




Review of Systematic Reviews in the Field of Telemedicine

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Abstract

Background: Although the systematic reviews regarding telemedicine have increased in recent decades, no comprehensive studies have been conducted to review these systematic reviews. The present study aimed to review the published systematic reviews regarding telemedicine applications for the report and appraisal of several aspects.

Methods: The literature search was performed in the PubMed database for the systematic reviews published during January 2010-June 2020 in the field of telemedicine using “telemedicine” Mesh terms. The extracted data from the selected articles were the year of publication, telemedicine specialty, clinical outcomes, cost evaluation, and satisfaction assessment. Data analysis was performed using descriptive statistics.

Results: Among 746 retrieved articles, 191 cases were selected and reviewed. Most of the studies were focused on telemedicine (n=35; 18.3%), followed by telerehabilitation (n=22; 11.5%), tele-diabetes (n=18; 9.4%), telecardiology (n=16; 8.3%), home telecare (n=13; 6.8%), telepsychiatry (n=12; 6.3%), teledermatology (n=11; 5.7%), and teleneurology (n=9; 4.7%). The selected studies were primarily focused on clinical outcomes (72.7%), followed by cost-effectiveness (32.4%) and user satisfaction (29.3%). In addition, they mostly indicated that telemedicine services yielded acceptable clinical outcomes (72.5%), cost-effectiveness (67.7%), and healthcare provider/patient satisfaction (83.9%).

Conclusion: Although telerehabilitation, tele-diabetes, telecardiology, home telecare, and telepsychiatry were studied further, there are still some specific specialties such as teleradiology, telepathology, and telepediatric that should be considered more. Moreover, investigation of various outcomes could result in a more comprehensive view of this field. Therefore, further investigations in this regard would improve telemedicine applications and encourage potential telemedicine providers to initiate these applications.

Keywords: Telemedicine, Telehealth, Systematic Review, Analysis

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Introduction

Telemedicine is the use of electronic information and communication technologies to exchange medical infor-

mation for the provision of healthcare services and medical education (1). Telemedicine could connect healthcare

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↑What is “already known” in this topic:

With the increased number of publications in the field of telemedicine, it becomes difficult to find its gaps and achieve a comprehensive understanding of telemedicine as a whole. To date, systematic reviews and guidelines have concentrated on specific telemedicine applications. There is no overview of the current situation regarding systematic reviews of telemedicine.

→What this article adds:

This study presents comprehensive data about telemedicine. Telerehabilitation, tele-diabetes, and telecardiology were studied further. Furthermore, some specific specialties such as teleradiology, telepathology, and telepediatric should be considered more. Studies were focused on clinical outcomes, followed by cost-effectiveness and user satisfaction.

providers to the patients living in geographically disparate locations, thereby increasing access to specialty and expert care (2). Telemedicine is used for various purposes, including prevention, diagnosis, consultation, evaluation, monitoring, mentoring, treatment, follow-up, and patient rehabilitation (3, 4). Telemedicine has been classified into several categories, including telepsychiatry, teledermatology, teleradiology, telepathology, telerehabilitation, and tele-education, which provide a wide range of care services (5, 6). Telepathology is a telemedicine application involving the practice of pathology at a distance using video imaging visualizations and telecommunications rather than viewing a specimen directly through a microscope (7). Teleradiology is the transmission of radiological patient images (e.g., X-rays, CT, and MRI) at a distance for diagnostic or consultative purposes (8). Telerehabilitation is a rehabilitation service used in cardiology, neurology, and orthopedics, which is delivered at a distance (9, 10).

Telemedicine plays a key role in healthcare systems as it makes the provision of healthcare services more accessible, especially in rural communities (11). Therefore, the use of telemedicine has significantly increased in recent years, and statistics suggest that telemedicine studies have increased continuously from 56 cases in 1992 to 3,861 studies in 2015 with a fluctuating trend (12, 13). Along with the growing number of original studies in telemedicine, systematic reviews have substantially increased over the past years, focusing on specific aspects of telemedicine. For instance, a systematic review evaluated telepsychiatry in terms of the prevalence and quality of asynchronous telepsychiatry and identified the areas in which more research was required (14). Another systematic review in this regard assessed user satisfaction with teledermatology services (15), and in another similar study, the published articles on telepathology projects were reviewed and compared in several aspects (16).

The number of studies regarding telemedicine has increased dramatically within the past decades, although the most interesting fields of telemedicine and their effectiveness have not been specified for systematic reviewers. There is still no credible evidence on the extended use of telemedicine in various fields, and its clinical, economic, and satisfaction benefits have not been generally considered (17, 18). So by the increased number of publications in the field of telemedicine, it becomes difficult to find its gaps and achieve a comprehensive understanding of telemedicine as a whole. Therefore, a systematic review regarding these studies could inform researchers about the trend of using telemedicine and bridge the gaps while also identifying the outcomes and priorities to evaluate the effectiveness of telemedicine systematic reviews. A study was performed with this purpose in 2010, reviewing the telemedicine systematic reviews published until the end of 2009 and identifying 55 systematic reviews, which indicated that most of the systematic reviews in this regard were focused on general outcomes such as feasibility and clinical, economic, and satisfaction outcomes. Furthermore, home telecare, telecardiology, telepsychiatry were the most interesting specialty fields in these systematic

reviews (19).

Given the progress in information and communication technologies and the advancement in internet access, the use of telemedicine has accelerated significantly in the past decade. Moreover, the growing use of telemedicine has increased the number of articles in this regard. Therefore, studies are required to inspect the changes and progress trends in telemedicine research since the past decade (20, 21). The present study aimed to systematically review the review studies focused on telemedicine to identify the year of the studies, specialty of telemedicine, clinical/cost-effectiveness, and satisfaction outcomes.

Methods

Search Strategy

This review study was performed via searching in the PubMed database in June 2020 to retrieve the articles published from January 2010 to June 2020 using only the “telemedicine” Mesh term. Approximately 80–90% of studies conducted in the field of telemedicine were accessible in the PubMed database (22). The search was limited to systematic reviews, English articles, and studies on human subjects.

