1818. 2020/04/13. DOI: 10.1016/j.sapharm.2020.04.003.
39. Livet M, Levitt JM, Lee A, et al. The pharmacist as a public health resource: Expanding telepharmacy services to address social determinants of health during the COVID-19 pandemic. *Exploratory Research in Clinical and Social Pharmacy* 2021; 2: 100032. DOI: https://doi.org/10.1016/j.rcsop.2021.100032.
40. Brown SA, Patel S, Rayan D, et al. A virtual-hybrid approach to launching a cardio-oncology clinic during a pandemic. *Cardiooncology* 2021; 7: 2. 2021/01/15. DOI: 10.1186/s40959-020-00088-2.

41. Park L, Kim JH, Waldman E, et al. Impact analysis of virtual ambulatory transplant pharmacists during COVID-19. *Journal of the American College of Clinical Pharmacy*. DOI: 10.1002/jac5.1488.
42. Falconer N, Monaghan C and Snoswell CL. The pharmacist informatician: providing an innovative model of care during the COVID-19 crisis. *Int J Pharm Pract* 2021; 29: 152-156. 2021/03/18. DOI: 10.1093/ijpp/riaa017.
43. Gona OJ, Madhan R and Shambu SK. Assessment of Clinical Pharmacists' Assistance for Patients With Established Cardiovascular Diseases During the COVID-19 Pandemic: Insights From Southern India. *Front Cardiovasc Med* 2020; 7: 599807. 2021/01/12. DOI: 10.3389/fcvm.2020.599807.
44. Huibo Li SZ, Da Li, Dechun Jiang, Fang Liu, Wei Guo, Zhenying Zhao, Yanfei Zhou, Jingting Liu, Rongsheng Zhao. The Establishment and Practice of Pharmacy Care Service Based on Internet Social Media: Telemedicine in Response to the COVID-19 Pandemic. *Frontiers in Pharmacology* 2021. DOI: https://doi.org/10.3389/fphar.2021.707442.
45. Koster ES, Philbert D and Bouvy ML. Impact of the COVID-19 epidemic on the provision of pharmaceutical care in community pharmacies. *Res Social Adm Pharm* 2021; 17: 2002-2004. 2020/12/16. DOI: 10.1016/j.sapharm.2020.07.001.
46. Muflih SM, Al-Azzam S, Abuhammad S, et al. Pharmacists' experience, competence and perception of telepharmacy technology in response to COVID-19. *Int J Clin Pract* 2021; 75: e14209. 2021/04/06. DOI: 10.1111/ijcp.14209.
47. Tortajada-Goitia B, Morillo-Verdugo R, Margusino-Framiñán L, et al. Survey on the situation of telepharmacy as applied to the outpatient care in hospital pharmacy departments in Spain during the COVID-19 pandemic. *Farm Hosp* 2020; 44: 135-140. 2020/07/11. DOI: 10.7399/fh.11527.
48. Wang D, Liu Y, Zeng F, et al. Evaluation of the role and usefulness of clinical pharmacists at the Fangcang Hospital during COVID-19 outbreak. *Int J Clin Pract* 2021: e14271. 2021/04/25. DOI: 10.1111/ijcp.14271.
49. Al Meslamani AZ, Kassem AB, El-Bassiouny NA, et al. An emergency plan for management of COVID-19 patients in rural areas. *International Journal of Clinical Practice* 2021. Article. DOI: 10.1111/ijcp.14563.
50. Ibrahim OM, Ibrahim RM, Z Al Meslamani A, et al. Role of telepharmacy in pharmacist counselling to coronavirus disease 2019 patients and medication dispensing errors. *Journal of Telemedicine and Telecare* 2020. Article. DOI: 10.1177/1357633X20964347.
51. Mohamed Ibrahim O, Ibrahim RM, Abdel-Qader DH, et al. Evaluation of Telepharmacy Services in Light of COVID-19. *Telemedicine and e-Health* 2021; 27: 649-656. Article. DOI: 10.1089/tmj.2020.0283.
52. Cope R, Fischetti B, Eladghm N, et al. Outpatient management of chronic warfarin therapy at a pharmacist-run anticoagulation clinic during the COVID-19 pandemic. *J Thromb Thrombolysis* 2021: 1-5. 2021/03/08. DOI: 10.1007/s11239-021-02410-w.
53. Sorbera M, Fischetti B, Khaimova R, et al. Evaluation of virologic suppression rates during the COVID-19 pandemic with outpatient interdisciplinary HIV care. *J Am Coll Clin Pharm* 2021 2021/07/08. DOI: 10.1002/jac5.1422.
54. Peláez Bejarano A, Villar Santos P, Robustillo-Cortés MLA, et al. Implementation of a novel home delivery service during pandemic. *Eur J Hosp Pharm* 2021; 28: e120-e123. 2020/10/30. DOI: 10.1136/ejhpharm-2020-002500.
55. McNamara A, Zhao M and Lee SY. Evaluating the primary care clinical pharmacist visit transition to telehealth during the COVID -19 pandemic by comparing medication related problems from telehealth visits and in-person visits. *JACCP: JOURNAL OF THE AMERICAN COLLEGE OF CLINICAL PHARMACY* 2021; 4: 914-923. DOI: 10.1002/jac5.1487.
56. Alhraiwil NJ, Al-Aqeel S, AlFaleh AF, et al. Impact of COVID-19 on the 937 Telephone Medical Consultation Service in Saudi Arabia. *Int J Telemed Appl* 2022; 2022: 4181322. 2022/01/22. DOI: 10.1155/2022/4181322.
57. Mohiuddin SI, Thorakkattil SA, Abushoumi F, et al. Implementation of pharmacist-led tele medication management clinic in ambulatory care settings: A patient-centered care model in COVID-19 Era. *Explor Res Clin Soc Pharm* 2021; 4: 100083. 2021/11/02. DOI: 10.1016/j.rcsop.2021.100083.
58. Li Z, Gan L, Zheng H, et al. Innovative Strategies and Efforts of Clinical Pharmacy Services During and After COVID-19 Epidemic: Experience from Shanghai Children's Hospital. *Risk Manag Healthc Policy* 2021; 14: 4759-4764. 2021/12/04. DOI: 10.2147/rmhp.S324937.
59. Grosman-Dziewiszek P, Wiatrak B, Jęśkowiak I, et al. Patients' Habits and the Role of Pharmacists and Telemedicine as Elements of a Modern Health Care System during the COVID-19 Pandemic. *J Clin Med*

2021; 10 2021/09/29. DOI: 10.3390/jcm10184211.

60. Itani R, Khojah HMJ, Jaffal F, et al. Provision of pharmaceutical care to suspected high-risk COVID-19 patients through telehealth: a nationwide simulated patient study. *BMC Health Serv Res* 2021; 21: 997. 2021/09/23. DOI: 10.1186/s12913-021-07014-x.

61. Al Ammari M, AlThiab K, AlJohani M, et al. Tele-pharmacy Anticoagulation Clinic During COVID-19 Pandemic: Patient Outcomes. *Front Pharmacol* 2021; 12: 652482. 2021/09/28. DOI: 10.3389/fphar.2021.652482.

62. Kovačević M, Ćulafić M, Vezmar Kovačević S, et al. Telepharmacy service experience during the COVID-19 pandemic in the Republic of Srpska, Bosnia and Herzegovina. *Health Soc Care Community* 2021 2021/09/29. DOI: 10.1111/hsc.13590.

63. Lee SWH, Chan CKY, Chua SS, et al. Comparative effectiveness of telemedicine strategies on type 2 diabetes management: A systematic review and network meta-analysis. *Sci Rep* 2017; 7: 12680. 2017/10/06. DOI: 10.1038/s41598-017-12987-z.

64. Chongmelaxme B, Lee S, Dhippayom T, et al. The effects of telemedicine on asthma control and patients' quality of life in adults: a systematic review and meta-analysis. *The Journal of Allergy and Clinical Immunology: In Practice* 2019; 7: 199-216. e111.

65. Hanjani LS, Caffery LJ, Freeman CR, et al. A scoping review of the use and impact of telehealth medication reviews. *Research in Social and Administrative Pharmacy* 2020; 16: 1140-1153.

66. Niznik JD, He H and Kane-Gill SL. Impact of clinical pharmacist services delivered via telemedicine in the outpatient or ambulatory care setting: A systematic review. *Res Social Adm Pharm* 2018; 14: 707-717. 2017/11/05. DOI: 10.1016/j.sapharm.2017.10.011.

67. Ohannessian R. Telemedicine: Potential applications in epidemic situations. *European Research in Telemedicine / La Recherche Européenne en Télémédecine* 2015; 4: 95-98. 2015/09/26. DOI: 10.1016/j.eurtel.2015.08.002.

68. Bynum A, Hopkins D, Thomas A, et al. The effect of telepharmacy counseling on metered-dose inhaler technique among adolescents with asthma in rural Arkansas. *Telemed J E Health* 2001; 7: 207-217. 2001/09/21. DOI: 10.1089/153056201316970902.

69. Witt DM and Humphries TL. A retrospective evaluation of the management of excessive anticoagulation in an established clinical pharmacy anticoagulation service compared to traditional care. *J Thromb Thrombolysis* 2003; 15: 113-118. 2003/11/18. DOI: 10.1023/b:thro.0000003325.62542.43.

70. Green BB, Cook AJ, Ralston JD, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. *Jama* 2008; 299: 2857-2867. 2008/06/26. DOI: 10.1001/jama.299.24.2857.

71. Salvo MC and Brooks AM. Glycemic control and preventive care measures of indigent diabetes patients within a pharmacist-managed insulin titration program vs standard care. *Ann Pharmacother* 2012; 46: 29-34. 2011/12/29. DOI: 10.1345/aph.1Q512.

72. Skrei A and Rundquist MM. Pharmacy Services in Telepharmacy: how's it working, where it's working, and what's required to practice in this new setting. 2017.

73. Ohannessian R, Duong TA and Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. *JMIR public health and surveillance* 2020; 6: e18810.

74. Alonso SG, de la Torre Díez I and Zapiraín BG. Predictive, personalized, preventive and participatory (4P) medicine applied to telemedicine and eHealth in the literature. *Journal of medical systems* 2019; 43: 1-10.

75. Negrini S, Donzelli S, Negrini A, et al. Feasibility and acceptability of telemedicine to substitute outpatient rehabilitation services in the COVID-19 emergency in Italy: an observational everyday clinical-life study. *Archives of physical medicine and rehabilitation* 2020; 101: 2027-2032.

76. Al-Jazairi A, Hijazi H, Samarkandi H, et al. What is the ideal clinical pharmacy practice model? A satisfaction comparative study. *Journal of the American College of Clinical Pharmacy* 2021; 4: 441-449.

77. Baretić M and Protrka N. Healthcare Information Technology: Fast and Accurate Information Access vs. Cyber-Security. *International Journal of E-Services and Mobile Applications (IJESMA)* 2021; 13: 77-87.

78. Solimini R, Busardò FP, Gibelli F, et al. Ethical and Legal Challenges of Telemedicine in the Era of the COVID-19 Pandemic. *Medicina* 2021; 57: 1314.

79. Hendy J, Reeves BC, Fulop N, et al. Challenges to implementing the national programme for information technology (NPfIT): a qualitative study. *Bmj* 2005; 331: 331-336.

80. Oberjé EJ, de Kinderen RJ, Evers SM, et al. Cost effectiveness of medication adherence-enhancing interventions: a systematic review of trial-based economic evaluations. *Pharmacoeconomics* 2013; 31: 1155-1168.
81. Mohammadyari S and Singh H. Understanding the effect of e-learning on individual performance: The role of digital literacy. *Computers & Education* 2015; 82: 11-25.
82. Poudel A and Nissen LM. Telepharmacy: a pharmacist's perspective on the clinical benefits and challenges. *Integr Pharm Res Pract* 2016; 5: 75-82. 2016/10/26. DOI: 10.2147/iprp.S101685.
83. Hyder MA and Razzak J. Telemedicine in the United States: An Introduction for Students and Residents. *J Med Internet Res* 2020; 22: e20839. 2020/11/21. DOI: 10.2196/20839.
84. Car J, Tan WS, Huang Z, et al. eHealth in the future of medications management: personalisation, monitoring and adherence. *BMC medicine* 2017; 15: 1-9.

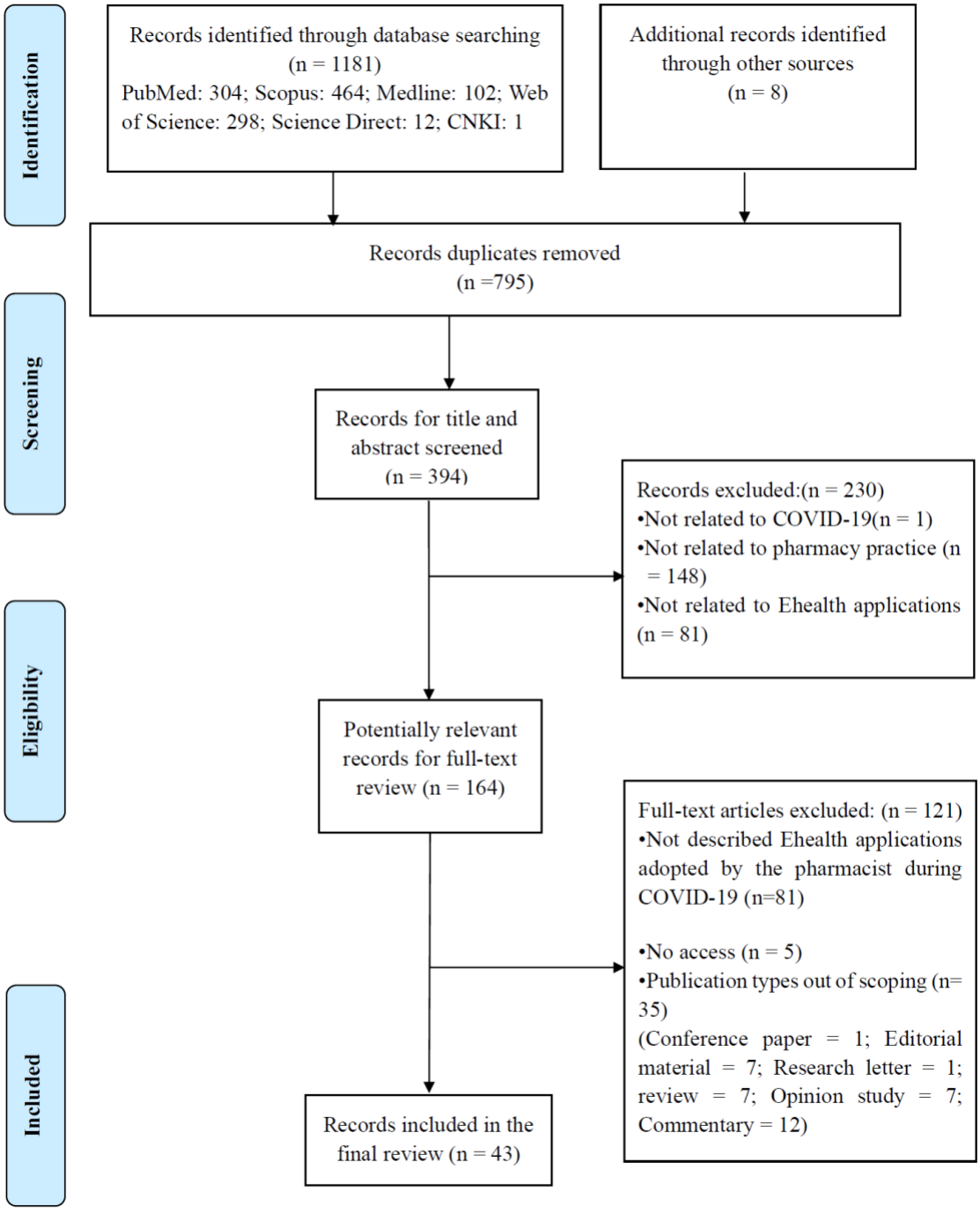

Figure 1. PRISMA flowchart of literature search and selection of publications

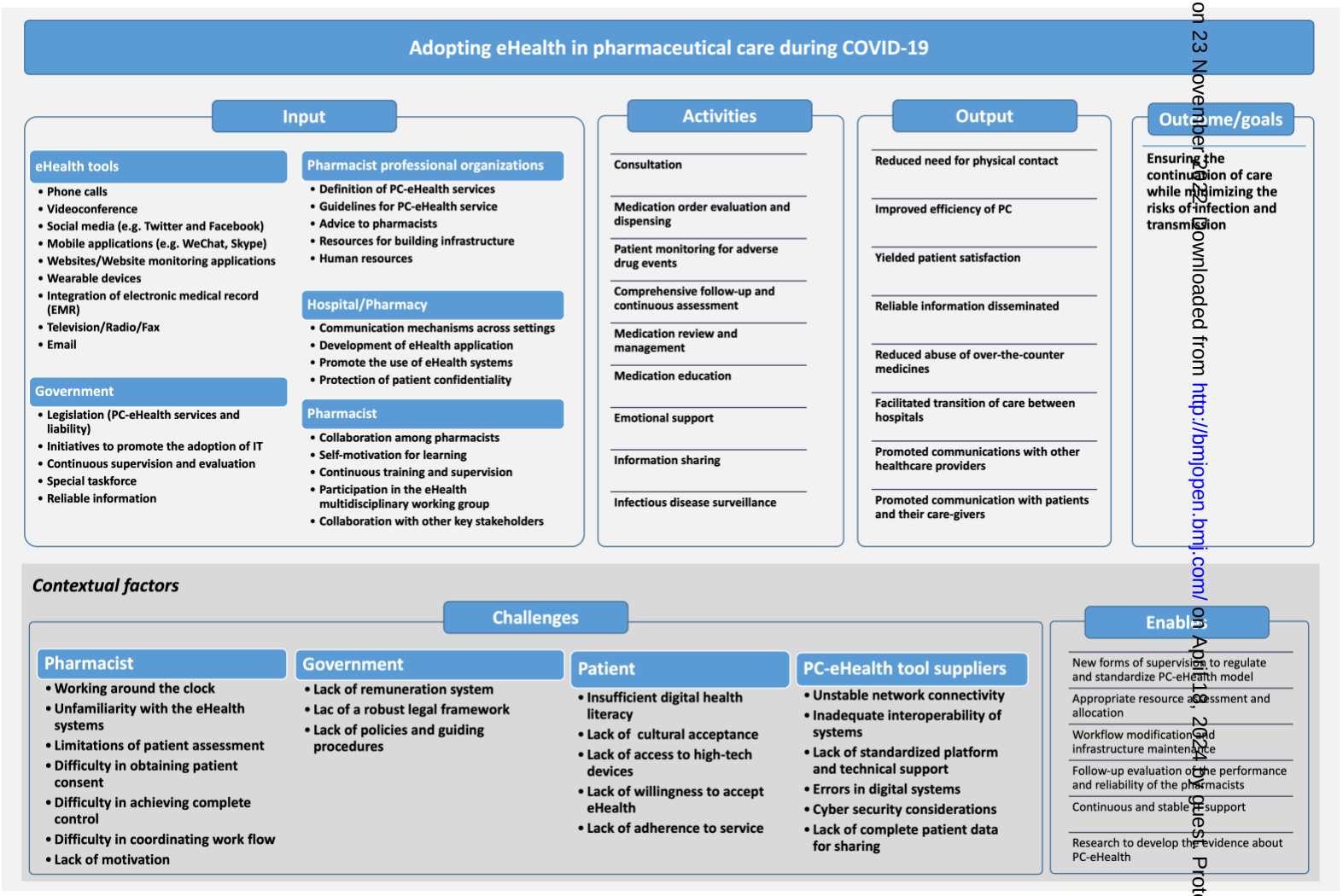

Figure 2. The logic model of adopting eHealth in pharmaceutical care during the COVID-19 pandemic

