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REVIEW

Cost-Effectiveness of Telemedicine in Asia: A Scoping Review

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Background: In the area where there is a lack of medical experts, telemedicine gives a lot of benefits to deal with the distance and limited public infrastructure.

Objective: This study aimed to review the literature on the cost-effectiveness of telemedicine in Asian countries and possibly to provide recommendations on implementing telemedicine in this region.

Methods: Articles were independently screened in two selected databases (PubMed and EBSCO). The framework of patient, intervention, comparison, and outcome (PICO) was applied by considering Asian population, the intervention of telemedicine, current situation (without telemedicine) as the comparator, and cost per QALY gained as the major outcome.

Results: A total of 870 articles were identified from two databases: PubMed (n = 689 articles) and EBSCO (n = 181 articles). After removing 181 duplicates, 689 articles were screened by title and abstract, excluding 665 records. After the full-text screening on 24 articles, 8 articles were selected for further analysis. Various perspectives were applied in the included studies, such as societal, healthcare, and program perspectives. All studies applied different time horizons, such as 3-month, 25-year, 40-year, and lifetime. Among all included studies, several studies applied mathematical modeling.

Conclusion: The implementation of telemedicine in Asia can be a promising intervention since it can enhance the effectiveness of health services by saving time and travel costs. It also can reduce the overall costs of treatment, improve patients' quality of life, and expand access to essential health services.

Keywords: cost per QALY gained, economic evaluation studies, cost utility analysis, cost-effective, cost saving

Introduction

Over the last decade, the use of telemedicine has improved patients' health because both of patients and physicians are able to interact two ways and real-time via the internet.[1] The main objective of telemedicine is to provide equal access of healthcare to the users. In the area where there is a lack of medical experts, telemedicine gives a lot of benefits to deal with the distance and limited public infrastructure. In particular, it is also beneficial for mitigating crises or emergencies, including for mitigating the pandemic of coronavirus disease 2019 (COVID-19). It can provide information about the treatment of COVID-19 that can be accessed quickly and easily, as reported in Singapore.[2] In particular, its services have been rising in some countries in Asia, according to a previous study by Suzuki et al in 2016.[3] Because of the internet penetration and the shortage of physicians, the use of telemedicine in Thailand and Indonesia has been increasing significantly.[3]

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Despite the fact that telemedicine offers a lot of advantages, its services have not been fully integrated into the national healthcare systems.[2] The progress of this integration was reported to be very slow, specifically in Asian countries.[4] This situation might be caused by several complicated factors.[5,6] A limited number of trainings for clinicians to implement telemedicine also contribute to the barriers that still exist in the national healthcare system.[7] To deal with this situation, economic evaluations of telemedicine in Asia are required to be implemented.[8] As a healthcare intervention, quality-adjusted life years (QALYs) can be measured as the final outcome of this intervention by taking this parameter and relevant costs into account in the studies.[9] This study aimed to review the literature on the cost-effectiveness of telemedicine in Asian countries and possibly to provide recommendations on implementing telemedicine in this region.

Methods

Articles were independently screened by three investigators (AS, ABA and RIPS) in a period of June–July 2021 in two selected databases (PubMed and EBSCO) by using following keywords: a combination of economic evaluation terms ("cost benefit analysis", "cost-effectiveness analysis", "cost utility analysis", "cost minimization analysis", "quality of life", "quality-adjusted life year"), and telemedicine terms ("video", "mobile", "mobile health", "telemedicine", "telemonitoring", "internet", "information technology"). The framework of patient, intervention, comparison, and outcome (PICO) was applied by considering Asian population, the intervention of telemedicine, current situation (without telemedicine) as the comparator, and cost per QALY gained as the major outcome.[10] Discrepancies were dealt with by consensus or by discussions with other investigators (WS and AAS).

