



Managing cardiovascular risk factors with telemedicine in primary care: A systematic review and meta-analysis of patients with arterial hypertension and type 2 diabetes

Matic Mihevc^{1,2} , Tina Virtič Potočnik^{1,3},
Črt Zavrnik^{1,2}, Zalika Klemenc-Ketiš^{1,3},
Antonija Poplas Susič^{1,2} and Marija Petek Šter²

Abstract

Objectives: To review the effect of telemedicine interventions on cardiovascular risk factors control in people with arterial hypertension (AH), type 2 diabetes (T2D), or both in primary care.

Methods: We conducted a systematic review in February 2024 using PubMed/MEDLINE, Cochrane Library, and EMBASE databases. We included randomised controlled trials from 2010 onwards, lasting ≥ 3 months, comparing telemedicine to standard care for managing cardiovascular risk factors in adults with AH, T2D, or both.

Results: Among 1803 records, 54 were included. Telemonitoring with teleconsultations showed the best outcomes. For AH, systolic blood pressure decreased by -5.63 mmHg (95% CI -9.13 to -2.13) at 6 months and -5.59 mmHg (95% CI -10.03 to -1.14) at 12 months compared to standard care. For T2D, HbA1c decreased by -0.45% (95% CI -0.90 to 0.00) at 6 months and -0.18% (95% CI -0.41 to 0.05) at 12 months compared to standard care. Blood glucose self-monitoring was as effective as telemonitoring for T2D at 6 months. The effect on diastolic blood pressure, low-density lipoprotein, triglycerides, and body mass index was non-significant.

Discussion: Telemedicine offers short-term benefits but lacks long-term effectiveness. Optimal outcomes require a combined telemedicine approach, health education co-intervention, ≥ 12 -month follow-up, and careful patient selection.

¹Primary Healthcare Research and Development Institute, Community Health Centre Ljubljana, Ljubljana, Slovenia

²Medical Faculty, Department of Family Medicine, University of Ljubljana, Ljubljana, Slovenia

³Medical Faculty, Department of Family Medicine, University of Maribor, Maribor, Slovenia

Corresponding author:

Assist Matic Mihevc, Family Medicine Specialist, Department of Family Medicine, Medical Faculty University of Ljubljana, Slovenia.

Email: mihevc.matic@zd-tr.si

Keywords

Telemonitoring, teleconsultations, blood pressure, HbA1c, lipids, health education

Received 14 June 2023; accepted 1 July 2024

Introduction

The rising prevalence of arterial hypertension (AH) and type 2 diabetes (T2D) presents significant challenges to global healthcare systems, particularly impacting cardiovascular disease-related mortality as preventative measures remain inadequate.^{1,2}

Development of cardiovascular disease in individuals with AH and T2D can be influenced by a variety of risk factors, both modifiable and non-modifiable. Effective control of blood pressure (BP) and blood glucose (BG) is crucial. From a clinical standpoint, a 10-mmHg reduction in systolic BP (SBP), 5-mmHg reduction in diastolic BP (DBP), and a 0.5% drop in glycated haemoglobin (HbA1c) is associated with up to a 20% reduction in major cardiovascular events and considered clinically relevant.^{3–5}

However, cardiovascular disease is not only associated with high BP or BG levels but also to shared risk factors such as high triglycerides (TG), high low-density lipoprotein (LDL), obesity (usually measured as body mass index, BMI), or chronic kidney disease. Dysfunction in one system can exacerbate problems in others, leading to negative health effects. Consequently, interventions that target one or two risk factors may also impact others in a reciprocal manner.^{1,5–7}

Primary care plays a central role in the management of AH and T2D, as well as in preventing their risk factors and complications. It serves as the main point of contact for patients and leads chronic disease management through screening, health education, treatment initiation, self-management support, and ongoing counselling to ultimately provide comprehensive and patient-centred healthcare.^{8–12}

Despite its central role, primary care faces growing challenges such as staff shortages, fragmentation of care, unequal access, and the

increasing complexity of chronic disease management.^{10,13} To overcome these challenges, telemedicine has emerged as a promising solution. Telemedicine, as defined by the World Health Organisation (WHO), facilitates the delivery of healthcare services across distances using information and communication technologies, encompassing diagnosis, treatment, prevention, research, evaluation, and professional education.^{11,14,15}

In the management of AH and T2D, telemedicine streamlines integrated care processes by enabling early disease detection, treatment decisions, self-monitoring, patient education, provider coordination, and adherence to clinical pathways.¹⁶ While the COVID-19 pandemic has accelerated the adoption of simpler telemedicine approaches such as teleconsultations¹⁷ or asynchronous telemedicine^{13,18} in primary care, the implementation of more complex measures like telemonitoring, mobile health or tele-education continues to be constrained by financial resources.^{19–21}

For future scale-up of telemedicine in primary care, it is vital to gather evidence regarding its clinical effectiveness and determine which remote care models deliver the optimal outcomes for managing AH and T2D. As telemedicine services have evolved, different approaches have emerged, and each approach or their combination should be evaluated. Previous reviews^{22–26} have focused primarily on BP and BG control in patients with isolated AH or T2D, whereas the effect on other risk factors and in cases of comorbid AH and T2D should also be explored.

The aim of this systematic review is to examine how various telemedicine approaches impact changes in cardiovascular risk factors, including SBP, DBP, HbA1c, LDL, TG, and BMI, compared to standard care in people with AH, T2D or both in primary care settings.

Methods

Design

A systematic review with meta-analysis was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.²⁷ The research protocol was registered in the PROSPERO international register of systematic reviews, with the registration number 227335.

Research questions

The research questions were formed based on the PIO strategy (population, intervention, outcome) and were as follows:

1. Which telemedicine intervention is the most effective in improving control of SBP, DBP, HbA1c, LDL, TG or BMI compared to standard care in people with AH, T2D, or both in primary care?
2. What is the difference in effectiveness of commonly used telemedicine approaches (telemonitoring, self-monitoring, teleconsultation, tele-education) for the control of SBP and HbA1c, depending on the combination used and the patient group (AH, T2D, or both)?

Search algorithm

In the first part, we systematically reviewed the existing literature in electronic databases, including PubMed/MEDLINE, Cochrane Library, and EMBASE, to retrieve relevant articles. The search strategy compromised using Medical Subject Headings for the concepts: “telemedicine” “hypertension”, “diabetes type 2”, “blood pressure”, “blood glucose”, “HbA1c”, “cholesterol”, “body mass index”, and “primary health care”. We employed the Boolean operators such as “AND”, “NOT”, and “OR” to construct a comprehensive search algorithm, as detailed in Appendix 1. The initial search was performed in November 2020, and an update search was

conducted in February 2024. In March 2024, we extended our collections of studies by conducting a comprehensive hand search of the publications from international bodies and their websites, including WHO, International Diabetes Federation, American Diabetes Association, and Centres for Disease Control. Additionally, we reviewed leading journals that focus on telemedicine and primary care, including Lancet Digital Health, npj Digital Medicine, Journal of Medical Internet Research, JMIR mHealth and uHealth, Journal of Telemedicine and Telecare, British Journal of General Practice, Annals of Family Medicine, European Journal of General Practice, Primary Care Diabetes, and Diabetes Research and Clinical Practice. We limited our search to original scientific articles published in English between 2010 and 2024 to focus on recent and significant literature while ensuring an adequate corpus of work for thorough analysis.

