Review

Cost-Effectiveness of Telemedicine vs Standard Care for the Management of Diabetes Mellitus, Hypertension, and Heart Failure: Meta-Analysis of Randomized Trials

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Abstract

Background: The effectiveness of telemedicine strategies for the efficient management of chronic diseases has been evaluated in a number of studies, and the most recent umbrella review of meta-analyses on the topic concluded that there is sufficient evidence supporting the use of telehealth for patients with diabetes, hypertension, and heart failure. However, in-depth assessments of the cost-effectiveness of telemedicine are severely lacking.

Objective: This meta-analysis aimed at estimating the incremental cost-effectiveness ratios (ICERs) of telemedicine for the management of type 2 diabetes mellitus, hypertension, and heart failure.

Methods: We searched MEDLINE, Scopus, ClinicalTrials.gov, and the Tufts Medical Center Cost-Effectiveness Analysis Registry for all randomized or quasi-randomized trials that evaluated the cost-effectiveness of telemedicine vs standard care for managing the selected diseases. The outcomes were the ICER per quality-adjusted life year (QALY) gained, a reduction in systolic blood pressure of 1 mm Hg, or a reduction in hemoglobin A_{1c} of 1% after 12 months of follow-up. Random-effects meta-analyses were run when sufficient data were provided, and weighted ICER means were computed.

Results: A total of 27 trials were included in this meta-analysis (with a total of 15,658 patients): 40.7% (n=11) on hypertension, all using telemonitoring; 22.2% (n=6) on heart failure; and 37% (n=10) on diabetes, mostly using telephone support. Meta-analyses were possible for only two outcomes, as most trials did not report a measure of dispersion: (1) the summary estimate of ICER per QALY gained among patients with heart failure based on 11.1% (n=3) of the trials (1825 patients) was US $45,741 ($P$=.24), whereas the weighted mean based on 18.5% (n=5) of the trials (3288 patients) was US $40,271 (SD 22,933) and (2) the summary estimate of ICER per systolic blood pressure reduction of 1 mm Hg based on 18.5% (n=5) of the studies (1986 patients) was US $27, whereas the weighted mean was US $132 (SD 227) based on 33.3% (n=9) of the trials (3450 patients). The weighted means of ICER per QALY gained for hypertension and diabetes were US $18,966 (SD 13,286; n=3, 11.1% of the studies and 1437 patients) and US $44,725 (SD 18,925; n=5, 18.5% of the studies and 2949 patients), respectively. Finally, the weighted mean of ICER per 1% hemoglobin A_{1c} reduction was US $3349 (SD 2249; n=7, 25.9% of the studies and 4157 patients). Some of the estimates were substantially lower when only recent trials were considered.

Conclusions: The results support using telemedicine as a cost-effective strategy to monitor hypertension, heart failure, and, depending on the willingness to pay, diabetes. Further randomized controlled trials reporting CIs for ICER are required to confirm these findings.

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Keywords: telemedicine; diabetes mellitus; hypertension; heart failure; cost-effectiveness; incremental cost-effectiveness ratio; ICER; telemonitoring; meta-analysis

Introduction

According to World Health Organization data from years 2000 to 2021, chronic conditions—diabetes, Alzheimer disease, and other noncommunicable diseases—caused growing morbidity and mortality worldwide [1]. The resulting productivity losses and health care use have a significant impact on health care financing [2], as outlined by a 2025 report that estimated the average expenditure for noncommunicable diseases across Organisation for Economic Co-operation and Development countries at US $207 million per 100,000 population [3].

In an effort to identify more efficient service delivery models, the main solutions that have been proposed are the enhancement of prevention services [4,5]; the addition of intermediate care [6,7]; and the introduction of telemedicine (or telehealth), which has rapidly expanded since the 1990s [8,9]. In particular, in the United States, the adoption of telehealth services peaked in 2020 with the COVID-19 pandemic, and although their use has since declined, they remain above prepandemic levels in both urban and rural settings [10].

Specifically, the effectiveness of telemedicine strategies for the management of chronic diseases has been evaluated in a number of studies [11,12], and the most recent umbrella review of meta-analyses on the topic concluded that there is sufficient evidence supporting the use of telehealth for patients with diabetes, hypertension, and heart failure [13]. However, the authors called for an in-depth assessment of the cost-effectiveness of telemedicine and joined several previous reports in criticizing the lack of homogeneity across cost evaluations in the field [14-17]. In addition, cost-effectiveness analyses are further complicated by the great variety of organizational models and technological solutions used in telemedicine, often producing contrasting results [18,19].