A systematic literature review of adopting eHealth in pharmaceutical care during COVID-19 pandemic: recommendations for strengthening pharmacy services

Characteristics of sources of evidence

	Authors (Publication Year)	Type of study	Location	Study aim	Targets of eHealth pharmacy service	Types of pharmacists involved
1	Abdallah et al. (2020)[20]	Descriptive study	Qatar	To share the experience and describe the measures adopted by the clinic as part of the Hamad Medical Corporation response to the emerging situation	Patients who were elderly or immunocompromised, and referred to the clinic or anticoagulation emergencies;	Hospital pharmacists
2	Do et al. (2021)[23]	Descriptive study	The United States	To discuss the objectives and strategies used by an ambulatory care action team operating within a large health system's pharmacy incident command structure during the initial response to the coronavirus disease 2019 (COVID-19) pandemic	Patients of the pulmonary clinic	Hospital pharmacists
3	Goff et al. (2020)[24]	Descriptive study	The United States	To described how pharmacists from high and low-middle income countries contributed to essential patient care and well-being of the public during the COVID-19 pandemic	General Public	Pharmacists specializing in infectious diseases (ID)
4	Liao et al. (2020)[26]	Descriptive study	China	To described the roles and contributions of pharmacists in Shanghai during the coronavirus disease 2019 (COVID-19) pandemic	Adult patients with COVID-19	Clinical pharmacists and pharmacists of traditional Chinese medicine (TCM)
5	Allison et al. (2021)[21]	Descriptive study	The United States	To evaluated how to balance the need to provide essential pharmacy services (both operational and clinical), develop	Inpatients and discharged patients	Hospital pharmacists

				telework strategies, and maintain a viable workforce for the duration of the COVID-19 pandemic		
6	Margusino-Framiñán et al. (2020)[28]	Descriptive study	Spain	To describe and analyze the experience of HPSs with outpatient Telepharmacy during the COVID-19 pandemic and exposed the lessons learned	Outpatients	Primary care pharmacists; Community Pharmacists
7	Mohammad et al. (2020)[29]	Descriptive study	The United States	To emphasize clinical and experiential challenges that ambulatory care clinical pharmacists had been facing, generate discussion, and provide examples of potential solutions that could serve as a framework for COVID-19 ambulatory care practices and experiential sites	Patients on warfarin therapy	Hospital pharmacists
8	Reardon et al. (2020)[30]	Descriptive study	Canada	To describe the UBC Pharmacists Clinic's technical systems and lessons learned using enabling technology and the provision of virtual patient care by pharmacists	Patients who needed to visit the pharmacist clinic	Hospital pharmacists
9	Segal et al. (2020)[31]	Descriptive study	The United States	To describe an expedited process used to obtain telehealth privileges for pharmacists and highlighted the experience providing clinical services to patients with COVID-19	Patients with chronic conditions and cancer	Hospital pharmacists
10	Warda et al. (2021)[32]	Descriptive study	The United States	To describe the uptake and impact of pharmacist-led virtual medication tours during telehealth visits in the CF clinic setting	Patients with cystic fibrosis	Pharmacists specializing in cystic fibrosis
11	Yerram et al. (2021)[33]	Descriptive study	The United States	To present the approach of restructuring clinical pharmacy services and providing direct patient care in outpatient clinics during the pandemic	Outpatients; Inpatients	Hospital pharmacists

12	Adam et al. (2021)[34]	Case series	Canada	To share the experiences of the pharmacy department of the Centre hospitalier de l'Université de Montréal (CHUM) in response to the COVID-19 pandemic	COVID-19 patients; Oncology outpatient	Pharmacists in the oncology outpatient; PhT (the ones responsible for prescription entry)
13	Al Mazrouei et al. (2021)[35]	Case series	United Arab Emirates (UAE)	To investigate the frequency, nature, and clinical significance of pharmacist interventions on over-the-counter (OTC) medicines with abuse potential across community pharmacies with and without virtual care	Patient who used over-the-counter medicines	Community pharmacists; Hospital pharmacists
14	Alhmoud et al. (2021)[36]	Cross-sectional survey	Qatar	To evaluate the impact of transitioning from clinic-based anticoagulation management services to drive-up and phone-based services during COVID-19 pandemic in Qatar	Patients who attended anticoagulation clinic over 1-year period (6 months before and 6 months after service transition)	Pharmacists providing anticoagulation services
15	Chen et al. (2021)[37]	Cross-sectional survey	China	To investigate the characteristics, acceptance, and initial impact of the Cloud SYSUCC app during a COVID-19 outbreak in a tertiary cancer hospital in China	Patient with cancer treated with prescription medicines (such as breast cancer, liver cancer, and thyroid cancer) who needed to visit the cancer center	Hospital pharmacists
16	Li et al. (2021)[38]	Cross-sectional survey	China	To retrieve and investigate the prevention and control measures of clinical pharmacists during the outbreak of novel coronavirus, summarize the roles and responsibilities of clinical pharmacists, and to propose innovative strategies for developing pharmacy services under the epidemic	Patients in Fangcang shelter hospitals	Hospital pharmacists
17	Livet et al. (2021)[39]	Cross-sectional survey	The United States	To describe the feasibility of expanding a comprehensive medication management (CMM) telepharmacy	Diabetic patients with HbA1c > 9, at least one additional comorbidity	Hospital pharmacists

				service to include social determinants of health(SDOH) support expanded service, evaluated stakeholders' experience with the service, and assessed short-term impact on patients with diabetes	five or more medications, and at least 18 years of age	
18	Brown et al. (2021)[40]	Retrospective study	The United States and the United Kingdom	To offer a template for other centers to develop their own new Cardio-Oncology clinics with Virtual-Hybrid Approach during the pandemic	Patients with cancers (e.g., breast, prostate, leukemia, lung) or cardiovascular toxicities (e.g., cardiomyopathy, hypertension) who needed to visit Cardio-Oncology clinic	Hospital pharmacists
19	Cashman et al. (2020)[22]	Descriptive study	Australia	To integrate the electronic healthcare delivery systems at a metropolitan hospital and a rural outreach haematology clinic to facilitate streamlined and safe outpatient car	Hematology outpatients	Pharmacists specializing in hematology/oncology
20	Kjerengtroen et al. (2020)[25]	Descriptive study	The United States	To describe and share the plan developed by Intermountain Medical Center (IMED) in Murray, UT which provides remote clinical pharmacy services to protect the health of pharmacy caregivers while maintaining appropriate clinical pharmacy coverage to optimally care for patients	Hospitalized patients in a quaternary, level I trauma and comprehensive stroke center and patients from off-site locations	Hospital pharmacists; Pharmacists specializing in critical care, internal medicine or cardiology
21	Marchese et al. (2021)[27]	Descriptive study	Canada	To describe, in a process map, the process changes that were made to the delivery of clinical pharmacy services to ambulatory cancer patients prescribed intravenous anticancer therapies at Odette Cancer Centre in March–April 2020	Patients receiving systemic cancer treatment	Pharmacists specializing in oncology

22	Park et al. (2021)[41]	Retrospective study	The United States	To describe a quality assurance and performance improvement initiative of the implementation of comprehensive medication management visits, pharmacists were able to assist LTP in the transition to telemedicine	Lung transplant providers (LTP)	Pharmacists specializing in cardiothoracic (CT) transplant
23	Falconer et al. (2021)[42]	Semi-structured interview	Australia	To determine the key opportunities for a pharmacist informatician to improve patient care and outcomes during the COVID-19 pandemic	Patients with COVID-19	Pharmacists specializing in informatics
24	Gona et al. (2020)[43]	Cross-sectional survey	India	To assess the clinical pharmacist-initiated telephone-based patient education and self-management support for patients with cardiovascular disease during the nationwide lockdown during COVID-19 pandemic	Patients with existing cardiovascular diseases	Hospital pharmacists
25	Koster et al. (2021)[45]	Cross-sectional survey	Netherlands	To describe the impact of the COVID-19 epidemic on the provision of pharmaceutical care in the Netherlands	Vulnerable patients	Community pharmacists
26	Muflih et al. (2021)[46]	Cross-sectional survey	Jordan	To examine pharmacists' attitudes towards clinical benefits and identify challenges regarding the use of telepharmacy during the COVID-19 pandemic in Jordan	Patients with COVID-19	Community pharmacists; Hospital pharmacists
27	Tortajada-Goitia et al. (2020)[47]	Cross-sectional survey	Spain	To analyze the status of the implementation and development of telepharmacy as applied to the pharmaceutical care of outpatients treated at hospital pharmacy services in Spain during the COVID-19 pandemic	Outpatients	Hospital pharmacists
28	Wang et al. (2021)[48]	Cross-sectional survey	China	To evaluate the usefulness of clinical prevention and control measures of	Patients with chronic diseases	Hospital pharmacists

				clinical pharmacists at Jianghan Fangcang Hospital		
29	Al Meslamani et al. (2021)[49]	Case series	Egypt	To describe the experience of six hospitals in the management of COVID-19 patients in rural areas through an assessment of proportions, types and clinical outcomes of remote clinical interventions	Patients with COVID-19 who lived in rural areas	Hospital pharmacists
30	Ibrahim et al. (2020)[50]	Case series	The United States	To examine differences in rates and types of pharmacist interventions related to COVID-19 and medication dispensing errors (MDEs) across community pharmacies with and without telepharmacy services	Patients with suspected or confirmed COVID-19 infection	Community pharmacists
31	Mohamed Ibrahim et al. (2021)[51]	Case series	United Arab Emirates (UAE)	To assess the predictors for effective telepharmacy services on increasing access of patients to care and reducing dispensing errors in community pharmacies	Patients with probable or confirmed COVID-19 infection	Community pharmacists
32	Cope et al. (2021)[52]	Retrospective study	The United States	To describe the care provided during the COVID-19 pandemic at a pharmacist-run anticoagulation clinic in the New York Metropolitan area and evaluates the impact on clinic outcomes	Outpatients with chronic diseases	Hospital pharmacists
33	Sorbera et al. (2021)[53]	Retrospective study	The United States	To measure the impact of pharmacy services including telehealth through the percentage of virologically suppressed patients (HIV ribonucleic acid [RNA] < 200 copies/mL) during the pre-COVID and post-COVID time periods	HIV-positive patients	Hospital pharmacists
34	Huibo Li et al. (2021)[44]	Cross-sectional survey	China	To establish and launch a telepharmacy framework to implement pharmaceutical care during the COVID-19 pandemic.	Patients with chronic diseases requiring long-term use of medications	Pharmacist volunteers

					who were quarantined at home	
35	Ana Peláez Bejarano, et al. (2021)[54]	Cross-sectional survey	Spanish	To design a model that would facilitate access to hospital medication during home quarantine due to COVID-19, and ensure patient satisfaction with this process	Patients with acute illnesses or complex chronic conditions who were confined to home quarantine due to the pandemic	Community pharmacists; Hospital pharmacists
36	Anusha McNamara, et al. (2021)[55]	Retrospective study	The United States	To evaluate the impact of clinical pharmacist care via in-person and telehealth by comparing the average MRPs resolved during the visits	Patients and individuals regardless of insurance status	Hospital pharmacists
37	Najla J. Alhraiwil, et al.(2021)[56]	Descriptive study	Saudi Arabia	To understand the impact of the COVID-19 pandemic on Call Center services, specifically medical consultations, to suggest future recommendations for patient care optimization	Citizens, residents, and visitors	Pharmacists
38	Syed Iqbal Mohiuddin, et al. (2021)[57]	Descriptive study	Saudi Arabia	To emphasize the implementation of the pharmacist-led medication management clinic services in the Johns Hopkins Aramco Healthcare (JHAH) ambulatory pharmacy care setting using communication technologies	Geriatric patients with chronic conditions	Clinic pharmacists responsible for medication management
39	Zhiling Li, et al. (2021)[58]	Descriptive study	China	To share our strategies and efforts with peers who are fighting against COVID-19 in other countries and regions	Pediatric patients with COVID-19	Hospital pharmacists
40	Patrycja Grosman-Dziewiszek, et al. (2021)[59]	Cross-sectional survey	Poland	To unvestigate the new coronavirus disease 's effect on patients' health habits, access to healthcare, and attitude to vaccination	Patients in general	Hospital pharmacists

41	Rania Itani, et al. (2021)[60]	Cross-sectional survey	Lebanon	To identify the pharmaceutical care provided by community pharmacists to suspected high-risk COVID-19 patients using telehealth	Elderly individuals and those with underlying chronic medical conditions	Community pharmacists
42	Maha Al Ammari, et al. (2021)[61]	Prospective study	Saudi Arabia	To assess the tele-pharmacy anticoagulation clinic's efficiency and patient satisfaction in Saudi Arabia during the COVID-19 pandemic	Patients with diabetes mellitus and hypertension	Hospital pharmacists
43	Milena Kovačević, et al. (2021)[62]	Descriptive study	Republic of Srpska, Bosnia and Herzegovina	To describe the remote pharmaceutical care service (telepharmacy) during the COVID-19 pandemic in the Republic of Srpska (RS), Bosnia and Herzegovina; To identify service users' needs and concerns and to describe community pharmacists' interventions	Patients with chronic or acute/subacute conditions	Community pharmacists

Major findings of the included literature

	Type of eHealth involved					Tool(s)	Intervention	Output summary
	Tele-education	Tele-consultation	Tele-monitoring	Tele-case-management	Tele-mentoring			
1	✓	✓	✓			▪ Phone calls	▪ Consultation ▪ Comprehensive assessment ▪ Medication review and management ▪ Patient monitoring ▪ Medication education	Elderly or immunocompromised patients referred to the clinic or anticoagulation emergencies were managed by hospital pharmacists through telephone calls. The number of patients who needed to physically attend the clinic significantly reduced.
2		✓	✓	✓		▪ Phone calls ▪ Videoconference	▪ Patient monitoring	Patients of the pulmonary clinic were converted to eHealth and monitored by hospital pharmacists.
3	✓					▪ Social media (Twitter) ▪ Television	▪ Public education	20 interviews with pharmacists specializing in infectious diseases were broadcasted through the local television health reporters, national news media, magazines, and tweets to provide education to the general public.
4		✓	✓	✓		▪ Website monitoring applications (The online platform "SPHCC Patient Care" based on six licensed internet hospitals) ▪ Mobile application (WeChat)	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring ▪ Medication order review ▪ Emotional support	Pharmacists (both clinical and traditional Chinese medicine (TCM)) continued to care for patients with COVID-19 using the website application. The need for patients to come to hospitals for treatment and follow-up was reduced.

5		✓	✓		✓	▪ Videoconference ▪ Phone calls *With the integration of The electronic medical record (EMR) system*	▪ Consultation ▪ Information sharing	All clinical pharmacy services continued to be provided through different means of eHealth without interruptions
6		✓			✓	▪ Website monitoring applications (Primary Health Care Center network in the healthcare area (CCSS))	▪ Consultation	During eight weeks, 3,095 patients were treated with pharmacists through eHealth (75% of the total), and 195 received their medication at home. Extraordinary perception of quality of the new model was received through multiple signs of appreciation from patients.
7	✓		✓	✓		▪ Phone calls; ▪ Videoconference (Zoom); ▪ Mobile applications (Skype, Facetime)	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring	Patients on warfarin therapy were continuously monitored by hospital pharmacists. Patient self-reported questionnaire scores found positive patient satisfaction with pharmacist eHealth care.
8		✓	✓	✓	✓	▪ Website monitoring applications ▪ Email ▪ Fax *With the integration of The electronic medical record (EMR) system*	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Information sharing	Follow-up appointments for patients who needed to visit the pharmacist clinic were conducted virtually by hospital pharmacists. The percentage of follow-up appointments done virtually increased to 64% in 2020 from 1.5% in 2019.

9	✓	✓	✓		✓	▪ Videoconference (ZOOM) *With the integration of The electronic medical record (EMR) system*	▪ Medication review and management ▪ Medication education	During the period of March 31 through April 28, 2020, clinical pharmacist telehealth services were offered to 139 patients. Of these patients, 83% (n = 116) completed telehealth visits, which reveals eHealth can ensure the continuous provision of pharmacy services during the epidemic.
10	✓	✓	✓	✓		▪ Phone calls ▪ Videoconference	▪ Medication review and management ▪ Medication order review	A total of 20 patients were consulted via eHealth by pharmacists specializing in cystic fibrosis as part of the clinic appointment between April and June 2020, which demonstrates that a virtual medication tour led by a pharmacist can be successfully incorporated into telehealth visits and be accepted by a majority of patients.
11	✓	✓	✓	✓	✓	▪ Mobile applications (Cisco Jabber 12.6, Doximity) ▪ Videoconference (Zoom)	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Medication education	A total of 265 clinical pharmacy specialist interventions involving COVID-19 healthcare team (both ICU and non-ICU) were performed sparing in-person patient visits for medical care for 199 patients.
12				✓	✓	▪ Mobile applications (PetalMD, Facebook) ▪ Email ▪ Videoconference	▪ Medication order review ▪ Information sharing	An analysis of the number of validated prescriptions showed that the pharmacists validate significantly 27% more prescriptions in telework when compared to a centralized workstation in the hospital without impacting the performance of the pharmacists in hospital.

13		✓	✓			▪ Phone calls ▪ Videoconference ▪ Mobile applications ▪ Website monitoring applications	▪ Consultation ▪ Medication review and management	Regarding over-the-counter medicines in pharmacies, the rates of potential abuse with and without eHealth services were 7.7% and 2.8% respectively; the rates of potential misuse with and without eHealth services were 16.6% and 13.7% respectively.
14		✓	✓			▪ Phone calls ▪ Website applications	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring	Patients' experience with the pharmaceutical service through eHealth was remarkably positive.
15	✓	✓				▪ Website monitoring applications (Cloud Sun Yat-sen University Cancer Center (SYSUCC)) *With the integration of the electronic medical record (EMR) system*	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Medication education	Patient with cancer treated with prescription medicines were managed by hospital pharmacists via the pharmacy service platform in the Cloud SYSUCC. 88% (88/100) of the patients were very satisfied with the remote pharmacy services provided.
16	✓	✓	✓	✓	✓	▪ Mobile applications (The "Online Pharmaceutical Monitoring"); ▪ Radio (Fangcang shelter radio station)	▪ Consultation ▪ Medication review and management ▪ Medication education ▪ Emotional support ▪ Information sharing	The online pharmaceutical service model not only effectively reduce the chance of hospital-acquired infections, but also improve the efficiency of pharmacy services, and achieve timely and effective professional medication guidance for patients throughout the entire process.