A scoping search was conducted by applying PRISMA flow diagram to identify telemedicine interventions in the disease management. In this study, we applied several inclusion and exclusion criteria. We included studies reported complete economic evaluations, such as cost-effectiveness analyses (CEA), cost-utility analyses (CUA), cost-minimization analyses (CMA), and cost–benefit analyses (CBA) by making comparison between telemedicine as the new intervention and without telemedicine as the current intervention. Furthermore, we included complete economic studies that were focused in Asian countries and published in the last ten years (2011–2021). We specifically excluded studies that were not published in English, not conducted in Asian countries, classified as non-original research articles (eg, systematic reviews, reviews, and meta-analysis), and only available in abstracts and conference proceedings.

To analyze the quality of reporting from each included study, we extracted data by using a predetermined standardized data extraction form, which was approved by all authors and amended as required. We extracted data regarding general study characteristics (eg, author, year of publication, setting and location, study objective, type of study, data collection and analytical method), and other specific methodological characteristics (eg, study perspective, comparison, time horizon, discount rate, choice of model, and parameters in the sensitivity analysis). If a study did not specify the year of currency and cost, we assumed it was the same as the publication year.

Result

Literature Search

A total of 870 articles were identified from two databases: PubMed (n = 689 articles) and EBSCO (n = 181 articles). After removing 181 duplicates, 689 articles were screened by title and abstract, excluding 665 records. After the full-text screening on 24 articles, 8 articles were selected for further analysis. More detailed information about PRISMA flow diagram of the study selection can be seen in Figure 1.

General Characteristics

We derived eight selected studies from five different countries, such as India (n = 3), China (n = 1), Singapore (n = 2), Japan (n = 1), and Thailand (n = 1).[11–18] All selected studies compared the intervention of telemedicine with regular interventions that have generally been used in healthcare facilities. Information about the general characteristics of the included studies can be seen in Table 1.

From three studies that were conducted in India, a study by Rachapelle et al highlighted the cost utility of telemedicine to screen for diabetic retinopathy in Rural Tamil Nadu, Southern India.[11] Other studies focused on mobile health and telephone-based interventions. A cluster randomized controlled trial study by Modi et al investigated the cost-effectiveness of a mobile health intervention in improving infant mortality to be implemented in Tribal Areas of Gujarat, India.[14] Another study by Arora et al explored the cost-effectiveness of telephone-based