By quantitatively synthesizing the available evidence on cost-effectiveness in this field, the present study sought to provide a more comprehensive assessment of the economic value of telemedicine interventions across 3 major chronic diseases. To this end, we carried out a meta-analysis of randomized controlled trials (RCTs) aimed at estimating the incremental cost-effectiveness ratios (ICERs) of telemedicine vs standard care for the management of diabetes, hypertension, and heart failure.

Methods

Search Strategy, Selection Criteria, and Methodological Quality

We searched MEDLINE, Scopus, ClinicalTrials.gov, and the Tufts Medical Center Cost-Effectiveness Analysis Registry for randomized or quasi-randomized clinical trials that used their data to evaluate the cost-effectiveness of telemedicine vs standard care for the management of type 2 diabetes mellitus, hypertension, and heart failure. The meta-analysis was limited to these 3 diseases as they all represent chronic cardiovascular conditions that are measurable through standardized tests and characterized by similar long-term care requirements and for which both cost-effectiveness evaluations and telemedicine interventions are well established in the literature, with RCTs dating back to before 2005 [20,21]. Indeed, several telemedicine trials conducted throughout the years have enrolled patients with multiple chronic diseases or risk factors, most often diabetes, hypertension, and heart failure [22-24], and suggest that telehealth could be efficacious in controlling these conditions [13]. To be included in this study, trials had to estimate the ICER per quality-adjusted life year (QALY) gained or the ICER per another primary outcome (1% reduction in hemoglobin A_{1c} [HbA_{1c}] for diabetes and 1–mm Hg reduction in systolic blood pressure [SBP] for hypertension) using a follow-up equal to or longer than 3 months [16].

Further details on the identification and selection processes are reported in Multimedia Appendix 1 [24-30].

Outcomes and Data Analysis

The primary outcome was the ICER per QALY gained, which is considered a foundational metric to evaluate the value of a health intervention and allows for cross-disease comparisons of health benefits by quantifying gains in both duration and quality of life [31,32]. The ICER was defined as the difference in costs divided by the difference in QALYs between telemedicine and standard care [33], indicating telemedicine cost per additional QALY gained. Secondary outcomes were ICER per 1% reduction in HbA_{1c} and ICER per 1–mm Hg reduction in SBP.

When available, we extracted the 95% CIs or uncertainty intervals, computed the SE of the ICER, and computed a summary estimate of the mean difference in ICER across individual studies using a random-effects [34] generic inverse variance approach to account for between-study heterogeneity

[35]. This approach was adopted as it is cited in the literature among those appropriate for meta-analyzing ICERs [36]. All costs were adjusted to 2025 USD, and between-study heterogeneity was quantified using the I^2 metric. Specifically, as inflation adjustment was reportedly performed in most (>80%) of the included studies, the current conversion simply aimed to adjust for the inflation that occurred between the time of publication and the year 2025 using the US consumer price index. Inflation adjustment was performed after currency conversion as practically all studies were conducted in high-income countries and the US inflation rate was considered sufficiently representative of all the study settings [37].

Meta-analysis was performed by pooling only studies with results in the same quadrant of the cost-effectiveness plane (ie, when ICERs indicated that the telemedicine intervention had a higher efficacy for an increased cost compared to control [36]). When most trials did not report an estimate of ICER SE, *P* value, or CIs, missing data imputation was inappropriate, and head-to-head meta-analysis could not be performed [38]. The health economic findings were synthesized narratively and presented using tables and graphics [2] in which the weighted mean of the ICER was shown. ICER means were weighted for the sample size, separately reported for each outcome, disease, and date of publication (excluding studies published before 2015). Given the variability in follow-up length of the included studies, in an attempt to reduce individual study variability, the estimates of the RCTs that used different follow-ups were recomputed assuming (1) constant effectiveness over time and (2) linear increase in costs with time (eg, the ICER of a trial with a 6-month follow-up was doubled). A 12-month follow-up was commonly assumed to be a sufficient time frame to detect meaningful changes in disease control from a clinical and organizational point of view. While this approach may overestimate the interventions' setup costs, it was selected over more complex modeling approaches to simplify the interpretation of the results given that most of the included studies (14/27, 51.9%) used a 12-month follow-up. As no meta-analysis included more than 7 trials, potential publication bias could not be assessed through formal testing of funnel plot asymmetry [39].