17			✓	✓	✓	▪ Phone calls ▪ Videoconference	▪ Comprehensive assessment	eHealth measures performed by hospital pharmacists for diabetic patients helped address 26 COVID-prompted social determinants of health (SDOH) concerns across 66 patients.
18	✓			✓	✓	▪ Phone calls ▪ Videoconference (A de novo Cardio-Oncology Clinic with Virtual-Hybrid Approach)	▪ Medication review and management ▪ Medication order review ▪ Patient monitoring ▪ Medication education ▪ Information sharing	35% of patients with cancers or cardiovascular toxicities who needed to visit Cardio-Oncology clinic were cared for by hospital pharmacists via eHealth, which reveals the Virtual-Hybrid Approach to build a de novo Cardio-Oncology Clinic is very useful during the pandemic.
19				✓		▪ Electronic health record (EHR) systems	▪ Medication order review	The centralised electronic health record has improved streamlined care during patient transitions between the two hospitals with enhanced continuity of documentation and management.
20	✓	✓	✓	✓	✓	▪ Phone calls ▪ Videoconference (The Intermountain Medical Center (IMED)) ▪ Wearable devices (The Vocera Badge) ▪ Website monitoring applications (The VigiLanz clinical surveillance platform)	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Medication education ▪ Information sharing ▪ Infectious disease surveillance	The plan to provide remote clinical pharmacy services help clinical pharmacists to readily communicate with nurses, physicians, other caregivers, and patients; allow clinical pharmacists to continue to participate in daily rounds, provide consultations under collaborative practice agreements, verify medication orders, collect medication histories, provide antimicrobial stewardship, and deliver medication education to patients from off-site locations; and allow for optimal care of hospitalized patients and promote social distancing, which may have the added benefit of decreasing the

								spread of SARS-CoV-2 among patients and caregivers.
21	✓	✓	✓			▪ Phone calls	▪ Consultation ▪ Comprehensive assessment ▪ Medication education	Pharmacists specializing in oncology performed 149 medication history and baseline assessments, and 72 medication therapy counsels remotely for patients receiving systemic cancer treatment through eHealth in 2 months, which demonstrates that clinical pharmacy service levels could be maintained by incorporating remote delivery approaches without significant investment in resources.
22			✓	✓		▪ Phone calls ▪ Mobile applications (Doximity or Google Voice) ▪ Email	▪ Comprehensive assessment ▪ Medication review and management ▪ Medication order review	From March to September 2020, pharmacists specializing in cardiothoracic transplant conducted 385 virtual visits on 157 Lung transplant providers (LTP) with an average of 20 minutes spent per visit. There were 891 total interventions made by the pharmacists and 778 medication discrepancies were identified.
23				✓	✓	▪ Phone calls ▪ Videoconference *With the integration of the electronic medical record (EMR) system*	▪ Medication review and management ▪ Information sharing ▪ Remote label printing	Pharmacists specializing in informatics ensured the timely supply of medications using real-time data support, which reveals informatics pharmacists have the potential to assist with maintaining high quality patient care during this pandemic, and in future disasters.

24	✓			✓	✓	▪ Phone calls	▪ Consultation ▪ Medication education	Hospital pharmacists adopted eHealth to increase patients' understanding of the pandemic and help mitigate infection exposure among patients, assuring the continuity of care in patients with established cardiovascular diseases.
25		✓	✓			▪ Phone calls ▪ Videoconference	▪ Consultation ▪ Medication education ▪ Information sharing	Community pharmacists continued to conducted medication reviews with remote pharmaceutical services for 44.2% vulnerable patients, which greatly minimized direct patient-provider contact.
26			✓			▪ Videoconference ▪ Mobile applications	▪ Patient monitoring	Both community and hospital pharmacists continued to monitor patients with COVID-19. Most of the participants (70.6%) expressed favourable attitudes towards telepharmacy.
27				✓	✓	▪ Videoconference *With the integration of the electronic medical record (EMR) system*	▪ Medication review and management ▪ Information sharing	Before the beginning of the crisis, 83.2% (n = 154) of hospital pharmacy services did not carry out remote pharmaceutical care activities. However, after the outbreak, as many as 87.6% of hospital pharmacists carried out remote pharmaceutical service and 119,972 patients received their medications through remote dispensing eHealth services, representing over 80% of outpatients receiving their medication through eHealth procedure, which shows the rate of implementation of telepharmacy in outpatient care in Spain during the study period in the pandemic was high.

28	✓		✓		✓	▪ Mobile applications (WeChat) ▪ Radio	▪ Consultation ▪ Medication review and management ▪ Patient monitoring ▪ Medication education ▪ Emotional support ▪ Information sharing	During a 45-day period, pharmacy service was provided by hospital pharmacists to patients with chronic diseases via eHealth that resulted in round 200 enquires resolved by clinical pharmacists, including drug usage (65.38%), medication reconciliation (55.13%), drug precautions (23.1%), adverse drug reactions (35.9%) and psychological counselling (32.05%).
29	✓	✓	✓	✓		▪ Phone calls ▪ Mobile applications (WhatsApp, short messages services (SMS))	▪ Medication review and management ▪ Medication order review ▪ Medication education	Hospital pharmacists on the eHealth teams conducted 3318 phone calls, 2116 WhatsApp® chats and 1128 interventions related to pharmacy practice for patients with COVID-19 who lived in rural areas. As a results, 312 prescribing errors (PEs) were identified of which 287 were corrected.
30		✓	✓	✓		▪ Phone calls Videoconference ▪ Website monitoring applications	▪ Consultation ▪ Medication review and management ▪ Medication order review	7908 MDEs (any unintended deviation from an interpretable written prescription or medication order) were detected in the remote eHealth group (50,026 dispensed items), and 4563 were reported in the control group which did not provide ehealth services (23,481 dispensed items) during the pandemic, which reveals having eHealth services available is better than none.
31		✓	✓	✓		▪ Videoconference	▪ Consultation ▪ Medication review and management ▪ Medication order review	Pharmacists provided 63,714 COVID-19–related recommendations with eHealth services compared with 15,539 in the control group that without remote pharmaceutical service, which reveals greater demand for pharmaceutical

								service with eHealth during the pandemic.
32			✓		▪	Specific IT support (Virtual–Venipuncture INR)	▪ Comprehensive assessment	Following the onset of COVID, 84 patients received care through eHealth, such as telephone and video by the anticoagulation clinic a total of 192 times, which indicates it is possible of managing chronic warfarin patients utilizing a hybrid virtual care model during the COVID-19 pandemic.
33	✓	✓	✓	✓	▪	Mobile applications (Signal and Google Voice, Doximity)	▪ Comprehensive assessment ▪ Medication review and management ▪ Medication order review ▪ Information sharing	Total of 241 HIV patients with medication refill requests sent to the clinical pharmacists, and half of them had one or more telehealth visits with clinical pharmacist, which reveals remote services can be an alternative for stable HIV-positive patients as a supplement to in-person visits.
34	✓	✓	✓	✓	▪	"Cloud Pharmacy Care" platform (a medication consultation service platform WeChat)	▪ Consultation ▪ Medication education	The "Cloud Pharmacy Care" platform had 1,432 views and 66 followers. During a 7-monther period, 39 cases of consultation were performed by volunteer pharmacists through this platform for chronically-ill patients quarantined at home. All consultations were completed within 4 h and 97.4% of patients found the eHealth services satisfactory.

35			✓	✓		▪ Phone calls	▪ Comprehensive assessment ▪ Medication review and management ▪ Medication order review ▪ Medication education	1186 patients requested remote pharmaceutical service with eHealth due to the treatment changes have been made during the pandemic, and most of them are very satisfied with the remote service, which proves that eHealth can adapt well to the pharmaceutical changes brought about by the epidemic.
36			✓	✓		▪ Phone calls	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring	During a 6-month period, 173 encounters between hospital pharmacists and patients took place through eHealth. Upon evaluation, the average medication related problems (MRPs) per encounter resolved through face to face (FTF) visits (1.79 [±1.56]) was significantly higher than that through telehealth (1.07 [±1.20]).
37		✓				▪ Phone calls ▪ Mobile application	▪ Consultation	Between March and September in 2019, 1,375,071 calls by the general public and visitors were handled by pharmacists. During the same time period in 2020, 5,446,275 similar calls were received, representing an increased of >296% increase, which shows pharmaceutical services with eHealth is the one of the best strategies to combat the COVID-19 pandemic in Saudi Arabia.
38	✓	✓	✓	✓	✓	▪ Phone calls ▪ Videoconference *With the integration of the electronic medical record (EMR) system*	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Patient monitoring ▪ Medication education	Clinic pharmacists continued to perform medication management for geriatric patients with chronic conditions. Enhanced access to patient care, reduced risk of hospital-acquired infections, enhanced medication adherence and increased the patient care quality during a health crisis were described.

39	✓	✓		✓		▪ Radio ▪ "Cloud pharmacy care" application ▪ Mobile application (WeChat) ▪ Service robots	▪ Consultation ▪ Medication education ▪ Information sharing	Hospital pharmacists continued to care for pediatric patients with COVID-19 via eHealth. Positive outcome such as optimized procurement procedure, improved efficiency, and reduced risk of infection by minimizing human contact was described.
40		✓		✓	✓	▪ Phone calls ▪ Videoconference ▪ Mobile application (Short messages services (SMS))	▪ Consultation ▪ Medication order review	926 participants completed the questionnaire satisfaction survey, and 457 (49.4%) respondents are satisfied with the advice provided by pharmacists, which proves remote pharmaceutical service with eHealth is appreciated by patients.
41		✓		✓		▪ Phone call	▪ Consultation ▪ Comprehensive assessment Information sharing ▪ Infectious disease surveillance	A total of 100 community pharmacies were phoned, and 59 % of the pharmacists retrieved both symptoms and treatment-related medical information, which means more than half of pharmacists can provide some pharmacy services through eHealth, however, still need a great improvement.
42		✓		✓		▪ Phone calls ▪ Mobile applications (WhatsApp) ▪ Hospital electronic system (BestCare)	▪ Comprehensive assessment Medication review and management	In total, 270 patients' mean of the INR values was 60%, and the patients were in the therapeutic range nearly 60% of the time. Also, of the sample, nearly half achieved intermediate to good anticoagulation control with a TTR above 50%, which means the services provided by pharmaceutical care could be improved by using a tele-pharmacy model, as this enables the utilization of technology for patients.

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43	✓	✓		✓	✓	▪ Phone calls	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Patient monitoring ▪ Medication education ▪ Emotional support	10 pharmacists from 7 community pharmacies offered eHealth service to 71 patients from April 13, 2020, up to May 21, 2020, which reveals remote pharmaceutical care service (telepharmacy) is deemed a convenient model in the Republic of Srpska during the COVID-19 pandemic.

Search Strategy

Source	Search syntax	Hits,28, January 2022
PubMed	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	304
Scopus	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	464
MEDILINE	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	102
Web of Science	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	298
Science Direct	(covid-19 OR coronavirus) AND (telemedicine OR telehealth OR“m-health” OR“e-health”) AND (pharmacy OR pharmacist)	12
CNKI	（新冠*）AND（远程医疗*）AND（药师*）	1

PubMed Search Strategy.

Search No.	Search terms	Hits
Pharmacy practice		
#1	Pharm*[Title/Abstract]	898177
eHealth		
#2	Tele*[Title/Abstract] OR mHealth[Title/Abstract] OR m-Health[Title/Abstract] OR mobile Health[Title/Abstract] OR electronic Health[Title/Abstract] OR eHealth[Title/Abstract] OR e-Health[Title/Abstract] OR e-medicine[Title/Abstract] OR eMedicine[Title/Abstract] OR electronic medicine[Title/Abstract] OR mobile medicine[Title/Abstract]	220321
COVID-19		
#3	COVID-19[Title/Abstract] OR COVID 19[Title/Abstract] OR Coronavirus[Title/Abstract] OR 2019-ncov[Title/Abstract] OR SARS-CoV-2[Title/Abstract] OR Sars2[Title/Abstract] OR cov-19[Title/Abstract]	223313
Limits (English, Chinese; full text; 2020-2022)		
Total		
#4	#1 AND #2 AND #3 Filters: English, Chinese, 2020-2022	304

Scopus Search Strategy.

Search No.	Search terms	Hits
Pharmacy practice		
#1	TITLE-ABS-KEY ("pharm*")	1653497
eHealth		
#2	TITLE-ABS-KEY ("tele*" OR "mobile health" OR "mhealth" OR "m-health" OR "electronic health" OR "ehealth" OR "e-health" OR “e-medicine” OR eMedicine OR “electronic medicine” OR “mobile medicine”)	1286160
COVID-19		
#3	TITLE-ABS-KEY ("covid-19" OR "covid19" OR "coronavirus" OR "2019-ncov" OR "sars-cov-2" OR "sars2" OR "cov-19")	304284
Limits (English, Chinese; 2020-2022)		
#4	LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Chinese")	
Total		
#5	#1 AND #2 AND #3 AND #4	464

MEDLINE Search Strategy.

Search No.	Search terms	Hits
Pharmacy practice		
#1	TI "pharm*" OR AB "pharm*"	241703
eHealth		
#2	TI "tele*" OR AB "tele*" OR TI "mobile health" OR AB "mobile health" OR TI "mhealth" OR AB "mhealth" OR TI "m-health" OR AB "m-health" OR TI "electronic health" OR AB "electronic health" OR TI "ehealth" OR AB "ehealth" OR TI "e-health" OR AB "e-health" OR TI"e-medicine" OR AB"e-medicine" OR TI "eMedicine" OR AB "eMedicine" OR TI "electronic medicine" OR AB "electronic medicine" OR TI "mobile medicine" OR AB "mobile medicine"	71583
COVID-19		
#3	TI "covid-19" OR AB "covid-19" OR TI "covid19" OR AB "covid19" OR TI "coronavirus" OR AB "coronavirus" OR TI "2019-ncov" OR AB "2019-ncov" OR TI "sars-cov-2" OR AB "sars-cov-2" OR TI "sars2" OR AB "sars2" OR TI "cov-19" OR AB "cov-19"	78144
Limits (English, Chinese; 2020-2022)		
Total		
#4	#1 AND #2 AND #3	102

Web of Science search strategy

Search No.	Search terms	Hits
Pharmacy practice		
#1	TS=("pharm*")	1004569
eHealth		
#2	TS=("tele*" or "mobile health" or "mhealth" or "m-health" or "electronic health" or "ehealth" or "e-health"or "e-medicine" or "eMedicine" or "electronic medicine" or "mobile medicine")	583377
COVID-19		
#3	TS=("covid-19" or "covid19" or "coronavirus" or "2019-ncov" or "sars-cov-2" or "sars2" or "cov-19")	256873
Limits (English, Chinese; 2020-2022)		
Total		
#4	#1 AND #2 AND #3	298

Science Direct search strategy

Search No.	Search terms	Hits
Pharmacy practice		
#1	pharmacy OR pharmacist	25083
eHealth		
#2	telemedicine OR telehealth OR“m-health” OR“e-health”	6377
COVID-19		
#3	covid-19 OR coronavirus	45052
Limits (2020-2021)		
Total		
#4	#1 AND #2 AND #3	12

CNKI search strategy

Search No.	Search terms	Hits
Pharmacy practice		
#1	药师*	36900
eHealth		
#2	远程*	257144
COVID-19		
#3	新冠*	34612
Limits (English, Chinese; 2020-2022)		
Total		
#4	#1 AND #2 AND #3	1

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3,4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	N/A
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	7
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	7
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	7
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	7

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	6,7
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	6,7
Study characteristics	17	Cite each included study and present its characteristics.	7
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N/A
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	7,8
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	12
	23b	Discuss any limitations of the evidence included in the review.	14
	23c	Discuss any limitations of the review processes used.	14
	23d	Discuss implications of the results for practice, policy, and future research.	13,14
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	14
Competing interests	26	Declare any competing interests of review authors.	14
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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A systematic literature review of adopting eHealth in pharmaceutical care during COVID-19 pandemic: recommendations for strengthening pharmacy services

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A systematic literature review of adopting eHealth in pharmaceutical care during COVID-19 pandemic: recommendations for strengthening pharmacy services

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Abstract

Objectives:

The study aimed to determine how eHealth was adopted in pharmaceutical care (PC), the outcome reported, and the contextual factors.

Design:

Systematic literature review in accordance with the Preferred Reporting Items for Systematic Review (PRISMA) guidelines.

Data Sources:

Literature was searched in six databases including PubMed, Scopus, Medline, Web of Science, Science Direct and China National Knowledge Infrastructure.

Eligibility Criteria:

Studies which reported the usage experiences of eHealth in any aspects of PC by pharmacists during the COVID-19 pandemic, written in English or Chinese, and published in peer-reviewed journals between December 2019 and March 2022 were included. Opinion articles, conference abstracts, correspondence, letters, and editorials were excluded.

Data extraction and synthesis:

The literature search was completed on 15 April 2022. Two researchers independently conducted the literature search and extracted the data into an Excel table informed by the logic model with the key components of goals, input, activities, output and contextual factors.

Results:

Forty-three studies were included in this review. During the COVID-19 pandemic, hospital pharmacists, community pharmacists, and specialist pharmacists in 17 countries continued to educate, consult, monitor and manage the patients and the general public via phone calls, videoconferences, mobile applications, social media, websites, and/or enhanced interoperability of electronic medical records. Assuring the continuity of pharmacy care, reduced need for hospital visits, and improved work accuracy and efficiency were the benefits of eHealth mostly reported. Contextual factors affecting the adoption of eHealth were multifaceted prompting supporting actions at the levels of government, hospital/pharmacy, pharmacists and patients.

Conclusion:

This study revealed the wide adoption of eHealth in PC during the pandemic and the emerging evidence for its importance. Proper adoption of eHealth will help reshape the mode of pharmacy services to ensure continuity, quality and efficiency of care amid the challenges of the pandemic.

PROSPERO registration number: CRD42022299812

Strengths and limitations of this study:

- This review analyzed literature on adopting eHealth in PC during COVID-19 pandemic written in either English or Chinese identified from 6 databases.
- The study complied with the Preferred Reporting Items for Systematic Review (PRISMA) guidelines to address the research question developed using the population, intervention, comparison, outcome and time frame (PICOT) framework.
- The use of logic model to guide data extraction and analysis helped to depict an overall landscape of all the factors relevant to the research question in a structured approach.
- Our search strategy might not have allowed the capture of all experiences of eHealth in PC if the pharmacist's role was embedded in an inter-professional program.