Inclusion Criteria

The inclusion criteria were the systematic reviews investigating telemedicine services that use telecommunication technologies such as telephone, videoconferencing, and the short messaging service (SMS) to set mutual communication between patients and healthcare providers for the provision/receiving healthcare services, as well as to foster interactions between healthcare providers for medical consultation.

Exclusion Criteria

Scoping reviews, narrative reviews, conference abstracts, articles without published abstracts, and the article without an available full text were excluded.

Article Selection

The search results were analyzed in the EndNote X9 bibliographic software. The titles and abstracts of the retrieved articles were screened by three authors (S. G., N. J., and S.G.) independently, and disagreements were resolved by consulting the other authors (S. H and K.B). In the next step, the full texts of the selected articles were screened by the same three authors, and the final list of the selected articles was prepared.

Data Extraction

Data were extracted from the selected articles by three authors (S. G., N. J., and S. G.) independently, including the name of the first author, the country, and year of publication, telemedicine specialty, clinical outcomes, cost-effectiveness outcomes, and satisfaction outcomes.

Statistical Analysis

Data analysis was performed using descriptive statistics such as frequency and frequency percent.

Results

In total, 746 articles were retrieved from the search in the PubMed database. After reviewing the titles and abstracts, 483 articles were excluded as they did not meet the inclusion criterion. Following that, the full texts of 263 articles were reviewed, and 72 articles were excluded as they were focused on non-telemedicine issues. Finally, 191 articles were selected based on the predetermined inclusion criterion (Fig. 1). The list of the selected articles and their data is shown in Appendix 1.

Countries

Most of the studies were conducted in the United States (n=44; 23.0%), Australia (n=35; 18.3%), United Kingdom (n=21; 10.9%), Canada (n=14; 7.3%), and China (n=11; 5.7%), and the remaining studies were distributed in other countries in smaller numbers (Fig. 2).

Year of Publication

Most of the studies were published in 2018 (n=43; 22.5%), 2017 (n=36; 18.8%), 2016 (n=24; 12.5%), 2015 (n=22; 11.5%), 2019 (n=15; 7.8%), and 2014 (n=15; 7.8%) (Fig. 3).

Telemedicine Specialty

Most of the studies were focused on general telemedicine (n=35; 18.3%), followed by telerehabilitation (n=22; 11.5%), tele-diabetes care (n=18; 9.4%), telecardiology (n=16; 8.3%), home telecare (n=13; 6.8%), telepsychiatry (n=12; 6.3%), teledermatology (n=11; 5.7%), and teleneurology (n=9; 4.7%) (Table 1).

Among the reviewed studies, 166 cases (86.9%) had reviewed articles using at least three different evaluation methods (clinical, economic, and satisfaction outcomes), and 25 cases (13.0%) had been focused on other out-

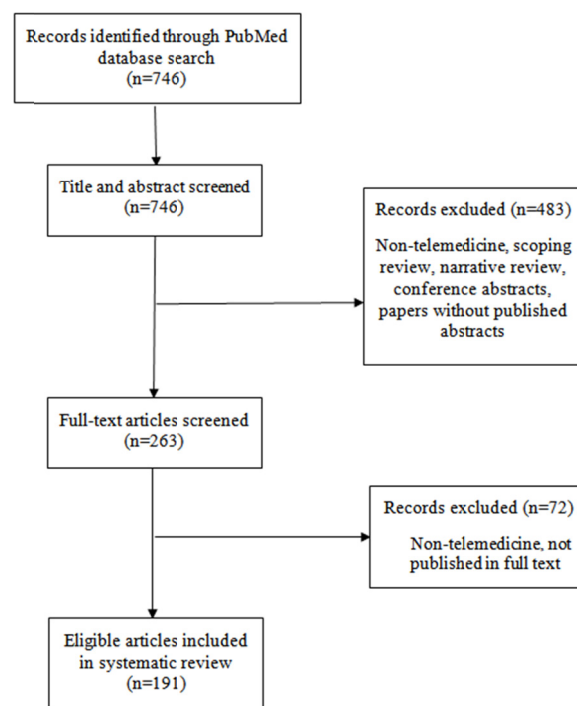


Fig. 1. PRISMA Flow Chart of Data Collection and Analysis

comes, such as wait/travel times, specialist referral rates, and emergency department visits. In addition, some of the studies were qualitative. Most of the studies also involved the specialty assessment of clinical outcomes (n=139; 72.7%), cost-effectiveness (n=62; 32.4%), and user satisfaction (n=56; 29.3%).

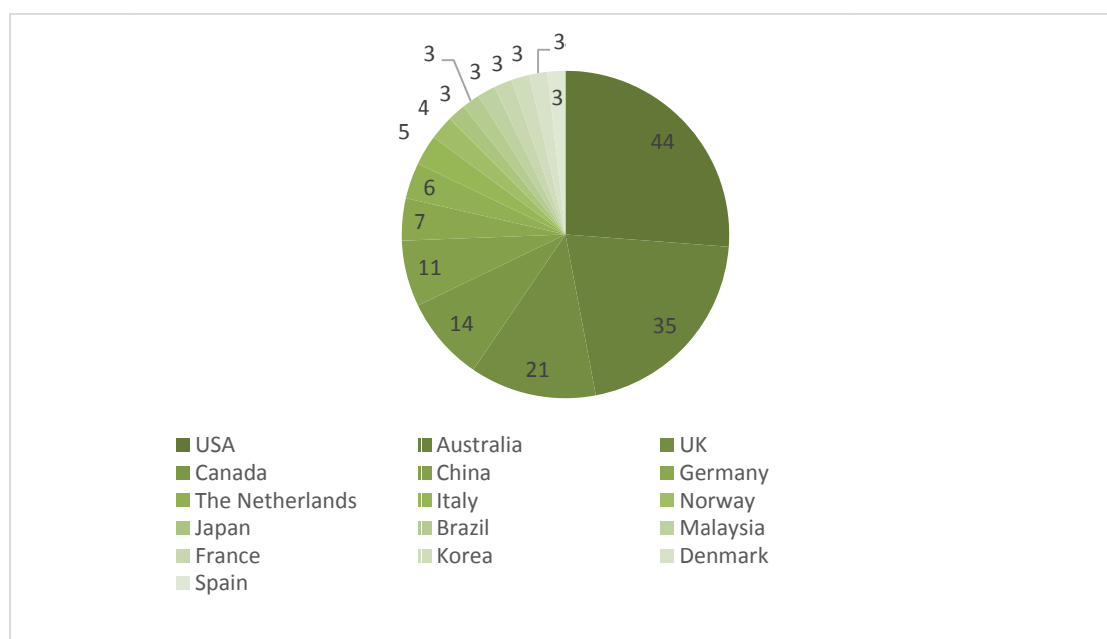


Fig. 2. Countries Involved in Telemedicine Systematic Reviews (n=191)