Study selection

To determine the eligibility of documents for further analysis, we applied the PICOTS criteria as outlined in Table 1. We included randomised controlled trials (RCTs) that assessed the effectiveness of telemedicine interventions in adults with AH, T2D or both in primary care setting. The decision to focus on RCTs was based on the research question and objectives of this systematic review. Studies were required to report a measurable change in at least one outcome of interest after a minimum follow-up period of 3 months, as this provides sufficient time to estimate intervention effects and stability of measurements and is consistent with methodology in previous reviews.^{1,28} While our review primarily centred on telemedicine interventions, we also considered synchronous patient-provider tele-education approaches. Originally encompassed within the broader category of telehealth,¹⁴ this term has been merged with other forms of telemedicine in several RCTs. Consequently, we

Table 1. PICOTS inclusion and exclusion criteria.

PICOTS	Inclusion criteria	Exclusion criteria
Population	People with AH, T2D or both ≥ 18 years of age	People with other conditions <18 years of age
Intervention	Telemedicine approaches as defined by the WHO, ¹⁵ including patient tele-education	Health applications related to nutrition, diet, mental health, adherence, or education without involvement of a healthcare professional Telemedicine interventions using only artificial intelligence algorithms and no human interaction
Control	Standard care involving face-to-face consultations	Standard care supplemented with telemedicine or educational co-intervention
Outcome	Change in SBP, DBP, HbA1c, TG, LDL, BMI	Other outcomes
Timeframe	A follow-up period ≥3 months	A follow-up period <3 months
Study design	Randomised controlled design Primary care setting	Qualitative study design Protocol for clinical study Hospital setting

deemed it important to examine its role independently to fully comprehend its effectiveness.

Data analysis

Qualitative extraction of data. Two independent researchers (MM & MPŠ) conducted screenings of the datasets using data extraction tool that included various study-related characteristics, including author, publication year, country, study design/setting, sample size, and inclusion criteria. Additionally, we extracted telemedicine intervention-related characteristics, such as the type and duration of the intervention, outcomes measured, and main findings. For categorising telemedicine approaches, we used definitions described in Table 2.

Quantitative extraction of data. In the quantitative analysis, we examined the mean differences in SBP, DBP, HbA1c, LDL, TG, and BMI between telemedicine and standard care group over a period of 3 to 60 months. To ensure consistency, we standardised all results by converting them from their original units

to the International System of Units commonly used in Europe. Specifically, for TG, we divided the results originally measured in milligrams per decilitre (mg/dL) by 88.57 to obtain values in millimoles per litre (mmol/L). Similarly, for LDL, we divided the results originally measured in mg/dL by 38.67 to obtain values in mmol/L.³²

Next, we calculated the mean difference between groups (Δ_{I-C}) to determine the variation in outcomes between the intervention and control groups. This involved subtracting the change from baseline to the observed timeframe in the intervention group (Δ_I) from the corresponding change in the control group (Δ_C). This process allowed us to assess the overall impact of the intervention compared to the control group. If Δ_{I-C} was already reported in the article, we extracted this data from the text along with the corresponding p-values.³³

Assessment of risk of bias. Two independent researchers (MM & MPŠ) evaluated the quality of the included studies using Version 2 of the Cochrane tool for assessing bias in

Table 2. Definition of approaches used in telemedicine interventions.

Approach	Definition
Telemonitoring	The use of validated automated devices that transmit patient vital signs and other data in real time to a monitoring centre, where abnormalities trigger a rapid response from health professionals. ^{11,14,15}
Self-monitoring	Monitoring vital signs at home using medical devices, without the need for an internet connection or real-time contact with healthcare providers. Users can enter readings into a health application for optional asynchronous feedback from health professionals. ²⁹
Mobile health (mHealth)	Practice of medicine supported by mobile devices and/or wireless infrastructure, often for the purpose of telemonitoring or tele-education. ³⁰
Teleconsultation	Medical consultation between patient and health professional synchronously via videoconferencing equipment or telephone without face-to-face contact. ¹⁴
Tele-education	Distance health promotion and self-management education using information and communication technologies with the involvement of health professionals. ³¹

randomised trials.³⁴ Disagreements were resolved by discussion, or, where this was not possible, by consultation with a research team (ČZ, TVP, ZKK, APS). The risk of bias assessment considered five domains: randomisation

process, deviations from intended interventions, missing outcome data, outcome measurement, selection of reported results. Ultimately, all domains were categorised as having either a low risk, some concerns, or a high risk of bias.

Meta-analysis

In meta-analysis, we aimed to evaluate the effectiveness of prevalent telemedicine approaches, focusing on interventions such as self-monitoring or telemonitoring of BP and BG, coupled with teleconsultations or tele-education, in comparison to standard care. Specifically, we examined their impact on two critical cardiovascular risk factors, SBP and HbA1c, over 6 and 12 months from baseline. Due to limited data availability, we were unable to conduct reliable meta-analyses for other telemedicine approaches or outcomes.

For our meta-analysis, we included only RCTs reporting means and standard deviations (SD) or 95% confidence intervals (CI) of observed outcomes. We followed the methods described in the Cochrane Handbook for Systematic Reviews of Interventions (version 6.4, 2023) for calculations. In cases where studies reported 95% CIs instead of SDs, we derived SDs using the formula: $SD = \sqrt{N \times (\text{upper limit} - \text{lower limit}) / 3.92}$, where N is the number of participants. For studies reporting standard errors (SE), SD was derived using the formula: $SD = SE \times \sqrt{N}$, where N is the number of participants.

Next, we employed the inverse variance approach in Review Manager (RevMan) version 5.4.1 by The Cochrane Collaboration to calculate pooled mean differences and 95% CIs. Heterogeneity was assessed using I^2 statistic, where a value below 50% indicated non-significant heterogeneity and prompted the use of a fixed-effect model, while values above 50% indicated significant heterogeneity, leading to the use of a random-effects model.³⁵

Finally, we assessed publication bias by visual inspection of funnel plots. When more than 3 studies were included in the meta-analysis, we assessed publication bias

quantitatively using Egger's regression test, which compares effect sizes with their precision (1/SE). Calculations were performed using IBM SPSS Statistics (version 25.0), with a p-value <0.05 indicating possible publication bias.³⁶

Certainty of the evidence

To determine the certainty of the evidence for the RCTs included in our meta-analysis, we used the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) tool. This tool systematically assesses several factors: risk of bias, inconsistency, indirectness, imprecision, and publication bias.³⁷ Two independent researchers (MM & MPŠ) rated each section. The overall GRADE score, ranging from very low (⊕), low (⊕⊕), moderate (⊕⊕⊕) to high (⊕⊕⊕⊕), was determined by discussion. If no consensus could be reached between MM & MPŠ, we consulted a larger research team (ČZ, TVP, ZKK, APS).