All meta-analyses were carried out using RevMan (version 5.4; The Cochrane Collaboration).

Results

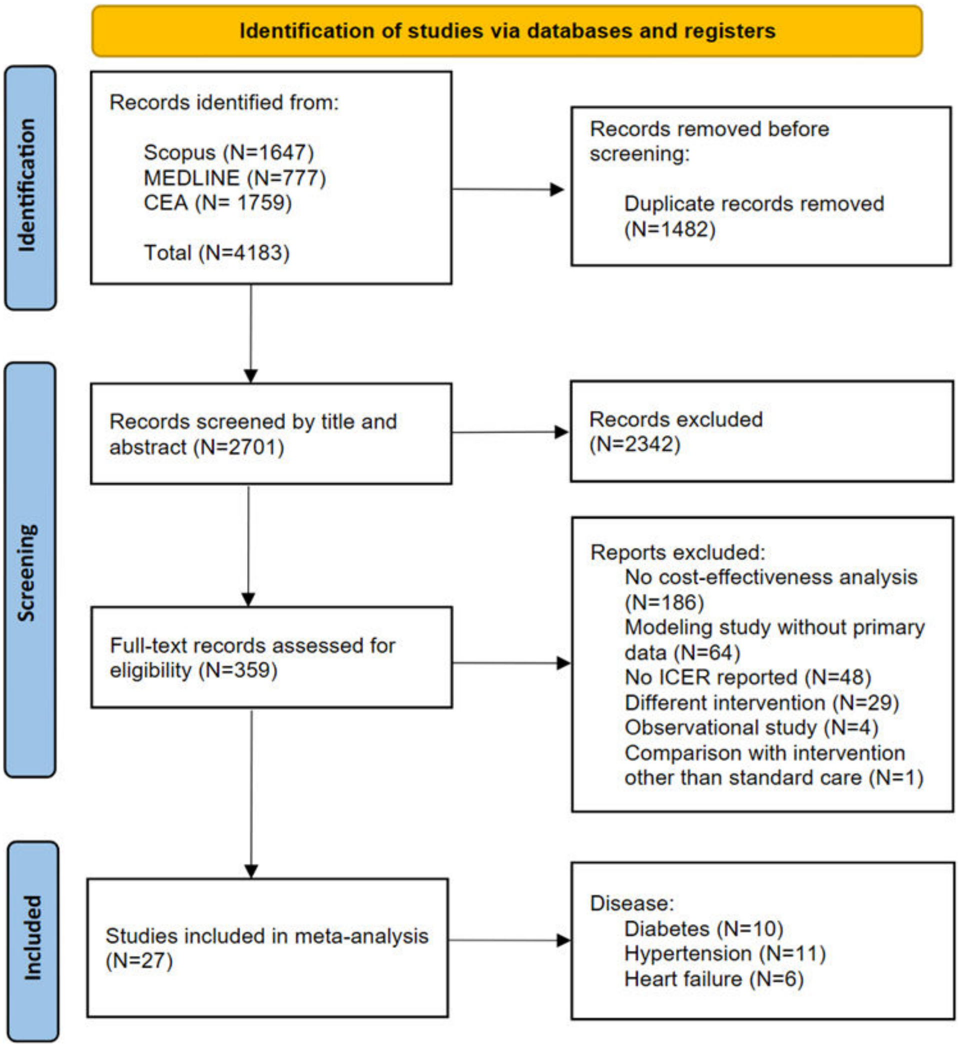
Study Selection and Characteristics

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of the selection process is summarized in Figure 1 [25]. Of the 4183 papers initially retrieved, a total of 27 (0.6%) RCTs used trial data to estimate and report one of the selected outcomes and were included in the meta-analyses.