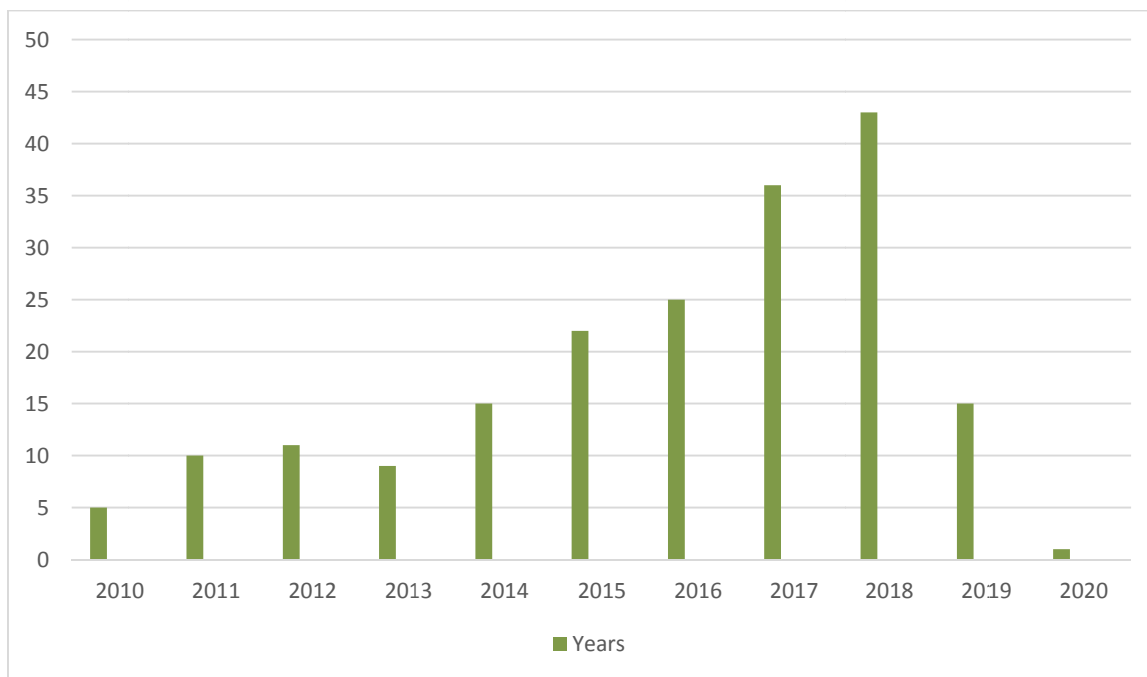


Fig. 3. Year of Publication

Table 1. Number of Specialty and Evaluation Outcomes for Each one

| Specialty | Number of Systematic Reviews* | Outcomes | | |
|----------------------|-------------------------------|--------------------|--------------------|-------------------|
| | | Clinical | Cost-effectiveness | Satisfaction |
| Telemedicine | 35 | 21 | 14 | 14 |
| Telerehabilitation | 22 | 20 | 3 | 7 |
| Tele-diabetes Care | 18 | 15 | 3 | 1 |
| Telecardiology | 16 | 13 | 6 | 1 |
| Home Telecare | 13 | 8 | 7 | 2 |
| Telepsychiatry | 12 | 9 | 4 | 5 |
| Teledermatology | 11 | 4 | 5 | 4 |
| Teleneurology | 9 | 7 | 2 | 3 |
| Telepulmonary | 8 | 8 | 1 | 1 |
| Teledentistry | 6 | 4 | 3 | 2 |
| Tele-ICU | 6 | 4 | 2 | 3 |
| Tele-emergency | 6 | 4 | 2 | 1 |
| Tele-oncology | 4 | 3 | 0 | 2 |
| Telegeriatrics | 4 | 2 | 3 | 2 |
| Tele-palliative Care | 3 | 3 | 2 | 1 |
| Teleaudiology | 3 | 0 | 1 | 2 |
| Telepharmacy | 3 | 3 | 1 | 1 |
| Teleophthalmology | 2 | 2 | 1 | 1 |
| Telegastrointestinal | 2 | 2 | 0 | 1 |
| Telerheumatology | 2 | 2 | 1 | 1 |
| Telesurgery | 1 | 1 | 1 | 0 |
| Teleradiology | 1 | 1 | 0 | 0 |
| Telepathology | 1 | 1 | 0 | 0 |
| Teleobstetrics | 1 | 1 | 0 | 1 |
| Teleneurology | 1 | 1 | 0 | 0 |
| Tele-education | 1 | 0 | 0 | 0 |
| Total | 191 | 139 (72.7%) | 62 (32.4%) | 56 (29.3%) |

*Number of systematic reviews on each specialty not equal to sum of three outcomes as some studies evaluated more than one outcome.