Results

Search results

The search algorithm yielded a total of 1803 references, as shown in Figure 1. After eliminating duplicate entries and screening the titles and abstracts, 1273 references were excluded. Following a thorough evaluation of the full texts, an additional 476 references were excluded. Ultimately, the analysis included 54 references. Details on the risk of bias assessment of included studies are provided in Appendix 2. Overall, 25 exhibited a low risk of bias, 27 had some concerns, and 2 were identified as having a high risk of bias.

Effect of telemedicine interventions on blood pressure

Telemedicine interventions have shown varying levels of effectiveness in controlling BP in people with AH, with only a limited number of interventions achieving a clinically

significant reduction of 10 mmHg in SBP and 5 mmHg in DBP.^{38,39} Table 3 summarises the reported effects of different telemedicine interventions on cardiovascular risk factors, including changes in SBP and DBP in people with AH. Notably, interventions combining BP telemonitoring with teleconsultations have consistently shown the most prominent results.

In the meta-analyses examining the effect of telemedicine interventions on SBP change compared to standard care (Table 4), the combination of BP telemonitoring with teleconsultations significantly reduces SBP at both 6- and 12-month intervals in patients with AH, exceeding the 5-mmHg threshold. However, when considering patients with AH and T2D, the impact is irrelevant, with minimal changes in SBP observed. The effect of BP self-monitoring combined with teleconsultation on SBP was insignificant. There was a high level of heterogeneity between studies, coupled with low publication bias. Certainty of the evidence was low to moderate. More detailed data are presented in Appendix 3.

In terms of DBP control, combining BP telemonitoring with teleconsultations in patients with AH resulted in mean reductions in DBP ranging from -2.2 to -4.4 mmHg after 6 months⁴³⁻⁴⁵ and from -3.6 to +0.3 mmHg after 12 months.^{29,38,47} Isolated interventions, such as teleconsultations or adherence monitoring,^{40,53} virtual visits,⁵⁶ or isolated mHealth tele-education approaches^{54,55} were found to be ineffective. A similar lack of clinical impact has been observed in patients with comorbid AH and T2D.⁶⁰⁻⁵⁹

Effect of telemedicine interventions on glycaemic control

The effectiveness of telemedicine interventions in controlling BG levels in people with isolated T2D or comorbid AH and T2D varies with the number of telemedicine approaches combined, with multicomponent interventions achieving a clinically significant mean reduction of 0.5% in

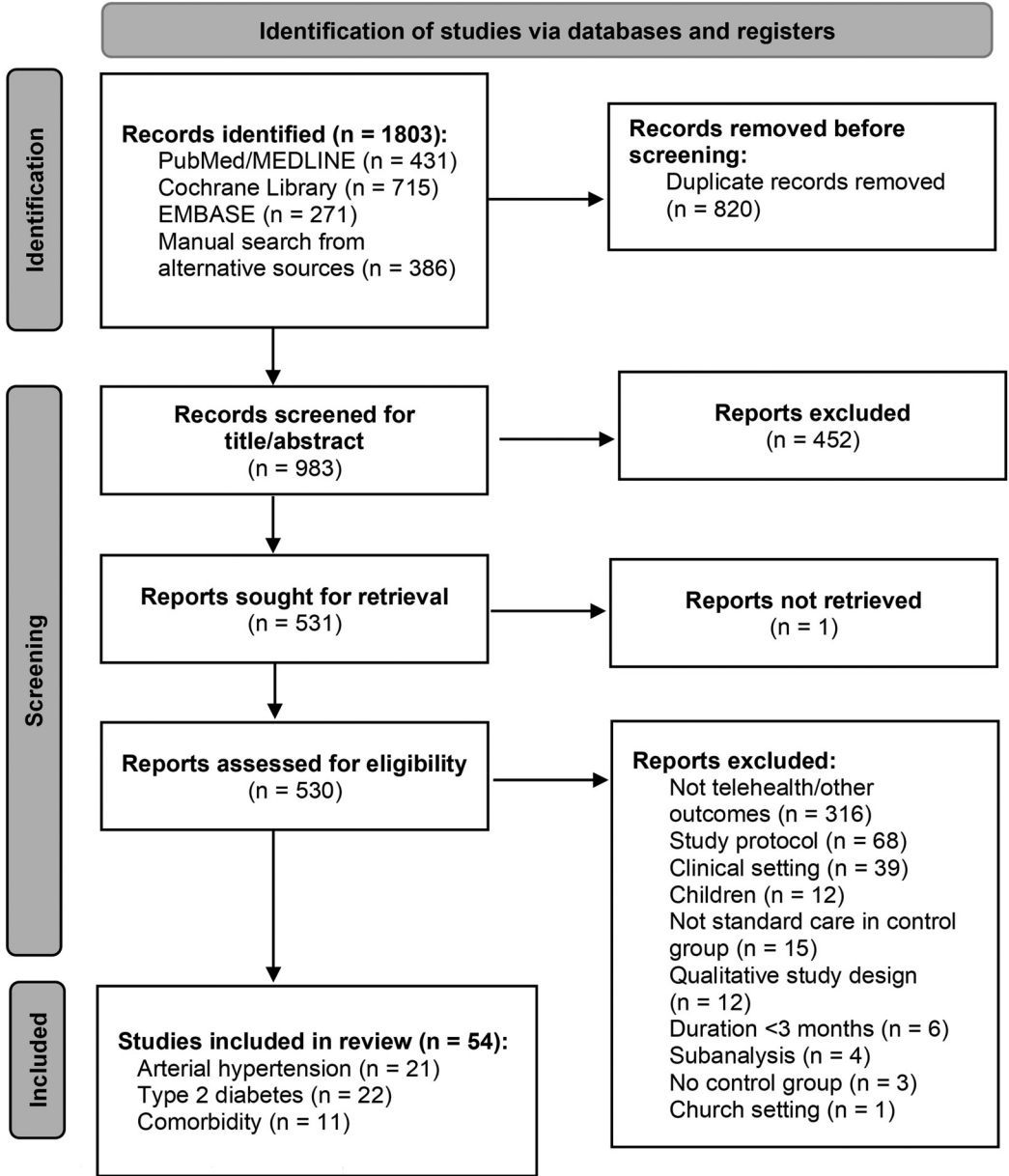


Figure 1. PRISMA flow diagram.

HbA1c after 6 months.^{62–65} However, this effect was not maintained beyond 12 months.^{62,63,66–70} A detailed overview of the reported effects of different telemedicine interventions on cardiovascular risk factors, including changes in HbA1c, in people with T2D or

comorbid AH and T2D is shown in Table 5 and Table 6, respectively.

In the meta-analyses (Table 7) examining the effect of telemedicine interventions on HbA1c change compared to standard care, the combination of two interventions (BG telemonitoring

Table 3. Reported effects of different telemedicine interventions on risk factors control in people with arterial hypertension. Results are presented as the mean difference (Δ) between telemedicine and standard care group, with statistically significant differences indicated by an asterisk (*).

