International Journal of Technology Assessment in Health Care, 34:4 (2018), 410–418.

doi:10.1017/S0266462318000454

Assessment

# COSTS OF HOME-BASED TELEMEDICINE PROGRAMS: A SYSTEMATIC REVIEW

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**Objectives:** The aim of this study was to systematically investigate existing literature on the costs of home-based telemedicine programs, and to further summarize how the costs of these telemedicine programs vary by equipment and services provided.

**Methods:** We undertook a systematic review of related literature by searching electronic bibliographic databases and identifying studies published from January 1, 2000, to November 30, 2017. The search was restricted to studies published in English, results from adult patients, and evaluation of home telemedicine programs implemented in the United States. Summarized telemedicine costs per unit of outcome measures were reported.

**Results:** Twelve studies were eligible for our review. The overall annual cost of providing home-based telemedicine varied substantially depending on specific chronic conditions, ranging from USD1,352 for heart failure to USD206,718 for congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes as a whole. The estimated cost per-patient-visit ranged from USD24 for cancer to USD39 for CHF, COPD, or chronic wound care.

**Conclusions:** The costs of home-based telemedicine programs varied substantially by program components, disease type, equipment used, and services provided. All the selected studies indicated that home telemedicine programs reduced care costs, although detailed cost data were either incomplete or not presented in detail. A comprehensive analysis of the cost of home-based telemedicine programs and their determinants is still required before the cost efficiency of these programs can be better understood, which becomes crucial for these programs to be more widely adopted and reimbursed.

**Keywords:** Telemedicine, Costs, Home-based, Chronic disease

The American Telemedicine Association defines telemedicine (or telehealth) as the use of medical information exchanged from one site to another by means of electronic communications and to improve patient clinical health status (1). Over the past 2 decades, telemedicine has been increasingly used in disease control and management, and is associated with benefits such as increased access to health services, cost-effectiveness, more educational opportunities, improved health outcomes, better quality of care, and enhanced social support for patients (2). For example, telemedicine allows for better quality of care by constantly monitoring patients' vital conditions, and provides for more efficient use of resources by reducing travel time for health professionals and patients (3).

Studies have also shown that telemedicine service provided in patients' homes or community clinics improved health outcomes through prompt consultation, guidance, and needed services, and in turn reduced the risk of hospitalization and emergency department use (4). Furthermore, consummate findings based on meta-analyses conducted to evaluate the effectiveness of telemedicine across various disease types, such as myocardial infarction (5), chronic obstructive pulmonary disease (6), diabetes (7), heart failure (8–11), mental health (12), pain management (13), and audiology (14) suggested the feasibility and prospect of using telemedicine to achieve better outcomes and/or reduced healthcare costs.

Although various review studies have documented the effectiveness of telemedicine in facilitating home-based disease control and management compared with usual care (15–18), few have assessed program costs. An important reason is that program cost has rarely been reported in published studies on telemedicine. Because by far third-party payers (e.g., Medicare, or private insurers) do not cover or subsidize the initial infrastructure costs of telemedicine or reimburse most services (19;20), program costs can be prohibiting for many telemedicine programs to be initiated or sustained.

In this study, we seek to examine the cost of home-based telemedicine services through a systematic review of the relevant literature. The primary objectives of this study were to: (i) understand the cost structure and components of home

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

telemedicine based on a systematic review of studies with a documentation of program costs; and (ii) summarize home telemedicine costs either on an annual or per-patient-visit basis.

## METHODS

### Data Sources and Literature Search

To identify studies reporting costs of home telemedicine programs, a systematic literature review was undertaken following guidelines from the Cochrane Collaboration guidelines (21) and the Preferred Reporting Items for Systematic Reviews and Meta- Analyses (PRISMA) (22). The literature search covered electronic bibliographic databases including PubMed, Embase, CINAHL, and Cochrane from January 1, 2000, to November 30, 2017. The search was limited to studies published in English, those involving only adult patients and focusing on home-based telemedicine programs implemented in the United States. Our goal was to establish comparability due to variability in care and healthcare systems across different countries.