Outcomes and Their Results

According to our findings, the telemedicine systematic reviews had mostly evaluated articles in terms of clinical outcomes (n=139), identifying clinical outcomes such as mortality and morbidity, quality of life, treatment progress, reduction of pain symptoms, and improved disease symptoms. Among 139 articles that assessed clinical outcomes, 101 (72.5%) studies were effective, 22 (15.8%)

were unclear, 15 (10.8%) were similar, and one study (0.7%) was ineffective. In addition, 62 studies assessed telemedicine systematic reviews from an economic perspective, mostly reporting that economic outcomes were cost-effective (n=42; 67.7%) and unclear (n=20; 32.2%). As for the assessment of satisfaction outcomes (n=56; 29.3%), most of the telemedicine systematic reviews (n=47; 83.9%) indicated that patients and healthcare pro-

Table 2. Assessed Outcomes and Their Results in Reviewed Studies

| Outcomes Result | Clinical N (%) | Cost-effectiveness N (%) | Satisfaction N (%) |
|-------------------------|-------------------|-----------------------------|-----------------------|
| Effective | 101 (72.5) | 42 (67.7) | 47 (83.9) |
| Unclear | 22 (15.8) | 20 (32.2) | 9 (16.1) |
| Similar (no difference) | 15 (10.8) | 0 | 0 (0) |
| Ineffective | 1 (0.7) | 0 | 0 (0) |
| Total | 139 | 62 | 56 |

viders were satisfied with using telemedicine services in multiple aspects, while the results were reported to be unclear in some cases (n=9; 16.1%) (Table 2).

Discussion

The number of studies regarding telemedicine has increased dramatically within the past decades. The systematic reviews on telemedicine have been conducted in various fields, mostly investigating general aspects such as telerehabilitation, tele-diabetes care, telecardiology, home telecare, and telepsychiatry. In most of these reviews, the primary objectives were to evaluate clinical outcomes, cost-effectiveness, and user satisfaction.

In the present study, we reviewed 35 systematic reviews focused on the general aspects of telemedicine. The most important reason for the large number of the studies was that most of the studies were focused on the general services and aspects of telemedicine (23-27). Telemedicine specialty was unclear in some cases (28, 29), and some of the studies were conducted on more than one specialty (30, 31); therefore, we also considered the general areas of telemedicine. Many of the studies regarding these general fields have indicated that telemedicine is a state-of-the-art technology (32), while its ambiguities have rarely been addressed (33).

Telerehabilitation is a novel field of study, and most of the investigations in this regard have been focused on telerehabilitation in neurological diseases, such as stroke and multiple sclerosis (MS). Stroke and MS are the most common cause of neurological disability in the community (34, 35). Telerehabilitation could effectively manage neurological issues beyond the clinical settings and provide equal access to patients who are geographically remote from their healthcare providers (36).

According to the current review, 18 systematic reviews were focused on tele-diabetes care. Diabetes is a chronic disease with a high prevalence rate and a leading cause of disability and death worldwide. The global prevalence of diabetes has nearly doubled since 1980, increasing from 108 million cases in 1980 to 422 million cases in 2014 (37), while the rate is predicted to reach 592 million by 2035 (38), making it difficult for diabetic patients to access specialized services, regular monitoring, and individualized treatment (39). Tele-diabetes services could efficiently improve access to healthcare clinicians and may even complete medical management since they could improve early-stage diagnosis, monitor disease progression, and promote disease management (40, 41). In general, telemedicine could remarkably contribute to diabetic patients by improving healthcare access, diagnosis, educa-

tion, consultation, and clinical outcomes (42, 43).

Telecardiology was the fourth most common focus in the reviewed studies, which was quite predicted considering that cardiovascular diseases have recently become a leading death worldwide, contributing to 17.3 million deaths per year (20). Studies have indicated that telecardiology could effectively decrease all-cause mortality, heart failure mortality, and hospitalization. Therefore, it has received special attention, and several studies have investigated telecardiology (44, 45).

Technology can play a great role in the care of people at home in many ways, and home telecare is one the most growing sector of health care (46), which is mostly applicable in chronic diseases, such as pulmonary and cardiovascular disorders. A study in this regard investigated heart failure telemonitoring, showing that telemonitoring could significantly reduce heart failure mortality (47). Therefore, home telecare technologies have great potential to increase access to healthcare services and improve the quality of care, particularly in the case of chronically ill patients (48).

In the present study, 13 systematic reviews were identified in the field of telepsychiatry. Mental disorders cover a wide range including depression, anxiety, panic disorder, phobias, and obsessive-compulsive disorder. Telepsychiatry could improve these disorders by various methods, such as consultation, training, and increasing physical activity, which may in turn decrease anxiety and depression (6, 49). The results of a systematic review in the field of telemedicine in 2010 are consistent with our findings. The mentioned study also indicated that telemedicine, home telecare, telecardiology, and telepsychiatry were the most compelling fields of research (19).

Only one systematic review was focused on teleradiology, and telepathology, and no studies reviewed telepediatrics. Teleradiology, telepathology, and telepediatrics have been reported to be the most popular, successful, and widely used clinical telemedicine specialties in recent years (50-53). The limited investigations in such specialties of telemedicine may have several reasons. First, telemedicine requires cutting-edge technology and costly equipment to provide healthcare services. Second, the low prevalence of some diseases may not urge the use of telemedicine for patient management. Third, no systematic reviews could be found for these specialties in the PubMed database. Therefore, it is suggested that researchers conduct more systematic reviews on subjects such as telepathology, teleradiology, and telepediatrics.

According to the study by Hersh et al., the review of clinical outcomes is essential to assessing the effectiveness of telemedicine (54). The clinical outcomes of tele-

medicine services in 72.6% of the reviewed studies were positive, while in 15.8% of the cases, the results of these outcomes were unclear. The lack of clarity in clinical outcome results due to low-quality evidence, which highlights the need to identify the clinical effectiveness of telemedicine (55-57). Moreover, some of the reviewed studies in the current research were only reports, not clarifying the effectiveness aspect, which could be due to the lack of research or significant disparities in the existing studies (23, 58). One study showed that telemedicine has no effects on clinical outcomes (59, 60). The effects of telemedicine depend on several factors, such as telemedicine duration, user adherence rate to the provided services, type of the intervention, and study design (61). In addition, clinical outcomes are influenced by patient-related factors such as age, education level, income status, type of disease, and medication complexity (62).