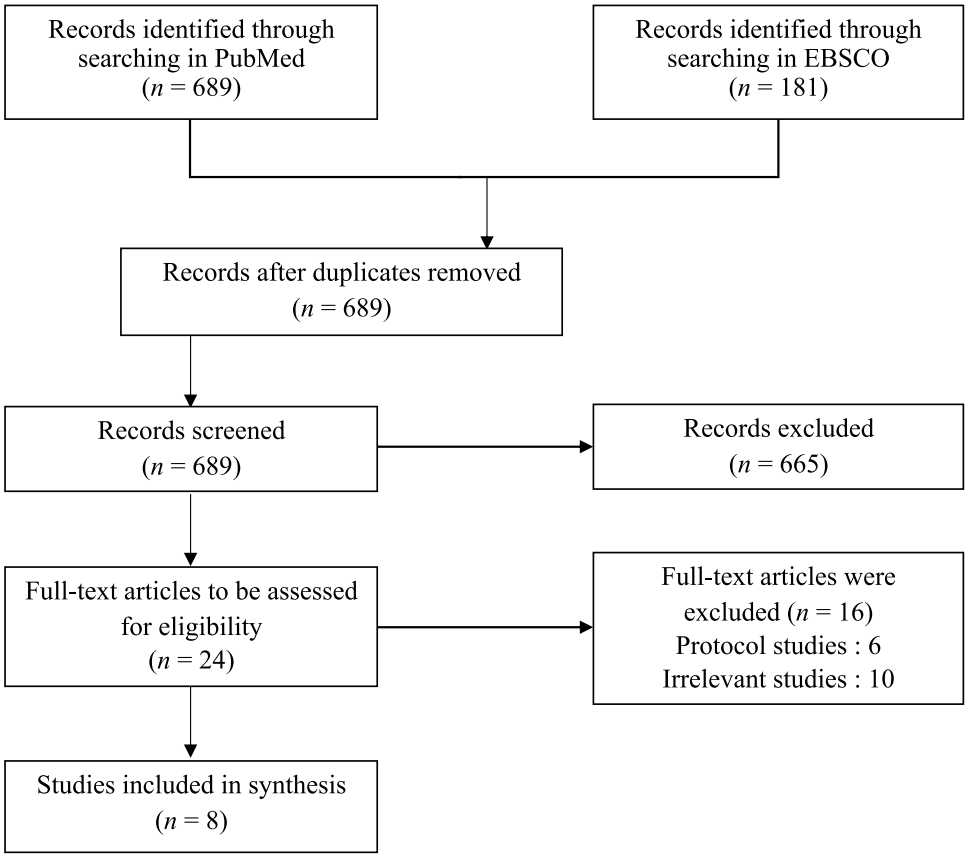

Figure 1 A flow diagram of study selection.
Notes: From *Annals of Internal Medicine*, Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. 2018;169(7):467-473, Copyright© [2018] American College of Physicians. All Rights Reserved. Adapted with permission of American College of Physicians, Inc.[29]

intervention to support the management of pressure ulcers in people with spinal cord injury in India and Bangladesh.[18]

From two studies that were conducted in Singapore, a study by Kaur et al in 2020 estimated the cost-effectiveness of using hearing aid (HA) plus aural rehabilitation versus delayed hearing aid in adults with hearing impairment.[15] Applying the urban setting in Singapore, Nguyen et al determined the incremental cost-effectiveness of a new telemedicine technician-based evaluation relative to a regular family physician (FP)-based evaluation of diabetic retinopathy (DR) from the perspectives of healthcare and societal.[17]

A study by Song and Kanaoka in Japan specifically investigated the effectiveness of mobile application for menstrual management ini Japanese working women through a randomized controlled trial that was coupled with a medical economic evaluation.[12] An economic evaluation study to evaluate the differential benefits of home visits with telephone calls and telephone calls only in Hong Kong, China was conducted by Wong et al in 2015.[13] Additionally, a study by Kitwitee et al in Thailand applied cost-utility analysis to evaluate the implementation of video-electroencephalography (VEEG) monitoring followed by surgery in adults with drug-resistant focal epilepsy.[16]

Methodological Characteristics

In economic evaluation studies, the choice of perspective is crucial since it affects the cost component to be considered in the study.[19] Various perspectives were applied in the included studies, such as societal (n = 4), societal and healthcare (n = 3), and program perspective (n = 1). Furthermore, the results of economic evaluation studies are related to the application of time horizon. All studies applied different time horizons. We found two studies applied a 25-year time horizon,[11,12] and three other studies applied different time horizon, such as 3-month,[18] 40-year,[16] and lifetime.[17] The rest of the studies (n = 3) did not confirm a time horizon. If studies applied the time