PubMed Auto Alerts was set up to provide weekly updates of new literature until January 15, 2018. The search terms (PubMed Mesh term) included: "*Telemedicine,*" "*Monitoring, Physiologic,*" "*Signal Processing, Computer-Assisted,*" "*Blood Pressure Monitors,*" "*Monitoring, Ambulatory,*" "*Remote Consultation,*" "*Diagnosis, Computer-Assisted,*" "*Therapy, Computer-Assisted,*" "*Costs and Cost Analysis,*" "*Models, Economic,*" "*Cost-Benefit Analysis,*" "*Home Care Services,*" "*English*," and "*All Adult*." The search strategy was presented in Supplementary Table 1. The review protocol has been registered in an international prospective register of systematic reviews (PROSPERO) (http://www.crd.york.ac.uk/prospero/).

### Study Selection

We defined the target patient population as 18 years of age and older who have one or more chronic diseases according to the World Health Organization definition (23). To be eligible, studies had to: (i) involve the use of home telemedicine to provide services; (ii) report information related to total costs or the cost components (staffing, equipment and others) of telemedicine. We considered home telemedicine to be any form of medical services that was conveyed through technology and communicated between remotely located care providers and patients at home (24).

Two investigators (J.Z. and M.A.M.) independently reviewed titles and abstracts to identify studies meeting the inclusion criteria. The same investigators performed full-text screenings of all studies that any of the investigators identified as relevant. Differences in screening decisions were resolved by consultation with a third investigator (T.L.M.), and exclusion of citations that underwent full-text screening was documented.

### Data Extraction, Synthesis, and Study Quality Assessment

Data were abstracted independently by two investigators (J.Z. and M.A.M.) using prespecified abstraction tables (Supplementary Tables 2 and 3). Discrepancy was resolved by consensus (three of twelve studies included). The percentage agreement was 75 percent. We provided a narrative synthesis of the findings from included studies that was structured around study characteristics such as technology type and vendor, funding source, and cost composition of telemedicine, including staffing, equipment, and others. We further provided summary tables organized by these attributes.

We described the economic costs of telemedicine from the perspective of telemedicine provider, which may include costs as capital investment (e.g., equipment or technology), facilities (e.g., office space and rental), maintenance and repair, administration, training, wages for personnel, and so on (25). We further categorized costs reported by each study into equipment, staffing, and miscellaneous. We calculated telemedicine program costs either on a per-patient-visit or per-year metric to standardize the data across included studies. We further adjusted all cost data to 2016 U.S. dollars, using the Consumer Price Index (26) to compare costs across years. For studies that did not report the years when cost data were collected, we used the publication year of the study as a proxy.

Finally, because our inclusion criteria were not limited to randomized clinical trials (RCTs), we evaluated the quality of included studies using the element of study design, which is part of the Grading of Recommendations Assessment, Development, and Evaluation system (27). Studies with the RCT design are rated as high-quality evidence, whereas observational studies are regarded as low-quality evidence of intervention effects.

## RESULTS

### Study Identification

The literature identified a total of 1,299 titles and abstracts, from which 1,213 were excluded based on title and abstract review, and seventy-four were excluded on the basis of full-text review. A total of twelve studies, representing a variety of disease types, telemedicine equipment used, , and sample sizes, were included in our review. Of the twelve studies reviewed, nine of them included cost data about the staffing and equipment of telemedicine programs. Figure 1 presents the PRISMA flow diagram detailing the process of study selection. The results in each selected study were reviewed and summarized qualitatively.

### Study Characteristics

Table 1 provides selected characteristics for each included study (more detailed characteristics of included studies are presented in Supplementary Table 2).