According to our findings, most of the studies demonstrated that telemedicine could reduce some treatment costs (but not entirely). In total, 20 studies also showed that the cost-effectiveness of telemedicine was unclear, which could be due to the limitations of the economic evaluations of telemedicine, lack of randomized controlled trials, small sample sizes, and absence of quality data and appropriate measures (63, 64). Economic evaluations provide data on the efficiency of telemedicine and clarify the advantages of telemedicine technology compared to face-to-face healthcare services (65).

In the current review, 56 studies assessed the satisfaction of patients and healthcare providers with telemedicine applications, mostly indicating user satisfaction with telemedicine. Assessing the satisfaction aspects of clients and clinicians significantly affects telemedicine outcomes and may enhance the treatment of patients and care delivery as well (66, 67).

According to the current review, the number of studies regarding telemedicine has increased (especially in the past decade), and most of these articles have been published in the United States and Australia. Notably, these high-income countries have widely dispersed populations and are the pioneers of telemedicine implementation (68). Furthermore, they have specific rules and regulations about telemedicine. Although telemedicine could be an effective approach to receiving health services in developing countries, telemedicine studies are still limited in these countries (69, 70).

To the best of our knowledge, this was the first comprehensive review of the systematic reviews regarding telemedicine. Some of the limitations of our study were that we only searched the PubMed database that might have missed some relevant studies. In addition, only English articles were included in this study. We did not access the full text of seven articles, and they had to be excluded from the study which led to a gap in the number of the relevant studies that may have provided further findings.

Conclusion

In this review study, 191 articles were identified regarding telemedicine interventions. Although telerehabilitation, tele-diabetes, telecardiology, home telecare, and

telepsychiatry were studied further, there are still some specific specialties such as teleradiology, telepathology, and telepediatric that should be considered more. Our study also indicates that clinical, cost-effectiveness, and satisfaction were three major criteria to assess the effect of telemedicine services. As the telemedicine field is rapidly growing, further investigations in this regard could undoubtedly improve telemedicine applications and encourage potential telemedicine providers to initiate these services.

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Conflict of Interests

The authors declare that they have no competing interests.

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Appendix 1. The list of the selected articles and their data

| Author | Year | Country | Specialty | Clinical Outcomes | Cost_ effectiveness Outcomes | Satisfaction Outcomes |
|------------------------------|------|------------------|----------------------|--------------------|------------------------------|-----------------------|
| Aldossary, et al.(1) | 2016 | Australia | Telemedicine | Yes, Unclear | Yes, Unclear | Yes, Unclear |
| Santos Alves, et al.(2) | 2019 | Brazil | Telegastrointestinal | Yes, Effective | No | No |
| Amatya, et al.(3) | 2014 | Australia | Telerehabilitation | Yes, Unclear | No | Yes, Unclear |
| Appleby, et al.(4) | 2019 | Australia | Telerehabilitation | Yes, Effective | No | Yes, Effective |
| Backhaus, et al.(5) | 2012 | USA | Telepsychiatry | Yes, Effective | No | Yes, Effective |
| Banbury, et al.(6) | 2018 | Australia | Home Telecare | Yes, Effective | No | No |
| Baron, et al.(7) | 2012 | UK | Tele-diabetes care | Yes, Unclear | No | No |
| Bashi, et al.(8) | 2017 | Australia | Telecardiology | Yes, Effective | No | No |
| Bashshur, et al.(9) | 2016 | USA | Telemedicine | No | Yes, Effective | No |
| Batastini, et al.(10) | 2016 | USA | Telepsychiatry | No | No | No |
| Batsis, et al.(11) | 2019 | Germany | Tele-emergency | No | No | No |
| Berryhill, et al.(12) | 2019 | USA | Telepsychiatry | Yes, Effective | No | No |
| Bittner, et al.(13) | 2015 | USA | Telerehabilitation | Yes, Effective | No | Yes, Effective |
| Blank, et al.(14) | 2012 | UK | Telemedicine | No | No | No |