Table 1 General Characteristics of Included Studies

Study	Title	Setting and Location	Study Objective	Data Collection and Analytical Method
Rachapelle et al[11] India, 2013.	The cost–utility of telemedicine to screen for DR in India.	Rural Tamil Nadu, Southern India.	To analyze the cost-effectiveness of a telemedicine screening program for diabetic DR in rural Southern India within different screening intervals.	• The cost-effectiveness analysis was based on direct (travel, food, accommodation, hospital fees and medicines) and indirect cost (paid work). • CEAC was used to characterize the uncertainty in cost-effectiveness analysis and applied to define WTP acceptance ranges. • Total societal cost of tele-screening was the sum of health provider and household expenditures, and total healthcare cost was the sum of household direct and indirect costs minus the provider costs.
Song and Kanaoka[12] Japan, 2018.	Effectiveness of mobile application for menstrual management of working women in Japan: RCT and medical economic evaluation.	Japanese working women.	To analyze the cost- effectiveness of mobile application for menstrual management in Japanese employed women.	• The total cost was equal to application fee, medical services, and productivity loss. • The effectiveness of the application was the reduction of dysmenorrhea incidence and depression after three months of using the application. • Two scenarios in the sensitivity analysis were application fee would increase 20% and incidence of dysmenorrhea and depression would decrease 20%.
Wong et al[13] China, 2015.	Economic evaluation of the differential benefits of home visits with telephone calls and telephone calls only in transitional discharge support.	Regional acute hospital in Hong Kong.	To inspect the difference between home visit plus telephone calls and telephone calls only in chronic disease patients after discharging from hospital.	• Costs and QALYs were calculated after 28 and 84 days of intervention and comparison was applied between two groups. • ICERs were calculated by dividing differences in costs with differences in QALYs. • Multiple imputations by chained equation methods were used to input variables, such as gender, age, activities of daily living score, and the missing QoL observations.

(*Continued*)

Table 1 (Continued).

Study	Title	Setting and Location	Study Objective	Data Collection and Analytical Method
Modi et al[14] India, 2020.	Costing and cost-effectiveness of a mobile health intervention in improving infant mortality in tribal areas of Gujarat, India: Cluster RCT.	Tribal and rural communities of Gujarat, India.	To evaluate how much a mobile health intervention could save the incremental cost per life-years when compared with usual maternal, neonatal, and child health care programs.	• ICERs were calculated by dividing incremental cost of the intervention with the number of infant deaths averted. • Study was analyzed with ITT and PP. • ITT implied all live births while PP would exclude women and infants who leave the maternal home up to 3 months.
Kaur et al[15] Singapore, 2020.	Cost-utility analysis of hearing aid device for older adults in the community: A delayed start study.	Singapore.	To examine cost-effectiveness of using hearing aid plus aural rehabilitation versus delayed hearing aid in adults with hearing impairment.	• Patients' utility were measured with QALY metric and calculated as a combination of health-related QoL and duration of life. • ICER at <$50.000 was considered to be cost-effective.
Kitwitee et al[16] Thailand, 2017.	Cost-utility of VEEG monitoring followed by surgery in adults with drug-resistant focal epilepsy in Thailand.	Specialized hospital in Thailand.	To examine cost-effectiveness of using the VEEG monitoring before surgery versus medical treatment without VEEG intervention in patients with drug-resistant focal epilepsy under Thai healthcare context.	• Surgical outcomes were collected after 1- and 2-year post-surgery. • Effectiveness was measured by life years and QALYs. • Non-healthcare cost was collected from the standard cost list for Health Technology Assessment in Thailand.
Nguyen et al[17] Singapore, 2016.	Cost-effectiveness of a national telemedicine DR screening program in Singapore.	Urban setting in Singapore.	To determine the incremental cost-effectiveness of SiDRP in a comparison with a regular FP-based evaluation in Singapore from health system and societal perspectives.	• Cost was estimated from healthcare system (medical cost) and societal perspectives (direct medical, direct non-medical and indirect costs). • Cost-effectiveness between SiDRP and FP was calculated by considering cost-effectiveness threshold at £30,000 or SGD63,000 per QALY gained.
Arora et al[18] India, 2017.	Cost-effectiveness analysis of telephone-based support for the management of pressure ulcers in people with spinal cord injury in India and Bangladesh.	Three sites in India and Bangladesh.	To find out the cost-effectiveness and cost-utility of management of pressure ulcers by telephone-based support from a societal perspective.	• The mean between groups were calculated by considering the baseline and follow-up size differences in pressure ulcer and using bootstrapping techniques. • ICER was calculated by considering every pressure ulcer size and QALYs gained.