The main study characteristics are reported in Multimedia Appendix 2 [40-65] stratified by disease: diabetes (10/27, 37% of the RCTs) [40-49], hypertension (11/27, 40.7% of the RCTs) [50-60], and heart failure (6/27, 22.2% of the RCTs) [58,61-65]. The first trial was published in 2005; 55.6% (15/27) of the studies were published after 2015 and were defined as "more recent." In total, 29.6% (8/27) of the RCTs were carried out in the United States; 18.5% (5/27) were carried out in the United Kingdom; 25.9% (7/27) were carried out in other European countries; and the remaining studies (7/27, 25.9%) were carried out in Australia, Bangladesh, Brazil, Russia, and Singapore. The sample sizes ranged from 117 to 1665 (564 on average, SD 444), and the duration of follow-up ranged from 3 to 60 months, although most of the trials (14/27, 51.9%) followed patients for 12 months. Almost all RCTs computed ICERs from the health care provider (13/27, 48.1%) or health care system (13/27, 48.1%) perspective; the interventions included telemonitoring in all trials on hypertension management (11/11, 100%), whereas most studies on diabetes and heart failure used some form of telephone coaching or support. Interestingly, 40.7% (11/27) of the studies did not report a willingness-to-pay (WTP) threshold, and among the studies providing a WTP threshold for QALYs, this was highly variable: from US $5000 to US $100,000. Only 7.4% (2/27) of the studies cited a threshold for 1–mm Hg reductions in SBP (US $27 to US $4071) [52, 57], and 3.7% (1/27) of the studies cited a threshold for 1% reductions in HbA_{1c} (US $1000) [40].

The methodological quality of the included RCTs is reported in Multimedia Appendix 3 [40-65]. Most RCTs (25/27, 92.6%) had an intermediate risk of bias, and only 7.4% (2/27) were judged to have a high risk of bias. The most common sources of concern were inadequate or insufficiently described methods to handle missing data (21/27, 77.8% of the RCTs), handle deviations from the intended interventions (20/27, 74.1%), and measure outcomes (17/27, 63%). The randomization process and the selection of the reported results were less concerning, especially in view of the wide standardization of outcomes for diabetes (HbA_{1c}) and hypertension (SBP).

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram [25]. CEA: Tufts Medical Center Cost-Effectiveness Analysis Registry; ICER: incremental cost-effectiveness ratio.



Primary Outcome: ICER per QALY Gained

In total, 48.1% (13/27) of the RCTs estimated the ICER per QALY gained (Multimedia Appendix 2), but only 3 of the trials on heart failure management reported sufficient data (95% CI, *P* value, or SE) to be included in the meta-analysis. Overall, based on a total sample of 1825 patients, the summary estimate of ICER per QALY gained of telemedicine vs standard care on a 12-month follow-up was US $45,741, with a large, nonsignificant 95% CI (–US $31,050 to US $122,533; *P*=.24). In the more recent RCT by González-Guerrero et al [65], the telehealth intervention was more effective and cost-saving compared to standard care.

The weighted means of the 48.1% (13/27) of the studies reporting the ICER per QALY gained are reported in Multimedia Appendix 4 [42,43,45,48,49,57-59,61-64]. The average ICER largely varied by disease, being highest for the management of diabetes (5/13, 38.5% of the studies, 2949 patients; US $44,725, SD 18,925), intermediate for heart failure (5/13, 38.5% of the trials, 3171 patients; US $40,271, SD 22,933), and lowest for hypertension (3/13, 23.1% of the studies, 1314 patients; US $18,966, SD 13,289).

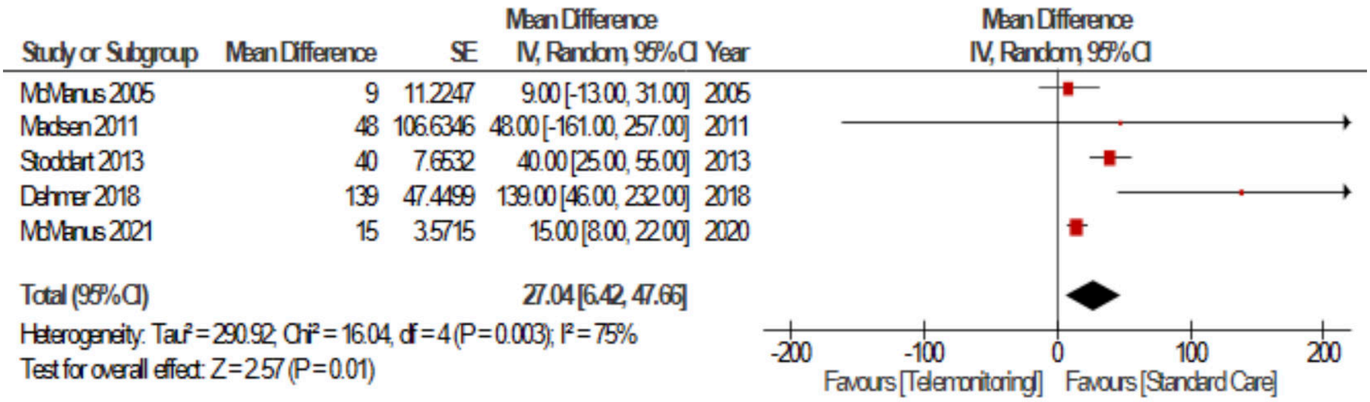
Secondary Outcomes: ICER per 1–mm Hg SBP Reduction and ICER per 1% HbA_{1c} Reduction