| Bolton, et al.(15) | 2011 | UK | Home Telecare | Yes, Effective | Yes, Effective | No |
| Brearily, et al.(16) | 2017 | USA | Teleneurology | Yes, Effective | No | No |
| Brons, et al.(17) | 2018 | Netherlands | Telecardiology | No | No | No |
| Bruce, et al.(18) | 2018 | USA | Teledermatology | No | No | No |
| Bueckers, et al.(19) | 2017 | Belgium | Telepulmonary | Yes, Effective | No | No |
| Bush, et al.(20) | 2016 | Kenya | Telerehabilitation | Yes, Effective | Yes, Unclear | Yes, Effective |
| Carrasqueiro, et al.(21) | 2011 | Portugal | Telemedicine | Yes, Unclear | No | Yes, Unclear |
| Chen, et al.(22) | 2015 | China | Telerehabilitation | Yes, Effective | No | No |
| Chen, et al.(23) | 2017 | China | Tele-ICU | Yes, Effective | Yes, Effective | No |
| Chi, et al.(24) | 2015 | USA | Telemedicine | Yes, Effective | Yes, Effective | Yes, Effective |
| Chipp(25) | 2012 | South Africa | Telepsychiatry | Yes, Effective | Yes, Effective | Yes, Effective |
| Chongmelaxme(26) | 2018 | Malaysia | Telepulmonary | Yes, Effective | No | No |
| Chow, et al.(27) | 2019 | Germany | Teledermatology | No | Yes, Effective | Yes, Effective |
| Chuchu, et al.(28) | 2018 | Cochrane Library | Teledermatology | Yes, Unclear | no | No |
| Cottrell, et al.(29) | 2017 | Australia | Telerehabilitation | Yes, Effective | No | No |
| Cox, et al.(30) | 2017 | UK | Tele-oncology | Yes, Effective | No | No |
| Cruz, et al.(31) | 2014 | Portugal | Home telecare | No | No | Yes, Effective |
| Cruz, et al.(32) | 2014 | Canada | Home telecare | Yes, Effective | Yes, Effective | No |
| Daniel, et al.(33) | 2013 | Shelby | Teledentistry | Yes, Effective | Yes, Effective | Yes, Effective |
| De la Torre-Díez, et al.(34) | 2015 | Spain | Telemedicine | No | Yes, Effective | No |
| De Waure, et al.(35) | 2012 | Italy | Telecardiology | Yes, Effective | No | No |
| Dietz, et al.(36) | 2019 | USA | Telepathology | Yes, Effective | No | No |
| Downes, et al.(37) | 2017 | Australia | Telemedicine | No | No | No |
| Du Toit, et al.(38) | 2017 | Australia | Tele-emergency | Yes, Effective | No | No |
| Edirippulige, et al.(39) | 2013 | Australia | Telemedicine | No | Yes, Effective | Yes, Effective |
| Ekelanda, et al.(40) | 2010 | UK | Telemedicine | Yes, Effective | Yes, Effective | Yes, Effective |
| Endler, et al.(41) | 2019 | Sweden | Teleobstetrics | Yes, Effective | No | Yes, Effective |
| Erridge, et al.(42) | 2019 | UK | Telesurgery | Yes, No difference | Yes, Unclear | No |
| Estai, et al.(43) | 2016 | Australia | Teledentistry | Yes, Effective | No | No |
| Estai, et al.(44) | 2017 | Australia | Teledentistry | No | Yes, Unclear | No |
| Farnia, et al.(45) | 2018 | France | Telecardiology | Yes, Unclear | Yes, Unclear | No |
| Faruque, et al. (46) | 2017 | Canada | Tele-diabetes care | Yes, Effective | No | No |
| Finnane, et al. (47) | 2016 | Australia | Teledermatology | Yes, Effective | No | Yes, Effective |
| French, et al.(48) | 2013 | UK | Teleneurology | No | No | No |
| Fuentes-Guiro', et al.(49) | 2016 | Spain | Teledermatology | No | Yes, Unclear | No |
| Fusaro, et al.(50) | 2019 | USA | Tele-ICU | Yes, Effective | No | No |
| Garg, et al.(51) | 2011 | USA | Telemedicine | No | No | No |
| Gentry, et al.(52) | 2018 | USA | Telemedicine | Yes, No difference | No | Yes, Effective |
| Gentry, et al.(53) | 2018 | USA | Telepsychiatry | No | Yes, Unclear | Yes, Effective |
| Gorst, et al.(54) | 2014 | UK | Home telecare | No | No | No |
| Gregersen, et al.(55) | 2016 | Denmark | Telepulmonary | Yes, Unclear | No | No |
| Grona, et al.(56) | 2017 | Canada | Teleneurology | Yes, Effective | Yes, Effective | Yes, Effective |
| Guise, et al. (57) | 2014 | Norway | Telemedicine | Yes, Unclear | No | No |
| Gunter, et al.(58) | 2016 | Australia | Telemedicine | Yes, Effective | Yes, Effective | Yes, Effective |
| Hailey, et al.(59) | 2011 | Canada | Telerehabilitation | Yes, Effective | No | No |
| Hameed, et al.(60) | 2014 | Austria | Telecardiology | No | Yes, Effective | No |
| Hancock, et al.(61) | 2019 | UK | Tele-palliative care | Yes, Unclear | Yes, Effective | No |
| Hanlon, et al.(62) | 2017 | UK | Telemedicine | Yes, Effective | No | No |
| Harst, et al.(63) | 2019 | Germany | Telemedicine | No | No | Yes, Effective |
| Hasselberg, et al.(64) | 2014 | South Africa | Telemedicine | Yes, Effective | No | Yes, Effective |
| Helsel, et al.(65) | 2018 | USA | Telegastrointestinal | Yes, Effective | No | Yes, Effective |