Introduction

Being an integral part of the health system, pharmaceutical system is charged with an important goal of ensuring the equitable access to pharmaceutical products and their quality use based on scientifically sound evidence and supported by pharmaceutical care (PC).[1] PC is defined as "*the responsible provision of drug therapy for the purpose of achieving definite outcomes that improve a patient's quality of life*".[2] By providing PC, pharmacists help to reduce drug-related problems, assuring rational drug use, supporting clinical management, and promoting healthy lifestyles.[3,4]

Since the onset of the COVID-19 pandemic, the delivery of PC has been inevitably disrupted by major public health measures compromising the provision of medicines and care. Nevertheless, pharmacists are expected not only to ensure the continuity of care but also to adapt PC to the new needs during the challenging time.[5] As such, eHealth has been increasingly adopted to support PC to overcome geographic barriers and enhance health outcome.[6]

According to the World Health Organization, eHealth is defined as "*the cost-effective and secure use of information and communication technology (ICT) through online in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge, and research*".[7] Reportedly, integrating eHealth into PC is beneficial to patient self-management and drug adherence, clinical disease management and health promotion.[3, 8-10] During the COVID-19 pandemic, as a result of public health measures resulting in reduced accessibility to hospitals or pharmacies, the traditional mode of in-person care delivery would no longer suffix. eHealth has, thus, been widely considered as an instrument for setting up a more innovative, efficient and resilient PC service model.[11]

The research interest in examining the interface between PC and eHealth has been growing. Some studies focused on evaluating particular PC-eHealth programs. Spanakis et al. evaluated a personalized eHealth platform that addressed key features of PC and found that eHealth could be used as a tool to allow pharmacists provide personalized PC services to optimize pharmacotherapy.[12] Other studies might focus on the application of PC-eHealth in the management of particular diseases. The study by Jeminiwa *et al* demonstrated the effectiveness of eHealth in improving adherence to inhaled corticosteroids among patients with persistent asthma.[13] Kilova et al. addressed the prospects for ICT in providing OC and how eHealth related technologies had aided in the promotion of patient care during the outbreak of the epidemic.[14, 15] Another review by

Ghina et al. primarily explored the eHealth services which could be used as an immediate alternative to PC for chronically-ill patients during an epidemic.[16]

At present, while most of the current research focused on how eHealth might benefit the continuous access to essential pharmacy services in the absence of in-person interactions between pharmacists and their patients, there is little systematic research about the "know-how" of integrating eHealth services and tools in PC to perform certain interventions or achieve predefined outcomes amid the challenges of the COVID-19 pandemic. Considering the potential benefits of applying eHealth in maintaining pharmaceutical services, empowering patients to improve compliance and adherence, reducing the risks of drug-related problems (e.g. adverse drug reactions or drug interactions) and supporting pharmacovigilance amid the challenges of the COVID-19 pandemic[17-19], this review aims to determine how eHealth was adopted in PC, the outcome reported and the contextual factors identified. The study findings are expected to be useful for informing the optimization of eHealth in PC whenever needed in future public health events.

Methods

Study design

This systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Review (PRISMA) guidelines.[17] The use of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 statement for guidance was to transparently report why the review was done, what the authors did, and what had been found during the course of identifying, selecting, appraising, and synthesizing studies.[17] The review protocol had been registered in The International prospective register of systematic reviews (PROSPERO) with the reference number: CRD42022299812 (available from https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022299812). A combination of 6 databases were used to optimize the yield of relevant research and the databases (including PubMed, Scopus, Medline, Web of Science, Science Direct and China National Knowledge Infrastructure (CNKI)) were selected because they specialized in scholarly literature related to health and medical topics. The literature search was completed on 15 April 2022.

Search strategy

The research question "How did pharmacists employ eHealth during the COVID-19 pandemic for the provision of care to their patients?" was developed using the population, intervention, comparison, outcome and time frame (PICOT) framework. [18] In the PICOT framework, the

population referred to pharmacists, either practiced alone or as a member of an inter-professional team and regardless of their work setting; the intervention referred to adopting eHealth for the purpose of tele-education, tele-consultation, tele-monitoring, tele-case-management, tele-mentoring); the comparison is not applicable; the outcome referred to the impact of the care on people cared by pharmacists via eHealth; and the time frame was the period of COVID-19 pandemic.

Considering the three major concepts "pharmaceutical care", "eHealth", and "COVID-19 pandemic" that constituted the research question of this review, their Medical Subject Headings (MeSH) terms as well as the corresponding keywords and phrases identified in related literature were used to formulate a comprehensive search strategy. Terms within "pharmaceutical care", "eHealth", and "COVID-19 pandemic" were combined with OR, and this results from each concept were combined with AND. A detailed description of the search strategies for each chosen database is provided in Supplementary File 1. Additionally, the reference lists and citations of included articles were examined to identify further papers for inclusion.

Eligibility criteria

Studies which reported the use of eHealth in any aspects of PC during the COVID-19 pandemic, published between December 2019 (when cases of COVID-19 infection were first reported) and March 2022, written in English or Chinese, and published in peer-reviewed journals were included. The study types were limited to descriptive studies, prospective observational studies, retrospective cohort studies, retrospective chart reviews, cross-sectional surveys, and qualitative studies. Studies which reported about the use of eHealth to support the use of medicines during the COVID-19 pandemic by healthcare professionals other than pharmacists were not considered. In addition, opinion articles, conference abstracts, correspondence, letters, and editorials were excluded.

Study selection, data extraction and presentation

All members in the research team responsible for literature screening which included two Master students (ZC and PT) and two senior researchers (HH and COLU) were fluent in both English and Chinese. Two of the authors (ZC and PT) independently conducted the literature search and applied the inclusion and exclusion criteria. After the removal of duplication, citations were screened for inclusion by title first, and the remaining papers were then screened by abstracts (ZC and PT). After initial screening, the full text of studies were screened (ZC and PT) with guidance from one of the senior researchers (COLU) who randomly selected and checked a percentage of the included and

excluded articles to ensure the eligibility of the included papers and the appropriateness of the excluded papers. Any differences were discussed and resolved among ZC, PT, HH and COLU by consensus.

Upon confirmation of the included studies, the reference lists were first examined to identify any further papers for inclusion (ZC and PT). This was followed by data extraction in which the required data from each included study was extracted and input into a pre-designed Excel table (ZC and PT). In addition to the characteristics of the included studies (such as first author, year of publication, study type, study location, study aim, targets of eHealth pharmacy service, and types of pharmacists involved), the design of the Excel table was also informed by the types of eHealth involved and the logic model featuring the key components of goals, input, activities, output and contextual factors.[19]

For the purpose of this study within the context of the logic model, "input" referred to the eHealth tools involved and the support from different stakeholders such as the government, pharmacist professional organizations, hospital, pharmacy and pharmacist; "activities" referred to services provided by pharmacists with eHealth; "output" and "outcome" referred to the impact of the services pharmacists provided with eHealth on the people they cared for. Any divergences during the data extraction process were resolved through discussion among ZC and PT, and subject to agreement by HH and COLU and final confirmation by all authors. Narrative synthesis was undertaken to summarize and report the findings.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Results

Study characteristics

As shown in Figure 1, 781 articles were retrieved initially. After removing duplicates (n = 795), and screening by the title and abstract (n = 565) and full text (n = 230), 43 articles were included in this review.[20-62] Among the included studies were 25 observational studies (including 13 cross-sectional studies[36-39, 43-48, 54, 59, 60], 5 case series[34, 35, 49-51], 5 retrospective study[40, 41, 52, 53, 55], 1 prospective study[61] and 1 interview study[42]) and 18 descriptive studies[20-33, 56-58, 62]. The general characteristics of the included studies are summarized in Supplementary Table 1. The majority of the studies reported

about the use of eHealth by hospital pharmacists[20, 21, 23, 25, 29-31, 33-35, 37-41, 43, 46-49, 52-55, 58, 59, 61], followed by community pharmacists[28, 35, 45, 46, 50, 51, 54, 60, 62]. Patients with chronic diseases[27, 31, 32, 34, 37, 39, 40, 43, 44, 48, 52, 54, 57, 60-62] were the primary targets populations of PC-eHealth interventions, followed by patients with COVID-19[26, 34, 42, 46, 49-51, 58] and cancer patients[27, 31, 37, 40].

Purposes of adopting eHealth in PC during the COVID-19 pandemic

The purpose of adopting eHealth, the eHealth tools used, the interventions provided by pharmacists with eHealth, and the intervention output are illustrated in Supplementary Table 2. Considering the lack of official definition or categorization framework of eHealth applied to PC, the purposes of adopting eHealth in the present study were informed by the current literature[8, 63-65] and thus categorized into: (1) tele-education (educating patients about how to take medicines and adverse drug effects, n=17)[20, 22, 24, 25, 29, 31-33, 37-39, 42, 47, 48, 56, 57, 62]; (2) tele-consultation (addressing patients' enquiries about drug-related problems, n=28)[20, 21, 23, 25-28, 30-33, 35-38, 44, 45, 49-51, 53, 56-62]; (3) tele-monitoring (monitor the patients' use of medications in real time, n=27)[20, 21, 23, 25-27, 29-33, 35, 36, 38, 39, 41, 44-46, 48-51, 53-55, 57]; (4) tele-case-management (continuously manage the patient's medication regimen according to the patient's conditions, n=30)[22, 23, 26, 27, 29, 30, 32-34, 37-42, 44, 46, 48-54, 56-61]; and (5) tele-mentoring (the use of eHealth by other healthcare workers to seek advice from pharmacists, n=19).[21, 25, 28, 30, 31, 33, 34, 38-40, 42-44, 47, 48, 53, 57, 59, 62] It is noteworthy that all but 5 studies[22, 24, 46, 52, 56] reported the use of eHealth for multiple purposes.

Interventions provided by pharmacists with eHealth

The services provided at the interface of PC-eHealth were multifaceted and could be categorized into one of 9 interventions as shown in Table 1. Apart from the core components of PC such as (1) consultation, (2) medication order evaluation and dispensing, (3) patient monitoring for adverse drug events, (4) comprehensive follow-up and continuous assessment, (5) medication review and management, and (6) medication education, pharmacists had reportedly extended their services towards caring for patients' mental well-being (intervention 7), facilitating collaboration with the healthcare team with information sharing (intervention 8), and public health measures (intervention 9) during the pandemic. In comparison, community pharmacists were more inclined to use eHealth in providing emotional support to their patients and the public to ease their anxiety about the pandemic development, while hospital pharmacists utilized eHealth to carry out various PC interventions.

Table 1: Interventions provided by pharmacists at the interface of PC-eHealth during the COVID-19 pandemic

Interventions	Description
Core components of PC	
(1) Consultation	Address patients' enquires related to medications as well as the COVID-19 pandemic[20, 21, 25-30, 33, 35-38, 43-45, 48, 50, 51, 55-60, 62]
(2) Medication order evaluation and dispensing	Evaluate, process and dispense electronic prescriptions[22, 25, 26, 30, 32, 33, 37, 40-42, 49-51, 53, 57, 59, 62]
(3) Patient monitoring for adverse drug events	Monitor the drug reaction of patient after taking the medication[20, 23, 26, 29, 36, 40, 46, 48, 55, 57, 62]
(4) Comprehensive follow-up and continuous assessment	Conduct follow-up physical and psychological assessments of the patients[20, 26, 27, 29, 36, 39, 41, 52, 53, 55, 60, 61]
(5) Medication review and management	Conduct individualized review and management of medications for patients with[20, 27-30, 32, 34, 35, 37, 39, 41, 42, 47-51, 53, 54, 57, 61, 62]
(6) Medication education	Offer instructions about the administration of medications[20, 28, 30, 34, 35, 37, 39, 40, 43-45, 48, 49, 54, 57, 58, 62]
Extended components of PC during the COVID-19 pandemic	
(7) Emotional support	Provide support to patients to alleviate their concerns about their diseases[23, 35, 48, 62]
(8) COVID-19 information sharing	Sharing of information about the patients or their medications with other members of the healthcare team[22, 24, 27, 31, 35, 37, 39, 42, 45, 47, 48, 53, 58, 60]
(9) Infectious disease surveillance	Detect any signs of possible infection with COVID-19 among patients while delivering pharmacy services remotely[25, 60]

Tool(s) involved in the PC-eHealth service models

Phone calls alone in the form of a hotline or as a combination with videoconference, social media and television, mobile applications, websites, and/or wearable devices were mostly employed to enable PC-eHealth service mode in the included studies.[20, 23, 25, 27, 32, 35, 36, 39-43, 45, 49, 50, 55-57, 59-62]

Videoconference was often used to allow face-to-face interactions and observations of body language and facial expressions between the pharmacists and the patients.[23, 25, 29, 31-35, 39, 40, 42, 45-47, 50, 51, 57, 59] Social media (e.g. Twitter[24] and Facebook[34]) , online networking services (e.g. Doximity[33, 41, 53]), mobile applications (e.g. WeChat[26, 38, 44, 58], Skype[29], Facetime[29], PetalMD[34], Cisco Jabber 12.6[33], Google voice[41, 53], WhatsApp[49, 61], short messages services[49, 59], Signal[53] and others[35, 46, 48, 56]), and wearable devices[25] had also been integrated into the PC-eHealth service models. Other communication means such as television[24], email[30, 34, 41], fax[30], and radio[48, 58] were also employed.

Some studies reported about the website monitoring applications developed by hospitals or pharmacies in response to the societal and patient needs during the pandemic. Examples were the

SPHCC Patient Care (an online platform formed by 6 licensed internet hospitals allowing pharmacists continue to care for patients with COVID-19 online)[26], the CCSS (a website monitoring application formed by a primary health care center network for assuring medication supply)[28], the Cloud SYSUCC (a website monitoring application developed by a university cancer center to enable pharmacists continuously manage cancer patients) [37], the VigiLanz (a clinical surveillance platform supported pharmacists to readily communicate with other healthcare providers and participate in daily patient care routine)[25], the Virtual–Venipuncture INR (an IT support that allowed pharmacists monitor the INR of patients receiving anticoagulants during the pandemic)[52], and several others[30, 35, 36, 44, 50, 58, 61]. A number of PC-eHealth service models was also pertained with an integration of the electronic medical record (EMR) system.[21, 22, 30, 31, 37, 42, 47, 57]

Other input relevant to establishing PC-eHealth service model

To aid in the establishment and development of PC using eHealth throughout the epidemic, key input at the levels of government, hospital and pharmacies, pharmacist professional organizations and pharmacists has been identified.

At the government level, legislation that defines the services of PC-eHealth and the liability for such services, safeguards data protection and promotes database interoperability was commonly discussed in the included studies.[31, 50, 57, 59, 61] Initiatives to upgrade remote information technology and outpatient clinic systems might be launched by the government[33, 35]. Continuous supervision and evaluation of PC-eHealth interventions by the government had been suggested[28, 57], which might require special department or taskforce to lead and faciliate the adoption and implementation of eHealth in PC and other healthcare services alike.[50, 61] It was also important for the government to provide reliable and up-to-date information about the COVID-19 pandemic to be disseminated via the PC-eHealth platform.[50]

For the hospitals or pharmacies, efficient and appropriate communication mechanisms were considered the utmost important to control the spread of the pandemic, which was why many of them had established networks across different healthcare settings and developed their own eHealth applications.[26,37, 55] Hospitals and pharmacies not only developed new eHealth systems on their own, but also promoted the use of the systems to other hospitals or pharmacies through training, empowering their interconnections to optimize their patient coverage.[22, 54] Staff had been asked to sign codes of conduct to protect patient confidentialiaty.[33]

Pharmacist professional organizations were expected to define PC-eHealth services[41, 47], offer advice to pharmacists about making eHealth plans and provide guidelines for PC-eHealth service provision[25, 43, 52, 53, 62], and support pharmacists with funding[47] and human resources[44] to establish the PC-eHealth infrastructure. At the pharmacist level, communication and collaboration among pharmacists from different sectors to care for complicated patients[20,29, 34], self-motivation to learn about the PC-eHealth guidelines[25], training and supervision by more experienced pharmacists[29, 38, 60] , participation in the eHealth multidisciplinary working group[43] and closer collaboration with other healthcare providers and other key stakeholders [51] were considered important factors.

Output of PC-eHealth interventions

The impact of adoption eHealth in PC during the pandemic was mainly in reducing the need for physical contact or visits to the hospital/clinic for minimizing the risks of infection and transmission[20, 21, 25, 26, 28, 30, 32, 33, 38, 43, 45, 48, 52-54, 58, 60, 62] as well as allowing the continuous monitoring of the patients in the absence of in-person interactions[21, 23, 26, 27, 29-31, 39-43, 45-47, 49, 51, 56, 57]. Some studies reported an improvement in the efficiency of PC due to the use of eHealth[25, 34, 38, 44, 50, 57, 58, 61] and patient satisfaction about the PC-eHealth services they received was also reported[28, 29, 32, 36, 37, 44, 46, 54, 59]. Other benefits of adopting eHealth in PC during the pandemic included the dissemination of reliable information[24], reduced abuse of over-the-counter medicines[35], facilitating transition of care between hospitals[22] and communications within the healthcare team and with patients and caregivers[25]. However, there was one study that reported a negative impact on the quality of PC after eHealth was integrated.[55]

Contextual factors affecting the adoption of eHealth in PC during the pandemic

Contextual factors affecting the adoption of eHealth in PC during the COVID-19 pandemic had been described in terms of challenges and enablers in the included studies. Challenges might arise at the levels of pharmacists, government, patients, and eHealth tool suppliers. For pharmacists, the shift from face-to-face towards eHealth service model resulting in long working hours had inevitably created conflicts between personal and professional lives[34]. Other issues such as unfamiliarity with the eHealth systems[22, 27], limitations of assessments due to a lack of in-person interactions[32, 35, 62] or eye contact[31], difficulty in obtaining consent from the patients to receive PC-eHealth service[31, 33], lack of control over the entire PC-eHealth process[28,62] were also discussed. Some pharmacists just did not have the motivation to adopt eHealth.[34, 56]

For government, evaluation of PC-eHealth services in order to inform a reasonable remuneration system[41,47, 56] and development of a robust legal framework, policies, and procedures to guide the use of eHealth in PC lagged behind.[47, 56] From the perspectives of the healthcare institutes, whether it be hospital or community pharmacies, a lack of electronic patient records[50, 51], a lack of funding to set up a teleworking envirnoment[45] and a lack of communication infrastructure readily in place for timely scaling up during the pandemic[34] were cited as the biggest challenges.

Patients' digital health literacy[30, 31, 45,31, 48, 56, 57] and cultural acceptance[31, 36, 37] might vary and unfamiliarity with new PC-eHealth systems might collectively discourage them from taking up PC-eHealth services. Moreover, a lack of access to high-tech devices[36] and a lack of willingness to accept eHealth services[31, 48, 57] might also be a barrier to patients' acceptance of PC-eHealth services. For some patients who had already receiving PC-eHealth interventions, a lack of adherence to the services could negatively impact on the outcome of eHealth service model. [28]

For the PC-eHealth tool suppliers, some of the biggest challenges experienced during the COVID-19 pandemic included the unstable network connectivity[21, 49], inadequate interoperability of systems provided by different providers[21], a lack of standardized platform and technical support within and across the care settings[33], errors in digital systems[43], cyber security considerations[27, 42], and the lack of complete patient data for sharing.[22] Operational networks not in time[44, 49]

To support the adoption of eHealth in PC for better management of patients during the pandemic, several enablers had been suggested. These included new forms of supervision to regulate and standardize pharmacists' interventions provided through PC-eHealth model[33,34, 37], strategies for appropriate resource assessment and allocation, workflow modification and infrastructure maintenance[23, 44, 55, 56], follow-up evaluation of the performance and reliability of the pharmacists[34], continuous and stable IT support[22, 58], and research to develop the evidence about the effectiveness and societal implications of PC-eHealth during pandemic[46, 54].