Abbreviations: CEAC, cost-effectiveness acceptability curve; DR, diabetic retinopathy; FP, family physician; ICER, incremental cost-effectiveness ratio; ITT, intention to treat; PP, pre-protocol; QALYs, quality-adjusted life years; QoL, quality of life; RCT, randomized controlled trial; SiDRP, Singapore Integrated Diabetic Retinopathy Program; VEEG, video-electroencephalography; WTP, willingness to pay.

horizon more than a year, then the health effect should be modified with a discount rate. We found that four studies applied a discount rate at 3%,[11,14,16,17] and one study applied a discount rate at 2%.[12]

Among all included studies, six studies applied mathematical modeling.[11,14–18] Rachapelle et al used a Markov model to measure the cost-utility by comparing 6 different screening intervals on 1000 rural diabetic patients, who were 40 years of age and had not previously been screened for DR.[11] A study by Kitwitee et al also used a Markov model to measure total cost and effectiveness.[16] In addition, a study by Kaur et al used Markov model to assess cost effectiveness in using HA, compared with non-HA group.[15] Modi et al considered relevant cost and effectiveness parameters in the implementation of mobile health intervention within a decision tree model.[14] Wong et al applied a randomized control trial to explore readmission outcome by comparing home visit plus phone calls with phone calls only for patients discharged from medical unit due to chronic illness.[13]

Furthermore, Arora et al used a Markov model to calculate the incremental cost-effectiveness ratio (ICER) in a comparison between telemedicine-based DR screening and FP-based DR screening over a lifetime.[18] A Markov model was also applied by Nguyen et al to estimate the cost-effectiveness of telemedicine by considering two major factors: (i) if telemedicine was less cost and higher utility, compared with regular model, telemedicine would be cost-saving; and (ii) if telemedicine was more expensive and higher utility, compared with regular model, ICER will be the difference in total costs divided by the difference in total QALYs gained.[17]

Additionally, sensitivity analysis is necessary to be included in economic evaluation studies to assess the impact of uncertain parameters in the ICER. From all retrieved studies, only two studies did not apply sensitivity analysis.[13,16] Other studies (n = 6) applied sensitivity analysis by considering various parameters, such as prevalence of the disease, intervention cost (eg, direct medical, direct non-medical, indirect, and other relevant costs), utility, disease degree, and other outcomes. More detailed information about the methodological characteristics of the included studies can be seen in Table 2.

Discussion

In this study, we reviewed eight articles that focused on investigating the cost-effectiveness of telemedicine in Asia.[11–18] Two studies by Arora et al and Wong et al specifically investigated the cost-effectiveness of mobile phone intervention in India and Bangladesh; and Hong Kong, respectively. Comparing telephone-based support with usual care in management of pressure ulcers in 120 people with spinal cord injury in India and Bangladesh, a study by Arora et al concluded the probability of the intervention to be cost-effective would be 41%.[18] In the context of reducing the hospital readmissions, a study by Wong et al confirmed that the intervention of home visit and calls was more effective than calls only.[13] In particular, two other studies focused on the cost-effectiveness of mobile health application. Focusing on the use of m-Health program for maternal, neonatal, and child healthcare management in Gujarat, India, a study by Modi et al concluded that the intervention was cost-effective and recommended to be implemented in a wider range of population in India.[14] Comparing the use of mobile application versus not using mobile application in female workers for menstrual management in Japan, a study by Song and Kanaoka highlighted the intervention group resulted QALYs and costs at 0.07 higher and $1170 lower than the control group, respectively.[12]

Considering the implementation of FP and Singapore Integrated Diabetic Retinopathy Program (SiDRP), a study by Nguyen et al concluded SiDRP as the new intervention showed better cost-effectiveness value than FP in the context of DR screening program.[17] Another similar study by Rachapelle et al in 2018 also highlighted that teleophthalmology screening program was considered to be more cost-effective than no DR screening in rural Tamil Nadu, Southern India.[11] In the context of video monitoring, a study by Kitwitee et al in Thailand confirmed the probability of VEEG to be cost-effective was 84% by applying a cost-effective threshold at THB 160,000 per QALY gain.[16] Taking the use of HA as a telemedicine, a study by Kaur et al confirmed that HA as a telemedicine could be cost-effective in a person with hearing-impairment after a short period of using the device and long-term cost-effectiveness of HA would depend on the duration of use of intervention.[15] More detailed information about the primary results of all included studies can be seen in Table 3.