Author (reference)	Sample size	Duration	Δ SBP [mmHg]	Δ DBP [mmHg]	Δ HbA1c [%]	Δ LDL [mmol/L]	Δ TG [mmol/L]	Δ BMI [kg/m ²]	Overall risk of bias
Adherence telemonitoring with pill bottle									
Mehta et al. ⁴⁰	149	4 M	+0.4	/	/	/	/	/	Some concerns
Blood pressure telemonitoring									
McManus et al. ⁴¹	527	12 M	-5.4*	-2.7*	/	/	/	/	Low
Blood pressure telemonitoring combined with teleconsultations									
Hoffmann Petersen et al. ⁴²	356	3 M	0.0	0.0	/	/	/	/	Some concerns
McKinstry et al. ⁴³	401	6 M	-4.3*	-2.3*	/	/	/	/	Low
Teo et al. ⁴⁴	217	6 M	-5.1	-4.4	/	/	/	/	Some concerns
Bove et al. ⁴⁵	241	6 M	-4.3	-2.2	/	-0.04	-0.18	-0.70	Some concerns
Logan et al. ⁴⁶	110	12 M	-6.8*	-3.6*	/	/	/	/	Some concerns
Margolis et al. ⁴⁷	3071	12 M	-0.8	+0.3	/	/	/	/	Low
McManus et al. ²⁹	1182	12 M	-4.7*	-1.3*	/	/	/	/	Low
Bosworth et al. ⁴⁸	296	18 M	-1.2	-0.5	/	/	/	/	Some concerns
Maciejewski et al. ⁴⁹	296	18 M (I) + 18 M (FU)	-3.6	/	/	/	/	/	Low
Margolis et al. ⁵⁰	450	12 M (I) + 42 M (FU)	-2.5	-1.0	/	/	/	/	Some concerns
Blood pressure telemonitoring combined with tele-education									
Bosworth et al. ⁴⁸	295	18 M	+2.2	+0.6	/	/	/	/	Some concerns
Maciejewski et al. ⁴⁹	295	36 M	-5.0*	/	/	/	/	/	Low
Blood pressure telemonitoring combined with teleconsultations and tele-education									

(continued)

Table 3. Continued

Author (reference)	Sample size	Duration	Δ SBP [mmHg]	Δ DBP [mmHg]	ΔHbA1c [%]	ΔLDL [mmol/L]	ΔTG [mmol/L]	ΔBMI [kg/m ²]	Overall risk of bias
Wakefield et al. ⁵¹	200	12 M	-7.5*	-3.5*	/	/	/	/	Some concerns
Bosworth et al. ⁴⁸	294	18 M	-3.6	-1.4	/	/	/	/	Some concerns
Maciejewski et al. ⁴⁹	294	18 M (I) + 18 M (FU)	-5.5*	/	/	/	/	/	Low
Blood pressure self-monitoring combined with teleconsultations									
McManus et al. ²⁹	1182	12 M	-3.5*	-1.5*	/	/	/	/	Low
Bray et al. ⁵²	263	12 M	-5.5	-1.0	/	/	/	/	Low
Kerry et al. ⁵³	381	12 M	+0.3	/	/	/	/	/	Low
Fu et al. ³⁹	420	18 M	-10.4*	-6.4*	/	-0.02	/	-0.28	Some concerns
Blood pressure self-monitoring combined with teleconsultations and health education									
McManus et al. ⁴¹	622	12 M	-3.5	-1.0	/	/	/	/	Low
mHealth tele-education									
Vedanthan et al. ⁵⁴	960	15 M	-3.4	+1.4	/	/	/	/	Some concerns
Marquez Contreras et al. ⁵⁵	148	12 M	-2.4	-2.6	/	/	/	/	Some concerns
Virtual visits									
Levine et al. ⁵⁶	1051	6 M	+0.4	/	/	/	/	/	Some concerns

Legend: SBP, systolic blood pressure; DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; LDL, low-density lipoprotein; TG, triglycerides; BMI, body mass index; M, month; I, intervention; FU, follow-up.

Table 4. Effect of telemedicine interventions on the change in systolic blood pressure (mmHg) compared to standard care, depending on the observed population, intervention type, and duration.

Population	Duration	Trials	References	Patients, n	MD in SBP (95% CI)	p	I ² (%)	Egger's test (t value, p)	Certainty of the evidence (GRADE)
BP self-monitoring combined with teleconsultations									
AH	6 M	3	29,39,53	1333	-3.20 mmHg (-9.54, 3.13)	0.320	88	t = 1.540, p = 0.367	⊕ ⊕
AH	12 M	4	29,39,52,53	1546	-4.26 mmHg (-9.93, 1.40)	0.140	86	t = 0.448, p = 0.658	⊕ ⊕
BP telemonitoring combined with teleconsultations									
AH	6 M	4	29,38,43,45	1741	-5.63 mmHg (-9.13, -2.13)	0.002	74	t = 0.034, p = 0.976	⊕ ⊕ ⊕
AH and T2D	6 M	2	57,58	439	+0.22 mmHg (-1.94, 2.39)	0.840	13	NA	⊕ ⊕
AH	12 M	4	29,38,46,47	4248	-5.59 mmHg (-10.03, -1.14)	0.010	86	t = 3.076, p = 0.091	⊕ ⊕ ⊕
AH and T2D	12 M	2	57,59	510	+0.31 mmHg (-1.69, 2.30)	0.760	25	NA	⊕ ⊕ ⊕

Legend: BP, blood pressure; AH, arterial hypertension; T2D, type 2 diabetes; MD, mean difference; SBP, systolic blood pressure; 95% CI, 95% confidence interval; I², heterogeneity index; NA, not applicable; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation.

Table 5. Reported effects of different telemedicine interventions on risk factors control in people with type 2 diabetes. Results are presented as the mean difference (Δ) between telemedicine and standard care group, with statistically significant differences indicated by an asterisk (*).