Discussion

Significant use of eHealth in PC during the COVID-19 pandemic

This review revealed that it was common for pharmacists to adopt eHealth to ensure the continuity of PC amid the threat of COVID-19 pandemic and the challenges pertained with public health measures. This is in alignment with the overall development trend in PC for different care settings.[66] During the pandemic, the most commonly reported purposes of using eHealth in PC were

tele-case-management, tele-consultation and tele-monitoring, often with the use of phone calls in combination with videoconference, social media and television, mobile applications, websites, and/or wearable devices. Specific to the needs during the pandemic, PC-eHealth was often employed to provide emotional support and to dissimilate pandemic-related information. The benefits of adopting eHealth, as reported in previous public health incidents[67], were widely recognised and mostly observed in terms of reduced need for physical contact, continuity of care and improved PC efficiency. However, due to the lack of face-to-face interactions, pharmacists may not be able to accurately evaluate the complete situation of patients especially to those who were not very proficient in using information technology. As such, the effectiveness of the pharmacy service provided via eHealth might be affected.

The logic model to guide the planning of eHealth adoption in PC

Integrating eHealth into PC was suggested as early as 20 years ago.[68] Since then, many studies had been carried out to investigate different PC-eHealth practice models designed for different patient groups.[69-72] However, up to date, the integration of eHealth into PC has not been generalized nor standardized, and a systematic approach to advancing the quality and coverage of PC with eHealth is still lacking. The COVID-19 pandemic has disturbed the traditional mode of healthcare delivery which has expectedly accelerated the uptake and scaling-up of eHealth.[73] However, as far as PC is concerned, the attempts made so far are rather extemporaneous as evident by the vast variety of tools, purposes of care and interventions identified in this study.

In order to systematically and graphically present the blueprint of "know-how", a logic model of establishing PC-eHealth during a pandemic has been built based on the study findings, detailing the goals to be achieved, the input and activities taken place, the output produced, and the contextual factors involved (Figure 2). This may serve as a framework for guiding and reinforcing the adoption of eHealth in PC to meet the challenges of COVID-19 pandemic or other public health incident alike.

The effectiveness of adopting eHealth in PC

Numerous studies have demonstrated the value of eHealth in healthcare services including PC. The effectiveness of eHealth adoption can be reflected in two aspects. On the one hand, the increase in the number of users receiving PC via eHealth. For example, Reardon et al. showed that 1.5% of 2036 initial patient appointments were conducted virtually via eHealth prior to the pandemic. This increased to 64% for follow-up appointments in 2019, indicating that an increasing number of patients rely on the PC delivered via eHealth.[34] Ibrahim et al. also reported that the proportions of

COVID-19 cases (either probable and confirmed) who received pharmaceutical services were 31.90% versus 11.74% and 6.07% versus 0.36%, respectively, in pharmacies with remote services (test group) versus pharmacies without remote services (control group).[58]

On the other hand, the effectiveness of eHealth adoption may also be assessed by comparing pharmacy services in hospitals and community pharmacies with and without eHealth. When providing pharmacy services through eHealth during the epidemic, patients can use relevant eHealth tools to book pharmacist services in advance, and can receive online pharmacy services at any location. Standard and faster dispensing procedures can be realized with the help of advanced technology, which may largely simplify the entire process of PC provision for patients to achieve higher efficiency of the entire pharmacy service process.[16,39]

With eHealth, electronic transaction and storage of patient information could help pharmacists to prevent mistakes in dispensing which would have happened with paper-based procedures, to help improve medication adherence, and to support analysis and decision making about medication availability with easily-accessible and structured data. Using community pharmacies as an example, the rate of potential OTC abuse across pharmacies with and without eHealth services was 5.8% versus 7.7% and potential OTC misuse across pharmacies with and without eHealth services was 13.7% versus 16.6%.[39]

The significance of eHealth to PC in the healthcare system

The accessibility to pharmacies and the perceived affordability positions pharmacists at the first line of contact within the healthcare system especially during a pandemic.[74] The emphasis placed on patient-center service has further driven the new paradigm of pharmacy practice and accelerated the adoption of eHealth for the expansion of pharmacists' professional role in pharmaceutical services. This implies a shift of focus towards the delivery of longitudinal value-added services for the patients as well as the closer collaboration with other healthcare professionals with higher level of data sharing. Besides, the use of "smart" technological solutions in the medicine dispensing process could relieve pharmacists' workload, leaving more free time for pharmacists to assume other components of pharmacy practice, allowing the accomplishment of more professional and advanced PC services.[75] Such transition, when properly executed, is considered extremely valuable for the patients, other healthcare professionals, and even the health systems in terms of not only improvement in health services quality and in patient health related outcomes, but also greater efficiency and economic savings.[76-78]

The heterogeneity of eHealth tools used in PC

The heterogeneity of eHealth tools employed in the PC-eHealth during the COVID-19 pandemic are associated with both benefits and concerns for both the patients and the pharmacists. Prior to the pandemic, the utilization of telemedicine was mainly to allow pharmacists to extend the reach of their interventions chronic disease management and telephone was the most common communication method.[8] With the additional use of videoconference, mobile applications, website application, social media and wearable devices as reported in this study, real-time interactions and data collection is now possible to achieve more personalized PC support.[79] Nevertheless, the capacity to operate different eHealth tools could be challenging to some patients.[80] and the hybrid mode of service provision would easily overwhelm a lot of pharmacists.[81]

Furthermore, the vast amount of personalized data generated from multiple sources and shared dynamically entails a new level of concerns over privacy and cybersecurity.[82] In the absence of a legal or regulatory framework, the practice of PC via different eHealth tools might lead to ethical and legal issues and subject pharmacists to liability consequences should any adverse events happen to the patients.[83] A lack of standardized design of PC-eHealth pose great challenges to scaling up and interoperability preventing a timely and thorough transformation of service mode whenever needed.[84] This is especially relevant during a pandemic when immediate actions are called for and healthcare resource allocation is particularly uncertain. To this end, it would be the priority of action for the regulatory bodies and pharmacist professional organizations to provide clear guidance on how to appropriately adopt eHealth in PC.

Adopting eHealth in PC in the context of the health system

In order to better develop and promote the measures to provide pharmacy services through eHealth during the epidemic, the government can try to take the lead in incorporating eHealth to support the role of pharmacists in public health measures. One of the essential criteria was for pharmacists and patients to acquire the necessary skills and to come to term the benefits of adopting eHealth. According to the technology acceptance model (TAM), an information systems theory that describes the acceptance and usage of a new technology from the users' perspective, there are 2 major factors affecting users' decision about when and how to use it: perceived usefulness (PU) and perceived ease-of-use (PEOU).[85] In other words, if a person believes that using a particular new technology would enhance the performance of some sort, and the new technology is easy to use, he/she will have the positive attitude and intention to use the new technology. As such, training and

evidence-based use of eHealth in improving PC for pharmacists and public education about basic skills of information technology and benefits of eHealth are important for achieving high proficiency and wide acceptance of eHealth in PC.

In addition, resources are needed to "upgrade" the healthcare system infrastructure to integrate eHealth into day-to-day practice. Equipment, internet access, information technology systems and process, sustainable engagement and initiative, competent staff and a well-designed, close-loop evaluation mechanism should be in place to form the basic infrastructure for eHealth in PC.[86] A lack of an appropriate infrastructure might affect the quality of PC leading to more harm than benefits to the patients.[87] In the context of a business operation such as community pharmacies, cost is one other key factors when adopting eHealth. The investment to achieve the readiness of the infrastructure can be expensive considering the costs of both hardware and software. While the focus on leveraging the advantage of any existing information and communication technology infrastructure should be prioritized, it is also necessary to monitor and manage the costs over time.[88]

Moving forward

For the efficiency use of healthcare resources particularly in the context of a pandemic, eHealth adoption and implementation in PC requires adequate planning and continuous evaluation of cost-effectiveness.[89] A more balanced research approach to investigate the pros and cons when adopting eHealth in PC is also warranted to better inform actions that support wider use of eHealth in PC as well as other areas of healthcare services. Indeed, any eHealth interventions in PC should be viewed a catalyst for change in the overall healthcare sector and should be adequately planned, piloted and progressively scaled up to ensure the expected deliverables. Other preparation should be carried out simultaneously. As eHealth continues to transform PC, strategies to help patients and pharmacists enhance digital literacy and build the knowledge of technology should take place to improve engagement and receptivity towards technological integration.[90]

For the PC-eHealth currently in operation, more efforts should be made to quantify the clinical and economic benefits for the patients or the public, and the long-term outcomes. [91,92] In order to secure resources to support PC-eHealth, a fine balance needs to be established between evidence-based integration of e-Health and constructive experimentation of PC.[93] Synthesizing the evidence is important for informing the future directions and implications for policy and practice.

Limitations of this review

It is possible that our search strategy did not capture all examples of PC-eHealth experiences during the pandemic if they were embedded as part of an inter-professional program, depending on how pharmacists were referenced in the text of available publications. The logic model developed in this study provided an overall landscape of all the factors relevant to the adoption of eHealth in PC during the pandemic but was not able to establish any causal chains among the components. Future research is warranted to confirm the interretionship among each factor in order to better future planning, monitoring and evaluation.

Conclusion

This study revealed the wide adoption of eHealth in PC during the pandemic and the emerging evidence for its importance. As the momentum of adopting eHealth in PC yielded during the COVID-19 pandemic will continue to drive further innovative development, an orchestrated, transdisciplinary approach adapted to different local contexts is needed to achieve the benefits of PC-eHealth. Future research should be directed to substantiate the assessment of eHealth in reshaping the mode of pharmacy service in terms of not only the continuity, but also the quality and efficiency of care amid the challenges of any pandemic.

Author statement

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None declared.

Patient consent for publication

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Ethics approval

Not applicable.

Data availability statement

No data are available

Figure 1. PRISMA flowchart of literature search and selection of publications

Figure 2. The logic model of adopting eHealth in pharmaceutical care during the COVID-19 pandemic

Reference:

1. Berenguer B, La Casa C, de la Matta MJ, et al. Pharmaceutical care: past, present and future. *Curr Pharm Des* 2004; 10: 3931-3946. 2004/12/08. DOI: 10.2174/1381612043382521.
2. Hepler CD and Strand LM. Opportunities and responsibilities in pharmaceutical care. *Am J Hosp Pharm* 1990; 47: 533-543. 1990/03/01.
3. Pande S, Hiller JE, Nkansah N, et al. The effect of pharmacist-provided non-dispensing services on patient outcomes, health service utilisation and costs in low- and middle-income countries. *Cochrane Database Syst Rev* 2013: Cd010398. 2013/03/02. DOI: 10.1002/14651858.Cd010398.
4. Wilke D, Schiek S, Bertsche T, et al. Verwendung von Routinedaten der gesetzlichen Krankenkasse in einer Pilotstudie zur Evaluation pharmazeutischer Interventionen im Krankenhaus. *Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen* 2017; 121: 21-28. DOI: https://doi.org/10.1016/j.zefq.2017.03.004.
5. Ghibu S, Juncan AM, Rus LL, et al. The Particularities of Pharmaceutical Care in Improving Public Health Service during the COVID-19 Pandemic. *Int J Environ Res Public Health* 2021; 18 2021/09/29. DOI: 10.3390/ijerph18189776.
6. World Health Organization. Telemedicine – Opportunities and developments in member states. *Report on the second global survey on eHealth* 2010; Vol. 2. (2010).
7. World Health Organization. 58th World Health Assembly. *Geneva,Switzerland: World Health Organization* 2005; WHA 58.28.
8. Niznik JD, He H and Kane-Gill SL. Impact of clinical pharmacist services delivered via telemedicine in the outpatient or ambulatory care setting: A systematic review. *Research in Social and Administrative Pharmacy* 2018; 14: 707-717. DOI: https://doi.org/10.1016/j.sapharm.2017.10.011.
9. Littauer SL, Dixon DL, Mishra VK, et al. Pharmacists providing care in the outpatient setting through telemedicine models: a narrative review. *Pharm Pract (Granada)* 2017; 15: 1134. 2018/01/11. DOI: 10.18549/PharmPract.2017.04.1134.
10. Nkansah N, Mostovetsky O, Yu C, et al. Effect of outpatient pharmacists' non-dispensing roles on patient outcomes and prescribing patterns. *Cochrane Database Syst Rev* 2010; 2010: Cd000336. 2010/07/09. DOI: 10.1002/14651858.CD000336.pub2.
11. George PP, Molina JA, Cheah J, et al. The evolving role of the community pharmacist in chronic disease management - a literature review. *Ann Acad Med Singap* 2010; 39: 861-867. 2010/12/18.
12. Spanakis M, Sfakianakis S, Kallergis G, et al. PharmActa: Personalized pharmaceutical care

eHealth platform for patients and pharmacists. *J Biomed Inform* 2019; 100: 103336. 2019/11/07. DOI: 10.1016/j.jbi.2019.103336.

13. Jeminiwa R, Hohmann L, Qian J, et al. Impact of eHealth on medication adherence among patients with asthma: A systematic review and meta-analysis. *Respir Med* 2019; 149: 59-68. 2019/02/26. DOI: 10.1016/j.rmed.2019.02.011.
14. Kilova K, Mihaylova A and Peikova L. Opportunities of information communication technologies for providing pharmaceutical care in the COVID-19 pandemic. *Pharmacia* 2021; 68: 9-14. Article. DOI: 10.3897/pharmacia.68.e56987.
15. Kow CS and Hasan SS. Pharmacist-patient communication amid COVID-19 pandemic: A review of available options and potential impact. *British Journal of Pharmacy* 2021; 6. DOI: 10.5920/bjpharm.836.
16. Ghina Nadhifah Iftinan NW, Keri Lestari Telepharmacy: A Potential Alternative Approach for Diabetic Patients During the COVID-19 Pandemic. *Journal of Multidisciplinary Healthcare* 2021.
17. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; 372: n71. DOI: 10.1136/bmj.n71.
18. Fandino W. Formulating a good research question: Pearls and pitfalls. *Indian J Anaesth* 2019; 63: 611-616. DOI: 10.4103/ija.IJA_198_19.
19. Moltó-Puigmartí C, Vonk R, van Ommeren G, et al. A logic model for pharmaceutical care. *J Health Serv Res Policy* 2018; 23: 148-157. 2018/05/23. DOI: 10.1177/1355819618768343.
20. Abdallah I, Eltahir A, Fernyhough L, et al. The experience of Hamad General Hospital collaborative anticoagulation clinic in Qatar during the COVID-19 pandemic. *J Thromb Thrombolysis* 2020: 1-7. 2020/10/06. DOI: 10.1007/s11239-020-02276-4.
21. Allison A, Shahan J, Goodner J, et al. Providing essential clinical pharmacy services during a pandemic: Virtual video rounding and precepting. *Am J Health Syst Pharm* 2021 2021/05/15. DOI: 10.1093/ajhp/zxab208.
22. Cashman H, Mayson E, Kliman D, et al. An integrated electronic health record facilitates a safer and more efficient rural outreach haematology service. *Internal Medicine Journal* 2020. Article. DOI: 10.1111/imj.14973.
23. Do T, Luon S, Boothe K, et al. Advancing ambulatory pharmacy practice through a crisis: Objectives and strategies used in an ambulatory care action team's response to the COVID-19 pandemic. *Am J Health Syst Pharm* 2021 2021/01/24. DOI: 10.1093/ajhp/zxab014.
24. Goff DA, Ashiru-Oredope D, Cairns KA, et al. Global contributions of pharmacists during the COVID-19 pandemic. *JACCP Journal of the American College of Clinical Pharmacy* 2020;

3: 1480-1492. Article. DOI: 10.1002/jac5.1329.

25. Kjerengtroen S, Wilde SM, Fontaine GV, et al. COVID-19 preparedness: Clinical pharmacy services remote staffing in a quaternary, level I trauma and comprehensive stroke center. *American Journal of Health-System Pharmacy* 2020; 77: 1250-1256. Article. DOI: 10.1093/ajhp/zxaa132.
26. Liao Y, Ma C, Lau AH, et al. Role of pharmacists during the COVID-19 pandemic in China - Shanghai Experiences. *J Am Coll Clin Pharm* 2020 2020/08/25. DOI: 10.1002/jac5.1288.
27. Marchese M, Heintzman A, Pasetka M, et al. Development of a process map for the delivery of virtual clinical pharmacy services at Odette Cancer Centre during the COVID-19 pandemic. *J Oncol Pharm Pract* 2021; 27: 650-657. 2021/02/09. DOI: 10.1177/1078155221991202.
28. Margusino-Framiñán L, Illarro-Uranga A, Lorenzo-Lorenzo K, et al. Pharmaceutical care to hospital outpatients during the COVID-19 pandemic. Telepharmacy. *Farm Hosp* 2020; 44: 61-65. 2020/06/14. DOI: 10.7399/fh.11498.
29. Mohammad I, Berlie HD, Lipari M, et al. Ambulatory Care Practice in the COVID-19 Era: Redesigning Clinical Services and Experiential Learning. *J Am Coll Clin Pharm* 2020 2020/08/25. DOI: 10.1002/jac5.1276.
30. Reardon J, Yuen J, Lim T, et al. Provision of Virtual Outpatient Care during the COVID-19 Pandemic and Beyond: Enabling Factors and Experiences from the UBC Pharmacists Clinic. *Innov Pharm* 2020; 11 2021/05/20. DOI: 10.24926/iip.v11i4.3432.
31. Segal EM, Alwan L, Pitney C, et al. Establishing clinical pharmacist telehealth services during the COVID-19 pandemic. *American Journal of Health-System Pharmacy* 2020; 77: 1403-1408. Article. DOI: 10.1093/ajhp/zxaa184.
32. Warda N and Rotolo SM. Virtual medication tours with a pharmacist as part of a cystic fibrosis telehealth visit. *J Am Pharm Assoc (2003)* 2021 2021/05/02. DOI: 10.1016/j.japh.2021.04.005.
33. Yerram P, Thackray J, Modelevsky LR, et al. Outpatient clinical pharmacy practice in the face of COVID-19 at a cancer center in New York City. *J Oncol Pharm Pract* 2021; 27: 389-394. 2021/01/19. DOI: 10.1177/1078155220987625.
34. Adam JP, Khazaka M, Charikhi F, et al. Management of human resources of a pharmacy department during the COVID-19 pandemic: Take-aways from the first wave. *Res Social Adm Pharm* 2021; 17: 1990-1996. 2020/11/16. DOI: 10.1016/j.sapharm.2020.10.014.
35. Al Mazrouei N, Ibrahim RM, Al Meslamani AZ, et al. Virtual pharmacist interventions on abuse of over-the-counter medications during COVID-19 versus traditional pharmacist interventions. *Journal of the American Pharmacists Association* 2021; 61: 331-339. Article. DOI: 10.1016/j.japh.2021.02.003.