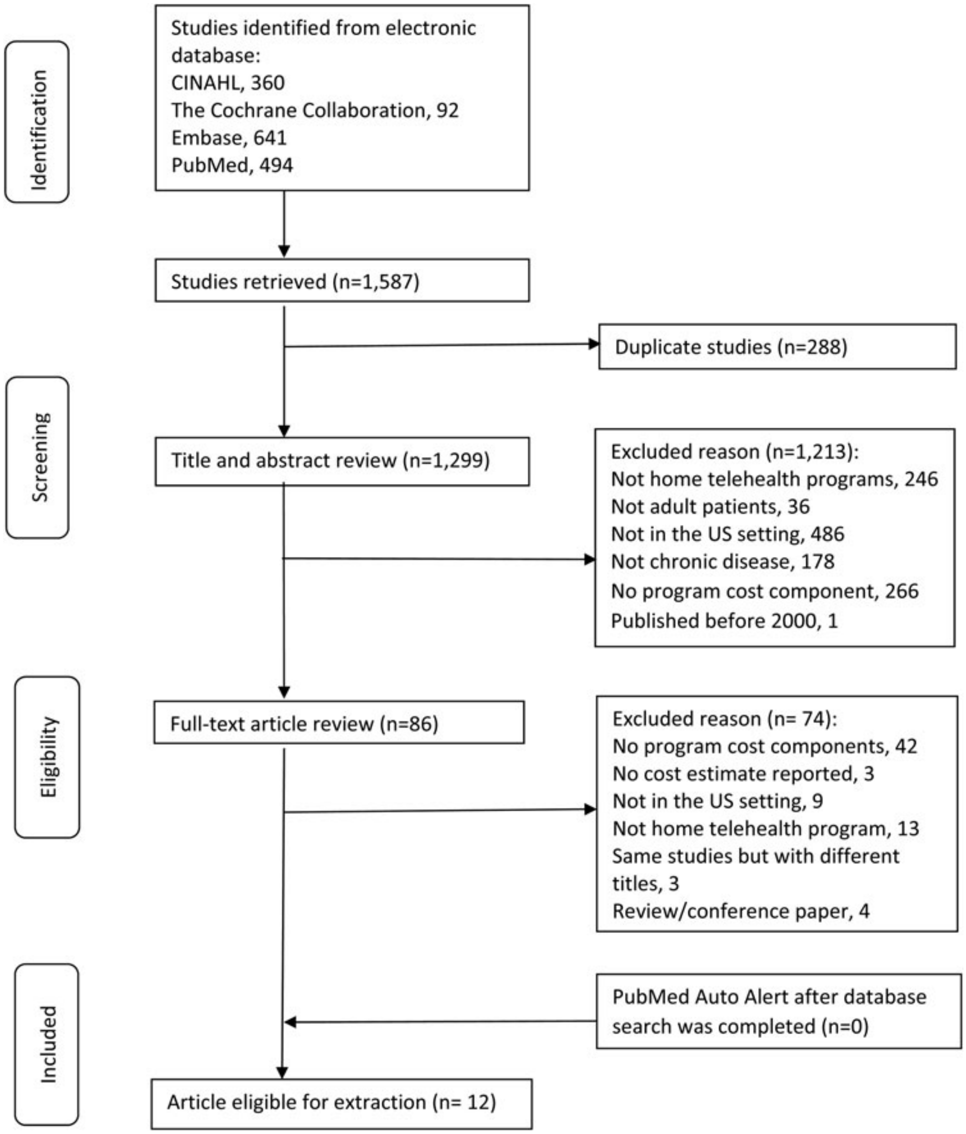


**Figure 1.** Search flow diagram for included studies.

***Study Objectives.*** Most studies ($n = 7$) compared home healthcare delivered by telemedicine to home healthcare delivered by traditional in-person visits. The other five studies evaluated the effectiveness of home diagnosis and the treatment of obstructive sleep apnea (28), readability of gathering data from home ventilator patients (29), cost-effectiveness of a portable coagulometer for elderly patients taking warfarin (30), development of a pilot telehealth program (31), and use of telepsychiatry consultation services (32).

***Study Design.*** Five studies used RCT design, four studies used case study design; two studies used quasi-experimental design; and one study used pilot feasibility study design. Most studies ($n = 7$) were of lower methodological rigor, suggesting potential risks to internal validity.

***Disease Type.*** The majority of included studies ($n = 7$) focused on a single disease (obstructive sleep apnea, diabetes, heart failure, cancer, mental health, or hypertension), and the other five studies targeted a variety of diseases.