One out of the 11 hypertension trials did not calculate an ICER as higher effectiveness was found in the control arm; therefore, it could not be used for either SBP reductions or QALY gained [60]. In total, 90% (9/10) of the studies on hypertension computed the ICER per 1–mm Hg SBP reduction, and 70% (7/10) of the RCTs on diabetes reported an ICER per 1% HbA_{1c} decrease. However, only 50% (5/10) of the trials on hypertension, including a total of 1986 patients, reported sufficient data and were included in a meta-analysis (Figure 2). Overall, the summary estimate of ICER per 1–mm Hg reduction in SBP of telemedicine vs standard care for a 12-month follow-up was US $27 (95% CI US $6.4-$47.7; *P*=.01). The weighted mean for the same outcome from the 90% (9/10) of the trials on hypertension that reported an ICER was US $132 (SD 227; [50-57,59] Multimedia Appendix 4).

With regard to the ICER per 1% HbA_{1c} reduction, no meta-analyses were possible as no trial reported a measure of dispersion from the mean, and the weighted mean of the

7 trials that reported an ICER, including a total of 4157 patients, was US $3349 (SD 2249; Multimedia Appendix 4 [40,41,43-46,48]). When only the 2 more recent trials were considered, the average ICER decreased to US $1629 (SD 743).

Figure 2. Random-effect meta-analysis of randomized controlled trials (RCTs) evaluating the cost-effectiveness of telemedicine versus standard care for blood pressure management: incremental cost-effectiveness ratio (ICER) needed to achieve a 1 mm Hg reduction in systolic blood pressure. In this generic inverse variance model, only RCTs that reported the SD or CIs could be included in the meta-analysis [50-52,55,56].



Discussion

The main findings from our review are the following: (1) after more than 20 years of implementation, the available evidence based on high-quality, randomized data is still limited, as only 27 studies (with a total of 15,658 patients) estimated an ICER for 3 of the most common diseases in the world [66]; (b) in addition to some expected and somewhat inevitable heterogeneity due to the model of care or intervention, 48.1% (n=13) of the trials did not report any data to derive CIs for any outcome, which further limited the possibility to run the meta-analyses and their validity; and (3) from the available trials, our analysis suggests that implementing telemedicine strategies was cost-effective, with large variations across diseases: the lowest weighted mean ICER per QALY gained for the adoption of telehealth for 12 months as compared to usual care was found in hypertension (US $18,966), followed by heart failure (US $40,271) and diabetes (US $44,725), and the summary ICER per 1–mm Hg SBP reduction was also the lowest at US $27.

An increasing body of evidence shows that telemedicine strategies for the management of chronic diseases may be similarly effective compared to usual care [26,67,68], and it is now crucial to obtain some reliable estimates on the cost-effectiveness that digital health services may offer in comparison to usual care [69]. The available evidence on the cost-effectiveness of telemedicine is highly heterogeneous and often comes from theoretical models with no primary data, and even the results of individual RCTs are complex to interpret by examining single trials. Although some systematic reviews have been previously published [2,70,71], the authors have reported the results narratively, and to our knowledge, this is the first quantitative meta-analysis of the cost-effectiveness of telemedicine vs standard care for the management of diabetes mellitus, hypertension, and heart failure.

Our findings are consistent with those of previous systematic reviews [2,12] describing remote patient monitoring–based tools as highly cost-effective interventions in hypertension and cardiovascular disease management. Another systematic review already demonstrated the potentiality of at-home blood pressure self-monitoring to be cost-effective over usual care, particularly in the long term [72]. However, as mentioned, this is the first study to summarize the results of previous studies using meta-analysis to evaluate the cost-effectiveness of telehealth solutions in both heart failure and hypertension.

With regard to diabetes management, no formal meta-analysis was possible as none of the RCTs included a measure of dispersion from the mean. However, the weighted mean of ICER per 1% HbA_{1c} reduction from the 5 trials that reported an ICER was US $3349, which decreased to US $1629 when considering only the 2 more recent trials [41,43]. Although these values are less favorable than those observed for hypertension and heart failure, they are nevertheless encouraging and should serve as a starting point for decision-makers and researchers. Especially for diabetes, but also for hypertension and heart failure, further economic evaluations from randomized trials are clearly, strongly needed, possibly using higher-quality reporting standards [73].