36. Alhmoud EN, Abd El Samad OB, Elewa H, et al. Drive-up INR testing and phone-based consultations service during COVID-19 pandemic in a pharmacist-lead anticoagulation clinic in Qatar: Monitoring, clinical, resource utilization, and patient- oriented outcomes. *J Am Coll Clin Pharm* 2021 2021/07/07. DOI: 10.1002/jac5.1469.
37. Chen ZJ, Liang WT, Liu Q, et al. Use of a Remote Oncology Pharmacy Service Platform for Patients With Cancer During the COVID-19 Pandemic: Implementation and User Acceptance Evaluation. *J Med Internet Res* 2021; 23: e24619. 2021/01/05. DOI: 10.2196/24619.
38. Li H, Zheng S, Liu F, et al. Fighting against COVID-19: Innovative strategies for clinical pharmacists. *Res Social Adm Pharm* 2021; 17: 1813-1818. 2020/04/13. DOI: 10.1016/j.sapharm.2020.04.003.
39. Livet M, Levitt JM, Lee A, et al. The pharmacist as a public health resource: Expanding telepharmacy services to address social determinants of health during the COVID-19 pandemic. *Exploratory Research in Clinical and Social Pharmacy* 2021; 2: 100032. DOI: https://doi.org/10.1016/j.rcsop.2021.100032.
40. Brown SA, Patel S, Rayan D, et al. A virtual-hybrid approach to launching a cardio-oncology clinic during a pandemic. *Cardiooncology* 2021; 7: 2. 2021/01/15. DOI: 10.1186/s40959-020-00088-2.
41. Park L, Kim JH, Waldman E, et al. Impact analysis of virtual ambulatory transplant pharmacists during COVID-19. *Journal of the American College of Clinical Pharmacy*. DOI: 10.1002/jac5.1488.
42. Falconer N, Monaghan C and Snoswell CL. The pharmacist informatician: providing an innovative model of care during the COVID-19 crisis. *Int J Pharm Pract* 2021; 29: 152-156. 2021/03/18. DOI: 10.1093/ijpp/riaa017.
43. Gona OJ, Madhan R and Shambu SK. Assessment of Clinical Pharmacists' Assistance for Patients With Established Cardiovascular Diseases During the COVID-19 Pandemic: Insights From Southern India. *Front Cardiovasc Med* 2020; 7: 599807. 2021/01/12. DOI: 10.3389/fcvm.2020.599807.
44. Huibo Li SZ, Da Li, Dechun Jiang, Fang Liu, Wei Guo, Zhenying Zhao, Yanfei Zhou, Jingting Liu, Rongsheng Zhao. The Establishment and Practice of Pharmacy Care Service Based on Internet Social Media: Telemedicine in Response to the COVID-19 Pandemic. *Frontiers in Pharmacology* 2021. DOI: https://doi.org/10.3389/fphar.2021.707442.
45. Koster ES, Philbert D and Bouvy ML. Impact of the COVID-19 epidemic on the provision of pharmaceutical care in community pharmacies. *Res Social Adm Pharm* 2021; 17: 2002-2004. 2020/12/16. DOI: 10.1016/j.sapharm.2020.07.001.

46. Muflih SM, Al-Azzam S, Abuhammad S, et al. Pharmacists' experience, competence and perception of telepharmacy technology in response to COVID-19. *Int J Clin Pract* 2021; 75: e14209. 2021/04/06. DOI: 10.1111/ijcp.14209.
47. Tortajada-Goitia B, Morillo-Verdugo R, Margusino-Framiñán L, et al. Survey on the situation of telepharmacy as applied to the outpatient care in hospital pharmacy departments in Spain during the COVID-19 pandemic. *Farm Hosp* 2020; 44: 135-140. 2020/07/11. DOI: 10.7399/fh.11527.
48. Wang D, Liu Y, Zeng F, et al. Evaluation of the role and usefulness of clinical pharmacists at the Fangcang Hospital during COVID-19 outbreak. *Int J Clin Pract* 2021: e14271. 2021/04/25. DOI: 10.1111/ijcp.14271.
49. Al Meslamani AZ, Kassem AB, El-Bassiouny NA, et al. An emergency plan for management of COVID-19 patients in rural areas. *International Journal of Clinical Practice* 2021. Article. DOI: 10.1111/ijcp.14563.
50. Ibrahim OM, Ibrahim RM, Z Al Meslamani A, et al. Role of telepharmacy in pharmacist counselling to coronavirus disease 2019 patients and medication dispensing errors. *Journal of Telemedicine and Telecare* 2020. Article. DOI: 10.1177/1357633X20964347.
51. Mohamed Ibrahim O, Ibrahim RM, Abdel-Qader DH, et al. Evaluation of Telepharmacy Services in Light of COVID-19. *Telemedicine and e-Health* 2021; 27: 649-656. Article. DOI: 10.1089/tmj.2020.0283.
52. Cope R, Fischetti B, Eladghm N, et al. Outpatient management of chronic warfarin therapy at a pharmacist-run anticoagulation clinic during the COVID-19 pandemic. *J Thromb Thrombolysis* 2021: 1-5. 2021/03/08. DOI: 10.1007/s11239-021-02410-w.
53. Sorbera M, Fischetti B, Khaimova R, et al. Evaluation of virologic suppression rates during the COVID-19 pandemic with outpatient interdisciplinary HIV care. *J Am Coll Clin Pharm* 2021 2021/07/08. DOI: 10.1002/jac5.1422.
54. Peláez Bejarano A, Villar Santos P, Robustillo-Cortés MLA, et al. Implementation of a novel home delivery service during pandemic. *Eur J Hosp Pharm* 2021; 28: e120-e123. 2020/10/30. DOI: 10.1136/ejhpharm-2020-002500.
55. McNamara A, Zhao M, Lee SY. Evaluating the primary care clinical pharmacist visit transition to telehealth during the COVID-19 pandemic by comparing medication related problems from telehealth visits and in-person visits. *J Am Coll Clin Pharm* 2021; 4(8):914-23.
56. Alhraiwil NJ, Al-Aqeel S, AlFaleh AF, et al. Impact of COVID-19 on the 937 Telephone Medical Consultation Service in Saudi Arabia. *Int J Telemed Appl* 2022; 2022: 4181322. 2022/01/22. DOI: 10.1155/2022/4181322.

57. Mohiuddin SI, Thorakkattil SA, Abushoumi F, et al. Implementation of pharmacist-led tele medication management clinic in ambulatory care settings: A patient-centered care model in COVID-19 Era. *Explor Res Clin Soc Pharm* 2021; 4: 100083. 2021/11/02. DOI: 10.1016/j.rcsop.2021.100083.

58. Li Z, Gan L, Zheng H, et al. Innovative Strategies and Efforts of Clinical Pharmacy Services During and After COVID-19 Epidemic: Experience from Shanghai Children's Hospital. *Risk Manag Healthc Policy* 2021; 14: 4759-4764. 2021/12/04. DOI: 10.2147/rmhp.S324937.

59. Grosman-Dziewiszek P, Wiatrak B, Jęśkowiak I, et al. Patients' Habits and the Role of Pharmacists and Telemedicine as Elements of a Modern Health Care System during the COVID-19 Pandemic. *J Clin Med* 2021; 10 2021/09/29. DOI: 10.3390/jcm10184211.

60. Itani R, Khojah HMJ, Jaffal F, et al. Provision of pharmaceutical care to suspected high-risk COVID-19 patients through telehealth: a nationwide simulated patient study. *BMC Health Serv Res* 2021; 21: 997. 2021/09/23. DOI: 10.1186/s12913-021-07014-x.

61. Al Ammari M, AlThiab K, AlJohani M, et al. Tele-pharmacy Anticoagulation Clinic During COVID-19 Pandemic: Patient Outcomes. *Front Pharmacol* 2021; 12: 652482. 2021/09/28. DOI: 10.3389/fphar.2021.652482.

62. Kovačević M, Ćulafić M, Vezmar Kovačević S, et al. Telepharmacy service experience during the COVID-19 pandemic in the Republic of Srpska, Bosnia and Herzegovina. *Health Soc Care Community* 2021 2021/09/29. DOI: 10.1111/hsc.13590.

63. Lee SWH, Chan CKY, Chua SS, et al. Comparative effectiveness of telemedicine strategies on type 2 diabetes management: A systematic review and network meta-analysis. *Sci Rep* 2017; 7: 12680. 2017/10/06. DOI: 10.1038/s41598-017-12987-z.

64. Chongmelaxme B, Lee S, Dhippayom T, et al. The effects of telemedicine on asthma control and patients' quality of life in adults: a systematic review and meta-analysis. *J Allergy Clin Immunol Pract* 2019; 7: 199-216. e111.

65. Hanjani LS, Caffery LJ, Freeman CR, et al. A scoping review of the use and impact of telehealth medication reviews. *Res Social Adm Pharm* 2020; 16: 1140-1153.

66. Niznik JD, He H and Kane-Gill SL. Impact of clinical pharmacist services delivered via telemedicine in the outpatient or ambulatory care setting: A systematic review. *Res Social Adm Pharm* 2018; 14: 707-717. 2017/11/05. DOI: 10.1016/j.sapharm.2017.10.011.

67. Ohannessian R. Telemedicine: Potential applications in epidemic situations. *European Research in Telemedicine / La Recherche Européenne en Télémédecine* 2015; 4: 95-98. 2015/09/26. DOI: 10.1016/j.eurtel.2015.08.002.

68. Bynum A, Hopkins D, Thomas A, et al. The effect of telepharmacy counseling on metered-

dose inhaler technique among adolescents with asthma in rural Arkansas. *Telemed J E Health* 2001; 7: 207-217. 2001/09/21. DOI: 10.1089/153056201316970902.

69. Witt DM and Humphries TL. A retrospective evaluation of the management of excessive anticoagulation in an established clinical pharmacy anticoagulation service compared to traditional care. *J Thromb Thrombolysis* 2003; 15: 113-118. 2003/11/18. DOI: 10.1023/b:thro.0000003325.62542.43.
70. Green BB, Cook AJ, Ralston JD, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. *Jama* 2008; 299: 2857-2867. 2008/06/26. DOI: 10.1001/jama.299.24.2857.
71. Salvo MC and Brooks AM. Glycemic control and preventive care measures of indigent diabetes patients within a pharmacist-managed insulin titration program vs standard care. *Ann Pharmacother* 2012; 46: 29-34. 2011/12/29. DOI: 10.1345/aph.1Q512.
72. Kimber MB, Peterson GM. Telepharmacy—enabling technology to provide quality pharmacy services in rural and remote communities. *J Pharm Pract Res* 2006; 36(2):128-33.
73. Ohannessian R, Duong TA and Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. *JMIR public health and surveillance* 2020; 6: e18810.
74. Ung COL. Community pharmacist in public health emergencies: quick to action against the coronavirus 2019-nCoV outbreak. *Res Social Adm Pharm 2020; 16*(4), pp.583-586.
75. Mooranian A, Emmerton L. and Hattingh L. The introduction of the national e-health record into Australian community pharmacy practice: pharmacists' perceptions. Int J Pharm Pract *2013; 21*(6), pp.405-412.
76. Poudel A and Nissen LM. Telepharmacy: a pharmacist's perspective on the clinical benefits and challenges. *Integr Pharm Res Pract* 2016; 5: 75-82. 2016/10/26. DOI: 10.2147/iprp.S101685.
77. Hyder MA and Razzak J. Telemedicine in the United States: An Introduction for Students and Residents. *J Med Internet Res* 2020; 22: e20839. 2020/11/21. DOI: 10.2196/20839.
78. Chisholm-Burns MA, Graff Zivin JS, Lee JK, et al. Economic effects of pharmacists on health outcomes in the United States: a systematic review. *Am J Health Syst Pharm* 2010; 67: 1624-1634
79. Alonso SG, de la Torre Díez I and Zapiraín BG. Predictive, personalized, preventive and participatory (4P) medicine applied to telemedicine and eHealth in the literature. *J Med Syst* 2019; 43: 1-10.
80. Negrini S, Donzelli S, Negrini A, et al. Feasibility and acceptability of telemedicine to

substitute outpatient rehabilitation services in the COVID-19 emergency in Italy: an observational everyday clinical-life study. *Arch Phys Med Rehabil* 2020; 101: 2027-2032.

81. Al-Jazairi A, Hijazi H, Samarkandi H, et al. What is the ideal clinical pharmacy practice model? A satisfaction comparative study. *J Am Coll Clin Pharm* 2021; 4: 441-449.
82. Baretić M and Protrka N. Healthcare Information Technology: Fast and Accurate Information Access vs. Cyber-Security. *Int J E-Serv Mob Appl* 2021; 13: 77-87.
83. Solimini R, Busardò FP, Gibelli F, et al. Ethical and Legal Challenges of Telemedicine in the Era of the COVID-19 Pandemic. *Medicina* 2021; 57: 1314.
84. Hendy J, Reeves BC, Fulop N, et al. Challenges to implementing the national programme for information technology (NPfIT): a qualitative study. *Bmj* 2005; 331: 331-336.
85. Holden RJ and Karsh BT. The technology acceptance model: its past and its future in health care. *J Biomed Inform 2010; 43*(1), pp.159-172.
86. Luxon L. Infrastructure – the key to healthcare improvement. *Future Hosp J* 2015; 2: 4–7.
87. Alotaibi YK and Federico F. The impact of health information technology on patient safety. *Saudi Med J* 2017; 38(12):1173.
88. Myers MB. Telemedicine: an emerging health care technology. *Health Care Manag (Frederick)* 2003; 22: 219–223.
89. Oberjé EJ, de Kinderen RJ, Evers SM, et al. Cost effectiveness of medication adherence-enhancing interventions: a systematic review of trial-based economic evaluations. *Pharmacoeconomics* 2013; 31: 1155-1168.
90. Mohammadyari S and Singh H. Understanding the effect of e-learning on individual performance: The role of digital literacy. *Comput Educ* 2015; 82: 11-25.
91. Poudel A and Nissen LM. Telepharmacy: a pharmacist's perspective on the clinical benefits and challenges. *Integr Pharm Res Pract* 2016; 5: 75-82. 2016/10/26. DOI: 10.2147/iprp.S101685.
92. Hyder MA and Razzak J. Telemedicine in the United States: An Introduction for Students and Residents. *J Med Internet Res* 2020; 22: e20839. 2020/11/21. DOI: 10.2196/20839.
93. Car J, Tan WS, Huang Z, et al. eHealth in the future of medications management: personalisation, monitoring and adherence. *BMC Med* 2017; 15: 1-9.

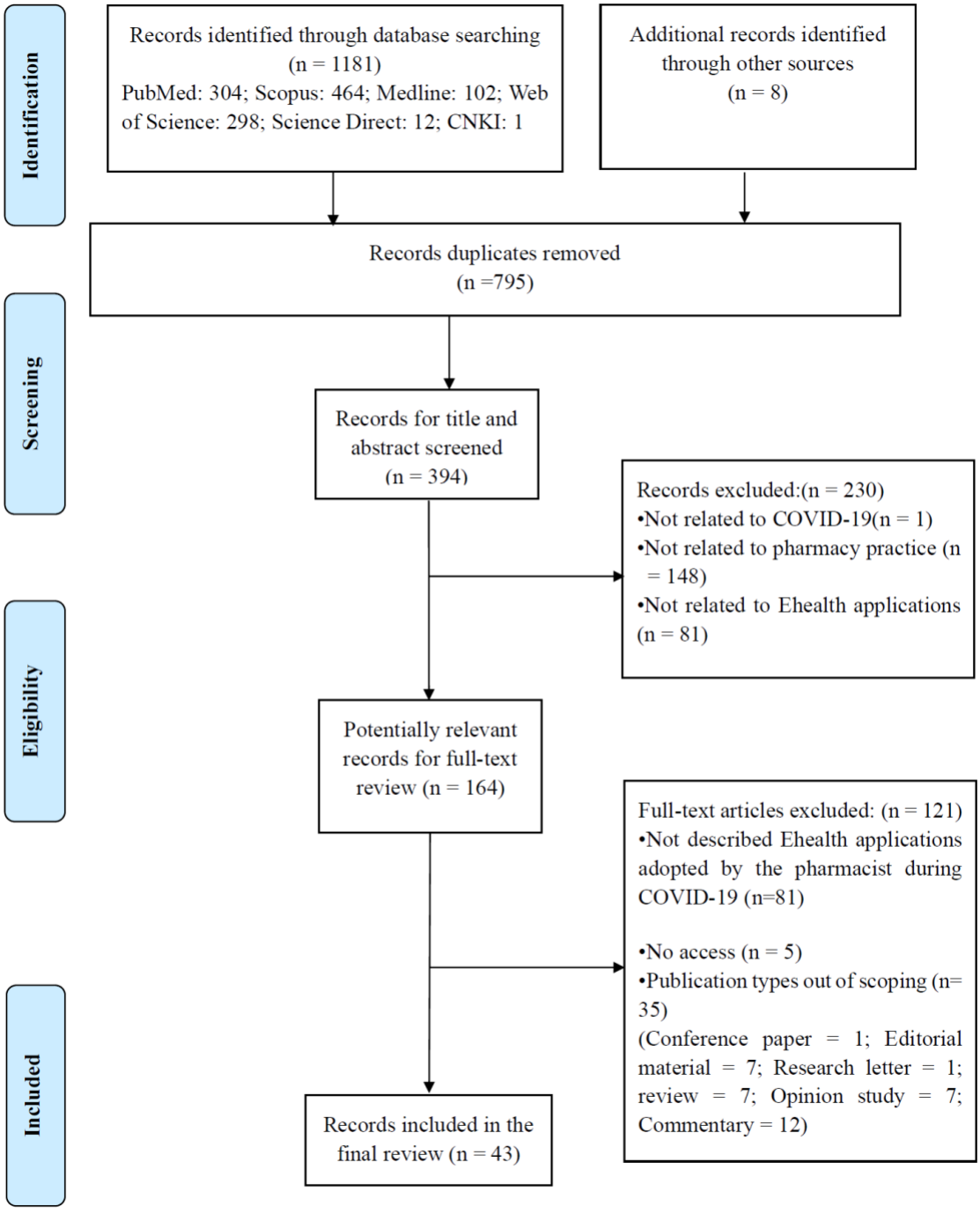

Figure 1. PRISMA flowchart of literature search and selection of publications

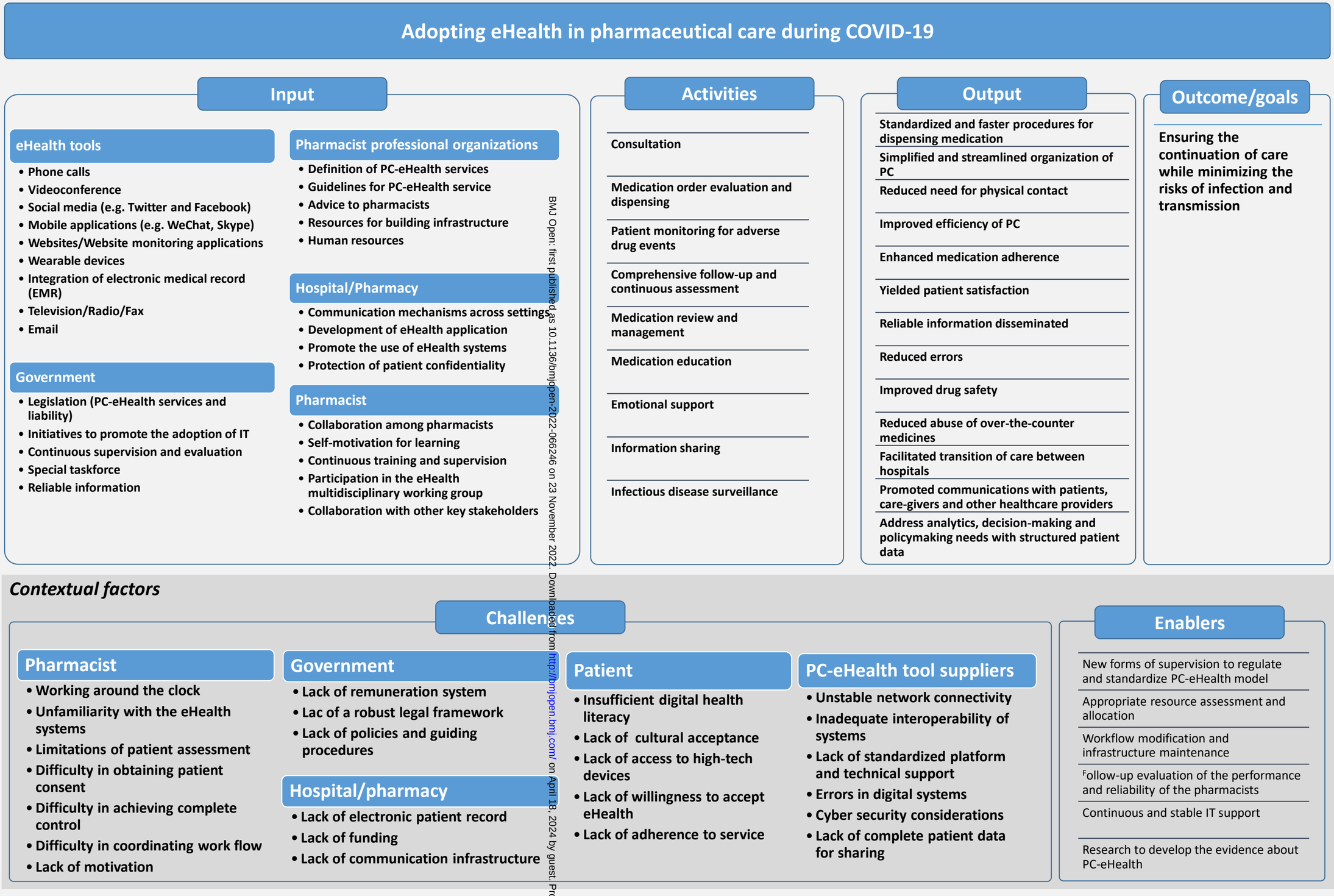

Figure 2. The logic model of *adopting eHealth* in pharmaceutical care during the COVID-19 pandemic