All of these included studies have proven that the use of telemedicine was more cost-effective than the traditional programs by increasing therapeutic effects and providing improvement in the efficiency of health services.[20] It can be highlighted that telemedicine is a promising approach to increase life expectancy and

Table 2 Methodological Characteristics of Included Studies

Study	Study Perspective	Comparison	Time Horizon	Discount Rate (%)	Choice of Model	Parameter in the Sensitivity Analysis
Rachapelle et al[11] India, 2013.	Societal and healthcare	Teleophthalmology vs regular screening	25 years	3	Markov model	Utility values, bilateral blindness from DR, annual transition probabilities, prevalence of DR among diabetic, proportion of patients misdiagnosed by retinal camera, mortality multipliers, and probability of attending for treatment after referral.
Song and Kanaoka[12] Japan, 2018.	Societal	Mobile application vs control group	25 years	2	RCT	Incidence, application fee, medical expense, labor productivity, total cost, and QALYs.
Wong et al[13] China, 2015.	Societal	Home visit with calls vs calls only	–	–	RCT	–
Modi et al[14] India, 2020.	Program	Mobile health intervention vs current maternal, neonatal, and child health services	–	3	Decision tree	Infant deaths averted, cost, cost per infant death averted, and cost per life year.
Kaur et al[15] Singapore, 2020.	Societal	VEEG vs treatment without VEEG	–	–	Markov model	Proportion of patients receiving surgery, surgical death, transient complication, permanent complication, seizure outcomes after surgery, seizure outcomes of medical treatment, sensorimotor rhythm, cost, and utility.
Kitwitee et al[16] Thailand, 2017.	Societal and healthcare	The fitted group (the one that used HA immediately added with short-term post audiological rehabilitation) vs the control group (the one that used HA three months later).	40 years	3	Markov model	–
Nguyen et al[17] Singapore, 2016.	Societal and healthcare	Telemedicine vs regular screening	Lifetime	3	Markov model	Prevalence of DR, specificity, DR transition probabilities, cost items, and utility.
Arora et al[18] India, 2017.	Societal	Telephone-based support vs regular care	3 months	–	Linear regression	Cost, reduction in pressure ulcer size (cm^2), average utility score over 12 weeks, and incremental QALYs.

Abbreviations: DR, diabetic retinopathy; HA, hearing aid; RCT, randomized controlled trial; VEEG, video-electroencephalography; QALYs, quality-adjusted life years.

to reduce infant mortality.[14,16] It can also increase the effectiveness of treatment.[18] In addition, the potential of telemedicine to be a cost-saving intervention has been confirmed by the evidence in a study by Nguyen et al,[17] which strengthened the results of a previous study by Ji et al in terms of telemedicine can save patients' time and travel costs.[21]

In the context of Sustainable Development Goals (SDGs), the United Nations has committed the SDGs to be achieved by 2030 with the 3rd SDG is to ensure healthy