Author (reference)	Sample size	Duration	Δ SBP [mmHg]	Δ DBP [mmHg]	Δ HbA1c [%]	Δ LDL [mmol/L]	Δ TG [mmol/L]	Δ BMI [kg/m ²]	Overall risk of bias
Blood glucose self-monitoring									
Parsons et al. ⁷¹	298	12 M	/	/	-0.75*	/	/	-0.28	Low
Blood glucose self-monitoring combined with teleconsultations									
Fortmann et al. ⁶²	126	6 M	+3.8	+1.0	-0.80*	-0.01	-0.09	+0.50	Some concerns
Parsons et al. ⁷¹	299	12 M	/	/	-0.87*	/	/	+0.09	Some concerns
Face-to-face training with pharmacist combined with teleconsultations									
Lum et al. ⁷²	264	6 M	-13.5	/	-0.30*	-0.30	-0.20	/	Some concerns
Healthcare workers video tele-education and teleconsultations									
Naik et al. ⁷³	225	12 M	/	/	-0.06	/	/	/	Some concerns
Leong et al. ⁶⁸	181	3 M	/	/	+0.06	/	/	/	Low
Health coach tele-education									
Christensen et al. ⁶⁵	170	6 M	+1.4	-0.7	-0.15	-0.17	-0.41	-0.89*	Low
mHealth pharmacist teleconsultation and tele-education									
Gerber et al. ⁷⁴	221	12 M	-3.1	-2.4	-0.62*	+0.07	+0.09	-1.25	Low
Blood glucose self-monitoring thought mHealth or other means combined with teleconsultations and tele-education									
Odnoletkova et al. ⁷⁵	574	6 M (I) + 12 M (FU)	-2.0	0	-0.20*	-0.07	-0.17	-0.40	Some concerns
Blood glucose +/- blood pressure telemonitoring combined with teleconsultations									
Liou et al. ⁷⁶	95	6 M	-5.7	+0.4	-0.60*	+0.19	0.00	-1.00	Some concerns
Vaughan et al. ⁶⁴	89	6 M	-6.9*	-3.2	-0.98*	/	/	-0.84	Some concerns
Lim et al. ⁷⁷	204	6 M	-2.8	-2.4	-0.40*	-0.09	+0.11	$\downarrow$	Low
Ilijaž et al. ⁶⁷	107	12 M	-2.8	+0.5	-0.60*	+0.10	0.00	-0.60	Low
Blood glucose +/- blood pressure telemonitoring combined with teleconsultations									
Yang et al. ⁷⁸	125	3 M	-3.7	-2.7	-0.35	-0.08	0.00	+0.15	Low
Warren et al. ⁶³	157	6 M	-12.0	-3.0	-0.90*	/	/	+0.80	Some concerns
Bujnowska-Fedak et al. ⁷⁹	100	6 M	+2.0	-2.5	-0.08	/	/	-0.80	Some concerns
Mudiyansele et al. ⁸⁰	177	12 M	-1.5	+1.42	-0.22	-0.02	-0.04	/	Some concerns

(continued)

Table 5. Continued

Author (reference)	Sample size	Duration	Δ SBP [mmHg]	Δ DBP [mmHg]	ΔHbA1c [%]	ΔLDL [mmol/L]	ΔTG [mmol/L]	ΔBMI [kg/m ²]	Overall risk of bias
Stevenson et al. ⁶⁹	457	12 M	/	/	-0.21*	/	/	/	Low
McFarland et al. ⁸¹	110	6 M	/	/	-0.50	/	/	/	Some concerns
Tang et al. ⁶⁶	415	12 M	-2.3	-0.7	-0.19	-0.16*	/	0.00	Low
Lee et al. ⁷⁰	240	12 M	-0.6	-0.6	-0.03	+0.01	+0.03	/	Some concerns
Jia et al. ⁸²	19 546	12 M	-0.8	-0.6	-0.32	/	-0.01	/	Low
Blood glucose +/- blood pressure telemonitoring combined with teleconsultations and peer support									
Anzaldo Campos et al. ⁸³	301	10 M	-3.4	-2.0	-1.70*	-0.02	-0.24	+0.31	Some concerns

Legend: SBP, systolic blood pressure; DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; LDL, low-density lipoprotein; TG, triglycerides; BMI, body mass index; M, month; I, intervention; FU, follow-up.

and teleconsultations) or three interventions (BG self-monitoring, teleconsultations, and tele-education) resulted in a mean reduction in HbA1c of around 0.5%. Notably, the effect was more consistent with the combination of three interventions. In contrast, the effect of the combination of teleconsultations and tele-education was clinically and statistically insignificant. Furthermore, the reduction in HbA1c at 12 months did not meet the clinically significant threshold of 0.5% for any of the interventions. Notably, the reduction observed in trials combining BG telemonitoring and teleconsultations remains statistically significant. The heterogeneity between RCTs was high for those involving BG telemonitoring but low for those involving BG self-monitoring and/or tele-education. Publication bias was low, except for interventions involving BG self-monitoring. Certainty of the evidence was low to moderate. More detailed data are provided in Appendix 3.

Effect of telemedicine interventions on lipid profile

The effect of telemedicine interventions on lipid profile control in people with AH and/or T2D is clinically irrelevant. In people with T2D the mean change in LDL is ranging from -0.30 to +0.10 mmol/L, whereas the mean change in TG is ranging from -0.41 to +0.11 mmol/L.^{62,65,67,72,74,75,77,82} In people with comorbid AH and T2D the mean change in LDL is ranging from -0.28 to +0.05 mmol/L, whereas the mean change in TG is ranging from -0.20 to +0.07 mmol/L.^{58,60-59,85-87} As the evidence is inconsistent, it is not possible to stratify effectiveness results by intervention type or duration. In both groups, the effectiveness was greater in intervention that included tele-education.^{65,75,85}

Effect of telemedicine interventions on body mass index

The effect of telemedicine interventions on BMI in people with AH and/or T2D is

Table 6. Reported effects of different telemedicine interventions on risk factors control in people with arterial hypertension and type 2 diabetes. Results are presented as the mean difference (Δ) between telemedicine and standard care group, with statistically significant differences indicated by an asterisk (*).

Author (reference)	Sample size	Duration	Δ SBP [mmHg]	Δ DBP [mmHg]	Δ HbA1c [%]	Δ LDL [mmol/L]	Δ TG [mmol/L]	Δ BMI [kg/m ²]	Overall risk of bias
Diabetologist teleconsultations									
Basudev et al. ⁸⁴	208	12 M	-8.0*	-2.0*	+0.20	/	/	-0.07	Some concerns
Nutritionist teleconsultations and tele-education									
Benson et al. ⁸⁵	118	12 M	/	/	-0.21	-0.27	/	+2.19	Low
Adherence telemonitoring with pillbox combined with pharmacist teleconsultations									
Choudhry et al. ⁸⁶	4078	12 M	+2.3	/	+0.20	-0.12	/	/	Low
Telemonitoring with pill ingestible sensor and body patch									
Frias et al. ⁸⁷	109	3 M	-4.6	-2.4	-0.48	-0.28	/	/	High
Blood glucose self-monitoring combined with teleconsultations and tele-education									
Ramallo-Farina et al. ⁶⁰	1123	24 M	-1.49	-0.82	-0.15	+0.05	-0.07	-0.20	Low
Weinstock et al. ⁶¹	1665	60 M	-4.3*	-2.6*	-0.29*	-0.10	/	/	Low
Blood glucose +/- blood pressure telemonitoring combined with teleconsultations									
Stone et al. ⁵⁸	150	6 M	-1.0	-3.5	-0.70*	-0.22	-0.20	↑	Low
Wild et al. ⁸⁸	321	9 M	-3.1*	-2.2*	-0.51*	/	/	↓	Low
Nicolucci et al. ⁵⁷	302	12 M	+0.7	+0.4	-0.33*	-0.02	-0.15	↑	Some concerns
Karhula et al. ⁵⁹	250	12 M	-0.2	-0.7	-0.11	+0.04	+0.07	↑	Low
Wakefield et al. ⁸⁹	209	12 M	-8.2	/	+0.14	/	/	/	High

Legend: SBP, systolic blood pressure; DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; LDL, low-density lipoprotein; TG, triglycerides; BMI, body mass index; M, month; I, intervention; FU, follow-up.

Table 7. Effect of telemedicine interventions on the change in HbA1c (%) compared to standard care, depending on the observed population, intervention type, and duration.