Supplementary file 1

A systematic literature review of adopting eHealth in pharmaceutical care during COVID-19 pandemic: recommendations for strengthening pharmacy services

Literature search strategy

Table 1. Overall literature search strategy

Concept 1		Concept 2		Concept 3	Limits
pharm* **OR** pharmacy **OR** pharmacies **OR** Pharmacist*	**AND**	Tele* **OR** mHealth **OR** m-Health **OR** mobile Health **OR** electronic Health **OR** eHealth **OR** e-Health **OR** e-medicine **OR** eMedicine **OR** electronic medicine **OR** mobile medicine	**AND**	COVID-19 **OR** COVID 19 **OR** Coronavirus **OR** 2019-ncov **OR** SARS-CoV-2 **OR** Sars2 **OR** cov-19	**Inclusion criteria:** • Studies which reported the use of eHealth in any aspects of PC during the COVID-19 pandemic, published between December 2019 and March 2022, written in English or Chinese, and published in peer-reviewed journals were included. • The study types were limited to descriptive studies, prospective observational studies, retrospective cohort studies, retrospective chart reviews, cross-sectional surveys, and qualitative studies. **Exclusion criteria:** • Studies which reported about the use of eHealth to support the use of medicines during the COVID-19 pandemic by healthcare professionals other than pharmacists • opinion articles, conference abstracts, correspondence, letters, and editorials

Table 2. Search Strategies used for each database

Source	Search syntax	Hits (15 April 2022)
PubMed	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	304
Scopus	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	464
MEDILINE	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	102
Web of Science	(covid-19 OR covid19 OR coronavirus OR 2019-ncov OR sars-cov-2 OR sars2 OR cov-19) AND (tele* OR mobile health OR mhealth OR m-health OR electronic health OR ehealth OR e-health OR e-medicine OR eMedicine OR electronic medicine OR mobile medicine) AND (pharm*)	298
Science Direct	(covid-19 OR coronavirus) AND (telemedicine OR telehealth OR“m-health” OR“e-health”) AND (pharmacy OR pharmacist)	12
CNKI	（新冠*）AND（远程医疗*）AND（药师*）	1

Table 3: Search history in PubMed (15 April 2022)

Search No.	Search terms	Hits
Pharmacy practice		
#1	Pharm*[Title/Abstract]	898177
eHealth		
#2	Tele*[Title/Abstract] OR mHealth[Title/Abstract] OR m-Health[Title/Abstract] OR mobile Health[Title/Abstract] OR electronic Health[Title/Abstract] OR eHealth[Title/Abstract] OR e-Health[Title/Abstract] OR e-medicine[Title/Abstract] OR eMedicine[Title/Abstract] OR electronic medicine[Title/Abstract] OR mobile medicine[Title/Abstract]	220321
COVID-19		
#3	COVID-19[Title/Abstract] OR COVID 19[Title/Abstract] OR Coronavirus[Title/Abstract] OR 2019-ncov[Title/Abstract] OR SARS-CoV-2[Title/Abstract] OR Sars2[Title/Abstract] OR cov-19[Title/Abstract]	223313
Limits (English, Chinese; full text; 2020-2022)		
Total		
#4	#1 AND #2 AND #3 Filters: English, Chinese, 2020-2022	304

Table 4: Search history in Scopus (15 April 2022)

Search No.	Search terms	Hits
Pharmacy practice		
#1	TITLE-ABS-KEY ("pharm*")	1653497
eHealth		
#2	TITLE-ABS-KEY ("tele*" OR "mobile health" OR "mhealth" OR "m-health" OR "electronic health" OR "ehealth" OR "e-health" OR "e-medicine" OR eMedicine OR "electronic medicine" OR "mobile medicine")	1286160
COVID-19		
#3	TITLE-ABS-KEY ("covid-19" OR "covid19" OR "coronavirus" OR "2019-ncov" OR "sars-cov-2" OR "sars2" OR "cov-19")	304284
Limits (English, Chinese; 2020-2022)		
#4	LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Chinese")	
Total		
#5	#1 AND #2 AND #3 AND #4	464

Table 5: Search history in MEDLINE (15 April 2022)

Search No.	Search terms	Hits
Pharmacy practice		
#1	TI "pharm*" OR AB "pharm*"	241703
eHealth		
#2	TI "tele*" OR AB "tele*" OR TI "mobile health" OR AB "mobile health" OR TI "mhealth" OR AB "mhealth" OR TI "m-health" OR AB "m-health" OR TI "electronic health" OR AB "electronic health" OR TI "ehealth" OR AB "ehealth" OR TI "e-health" OR AB "e-health" OR TI"e-medicine" OR AB"e-medicine" OR TI "eMedicine" OR AB "eMedicine" OR TI "electronic medicine" OR AB "electronic medicine" OR TI "mobile medicine" OR AB "mobile medicine"	71583
COVID-19		
#3	TI "covid-19" OR AB "covid-19" OR TI "covid19" OR AB "covid19" OR TI "coronavirus" OR AB "coronavirus" OR TI "2019-ncov" OR AB "2019-ncov" OR TI "sars-cov-2" OR AB "sars-cov-2" OR TI "sars2" OR AB "sars2" OR TI "cov-19" OR AB "cov-19"	78144
Limits (English, Chinese; 2020-2022)		
Total		
#4	#1 AND #2 AND #3	102

Table 6: Search history in Web of Science (15 April 2022)

Search No.	Search terms	Hits
Pharmacy practice		
#1	TS=("pharm*")	1004569
eHealth		
#2	TS=("tele*" or "mobile health" or "mhealth" or "m-health" or "electronic health" or "ehealth" or "e-health"or "e-medicine" or "eMedicine" or "electronic medicine" or "mobile medicine")	583377
COVID-19		
#3	TS=("covid-19" or "covid19" or "coronavirus" or "2019-ncov" or "sars-cov-2" or "sars2" or "cov-19")	256873
Limits (English, Chinese; 2020-2022)		
Total		
#4	#1 AND #2 AND #3	298

Table 7: Search history in Science Direct (15 April 2022)

Search No.	Search terms	Hits
Pharmacy practice		
#1	pharmacy OR pharmacist	25083
eHealth		
#2	telemedicine OR telehealth OR“m-health” OR“e-health”	6377
COVID-19		
#3	covid-19 OR coronavirus	45052
Limits (2020-2021)		
Total		
#4	#1 AND #2 AND #3	12

Table 8: Search history in CNKI (15 April 2022)

Search No.	Search terms	Hits
Pharmacy practice		
#1	药师*	36900
eHealth		
#2	远程*	257144
COVID-19		
#3	新冠*	34612
Limits (English, Chinese; 2020-2022)		
Total		
#4	#1 AND #2 AND #3	1

Supplementary Table 1. Characteristics of sources of evidence

	Authors (Publication Year)	Type of study	Location	Study aim	Targets of eHealth pharmacy service	Types of pharmacists involved
1	Abdallah et al. (2020)[20]	Descriptive study	Qatar	To share the experience and describe the measures adopted by the clinic as part of the Hamad Medical Corporation response to the emerging situation	Patients who were elderly or immunocompromised, and referred to the clinic or anticoagulation emergencies;	Hospital pharmacists
2	Do et al. (2021)[23]	Descriptive study	The United States	To discuss the objectives and strategies used by an ambulatory care action team operating within a large health system's pharmacy incident command structure during the initial response to the coronavirus disease 2019 (COVID-19) pandemic	Patients of the pulmonary clinic	Hospital pharmacists
3	Goff et al. (2020)[24]	Descriptive study	The United States	To described how pharmacists from high and low-middle income countries contributed to essential patient care and well-being of the public during the COVID-19 pandemic	General Public	Pharmacists specializing in infectious diseases (ID)
4	Liao et al. (2020)[26]	Descriptive study	China	To described the roles and contributions of pharmacists in Shanghai during the coronavirus disease 2019 (COVID-19) pandemic	Adult patients with COVID-19	Clinical pharmacists and pharmacists of traditional Chinese medicine (TCM)
5	Allison et al. (2021)[21]	Descriptive study	The United States	To evaluated how to balance the need to provide essential pharmacy services (both operational and clinical), develop telework strategies, and maintain a viable workforce for the duration of the COVID-19 pandemic	Inpatients and discharged patients	Hospital pharmacists

6	Margusino-Framiñán et al. (2020)[28]	Descriptive study	Spain	To describe and analyze the experience of HPSs with outpatient Telepharmacy during the COVID-19 pandemic and exposed the lessons learned	Outpatients	Primary care pharmacists; Community Pharmacists
7	Mohammad et al. (2020)[29]	Descriptive study	The United States	To emphasize clinical and experiential challenges that ambulatory care clinical pharmacists had been facing, generate discussion, and provide examples of potential solutions that could serve as a framework for COVID-19 ambulatory care practices and experiential sites	Patients on warfarin therapy	Hospital pharmacists
8	Reardon et al. (2020)[30]	Descriptive study	Canada	To describe the UBC Pharmacists Clinic's technical systems and lessons learned using enabling technology and the provision of virtual patient care by pharmacists	Patients who needed to visit the pharmacist clinic	Hospital pharmacists
9	Segal et al. (2020)[31]	Descriptive study	The United States	To describe an expedited process used to obtain telehealth privileges for pharmacists and highlighted the experience providing clinical services to patients with COVID-19	Patients with chronic conditions and cancer	Hospital pharmacists
10	Warda et al. (2021)[32]	Descriptive study	The United States	To describe the uptake and impact of pharmacist-led virtual medication tours during telehealth visits in the CF clinic setting	Patients with cystic fibrosis	Pharmacists specializing in cystic fibrosis
11	Yerram et al. (2021)[33]	Descriptive study	The United States	To present the approach of restructuring clinical pharmacy services and providing direct patient care in outpatient clinics during the pandemic	Outpatients; Inpatients	Hospital pharmacists
12	Adam et al. (2021)[34]	Case series	Canada	To share the experiences of the pharmacy department of the Centre hospitalier de l'Université de Montréal	COVID-19 patients; Oncology outpatient	Pharmacists in the oncology outpatient; PhT (the ones

				(CHUM) in response to the COVID-19 pandemic		responsible for prescription entry)
13	Al Mazrouei et al. (2021)[35]	Case series	United Arab Emirates (UAE)	To investigate the frequency, nature, and clinical significance of pharmacist interventions on over-the-counter (OTC) medicines with abuse potential across community pharmacies with and without virtual care	Patient who used over-the-counter medicines	Community pharmacists; Hospital pharmacists
14	Alhmoud et al. (2021)[36]	Cross-sectional survey	Qatar	To evaluate the impact of transitioning from clinic-based anticoagulation management services to drive-up and phone-based services during COVID-19 pandemic in Qatar	Patients who attended anticoagulation clinic over 1-year period (6 months before and 6 months after service transition)	Pharmacists providing anticoagulation services
15	Chen et al. (2021)[37]	Cross-sectional survey	China	To investigate the characteristics, acceptance, and initial impact of the Cloud SYSUCC app during a COVID-19 outbreak in a tertiary cancer hospital in China	Patient with cancer treated with prescription medicines (such as breast cancer, liver cancer, and thyroid cancer) who needed to visit the cancer center	Hospital pharmacists
16	Li et al. (2021)[38]	Cross-sectional survey	China	To retrieve and investigate the prevention and control measures of clinical pharmacists during the outbreak of novel coronavirus, summarize the roles and responsibilities of clinical pharmacists, and to propose innovative strategies for developing pharmacy services under the epidemic	Patients in Fangcang shelter hospitals	Hospital pharmacists
17	Livet et al. (2021)[39]	Cross-sectional survey	The United States	To describe the feasibility of expanding a comprehensive medication management (CMM) telepharmacy service to include social determinants of health(SDOH) support expanded service, evaluated stakeholders'	Diabetic patients with HbA1c > 9, at least one additional comorbidity, five or more medications, and at least 18 years of age	Hospital pharmacists

				experience with the service, and assessed short-term impact on patients with diabetes		
18	Brown et al. (2021)[40]	Retrospective study	The United States and the United Kingdom	To offer a template for other centers to develop their own new Cardio-Oncology clinics with Virtual-Hybrid Approach during the pandemic	Patients with cancers (e.g., breast, prostate, leukemia, lung) or cardiovascular toxicities (e.g., cardiomyopathy, hypertension) who needed to visit Cardio-Oncology clinic	Hospital pharmacists
19	Cashman et al. (2020)[22]	Descriptive study	Australia	To integrate the electronic healthcare delivery systems at a metropolitan hospital and a rural outreach haematology clinic to facilitate streamlined and safe outpatient car	Hematology outpatients	Pharmacists specializing in hematology/oncology
20	Kjerengtroen et al. (2020)[25]	Descriptive study	The United States	To describe and share the plan developed by Intermountain Medical Center (IMED) in Murray, UT which provides remote clinical pharmacy services to protect the health of pharmacy caregivers while maintaining appropriate clinical pharmacy coverage to optimally care for patients	Hospitalized patients in a quaternary, level I trauma and comprehensive stroke center and patients from off-site locations	Hospital pharmacists; Pharmacists specializing in critical care, internal medicine or cardiology
21	Marchese et al. (2021)[27]	Descriptive study	Canada	To describe, in a process map, the process changes that were made to the delivery of clinical pharmacy services to ambulatory cancer patients prescribed intravenous anticancer therapies at Odette Cancer Centre in March–April 2020	Patients receiving systemic cancer treatment	Pharmacists specializing in oncology
22	Park et al. (2021)[41]	Retrospective study	The United States	To describe a quality assurance and performance improvement initiative of the implementation of comprehensive	Lung transplant providers (LTP)	Pharmacists specializing in

				medication management visits, pharmacists were able to assist LTP in the transition to telemedicine		cardiothoracic (CT) transplant
23	Falconer et al. (2021)[42]	Semi-structured interview	Australia	To determine the key opportunities for a pharmacist informatician to improve patient care and outcomes during the COVID-19 pandemic	Patients with COVID-19	Pharmacists specializing in informatics
24	Gona et al. (2020)[43]	Cross-sectional survey	India	To assess the clinical pharmacist-initiated telephone-based patient education and self-management support for patients with cardiovascular disease during the nationwide lockdown during COVID-19 pandemic	Patients with existing cardiovascular diseases	Hospital pharmacists
25	Koster et al. (2021)[45]	Cross-sectional survey	Netherlands	To describe the impact of the COVID-19 epidemic on the provision of pharmaceutical care in the Netherlands	Vulnerable patients	Community pharmacists
26	Muflih et al. (2021)[46]	Cross-sectional survey	Jordan	To examine pharmacists' attitudes towards clinical benefits and identify challenges regarding the use of telepharmacy during the COVID-19 pandemic in Jordan	Patients with COVID-19	Community pharmacists; Hospital pharmacists
27	Tortajada-Goitia et al. (2020)[47]	Cross-sectional survey	Spain	To analyze the status of the implementation and development of telepharmacy as applied to the pharmaceutical care of outpatients treated at hospital pharmacy services in Spain during the COVID-19 pandemic	Outpatients	Hospital pharmacists
28	Wang et al. (2021)[48]	Cross-sectional survey	China	To evaluate the usefulness of clinical prevention and control measures of clinical pharmacists at Jianghan Fangcang Hospital	Patients with chronic diseases	Hospital pharmacists

29	Al Meslamani et al. (2021)[49]	Case series	Egypt	To describe the experience of six hospitals in the management of COVID-19 patients in rural areas through an assessment of proportions, types and clinical outcomes of remote clinical interventions	Patients with COVID-19 who lived in rural areas	Hospital pharmacists
30	Ibrahim et al. (2020)[50]	Case series	The United States	To examine differences in rates and types of pharmacist interventions related to COVID-19 and medication dispensing errors (MDEs) across community pharmacies with and without telepharmacy services	Patients with suspected or confirmed COVID-19 infection	Community pharmacists
31	Mohamed Ibrahim et al. (2021)[51]	Case series	United Arab Emirates (UAE)	To assess the predictors for effective telepharmacy services on increasing access of patients to care and reducing dispensing errors in community pharmacies	Patients with probable or confirmed COVID-19 infection	Community pharmacists
32	Cope et al. (2021)[52]	Retrospective study	The United States	To describe the care provided during the COVID-19 pandemic at a pharmacist-run anticoagulation clinic in the New York Metropolitan area and evaluates the impact on clinic outcomes	Outpatients with chronic diseases	Hospital pharmacists
33	Sorbera et al. (2021)[53]	Retrospective study	The United States	To measure the impact of pharmacy services including telehealth through the percentage of virologically suppressed patients (HIV ribonucleic acid [RNA] < 200 copies/mL) during the pre-COVID and post-COVID time periods	HIV-positive patients	Hospital pharmacists
34	Huibo Li et al. (2021)[44]	Cross-sectional survey	China	To establish and launch a telepharmacy framework to implement pharmaceutical care during the COVID-19 pandemic.	Patients with chronic diseases requiring long-term use of medications who were quarantined at home	Pharmacist volunteers