Table 3 Primary Results

Study	Main Conclusion
Rachapelle et al[11] India, 2013.	Applying a health provider perspective, teleophthalmology screening for DR is cost-effective compared with no screening in rural Indian setting. The results are dependent on the administrative costs (eg, for establishing and maintaining screening at regular intervals) and program coverage.
Song and Kanaoka[12] Japan, 2018.	The aggregate of medical expenses, productivity loss, and application fee for the intervention group was reported to be lower ($1170 per individual) than for the non-intervention group. The results conclude that using the application is cost-effective and might reduce the incidence of dysmenorrhea and depression.
Wong et al[13] China, 2015.	Both of home visits and calls only are cost-effective for transitional care support, but calls only have a higher chance of being cost-effective for a sustained period after intervention in patients with chronic illness.
Modi et al[14] India, 2020.	A mobile health intervention is cost-effective from a program perspective at an incremental cost of $74 per life-years saved. Considering district scale-up, the program is even more cost-effective. Hence, the program is recommended for replication elsewhere in India.
Kaur et al[15] Singapore, 2020.	HA intervention can be cost-effective and improve the QoL of hearing-impaired older individuals within a brief period of device fitting. Its continued usage would impact the long-term cost-effectiveness value.
Kitwitee et al[16] Thailand, 2017.	VEEG was considered to be cost-effective for patients with drug-resistant epilepsy. Therefore, in Thailand, it is recommended to be included in the benefit package of health insurance.
Nguyen et al[17] Singapore, 2016.	In Singapore, telemedicine-based DR screening using technicians in the primary care setting is cost saving, compared with the FP-based evaluation.
Arora et al[18] India, 2017.	In the context of QALYs, telephone-based support could help people to manage pressure ulcers at home by providing good value for money with an 87% probability of being cost-effective, according to 3 times gross domestic product. The inclusion of productivity costs in sensitivity analyses did not alter this finding.

Abbreviations: DR, diabetic retinopathy; FP, family physician; HA, hearing aid; RCT, randomized controlled trial; VEEG, video-electroencephalography; QALYs, quality-adjusted life years; QoL, quality of life.

living and promote well-being for all people at all ages.[22] It can be highlighted that all human beings have the same rights to access good health service that will support sustainable development and socioeconomic improvements. As an alternative choice, telemedicine can be used for people with limited access to direct health services. In low-income countries, it can be an alternative for patients who cannot afford good healthcare services that are not covered by the social insurance. For health crisis mitigation, the use of telemedicine can also be optimized because of its cost-effectiveness.[1]

In Asia, telemedicine has become popular and has been used to expand more access to essential health services, specifically for rural communities who have barriers to getting accessible healthcare facilities because they are concentrated in urban areas. Other problems that patients from rural areas may face are poor infrastructures and complicated geographic locations. In this case, telemedicine has the ability to deliver healthcare services, provide better information, decrease discrepancies in the healthcare, and improve healthcare outcomes.[23,24] In particular, telemedicine can assist the healthcare system to be more patient-centered.[25] Because of the increasing number of smartphones' users, the extensive use of internet, and the application of electronic medical records, the possibility of telemedicine to be included in the healthcare system is getting higher.[26] Nevertheless, the illiteracy of technology and the unaffordability of supporting devices remain the biggest challenges in the implementation of telemedicine in low-income countries.[27,28]

To our knowledge, this study is the first scoping review study that focused on the economic evaluations of telemedicine in Asia. Despite the fact that this study has a major novelty, it also has several limitations. First, we were unable to conduct a meta-analysis due to heterogeneity of the included studies. Nevertheless, we have provided a narrative review by outlining the current evidence on this topic and highlighting gap that remains unexplored for future studies. Secondly, we found the risk of publication bias since we only focused on peer-reviewed published studies to ensure comparable study quality. Nevertheless, this study provides an overview about the potential cost-effectiveness of telemedicine in health services to improve patients' quality of life as the final outcome. Hopefully,

this study can assist the stakeholders in making decisions regarding the implementation of telemedicine in Asia.

Conclusions

The results suggest that the implementation of telemedicine in Asia can be a promising intervention since it can enhance the effectiveness of health services by saving time and travel costs. It also can reduce the overall costs of treatment, improve patients' quality of life and expand access to essential health services.

Disclosure

The authors report no conflicts of interest in this work.

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