***Number of Subjects.*** The number of subjects monitored by telemedicine in selected studies ranged from 4 to 171.

***Equipmenty and Vendor.*** The equipment applied in each of the eligible studies differed by study objectives and the disease type, varying from a plain old telephone service system with a camera and modem mounted on top of a television (29), to a U.S. Food and Drug Administration Class II medical device that collects key vital signs (blood pressure, heart rate, oxygen saturation, temperature) (33). Seven studies did not report the vendor of the telemedicine equipment applied in


https://doi.org/10.1017/S0266462318000454 Published online by Cambridge University Press

**Table 1.** Summary of Selected Characteristics of Included Studies

| First author, year | Study design | Disease | No. of subjects | Length of study (month) | Equipment; vendor | Outcome measure | Setting; location |
|---|---|---|---|---|---|---|---|
| Fletcher, 2000 (28) | Prospective case study | Obstructive sleep apnea | 63 | N/A | Unattended home monitoring along with automatic titrating continuous positive airway pressure; DeVilbiss | Number of subjects able to be diagnosed by unattended home monitoring | Academic; N/A |
| Dansky, 2001 (48) | RCT | Diabetes | 171 | 18 | Camera with a close-up lens, medical sensors (sphygmomanometer and stethoscope); American Telecare, Inc | Costs associated with providing telehomecare services | Academic & Community; Urban |
| Smith, 2002 (29) | Pilot feasibility study | Obstructive sleep apnea | 5 | 6 | Included a camera and modem mounted on top of a television (transmitted by means of Plain Old Telephone Service [POTS]); N/A | The reliability of gathering data from home ventilator patients compared with data recorded by a home health nurse in the subject's home | Academic; N/A |
| Benatar, 2003 (34) | RCT | Heart failure | 216 | 12 | Transtelephonic home monitoring devices programmed to measure blood pressure, heart rate, arterial oxygen saturation, and weight; AvidCare Corporation | HF readmissions , length of stay, HF hospitalization charges, and pre- and post-intervention quality-of-life measurements | Academic; Urban |
| Cheung, 2003 (30) | Prospective case study | Prosthetic valve, atrial fibrillation, cardiomyopathy, stroke, MI, and deep venous thrombosis or pulmonary embolism (with the use of warfarin) | 35 | 24 | Portable coagulometer; Basel | International Normalized Ratio of a drop of whole blood | Community; Urban |
| Bohnekamp, 2004 (36) | Quasi-experimental study | Cancer | 28 | N/A | A home health monitor and equipment for connecting to a TV; N/A | Type of care, costs, patient satisfaction, ostomy adjustment, and time to achieve ostomy self-care | Academic; N/A |
| Noel, 2004 (35) | RCT | CHF, COPD, and diabetes | 104 | 6 | Camera, a touch screen interface and FDA-approved peripheral devices plug into the telehealth unit; N/A | Quality-of-life, health resource use, and costs | VA Healthcare System; N/A |
| Walsh, 2005 (31) | Case study | Heart disease and diabetes | 4 | N/A | Blood pressure cuff, electronic stethoscope, video camera, with magnifier, monitor, pulse oximetry, digital scale and glucose monitor; N/A | Costs, projected savings, and patient satisfaction | Community; N/A |
| Finkelstein, 2006 (37) | RCT | CHF, COPD, and chronic wound care | 53 | 36 | A set-top box connected to the subject's television set and telephone line and an eyeball camera was placed on the box; 8 × 8 Inc. & Philips Electronics | Mortality, morbidity, transfer to a different level of care, costs, and satisfaction | Academic & Community; Rural |
| Hicks, 2009 (33) | Quasi-experimental study | Surgical aftercare, cardiovascular problems, lung problems, cancer, diabetes, and infections | 94 | N/A | FDA Class II medical device that collects key vital signs (blood pressure, heart rate, oxygen saturation, temperature); N/A | Additional costs and benefits associated with home telehealth monitoring, and client and provider satisfaction | Academic & Community; Rural |

**Table 1.** Continued

| First author, year | Study design | Disease | No. of subjects | Length of study (month) | Equipment; vendor | Outcome measure | Setting; location |
|---|---|---|---|---|---|---|---|
| Rabinowitz, 2010 (32) | Case study | Mental health | 106 | N/A | State-of-the-art videoconferencing equipment and large-screen monitors; Polycom | Potential cost and time savings (tele-psychiatry vs. in-person care) | Academic & Community; N/A |
| Reed, 2010 (38) | RCT | Hypertension | 61 | 24 | Electronic blood pressure measurement devices; N/A | Direct and patient time costs | Academic; Urban |

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HF, heart failure; FDA, Food and Drug Administration; MI, myocardial infarction, N/A, not applicable; RCT, randomized controlled trial.

their studies, which would make it difficult to infer about any potential conflict of financial interest as a result of ties between the study team and the vendors.