With regard to the policy implications of our findings, they inevitably vary depending on the national contexts considered as decision-makers compare the ICER to a WTP threshold: if the ICER is below that threshold, the treatment is deemed cost-effective. Most studies consider a WTP threshold per QALY between US $30,000 and US $50,000 as acceptable from the health system perspective [2]. Similarly, in the United Kingdom, the National Institute for Health and Care Excellence has traditionally used a threshold of £20,000 to £30,000 per QALY (£1=US $1.35 as of July 17, 2026) [74]. Differently, in the United States, there is no single official threshold, but a WTP per QALY at around US $50,000 to US $150,000 is informally used by analysts [75]. This variability from one context to another can make it challenging to establish cost-effectiveness worldwide because each local context requires its policymakers to determine whether the cost of interventions is worthwhile. Acknowledging this variability, the estimates provided in this analysis can be used as a starting point in planning health care policies worldwide. Further in-depth research is needed to better define WTP per QALY thresholds for these telehealth solutions across different settings considering specific socioeconomic conditions, health priorities, and characteristics of each health care system. Further research should therefore be extended to low-income settings where evidence on the effectiveness and cost-effectiveness of telehealth services is lacking and where a significant percentage of people affected by chronic diseases such as diabetes live [73].

This study has some limitations that must be considered in interpreting the results. First, as mentioned, the available data are relatively scarce, and we could only compute a weighted mean for the ICER on diabetes management. Another example is the discrepancy between the US $45,741 summary estimate and the US $31,976 weighted mean of the ICER per QALY gained for heart failure. The summary estimate was based on only 3 trials and presented large CIs, to the point that cost-effectiveness could not be confirmed, whereas the weighted mean was based on all 5 eligible trials. Future cost-effectiveness analyses should include either SEs or CIs around the ICER to allow for their inclusion in subsequent meta-analyses. Second, some of the trials (8/27, 30%) were carried out 15 years ago or more, and the costs of telemedicine may have relevantly changed, as suggested by the highly volatile WTP thresholds. Indeed, when the analyses were restricted to the most recent trials, we observed a marked improvement in the selected outcomes for both heart failure and hypertension, which may reflect the general decrease in the costs associated with telemonitoring and tele-support [56]. Given the limited number of trials, however, this finding requires confirmation from more recent studies. Third, almost all the RCTs included in this meta-analysis (26/27, 96%) computed ICERs from the health care provider or health care system perspective, and this perspective may fail to capture additional benefits of telemedicine, including potential time and cost savings for patients [73]. Fourth, due to the limited number of studies included in each subgroup, it was not possible to identify whether different technologies used to support telemedicine (eg, computer, SMS, or smartphone), the use of interactive or noninteractive technology, the addition of telemonitoring, or a combination of these factors led to improved results.

The results of the present meta-analysis support the use of telemedicine as a cost-effective strategy to monitor hypertension; heart failure; and, depending on the WTP, diabetes mellitus. More RCTs reporting CIs for the ICER are, however, required to confirm these findings.

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Data Availability

The datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Search strategy, selection criteria, and methodological quality.
[DOC File (Microsoft Word File), 28 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Randomized controlled trials evaluating the cost-effectiveness of telemedicine vs standard care for the management of type 2 diabetes and hypertension that estimated an incremental cost-effectiveness ratio value per 1 clinical outcome.
[DOC File (Microsoft Word File), 169 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Quality assessment of the included randomized controlled trials according to version 2 of the Cochrane risk-of-bias tool for randomized trials (Sterne et al [76]).
[DOC File (Microsoft Word File), 101 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Incremental cost-effectiveness ratios of telemedicine versus standard care for type 2 diabetes, hypertension, and heart failure, evaluating quality-adjusted life years, blood pressure, and hemoglobin A_{1c} outcomes across randomized controlled trials.
[DOC File (Microsoft Word File), 327 KB-Multimedia Appendix 4]

Checklist 1

PRISMA checklist.
[PDF File (Adobe File), 300 KB-Checklist 1]

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Abbreviations

HbA_{1c}: hemoglobin A_{1c}
ICER: incremental cost-effectiveness ratio
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QALY: quality-adjusted life year
RCT: randomized controlled trial
SBP: systolic blood pressure
WTP: willingness to pay

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