35	Ana Peláez Bejarano, et al. (2021)[54]	Cross-sectional survey	Spanish	To design a model that would facilitate access to hospital medication during home quarantine due to COVID-19, and ensure patient satisfaction with this process	Patients with acute illnesses or complex chronic conditions who were confined to home quarantine due to the pandemic	Community pharmacists; Hospital pharmacists
36	Anusha McNamara, et al. (2021)[55]	Retrospective study	The United States	To evaluate the impact of clinical pharmacist care via in-person and telehealth by comparing the average MRPs resolved during the visits	Patients and individuals, regardless of insurance status	Hospital pharmacists
37	Najla J. Alhraiwil, et al.(2021)[56]	Descriptive study	Saudi Arabia	To understand the impact of the COVID-19 pandemic on Call Center services, specifically medical consultations, to suggest future recommendations for patient care optimization	Citizens, residents, and visitors	Pharmacists
38	Syed Iqbal Mohiuddin, et al. (2021)[57]	Descriptive study	Saudi Arabia	To emphasize the implementation of the pharmacist-led medication management clinic services in the Johns Hopkins Aramco Healthcare (JHAH) ambulatory pharmacy care setting using communication technologies	Geriatric patients with chronic conditions	Clinic pharmacists responsible for medication management
39	Zhiling Li, et al. (2021)[58]	Descriptive study	China	To share our strategies and efforts with peers who are fighting against COVID-19 in other countries and regions	Pediatric patients with COVID-19	Hospital pharmacists
40	Patrycja Grosman-Dziewiszek, et al. (2021)[59]	Cross-sectional survey	Poland	To unvestigate the new coronavirus disease 's effect on patients' health habits, access to healthcare, and attitude to vaccination	Patients in general	Hospital pharmacists
41	Rania Itani, et al. (2021)[60]	Cross-sectional survey	Lebanon	To identify the pharmaceutical care provided by community pharmacists to suspected high-risk COVID-19 patients using telehealth	Elderly individuals and those with underlying chronic medical conditions	Community pharmacists

42	Maha Al Ammari, et al. (2021)[61]	Prospective study	Saudi Arabia	To assess the tele-pharmacy anticoagulation clinic's efficiency and patient satisfaction in Saudi Arabia during the COVID-19 pandemic	Patients with diabetes mellitus and hypertension	Hospital pharmacists
43	Milena Kovačević, et al. (2021)[62]	Descriptive study	Republic of Srpska, Bosnia and Herzegovina	To describe the remote pharmaceutical care service (telepharmacy) during the COVID-19 pandemic in the Republic of Srpska (RS), Bosnia and Herzegovina; To identify service users' needs and concerns and to describe community pharmacists' interventions	Patients with chronic or acute/subacute conditions	Community pharmacists

Supplementary Table 2. Major findings of the included literature

	Type of eHealth involved					Tool(s)	Intervention	Output summary
	Tele-education	Tele-consultation	Tele-monitoring	Tele-case-management	Tele-mentoring			
1	✓	✓	✓			▪ Phone calls	▪ Consultation ▪ Comprehensive assessment ▪ Medication review and management ▪ Patient monitoring ▪ Medication education	Elderly or immunocompromised patients referred to the clinic or anticoagulation emergencies were managed by hospital pharmacists through telephone calls. The number of patients who needed to physically attend the clinic significantly reduced.
2		✓	✓	✓		▪ Phone calls ▪ Videoconference	▪ Patient monitoring	Patients of the pulmonary clinic were converted to eHealth and monitored by hospital pharmacists.
3	✓					▪ Social media (Twitter) ▪ Television	▪ Public education	20 interviews with pharmacists specialising in infectious diseases were broadcasted through the local television health reporters, national news media, magazines, and tweets to provide education to the general public.
4		✓	✓	✓		▪ Website monitoring applications (The online platform "SPHCC Patient Care" based on six licensed internet hospitals) ▪ Mobile application (WeChat)	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring ▪ Medication order review ▪ Emotional support	Pharmacists (both clinical and traditional Chinese medicine (TCM)) continued to care for patients with COVID-19 using the website application. The need for patients to come to hospitals for treatment and follow-up was reduced.

5		✓	✓		✓	▪ Videoconference ▪ Phone calls *With the integration of The electronic medical record (EMR) system*	▪ Consultation ▪ Information sharing	All clinical pharmacy services continued to be provided through different means of eHealth without interruptions
6		✓			✓	▪ Website monitoring applications (Primary Health Care Center network in the healthcare area (CCSS))	▪ Consultation	During eight weeks, 3,095 patients were treated with pharmacists through eHealth (55% of the total), and 195 received their medication at home. Extraordinary perception of quality of the new model was received through multiple signs of appreciation from patients.
7	✓		✓	✓		▪ Phone calls; ▪ Videoconference (Zoom); ▪ Mobile applications (Skype, Facetime)	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring	Patients on warfarin therapy were continuously monitored by hospital pharmacists. Patient self-reported questionnaire scores found positive patient satisfaction with pharmacist eHealth care.
8		✓	✓	✓	✓	▪ Website monitoring applications ▪ Email ▪ Fax *With the integration of The electronic medical record (EMR) system*	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Information sharing	Follow-up appointments for patients who needed to visit the pharmacist clinic were conducted virtually by hospital pharmacists. The percentage of follow-up appointments done virtually increased to 64% in 2020 from 1.5% in 2019.

9	✓	✓	✓		✓	▪ Videoconference (ZOOM) *With the integration of The electronic medical record (EMR) system*	▪ Medication review and management ▪ Medication education	During the period of March 31 through April 28, 2020, clinical pharmacist telehealth services were offered to 139 patients. Of these patients, 83% (n = 116) completed telehealth visits, which reveals eHealth can ensure the continuous provision of pharmacy services during the epidemic.
10	✓	✓	✓	✓		▪ Phone calls ▪ Videoconference	▪ Medication review and management ▪ Medication order review	A total of 20 patients were consulted via eHealth by pharmacists specializing in cystic fibrosis as part of the clinic appointment between April and June 2020, which demonstrates that a virtual medication tour led by a pharmacist can be successfully incorporated into telehealth visits and be accepted by a majority of patients.
11	✓	✓	✓	✓	✓	▪ Mobile applications (Cisco Jabber 12.6, Doxymity) ▪ Videoconference (Zoom)	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Medication education	A total of 265 clinical pharmacy specialists' interventions involving COVID-19 healthcare team (both ICU and non-ICU) were performed sparing in-person patient visits for medical care for 199 patients.
12				✓	✓	▪ Mobile applications (PetalMD, Facebook) ▪ Email ▪ Videoconference	▪ Medication order review ▪ Information sharing	An analysis of the number of validated prescriptions showed that the pharmacists validate significantly 27% more prescriptions in telework when compared to a centralized workstation in the hospital without impacting the performance of the pharmacists in hospital.

13		✓	✓			▪ Phone calls ▪ Videoconference ▪ Mobile applications ▪ Website monitoring applications	▪ Consultation ▪ Medication review and management	Regarding over-the-counter medicines in pharmacies, the rates of potential abuse with and without eHealth services were 7.7% and 5.8% respectively; the rates of potential misuse with and without eHealth services were 16.6% and 13.7% respectively.
14		✓	✓			▪ Phone calls ▪ Website applications	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring	Patients' experience with the pharmaceutical service through eHealth was remarkably positive.
15	✓	✓				▪ Website monitoring applications (Cloud Sun Yat-sen University Cancer Center (SYSUCC)) *With the integration of the electronic medical record (EMR) system*	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Medication education	Patient with cancer treated with prescription medicines were managed by hospital pharmacists via the pharmacy service platform in the Cloud SYSUCC. 88% (88/100) of the patients were very satisfied with the remote pharmacy services provided.
16	✓	✓	✓	✓	✓	▪ Mobile applications (The "Online Pharmaceutical Monitoring"); ▪ Radio (Fangcang shelter radio station)	▪ Consultation ▪ Medication review and management ▪ Medication education ▪ Emotional support ▪ Information sharing	The online pharmaceutical service model not only effectively reduce the chance of hospital-acquired infections, but also improve the efficiency of pharmacy services, and achieve timely and effective professional medication guidance for patients throughout the entire process.

17			✓	✓	✓	▪ Phone calls ▪ Videoconference	▪ Comprehensive assessment	eHealth measures performed by hospital pharmacists for diabetic patients helped address 26 COVID-prompted social determinants of health (SDOH) concerns across 68 patients.
18	✓			✓	✓	▪ Phone calls ▪ Videoconference (A de novo Cardio-Oncology Clinic with Virtual-Hybrid Approach)	▪ Medication review and management ▪ Medication order review ▪ Patient monitoring ▪ Medication education ▪ Information sharing	35% of patients with cancers or cardiovascular toxicities who needed to visit Cardio-Oncology clinic were cared for by hospital pharmacists via eHealth, which reveals the Virtual-Hybrid Approach to build a de novo Cardio-Oncology Clinic is very useful during the pandemic.
19				✓		▪ Electronic health record (EHR) systems	▪ Medication order review	The centralised electronic health record has improved streamlined care during patient transitions between the two hospitals with enhanced continuity of documentation and management.
20	✓	✓	✓	✓	✓	▪ Phone calls ▪ Videoconference (The Intermountain Medical Center (IMED)) ▪ Wearable devices (The Vocera Badge) ▪ Website monitoring applications (The VigiLanz clinical surveillance platform)	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Medication education ▪ Information sharing ▪ Infectious disease surveillance	The plan to provide remote clinical pharmacy services help clinical pharmacists to readily communicate with nurses, physicians, other caregivers, and patients; allow clinical pharmacists to continue to participate in daily rounds, provide consultations under collaborative practice agreements, verify medication orders, collect medication histories, provide antimicrobial stewardship, and deliver medication education to patients from off-site locations; and allow for optimal care of hospitalized patients and promote social distancing, which may have the added benefit of decreasing the

								spread of SARS-CoV-2 among patients and caregivers.
21	✓	✓	✓			▪ Phone calls	▪ Consultation ▪ Comprehensive assessment ▪ Medication education	Pharmacists specializing in oncology performed 149 medication history and baseline assessments, and 72 medication therapy counsels remotely for patients receiving systemic cancer treatment through eHealth in 2 months, which demonstrates that clinical pharmacy service levels could be maintained by incorporating remote delivery approaches without significant investment in resources.
22			✓	✓		▪ Phone calls ▪ Mobile applications (Doximity or Google Voice) ▪ Email	▪ Comprehensive assessment ▪ Medication review and management ▪ Medication order review	From March to September 2020, pharmacists specializing in cardiothoracic transplant conducted 385 virtual visits on 157 Lung transplant providers (LTP) with an average of 20 minutes spent per visit. There were 891 total interventions made by the pharmacists and 778 medication discrepancies were identified.
23				✓	✓	▪ Phone calls ▪ Videoconference *With the integration of the electronic medical record (EMR) system*	▪ Medication review and management ▪ Information sharing ▪ Remote label printing	Pharmacists specializing in informatics ensured the timely supply of medications using real-time data support, which reveals informatics pharmacists have the potential to assist with maintaining high quality patient care during this pandemic, and in future disasters.

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24	✓			✓	✓	▪ Phone calls	▪ Consultation ▪ Medication education	Hospital pharmacists adopted eHealth to increase patients' understanding of the pandemic and help mitigate infection exposure among patients, assuring the continuity of care in patients with established cardiovascular diseases.
25		✓	✓			▪ Phone calls ▪ Videoconference	▪ Consultation ▪ Medication education ▪ Information sharing	Community pharmacists continued to conducted medication reviews with remote pharmaceutical services for 44.2% vulnerable patients, which greatly minimizes direct patient-provider contact.
26			✓			▪ Videoconference ▪ Mobile applications	▪ Patient monitoring	Both community and hospital pharmacists continued to monitor patients with COVID-19. Most of the participants (70.6%) expressed favourable attitudes towards telepharmacy.
27				✓	✓	▪ Videoconference *With the integration of the electronic medical record (EMR) system*	▪ Medication review and management ▪ Information sharing	Before the beginning of the crisis, 83.2% (n = 154) of hospital pharmacy services did not carry out remote pharmaceutical care activities. However, after the outbreak, as many as 87.6% of hospital pharmacists carried out remote pharmaceutical service and 119,972 patients received their medications through remote dispensing eHealth services, representing over 80% of outpatients receiving their medication through eHealth procedure, which shows the rate of implementation of telepharmacy in outpatient care in Spain during the study period in the pandemic was high.

28	✓		✓		✓	▪ Mobile applications (WeChat) ▪ Radio	▪ Consultation ▪ Medication review and management ▪ Patient monitoring ▪ Medication education ▪ Emotional support ▪ Information sharing	During a 35-day period, pharmacy service was provided by hospital pharmacists to patients with chronic diseases via eHealth that resulted in round 200 enquires resolved by clinical pharmacists, including drug usage (65.38%), medication reconciliation (55.13%), drug precautions (23.1%), adverse drug reactions (35.9%) and psychological counselling (32.05%).
29	✓	✓	✓	✓		▪ Phone calls ▪ Mobile applications (WhatsApp, short messages services (SMS))	▪ Medication review and management ▪ Medication order review ▪ Medication education	Hospital pharmacists on the eHealth teams conducted 3318 phone calls, 2116 WhatsApp® chats and 1128 interventions related to pharmacy practice for patients with COVID-19 who lived in rural areas. As a results, 312 prescribing errors (PEs) were identified, of which 287 were corrected.
30		✓	✓	✓		▪ Phone calls Videoconference ▪ Website monitoring applications	▪ Consultation ▪ Medication review and management ▪ Medication order review	7908 MDEs (any unintended deviation from an interpretable written prescription or medication order) were detected in the remote eHealth group (50,026 dispensed items), and 4563 were reported in the control group which did not provide ehealth services (23,481 dispensed items) during the pandemic, which reveals having eHealth services available is better than none.
31		✓	✓	✓		▪ Videoconference	▪ Consultation ▪ Medication review and management ▪ Medication order review	Pharmacies provided 63,714 COVID-19–related recommendations with eHealth services compared with 15,539 in the control group that without remote pharmaceutical service, which reveals greater demand for pharmaceutical

							service with eHealth during the pandemic.
32			✓		▪ Specific IT support (Virtual–Venipuncture INR)	▪ Comprehensive assessment	Following the onset of COVID, 84 patients received care through eHealth, such as telephone and video by the anticoagulation clinic a total of 192 times, which indicates it is possible of managing chronic warfarin patients utilizing a hybrid virtual care model during the COVID-19 pandemic.
33	✓	✓	✓	✓	▪ Mobile applications (Signal and Google Voice, Doximity)	▪ Comprehensive assessment ▪ Medication review and management ▪ Medication order review ▪ Information sharing	Total of 211 HIV patients with medication refill requests sent to the clinical pharmacists, and half of them had one or more telehealth visits with clinical pharmacist, which reveals remote services can be an alternative for stable HIV-positive patients as a supplement to in-person visits.
34	✓	✓	✓	✓	▪ "Cloud Pharmacy Care" platform (a medication consultation service platform WeChat)	▪ Consultation ▪ Medication education	The "Cloud Pharmacy Care" platform had 1,432 views and 66 followers. During a 2-monther period, 39 cases of consultation were performed by volunteer pharmacists through this platform for chronically-ill patients quarantined at home. All consultations were completed within 4 h and 97.4% of patients found the eHealth services satisfactory.

35			✓	✓		▪ Phone calls	▪ Comprehensive assessment ▪ Medication review and management ▪ Medication order review ▪ Medication education	1186 patients requested remote pharmaceutical service with eHealth due to the treatment changes have been made during the pandemic, and most of them are very satisfied with the remote service, which proves that eHealth can adapt well to the pharmaceutical changes brought about by the epidemic.
36			✓	✓		▪ Phone calls	▪ Consultation ▪ Comprehensive assessment ▪ Patient monitoring	During a 6-month period, 173 encounters between hospital pharmacists and patients took place through eHealth. Upon evaluation, the average medication related problems (MRPs) per encounter resolved through face to face (FTF) visits (1.70 [±1.56]) was significantly higher than that through telehealth (1.07 [±1.20]).
37		✓				▪ Phone calls ▪ Mobile application	▪ Consultation	Between March and September in 2019, 1,375,021 calls by the general public and visitors were handled by pharmacists. During the same time period in 2020, 5,446,275 similar calls were received, representing an increased of >296% increase, which shows pharmaceutical services with eHealth is the one of the best strategies to combat the COVID-19 pandemic in Saudi Arabia.
38	✓	✓	✓	✓	✓	▪ Phone calls ▪ Videoconference *With the integration of the electronic medical record (EMR) system*	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Patient monitoring ▪ Medication education	Clinic pharmacists continued to perform medication management for geriatric patients with chronic conditions. Enhanced access to patient care, reduced risk of hospital-acquired infections, enhanced medication adherence and increased the patient care quality during a health crisis were described.

39	✓	✓		✓		▪ Radio ▪ "Cloud pharmacy care" application ▪ Mobile application (WeChat) ▪ Service robots	▪ Consultation ▪ Medication education ▪ Information sharing	Hospital pharmacists continued to care for pediatric patients with COVID-19 via eHealth. Positive outcome such as optimized procurement procedure, improved efficiency, and reduced risk of infection by minimizing human contact was described.
40		✓		✓	✓	▪ Phone calls ▪ Videoconference ▪ Mobile application (Short messages services (SMS))	▪ Consultation ▪ Medication order review	926 participants completed the questionnaire satisfaction survey, and 457 (49.4%) respondents are satisfied with the advice provided by pharmacists, which proves remote pharmaceutical service with eHealth is appreciated by patients.
41		✓		✓		▪ Phone call	▪ Consultation ▪ Comprehensive assessment Information sharing ▪ Infectious disease surveillance	A total of 100 community pharmacies were phoned, and 59 % of the pharmacists retrieved both symptoms and treatment-related medical information, which means more than half of pharmacists can provide some pharmacy services through eHealth, however, still need a great improvement.
42		✓		✓		▪ Phone calls ▪ Mobile applications (WhatsApp) ▪ Hospital electronic system (BestCare)	▪ Comprehensive assessment Medication review and management	In total, 270 patients' mean of the INR values was 60%, and the patients were in the therapeutic range nearly 60% of the time. Also, of the sample, nearly half achieved intermediate to good anticoagulation control with a TTR above 50%, which means the services provided by pharmaceutical care could be improved by using a tele-pharmacy model, as this enables the utilization of technology for patients.

43	✓	✓		✓	✓	▪ Phone calls	▪ Consultation ▪ Medication review and management ▪ Medication order review ▪ Patient monitoring ▪ Medication education ▪ Emotional support	10 pharmacists from 7 community pharmacies offered eHealth service to 71 patients from April 13, 2020, up to May 21, 2020, which reveals remote pharmaceutical care service (telepharmacy) is deemed a convenient model in the Republic of Srpska during the COVID-19 pandemic.

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3,4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	N/A
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	7
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	7
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	7
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	7

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	6,7
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	6,7
Study characteristics	17	Cite each included study and present its characteristics.	7
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N/A
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	7,8
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	12
	23b	Discuss any limitations of the evidence included in the review.	14
	23c	Discuss any limitations of the review processes used.	14
	23d	Discuss implications of the results for practice, policy, and future research.	13,14
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	14
Competing interests	26	Declare any competing interests of review authors.	14
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71