*Study Setting.* Most of the studies were conducted in an academic setting ($n = 5$) or through an academic-community partnership ($n = 4$), whereas the rest were either implemented by a community organization or the Veteran Affairs healthcare system.

*Location.* Four studies were conducted in an urban area, and three studies were in a rural area. Five studies did not specify the location where the telehealth programs were carried out.

*Key Personnel.* Nurses, including advanced practice nurses, clinical nurse specialists, and registered nurses, were the key personnel in most of the included studies ($n = 10$), whereas physician was reported as the key personnel in only one study. One study did not specify its key personnel.

*Funding Source.* The majority of the studies ($n = 7$) were funded by a government agency, including the Department of Commerce, the National Institute of Health, the Agency for Healthcare Research and Quality, and the Veteran's Administration Health Services Department of Research and Development. Four studies did not specify the funding resource, and one study was supported by an academic institution.

### Cost Composition of Telemedicine

*Measurement Metric.* There was significant variation in the cost measurement metrics reported by each individual study (Table 2). Based on these studies, the estimated cost of implementing a telemedicine program, including the costs of equipment, staffing, and overhead, ranged from USD1,352 for heart failure (34) to USD206,718 for congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes as a whole (35) of 2016 U.S. dollars on an annual basis; or from USD24 for cancer (36) (3.57 virtual visit) to USD39 for CHF, COPD, and chronic wound care (37) (292 virtual visits) per-patient-visit.

*Cost Category.* Similarly, we found a significant variation in the cost categories reported in the individual studies (Supplementary Table 3). We divided telemedicine costs into equipment, staffing, and miscellaneous to accommodate differences. Two studies provided the most economic details of the telemedicine programs. Finkelstein et al. (37) reported the costs of the equipment, cost of travel (nurse and technician), cost of personnel time, overhead costs, and Reed et al. (38) reported startup costs, ongoing fixed costs (office space and telephone service with voice mail), personnel costs, and variable costs (toner, paper, postage stamps, and envelopes).



https://doi.org/10.1017/S0266462318000454 Published online by Cambridge University Press

**Table 2.** Summary of Cost Estimates of Included Studies

| First author, year | Disease | Cost metrics | Estimate (inflated to U.S. 2016 dollars) | Cost benefits |
|---|---|---|---|---|
| Fletcher, 2000 (28) | Obstructive sleep apnea | Total home diagnosis and treatment costs | USD41,106 | Reduced diagnostic and treatment costs by USD1,128 per patient |
| Dansky, 2001 (48) | Diabetes | Total costs of telehomecare per year | USD26,634 | Reduce home visit costs between USD319-USD697 per patient per episode for patients who were in home care for 60 days |
| Smith, 2002 (29) | Obstructive sleep apnea | Total costs of telehealth (visits, materials, and travel for installation and pick-up) per 6-month | USD3,590/year | Reduced costs by USD41 per visit |
| Benatar, 2003 (34) | Heart failure | Total fractionated costs of telemonitoring per day | USD1,352/year | Reduced readmission charged by USD136,332 at a 1-year period |
| Cheung, 2003 (30) | Prosthetic valve, atrial fibrillation, cardiomyopathy, stroke, MI, and deep venous thrombosis or pulmonary embolism (with the use of warfarin) | Average costs per International Normalized Ratio | USD9/INR | Reduced costs of INR measurement by USD10.45/INR |
| Bohnekamp, 2004 (36) | Cancer | Average costs of per telenursing visit | USD24/per visit | Reduced costs by USD44.1 per telenursing visit |
| Noel, 2004 (35) | CHF, COPD, and diabetes | Total costs of telehealth unit per 6-month | USD206,718/year | Reduced healthcare costs, including transportation, RN home visits, bed-day-of-care (admission and discharge days plus integral days as inpatient), ER visit, specialty clinical, and primary care, by USD2,648 per patients at a 6-month period |
| Walsh, 2005 (31) | Heart disease and diabetes | Total costs of telehealth monitoring | USD24,716-USD27,296 | Reduced costs of skilled nurse visits by USD3,432 at a 6-month period |
| Finkelstein, 2006 (37) | CHF, COPD, chronic wound care | Average total costs per visit (virtual visits & monitoring) at a 6-month period | USD39/visit; total cost of USD22,816/year | Reduced average costs by USD15.16 per visit (total costs saving = USD41,361) compared with the actual visit group |
| Hicks, 2009 (33) | Surgical aftercare, cardiovascular problems, lung problems, cancer, diabetes, and infections | Total costs of telemedicine per 6-month | USD64,810; 129,620/year | Reduced hospitalization expenses by USD126,899 |
| Rabinowitz, 2010 (32) | Mental health | Total costs of telepsychiatry per year | USD32,242 | Psychiatric visit reduced potential patients-to-physician travel (estimated at USD20, USD30 and USD40/hour) and physician-to-patient travel (estimated at USD100, USD200, and USD300/hour) costs by USD13,060-USD46,798 and USD63,668-USD232,361, respectively |
| Reed, 2010 (38) | Hypertension | Total costs of home blood pressure monitoring & telephonic behavioral intervention per year | Fixed costs of USD59,844; variable costs per patient of USD137 | Combined intervention reduced direct medical costs by USD627 compared with usual care during 2 years; by the incremental 2-year cost per 1-point reduction in systolic blood pressure was USD107 in direct medical costs and USD297 when including patient time costs |