Appendix 1. Ctd

| Author | Year | Country | Specialty | Clinical Outcomes | Cost_ effectiveness Outcomes | Satisfaction Outcomes |
|-----------------------------------|------|-----------------|----------------------|--------------------|------------------------------|-----------------------|
| Hong, et al.(66) | 2018 | Korea | Telepulmonary | Yes, Effective | No | No |
| Hu, et al.(67) | 2018 | China | Tele-diabetes care | Yes, Effective | No | No |
| Huang, et al.(68) | 2018 | Taiwan | Telemedicine | Yes, Effective | No | No |
| Huang, et al.(69) | 2015 | China | Telerehabilitation | Yes, No difference | Yes, Unclear | No |
| Hubers, et al.(70) | 2011 | Netherlands | Tele-emergency | Yes, Effective | No | No |
| Hwang, et al.(71) | 2015 | Australia | Telerehabilitation | Yes, No difference | No | No |
| Meurer,et al.(72) | 2015 | Australia | Teledentistry | Yes, Unclear | No | No |
| Irving,et al.(73) | 2017 | Australia | Teledentistry | Yes, Effective | Yes, Effective | Yes, Effective |
| Ito, et al.(74) | 2017 | Japan | Telemedicine | No | No | No |
| Jayakody, et al.(75) | 2016 | Australia | Telemedicine | Yes, Unclear | No | No |
| Jess,et al.(76) | 2019 | Denmark | Tele-palliative care | Yes, Unclear | Yes, Effective | No |
| Jhaveri,et al.(77) | 2015 | Australia | Telemedicine | Yes, Unclear | No | No |
| Jiang, et al.(78) | 2017 | Japan | Telepsychiatry | Yes, Effective | No | No |
| Jiang, et al.(79) | 2016 | China | Telerehabilitation | Yes, Effective | No | No |
| Tim Johansson, et al.(80) | 2010 | Austria | Telerehabilitation | Yes, Effective | No | Yes, Effective |
| Tomoko, et al.(81) | 2014 | Japan | Home telecare | Yes, Effective | No | No |
| Kane-Gill, et al. (82) | 2017 | US | Telepharmacy | Yes, Effective | Yes, Effective | No |
| Aikaterini, et al.(83) | 2017 | UK | Telecardiology | Yes, Effective | No | No |
| Kepplinger, et al.(84) | 2016 | Germany | Teleneurology | Yes, Effective | No | No |
| Fary khan, et al. (85) | 2015 | Australia | Telerehabilitation | Yes, Unclear | No | Yes, Unclear |
| Khanal, et al. (86) | 2015 | Nepal | Telemedicine | No | No | No |
| Kitsiou, et al. (87) | 2013 | Canada | Home telecare | No | No | No |
| Kitsiou, et al.(88) | 2015 | USA | Home telecare | Yes, Effective | Yes, Unclear | No |
| Klersy, et al. (89) | 2016 | Italy | Telecardiology | Yes, Effective | Yes, Effective | No |
| Koblauch, et al. (90) | 2016 | Denmark | Telepsychiatry | Yes, Unclear | No | No |
| Kotb, et al. (91) | 2015 | Canada | Telecardiology | Yes, Effective | No | No |
| Kraft, et al. (92) | 2017 | Germany | Teleneurology | Yes, Unclear | No | No |
| Kruse, et al. (93) | 2016 | USA | Telemedicine | Yes, Effective | Yes, Effective | Yes, Effective |
| Kumar, et al. (94) | 2015 | USA | Telemedicine | No | Yes, Effective | No |
| Larson, et al. (95) | 2018 | USA | Tele-oncology | Yes, Effective | No | No |
| Laver, et al. (96) | 2020 | Australia | Telerehabilitation | Yes, No difference | No | Yes, Unclear |
| Lee, et al. (97) | 2018 | Malaysia | Tele-diabetes care | No | Yes, Effective | No |
| Lee, et al. (98) | 2018 | Canada | Telecardiology | Yes, No difference | No | No |
| Lee, et al. (99) | 2018 | UK | Tele-diabetes care | Yes, Effective | No | No |
| Lee, et al. (100) | 2017 | Malaysia | Tele-diabetes care | Yes, Effective | No | No |
| Ling Li, et al. (101) | 2018 | China | Tele_ICU | No | No | Yes, Effective |
| Liddy, et al. (102) | 2018 | Canada | Telemedicine | Yes, Effective | Yes, Effective | Yes, Effective |
| Lin, et al. (103) | 2017 | China | Telecardiology | Yes, Effective | No | No |
| Liptrot , et al.(104) | 2017 | UK | Tele-oncology | Yes, Effective | No | Yes, Effective |
| Lo´pez-Villegas, et al.(105) | 2015 | Norway | Telecardiology | Yes, Effective | Yes, Effective | No |
| Lu, et al. (106) | 2018 | USA | Telemedicine | Yes, Effective | No | Yes, Effective |
| Lundell, et al. (107) | 2015 | Sweden | Telepulmonary | Yes, Effective | No | No |
| Li Luo, et al. (108) | 2017 | China | Teleneurology | Yes, Effective | No | No |
| Luxton, et al. (109) | 2010 | USA | Telepsychiatry | No | No | No |
| Mackintosh, et al. (110) | 2016 | UK | Telemedicine | Yes, Effective | Yes, Unclear | No |
| Marcolino, et al. (111) | 2013 | The Netherlands | Tele-diabetes care | Yes, Effective | No | No |
| Marcolino, et al. (112) | 2019 | The Netherlands | Telecardiology | Yes, Effective | No | No |
| Marin`o, et al. (113) | 2013 | Australia | Teledentistry | No | No | No |
| Marsh-Feiley, et al. (114) | 2018 | United Kingdom | Teleradiology | Yes, Effective | No | No |
| Martin, et al. (115) | 2017 | Australia | Tele-education | No | No | No |
| chiara, et al. (116) | 2018 | Italy | Tele-oncology | No | No | Yes, Unclear |
| McDougall, et al. (117) | 2017 | USA | Telerheumatology | Yes, Effective | Yes, Unclear | No |
| McGill, et al. (118) | 2017 | USA | Teleaudiology | No | No | Yes, Effective |
| Tzeyu L. Michaud, et al.(119) | 2018 | USA | Home telecare | No | Yes, Effective | No |
| Ming, et al. (120) | 2016 | UK | Tele-diabetes care | Yes, Unclear | No | No |
| Mistry. (121) | 2012 | UK | Telemedicine | No | Yes, Unclear | No |
| Molini-Avejonas, et al.(122) | 2015 | Brazil | Teleaudiology | No | Yes, Effective | Yes, Effective |
| Moreira, et al. (123) | 2014 | Brazil | Telepharmacy | Yes, Unclear | No | No |
| Mounessa, et al. (124) | 2017 | USA | Teledermatology | No | No | Yes, Effective |
| Murphie, et al. (125) | 2017 | UK | Telepulmonary | Yes, Effective | Yes, Unclear | Yes, Effective |
| Nadar, et al. (126) | 2018 | Canada | Telemedicine | Yes, Unclear | No | No |
| Nair, et al. (127) | 2018 | Australia | Telepsychiatry | Yes, Unclear | No | No |
| Narasimha, et al.(128) | 2017 | USA | Telegeriatrics | No | Yes, Unclear | Yes, Effective |
| Nordheim, et al. (129) | 2014 | Norway | Tele-diabetes care | Yes, No difference | No | No |
| Nordio, et al. (130) | 2018 | Italy | Telerehabilitation | No | No | No |
| Debra Parker Oliver , et al.(131) | 2012 | USA | Telemedicine | Yes, No difference | No | No |
| Orlando , et al.(132) | 2019 | Australia | Telemedicine | No | No | Yes, Effective |