Population	Duration	Trials	References	Patients, n	MD in HbA1c (95% CI)	p	I ² (%)	Egger's test (t value, p)	Certainty of the evidence (GRADE)
BG self-monitoring combined with teleconsultations and tele-education									
T2D	6 M	7	62,64,67,71,75-77	1639	-0.47% (-0.60, -0.35)	<0.001	44	t = 3.061, p = 0.028	⊕ ⊕ ⊕
BG telemonitoring combined with teleconsultations									
T2D	6 M	5	63,66,70,79,81	887	-0.45% (-0.90, 0.00)	0.050	87	t = 1.051, p = 0.370	⊕ ⊕ ⊕
T2D and AH	6 M	2	57,58	439	-0.53% (-1.07, 0.00)	0.050	61	NA	⊕ ⊕
T2D	12 M	4	66,69,70,82	18,558	-0.18% (-0.41, 0.05)	0.120	95	t = 0.231, p = 0.839	⊕ ⊕ ⊕
T2D and AH	12 M	2	57,59	519	-0.21% (-0.37, -0.06)	0.008	0	NA	⊕ ⊕ ⊕
Teleconsultations combined with tele-education									
T2D	6 M	4	65,72-74	709	-0.14% (-0.38, 0.10)	0.240	45	t = -0.420, p = 0.715	⊕ ⊕ ⊕
T2D	12 M	2	73,74	384	-0.36% (-0.83, 0.10)	0.130	17	NA	⊕ ⊕

Legend: BG, blood glucose; AH, arterial hypertension; T2D, type 2 diabetes; MD, mean difference; HbA1c, glycated haemoglobin; 95% CI, 95% confidence interval; I², heterogeneity index; NA, not applicable; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation.

clinically irrelevant. In people with T2D the mean change in BMI ranges from -1.25 to $+0.80$ kg/m²,^{62–67,71,74,75,78,79,83} whereas in people with AH and T2D the mean change in BMI ranges from -0.20 to $+2.19$ kg/m².^{60,84,85} As the evidence is inconsistent, it is not possible to stratify effectiveness results by intervention type or duration.

Discussion

Summary of findings and comparison with the existing literature

The systematic review indicates significant improvements in SBP and HbA1c across various telemedicine approaches for both AH and T2D, while the impact on DBP, lipid profile and BMI was clinically insignificant. However, studies consistently show stronger evidence of positive outcomes in people with T2D compared to those with AH. Positive outcomes are demonstrated as early as 3 months, with more consistent and sustained improvements seen with longer durations, particularly over 12 months. However, the effectiveness and ideal duration vary depending on the type of intervention and patient group.

In contrast to previous reviews that mainly focused on the impact of telemedicine approaches on BP and BG control in primary care,^{22,23} or specifically examined a single type of telemedicine, such as synchronous telemedicine,²⁴ or limited their analysis to people with AH²⁵ or T2D,^{22,23,26} our review encompasses the entire spectrum of telemedicine approaches for people with AH, T2D, or both.

The most effective method of managing AH entails a combination of BP telemonitoring and teleconsultations.^{29,38} Our meta-analysis found that this approach exceeded the 5-mmHg threshold but fell short of the desired 10-mmHg SBP target. Long-term benefits have been observed with BP telemonitoring interventions lasting at least 12 months, extending up to 54 months, with the most significant impact seen within the first 18

months.^{49,50} These findings align with previous reviews, which highlighted specific subgroups benefiting more from telemedicine interventions, including individuals with higher BP, obesity, previous stroke, diabetes, blacks, low-income individuals, and those with low treatment adherence.^{53,89–91} In our meta-analysis, BP telemonitoring was effective only in patients with isolated AH and not in those with comorbid T2D. This may be due to study criteria focusing on HbA1c rather than changes in SBP, the emergence of novel T2D treatments that have a positive impact on BP control, and lower patient adherence to monitoring due to tracking multiple parameters.^{11,21} Further research is needed to better understand this phenomenon.

Several studies have shown a 0.5% reduction in HbA1c in people with T2D after 6 months,^{62–65} although this reduction tends to decrease after 12 months compared to standard care.^{63,66,69,80} Effective management of T2D in our meta-analysis involved either a combination of two approaches (BG telemonitoring and teleconsultations)^{63,69,82} or three approaches (BG self-monitoring, teleconsultations, and tele-education).^{62,71} BG telemonitoring had a stronger effect in individuals with AH and T2D compared to those with isolated T2D. Positive long-term effects were found when BG self-monitoring was combined with nurse-led telecoaching over 6 months, extending to 18 months from baseline.⁷⁵ In another study, BG self-monitoring combined with teleconsultations and tele-education over a 5-year period maintained the positive effect over the entire intervention period.⁶¹ These findings align with previous reviews, which highlighted greater benefits for recently diagnosed T2D patients, those receiving telemonitoring or remote case management, and those with baseline HbA1c levels $>8\%$.^{28,92}

Despite the favourable impact of telemedicine on SBP and HbA1c levels, the current evidence suggests that its effect on changes in DBP, lipid profile and BMI is considered clinically irrelevant for both AH and T2D.^{58,60–}

^{59,85–87} and is consistent with previous reviews.^{28,92,93} While some reviews described statistically significant reductions in BMI or LDL using telemedicine,^{92,93} no meta-analysis found a clinically significant reduction in BMI of 2.0 points or a reduction in LDL of 1.0 mmol/L, which would reduce the risk of cardiovascular events by 20%.⁹⁴ However, the results were greater for BMI than for LDL reduction and were more pronounced when mHealth, video consultations or remote case management were used and when interventions lasted ≥ 6 months.^{64,65,74,75,92} To address risk factors more effectively, it is crucial to develop alternative interventions focusing on diet, physical activity, and health education. These could include structured lifestyle programmes, personalised dietary advice and tailored physical activity plans. Community-based initiatives, support groups or two-way SMS reminders could improve adherence.^{8,16,95} Furthermore, technology-based tools such as fitness trackers and diet monitoring apps can provide ongoing support and encourage positive health behaviours.⁹⁶

Implications for research and practice

Scaling up clinically effective telemedicine interventions in primary care requires consideration of patient-specific factors, including underlying conditions and expectations, health literacy, communication preferences, and complexity of system design.^{12,13,16,21} Additionally, specific inclusion criteria should be established for these interventions, with individuals having multimorbidity, older age, low treatment adherence, or recently diagnosed AH or T2D being ideal candidates.^{28,97} Proficiency in using modern technologies during pre-testing may also enhance the benefits of telemedicine interventions compared to less proficient users.¹⁶

Regarding the duration of telemedicine interventions, our meta-analysis highlights that the effectiveness, particularly in reducing SBP and HbA1c, is most notable within the

initial 6 months but declines afterward. However, interventions lasting 6 to 12 months have shown favourable outcomes for up to 54 months from baseline.^{49,50,61}

System design is crucial, with a combination of telemonitoring or mHealth with teleconsultations being recommended as the gold standard.^{23,24,28,92,97} Additionally, integrating health education into interventions can enhance their effectiveness and address lifestyle risk factors, potentially improving lipid profile and body weight.^{49,60,64,65}