MI, myocardial infarction; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; INR, international normalized ratio.

Nine studies provided data on the equipment and staffing costs. Most staffing costs ($n = 8$) resulted from nurse time and were calculated per telemedicine visit or per year. Three studies did not report staffing costs (30;32;35). Because the cost of equipment is subject to the type of telemedicine equipment installed at a given patient's home, it varied from USD832 for patients with chronic heart failure (cellular telephone, biotechnology, and home monitor) (34) to USD40,596 for patients with surgical aftercare, cardiovascular problems, lung problems, cancer, diabetes, or infections (U.S. Food and Drug Administration Class II medical device that collects key vital signs) (33) on an annual basis.

## DISCUSSION

We identified twelve studies which met the inclusion criteria for the systematic review. Due to the substantial heterogeneity among included studies in terms of the cost data reported, we did not conduct quantitative synthesis or meta-analysis of the selected studies. While our study was limited to programs in the United States, many of the approaches taken could be applied to programs in other countries and the wide range of costs and types found in the United States may subsume examples elsewhere.

Despite significant variations in reported costs and several studies failing to include details of critical cost components for their telemedicine programs, our review found that telemedicine costs ranged from USD1,352 to USD206,718 annually, or from USD24 to USD39 for per-patient visit. In consideration of the estimated cost by Burgiss and Dimmick (3) of approximately USD69 (inflated to 2016 U.S. dollars) for a nurse to travel to a home, our pooled results (USD24 (36)-USD39 (37) per telenursing visit) suggested that telemedicine can be cost-effective relative to medical care provided through in-person home visits.

Nevertheless, the lack of quantitative data of the costs of telemedicine is one of the main challenges of evaluating its sustainability and economic impact (25;39;40). Only 20 percent of all published telemedicine studies contain quantitative cost data or make reference to the costs of telemedicine, regardless of setting (39), and even when they included such data in their report, it was usually a rough estimate of total costs without any break-down by cost category, which limits both the scope and validity of the evaluation. Forty-two percent of acute care hospitals across the country adopted telemedicine in their clinical practices, based on data from the 2012 annual survey of the Information Technology Supplement to the American Hospital Association (41); however, very little economic evidence of telemedicine was reported in the existing literature, pointing to a major vacuum when it comes to sustaining these programs over time based on their documented cost benefit or return on investment for patients, care providers, or payers.

We must, therefore, conclude that the costs and benefits of telemedicine intervention should be weighed before decisions on implementation are made (42). Future studies with detailed, itemized, and comparative economic data, either categorized as was done in the present study, or categorized into fixed and variable costs as proposed by Dávalos et al. (25), would facilitate rigorous economic evaluation of such programs. This would provide a more comprehensive understanding of the cost benefits of telemedicine programs so that policy makers, telemedicine care providers, program administrators, payers, and other stakeholders can make informed decisions about how and when to use telemedicine healthcare (25).