Appendix 1. Ctd

| Author | Year | Country | Specialty | Clinical Outcomes | Cost_ effectiveness Outcomes | Satisfaction Outcomes |
|------------------------------|------|-------------|----------------------|--------------------|------------------------------|-----------------------|
| Owensworth, et al. (133) | 2018 | Australia | Telerehabilitation | Yes, Effective | No | No |
| Pandor, et al. (134) | 2013 | England | Home telecare | Yes, Effective | Yes, Effective | No |
| Pastora-Bernal, et al.(135) | 2017 | Spain | Telerehabilitation | Yes, Effective | No | No |
| Pedone, et al.(136) | 2015 | Poland | Telepulmonary | Yes, Effective | No | No |
| Peeters, et al. (137) | 2011 | Netherland | Home telecare | No | Yes, Unclear | No |
| Pekmezaris, et al. (138) | 2018 | USA | Home telecare | Yes, Effective | No | No |
| Peretz, et al. (139) | 2018 | Canada | Telegeriatrics | No | Yes, Unclear | No |
| Piga, et al. (140) | 2017 | Italy | Telerheumatology | Yes, Effective | No | Yes, Effective |
| Proctor, et al. (141) | 2018 | UK | Telepsychiatry | Yes, Effective | No | No |
| Purcell, et al. (142) | 2014 | Australia | Telecardiology | Yes, Effective | Yes, Effective | No |
| Radhakrishnan, et al.(143) | 2016 | USA | Home telecare | Yes, Effective | Yes, Effective | Yes, Effective |
| Ramnath, et al.(144) | 2014 | USA | Tele-ICU care | Yes, Effective | Yes, Effective | Yes, Effective |
| Raphael, et al. (145) | 2016 | New Zealand | Telegeriatrics | Yes, Effective | No | Yes, Unclear |
| Rasekaba, et al. (146) | 2015 | Australia | Tele-diabetes care | Yes, No difference | No | No |
| Rawstorn, et al. (147) | 2016 | New Zealand | Telerehabilitation | Yes, Effective | No | No |
| Ricci-Cabello, et al.(148) | 2019 | Canada | Telecardiology | No | No | No |
| Rietdijk, et al. (149) | 2012 | Australia | Teleneurology | Yes, Effective | No | Yes, Effective |
| Rogers, et al. (150) | 2017 | USA | Tele-emergency | Yes, Effective | Yes, Unclear | No |
| Rubin, et al. (151) | 2013 | USA | Teleneurology | No | Yes, Effective | No |
| Rubin, et al. (152) | 2013 | USA | Telerehabilitation | No | No | Yes, Effective |
| Rush, et al. (153) | 2018 | Canada | Telemedicine | Yes, Effective | No | Yes, Effective |
| Saleh, et al. (154) | 2018 | USA | Telemedicine | Yes, Effective | Yes, Effective | No |
| Salmoiraghi, et al. (155) | 2015 | UK | Telepsychiatry | Yes, Effective | Yes, Effective | Yes, Effective |
| Sarfo, et al. (156) | 2017 | Ghana | Teleneurology | Yes, No difference | No | Yes, Effective |
| Sarfo , et al.(157) | 2018 | Ghana | Telerehabilitation | Yes, No difference | No | No |
| Scott Kruse, et al. (158) | 2018 | USA | Telemedicine | No | No | No |
| Shi , et al. (159) | 2015 | China | Tele-diabetes care | Yes, Effective | No | No |
| Shukla , et al. (160) | 2017 | India | Telerehabilitation | Yes, Effective | No | No |
| Snoswell, et al. (161) | 2016 | Australia | Teledermatology | No | Yes, Effective | No |
| So, et al. (162) | 2018 | Korea | Tele-diabetes care | Yes, Effective | No | No |
| Speyer, et al. (163) | 2018 | Australia | Tele-diabetes care | Yes, No difference | Yes, Effective | No |
| Strnad, et al. (164) | 2018 | USA | Telepharmacy | Yes, Effective | No | Yes, Effective |
| Su, et al. (165) | 2016 | USA | Tele-diabetes care | Yes, No difference | No | No |
| Suksomboon , et al.(166) | 2014 | Thailand | Tele-diabetes care | Yes, Effective | No | No |
| Sutherland, et al. (167) | 2018 | Australia | Telepsychiatry | Yes, No difference | Yes, Effective | Yes, Effective |
| Tan, et al. (168) | 2017 | Australia | teleophthalmology | Yes, Effective | No | No |
| Tao, et al. (169) | 2018 | Australia | Teleaudiology | No | No | No |
| Tchero, et al. (170) | 2017 | France | Tele-diabetes care | Yes, No difference | No | Yes, Effective |
| Tchero, et al. (171) | 2018 | France | Telerehabilitation | Yes, Effective | No | No |
| Thomas, et al.(172) | 2014 | Canada | Teleophthalmology | Yes, Effective | Yes, Effective | No |
| Trettel, et al. (173) | 2018 | Germany | Teledermatology | No | No | No |
| van den Berg, et al. (174) | 2012 | Germany | Telegeriatrics | Yes, Effective | Yes, Effective | No |
| Van Egmond, et al.(175) | 2018 | Netherland | Telerehabilitation | Yes, Effective | Yes, Effective | No |
| Verberk, et al. (176) | 2011 | England | Telecardiology | Yes, Effective | Yes, Unclear | No |
| Vyas, et al. (177) | 2017 | USA | Teledermatology | Yes, Effective | Yes, Effective | Yes, Unclear |
| Wade, et al. (178) | 2010 | Australia | Telemedicine | No | Yes, Effective | No |
| Wallace, et al. (179) | 2012 | UK | Teleneurology | Yes, Effective | No | No |
| Ward, et al. (180) | 2015 | USA | Tele-emergency | Yes, Effective | Yes, Unclear | Yes, Effective |
| Warshaw, et al. (181) | 2011 | USA | Teledermatology | Yes, Unclear | Yes, Effective | No |
| Wickramasinghe, et al. (182) | 2016 | Australia. | Tele-diabetes care | No | No | No |
| Wilcox, et al. (183) | 2012 | Canada | Telemedicine | Yes, Effective | No | No |
| Winburn , et al.(184) | 2018 | USA | Tele emergency | No | No | No |
| Wootton, et al. (185) | 2011 | Norway | Teledermatology | No | No | No |
| Young, et al. (186) | 2011 | USA | Tele-ICU | No | No | Yes, Effective |
| Young , et al.(187) | 2011 | USA | Tele-ICU | Yes, Unclear | No | No |
| Yun, et al. (188) | 2018 | Korea | Telecardiology | Yes, Effective | No | Yes, Unclear |
| Zhai, et al.(189) | 2014 | China | Tele-diabetes care | No | Yes, Unclear | No |
| Zhao, et al.(190) | 2015 | China | Telepulmonary | Yes, Ineffective | No | No |
| Zheng, et al. (191) | 2016 | USA | Tele-palliative care | Yes, Effective | No | Yes, Effective |

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