Despite the effectiveness of telemedicine interventions, our systematic review identified several limitations in the study design (lack of blinding of patients, increased risk of selection bias, high or unclear loss to follow-up), heterogeneity between studies, small sample sizes, and underreporting of relevant information. Future research should prioritise long-term studies with at least 5 years of follow-up, especially in the multimorbid elderly population.^{11,13,97,98} Furthermore, the incorporation of cardiovascular disease biomarkers such as HF1, HF2 or CKD273 into telemedicine interventions could further motivate patients to manage their conditions effectively.⁹⁹

Limitations

Although the study used a double-blind review method following PRISMA standards, it is important to acknowledge its limitations. Firstly, relevant studies may have been missed if authors did not use precise search terms or describe the primary care setting accurately. Secondly, some full-text articles were excluded because they did not meet the specific WHO definition of telemedicine used in the study, particularly in cases where there was no direct interaction with healthcare workers. Thirdly, due to the broad scope of the review, meta-analyses were only conducted for the most prevalent telemedicine approaches and outcomes reported. However, further research on less common approaches and their combinations beyond primary care

should be conducted to obtain enough studies to power meta-analyses. Next, subjective judgements may have influenced the assessment of bias in included studies using the Cochrane tool, potentially leading to inconsistencies. However, we addressed this limitation with discussion among the broader research group. Finally, we used Egger's regression method to assess publication bias, whereas assessing publication bias in the small number of studies included in the meta-analysis is challenging and should be interpreted with caution.

Conclusions

Telemedicine has emerged as a promising modality within primary care, with considerable potential to improve clinical outcomes in people with AH and T2D. Our review shows that the integration of telemedicine interventions is effective for up to 18 months in people with AH and up to five years in people with T2D. However, it is noteworthy that clinically significant benefits were mainly observed in people with T2D, especially within the initial six months, while the sustained reduction in HbA1c levels decreased over time. However, in the context of the expansion of telemedicine, it is notable that almost no telemedicine approach worsened control of AH and T2D compared with standard care, and in most cases, at least maintained a steady state. To ensure the optimal development of telemedicine in primary care, the establishment of evidence-based clinical guidelines with precise delineation of intervention modalities, target patient cohorts, and recommended intervention durations is imperative. This approach will not only facilitate the generation of robust scientific evidence but also promote clinically impactful and cost-effective outcomes.

Contributorship

MM and MPŠ conceived the study, researched literature, and analysed data. MM wrote first draft of the manuscript. All authors reviewed and edited

the manuscript and approved the final version of the manuscript.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the H2020 Health, (grant number 825432 - SCUBY). The authors also acknowledge the financial support from the Slovenian Research Agency (research core funding No. P3-0339).

Ethical Approval

Not applicable

Guarantor

MM

ORCID iD

Matic Mihevc  <https://orcid.org/0000-0003-4041-8682>

Supplemental material

Supplemental material for this article is available online.

References

1. Visseren FLJ, Mach F, Smulders YM, et al. 2021 ESC guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J* 2021; 42: 3227–3337.
2. Mensah GA, Fuster V, Murray CJL, et al. Global burden of cardiovascular diseases and risks, 1990–2022. *J Am Coll Cardiol* 2023; 82: 2350–2473.
3. Etehad D, Emdin CA, Kiran A, et al. Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. *Lancet* 2016; 387: 957–967.
4. MacMahon S, Peto R, Cutler J, et al. Blood pressure, stroke, and coronary heart disease. Part 1, prolonged differences in blood pressure:

- prospective observational studies corrected for the regression dilution bias. *Lancet* 1990; 335: 765–774.
5. Chen J, Yin D, and Dou K. Intensified glycemic control by HbA1c for patients with coronary heart disease and type 2 diabetes: a review of findings and conclusions. *Cardiovasc Diabetol* 2023; 22: 146.
 6. Martín-Timón I. Type 2 diabetes and cardiovascular disease: have all risk factors the same strength? *World J Diabetes* 2014; 5: 444.
 7. Arnold SV, Kosiborod M, Wang J, et al. Burden of cardio-renal-metabolic conditions in adults with type 2 diabetes within the diabetes collaborative registry. *Diabetes Obes Metab* 2018; 20: 2000–2003.
 8. Klemenc-Ketiš Z, Stojnić N, Zavrník Č, et al. Implementation of integrated primary care for patients with diabetes and hypertension: a case from Slovenia. *Int J Integr Care* 2021; 21: 15.
 9. Mihevc M, Vrtič Potočnik T, Zavrník Č, et al. Beyond diagnosis: investigating factors influencing health-related quality of life in older people with type 2 diabetes in Slovenia. *Prim Care Diabetes* 2024; 18: 157–162.
 10. Endalamaw A, Khatri RB, Erku D, et al. Successes and challenges towards improving quality of primary health care services: a scoping review. *BMC Health Serv Res* 2023; 23: 893.
 11. Mihevc M, Zavrník Č, Mori Lukančič M, et al. Telemonitoring of elderly with hypertension and type 2 diabetes at the primary care level: protocol for a multicentric randomized controlled pilot study. *Zdr Varst* 2022; 61: 216–223.
 12. Noordman J, Meurs M, Poortvliet R, et al. Contextual factors for the successful implementation of self-management interventions for chronic diseases: a qualitative review of reviews. *Chronic Illn* 2024; 20: 3–22.
 13. Mihevc M, Podgoršek D, Gajšek J, et al. The rise of telemedicine in primary care: understanding patients' and healthcare workers' perspectives on acceptability of the COVID-19 remote care model. *Fam Med Prim Care Rev* 2023; 25: 297–301.
 14. Tuckson RV, Edmunds M, and Hodgkins ML. Telehealth. *N Engl J Med* 2017; 377: 1585–1592.
 15. Bashshur R, Shannon G, Krupinski E, et al. The taxonomy of telemedicine. *Telemed J E Health* 2011; 17: 484–494.
 16. Mihevc M, Mori Lukančič M, Zavrník Č, et al. Towards integrated care for the elderly: exploring the acceptability of telemonitoring for hypertension and type 2 diabetes management. *Int J Integr Care* 2024; 24: 16.
 17. Vodička S and Zelko E. Remote consultations in general practice – A systematic review. *Zdr Varst* 2022; 61: 224–230.
 18. Mihevc M, Podgoršek D, Gajšek J, et al. A remote care model for patients at high risk of hospital admission due to COVID-19 deterioration: who makes it at home? - a multicenter follow-up case from Slovenia. *Croat Med J* 2023; 64: 170–178.
 19. Etz RS, Solid CA, Gonzalez MM, et al. Telemedicine in primary care: lessons learned about implementing health care innovations during the COVID-19 pandemic. *Ann Fam Med* 2023; 21: 297–304.
 20. Stummer FO, Voggenreiter L, Gomez Pellin MDLC, et al. Insights into the use of telemedicine in primary care in times of the SARS-CoV-2 pandemic - a cross-sectional analysis based on the international PRICOV-19 study in Austria. *BMC Prim Care* 2023; 24: 218.
 21. Mihevc M, Zavrník Č, Mori Lukančič M, et al. Bottom-up analysis of telemonitoring costs: a case study in slovenian primary care. *Zdr Varst* 2024; 63: 5–13.
 22. Almaqhawi A, Turkistani J, Albahrani S, et al. Effect of telemedicine on glycated haemoglobin in people with type 2 diabetes in the MENA region: a systematic review and meta-analysis. *Fam Med Prim Care Rev* 2022; 24: 361–369.
 23. Robson N and Hosseinzadeh H. Impact of telehealth care among adults living with type 2 diabetes in primary care: a systematic review and meta-analysis of randomised controlled trials. *Int J Environ Res Public Health* 2021; 18: 12171.
 24. Mabeza RMS, Maynard K, and Tarn DM. Influence of synchronous primary care telemedicine versus in-person visits on diabetes, hypertension, and hyperlipidemia outcomes: a systematic review. *BMC Prim Care* 2022; 23: 52.
 25. Idris H, Nugraheni WP, Rachmawati T, et al. How is telehealth currently being utilized to help in hypertension management within primary healthcare settings? A scoping review. *Int J Environ Res Public Health* 2024; 21: 90.