Lack of reimbursement for telemedicine service remains one of the major barriers for the implementation of these programs (20). Despite the reported cost-effectiveness of telemedicine in chronic disease management (43), we did not find any documented reimbursement data that has been reported in the twelve selected studies. All included studies were either funded by a government agency or university, which does not augur well for the sustainability of these programs in the long-term.

Self-sustainability is a key factor that drives the proliferation of telemedicine application. Financial support for the infrastructure of telemedicine programs would facilitate its expansion and adoption; for example, in the case of heart failure, evidence indicated that, although telemonitoring requires an initial financial investment, it will substantially reduce costs in the long term by reducing hospital readmissions and travel costs (42). Gaining advocacy and support for telemedicine reimbursement from policy makers, payers, care providers, and other stakeholders calls for comprehensive evaluation of program costs by disease type, equipment used, service package and dosage, and other aspects of telemedicine delivery.

Although Medicare reimburses teleservice provided by physicians, physician assistants, nurses, clinical social works, dietitians, or nutrition professionals (19), nurses were the key personnel in most of the included studies (ten of twelve). This, to some extent, reflects the applicability and adoptability of telemedicine programs in certain clinical fields. More physicians' or other professionals' involvement in future telemedicine delivery might be needed if this can help improve the quality of care in a cost-effective manner.

To our knowledge, our review is one of the few studies seeking to assess the cost composition of home-based telemedicine intervention despite insufficient cost information documented in published studies. Kumar et al. (44) conducted a systematic review on tele-intensive care unit and provided empirical evidence using data from Veterans Affairs hospitals. They concluded that without further information, clinicians and administrators should carefully consider the trade-off between the clinical and economic benefits of these programs before investing. Similarly, our findings highlight the paucity of cost analysis for home telemedicine and the need of filling this gap before telemedicine can be more widely adopted and reimbursed.

In addition to the paucity of cost data, the need for future economic evaluation of telemedicine programs also arises from inconsistency in documented cost-effectiveness of these programs. For example, Kidholm and Kristensen (45) conducted a scoping review of economic evaluations of home monitoring program with study design restricted to RCTs and only including studies with the information of program costs and equipment costs. It was found that equipment costs constituted 16–73 percent of the total costs of programs and home monitoring resulted in the increased average costs per patient compared with usual care. By contrast, in our study, all included studies showed that home-based telemedicine reduced costs compared with usual care. The discrepancy may be resulted from potential differences in how the component costs of telemedicine interventions were defined and measured across different studies, given that less strict inclusion criteria were used in our study.

### Limitations

Several limitations of this study should be noted. Although all twelve studies we reviewed provided cost data for home telemedicine, our review is limited by the small number of included studies and the observation that not all of them presented detailed cost data categorized into staff, equipment, and other categories. This, by itself, reinforces the lack of evidence for telemedicine costs in the existing literature. Furthermore, the lack of consistency and comparability in the types of telemedicine and the cost information reported across the twelve studies included in our analysis also made it difficult for us to aggregate the pooled data in a meta-analysis.

We recognized that publication biases may have played a part in our review, in that studies with cost-effective findings of telemedicine programs would be more likely to be published and that, furthermore, they would be more likely to report the cost data of a program (46;47). Therefore, the data we extracted from selected studies may not include those programs with higher costs. Despite these limitations, our study, based on a systematic review of the literature, represents a rare effort in understanding common cost components of home telemedicine, and reveals the urgent need to conduct economic analysis of telemedicine programs with comprehensive cost data so as to establish an empirical foundation for initiating and sustaining home telemedicine programs.

## CONCLUSION

In conclusion, the costs of home-based telemedicine programs varied by the program component, disease type, equipment used, and services provided. All the selected studies indicated that telemedicine programs reduced costs, although detailed costs data were either incomplete or not presented in detail in these studies. This omission and the lack of detailed data on program costs have made it difficult for home-based telemedicine programs to make a solid economic case to policy makers, care providers, administrators, payers, or other stakeholders when considering reimbursement or investment in these programs.

## SUPPLEMENTARY MATERIAL

The supplementary material for this article can be found at https://doi.org/10.1017/S0266462318000454.

Supplementary Table 1: https://doi.org/10.1017/S0266462318000454

Supplementary Table 2: https://doi.org/10.1017/S0266462318000454

Supplementary Table 3: https://doi.org/10.1017/S0266462318000454

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

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