26. So CF and Chung JW. Telehealth for diabetes self-management in primary healthcare: a systematic review and meta-analysis. *J Telemed Telecare* 2018; 24: 356–364.
27. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Br Med J* 2021; 372: n71.
28. Timpel P, Oswald S, Schwarz PEH, et al. Mapping the evidence on the effectiveness of telemedicine interventions in diabetes, dyslipidemia, and hypertension: an umbrella review of systematic reviews and meta-analyses. *J Med Internet Res* 2020; 22: e16791.
29. McManus RJ, Mant J, Franssen M, et al. Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication (TASMINH4): an unmasked randomised controlled trial. *Lancet* 2018; 391: 949–959.
30. Istepanian RSH. Mobile health (m-health) in retrospect: the known unknowns. *Int J Environ Res Public Health* 2022; 19: 3747.
31. Greenwood DA, Gee PM, Fatkin KJ, et al. A systematic review of reviews evaluating technology-enabled diabetes self-management education and support. *J Diabetes Sci Technol* 2017; 11: 1015–1027.
32. Kratz A, Ferraro M, Sluss PM, et al. Normal reference laboratory values. *N Engl J Med* 2004; 351: 1548–1563.
33. Chi K-Y, Li M-Y, Chen C, et al. Ten circumstances and solutions for finding the sample mean and standard deviation for meta-analysis. *Syst Rev* 2023; 12: 62.
34. Sterne JAC, Savović J, Page MJ, et al. Rob 2: a revised tool for assessing risk of bias in randomised trials. *Br Med J* 2019; 366: 14898.
35. Higgins JP and Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med* 2002; 21: 1539–1558.
36. Sen S and Yildirim I. A tutorial on how to conduct meta-analysis with IBM SPSS statistics. *Psych* 2022; 4: 640–667.
37. Malmivaara A. Methodological considerations of the GRADE method. *Ann Med* 2015; 47: 1–5.
38. Margolis KL, Asche SE, Bergdall AR, et al. Effect of home blood pressure telemonitoring and pharmacist management on blood pressure control: a cluster randomized clinical trial. *JAMA* 2013; 310: 46–56.
39. Fu SN, Dao MC, Luk W, et al. A cluster-randomized study on the risk assessment and management program for home blood pressure monitoring in an older population with inadequate health literacy. *J Clin Hypertens (Greenwich)* 2020; 22: 1565–1576.
40. Mehta SJ, Volpp KG, Troxel AB, et al. Electronic pill bottles or bidirectional text messaging to improve hypertension medication adherence (way 2 text): a randomized clinical trial. *J Gen Intern Med* 2019; 34: 2397–2404.
41. McManus RJ, Little P, Stuart B, et al. Home and online management and evaluation of blood pressure (HOME BP) using a digital intervention in poorly controlled hypertension: randomised controlled trial. *Br Med J* 2021; 372: m4858.
42. Hoffmann-Petersen N, Lauritzen T, Bech JN, et al. Short-term telemedical home blood pressure monitoring does not improve blood pressure in uncomplicated hypertensive patients. *J Hum Hypertens* 2017; 31: 93–98.
43. McKinstry B, Hanley J, Wild S, et al. Telemonitoring based service redesign for the management of uncontrolled hypertension: multicentre randomised controlled trial. *Br Med J* 2013; 346: f3030.
44. Teo VH, Teo SH, Burkill SM, et al. Effects of technology-enabled blood pressure monitoring in primary care: a quasi-experimental trial. *J Telemed Telecare* 2024; 30: 121–130.
45. Bove AA, Homko CJ, Santamore WP, et al. Managing hypertension in urban underserved subjects using telemedicine - a clinical trial. *Am Heart J* 2013; 165: 615–621.
46. Logan AG, Irvine MJ, McIsaac WJ, et al. Effect of home blood pressure telemonitoring with self-care support on uncontrolled systolic hypertension in diabetics. *Hypertension* 2012; 60: 51–57.
47. Margolis KL, Bergdall AR, Crain AL, et al. Comparing pharmacist-led telehealth care and clinic-based care for uncontrolled high blood pressure: the Hyperlink 3 pragmatic cluster-randomized trial. *Hypertension* 2022; 79: 2708–2720.
48. Bosworth HB, Powers BJ, Olsen MK, et al. Home blood pressure management and improved blood pressure control: results from a randomized controlled trial. *Arch Intern Med* 2011; 171: 1173–1180.

49. Maciejewski ML, Bosworth HB, Olsen MK, et al. Do the benefits of participation in a hypertension self-management trial persist after patients resume usual care? *Circ Cardiovasc Qual Outcomes* 2014; 7: 269–275.
50. Margolis KL, Asche SE, Dehmer SP, et al. Long-term outcomes of the effects of home blood pressure telemonitoring and pharmacist management on blood pressure among adults with uncontrolled hypertension: follow-up of a cluster randomized clinical trial. *JAMA Netw Open* 2018; 1: e181617.
51. Wakefield BJ, Koopman RJ, Keplinger LE, et al. Effect of home telemonitoring on glycemic and blood pressure control in primary care clinic patients with diabetes. *Telemed J E Health* 2014; 20: 199–205.
52. Bray EP, Jones MI, Banting M, et al. Performance and persistence of a blood pressure self-management intervention: telemonitoring and self-management in hypertension (TASMINH2) trial. *J Hum Hypertens* 2015; 29: 436–441.
53. Kerry SM, Markus HS, Khong TK, et al. Home blood pressure monitoring with nurse-led telephone support among patients with hypertension and a history of stroke: a community-based randomized controlled trial. *CMAJ* 2013; 185: 23–31.
54. Vedanthan R, Kamano JH, DeLong AK, et al. Community health workers improve linkage to hypertension care in western Kenya. *J Am Coll Cardiol* 2019; 74: 1897–1906.
55. Márquez Contreras E, Márquez Rivero S, Rodríguez García E, et al. Specific hypertension smartphone application to improve medication adherence in hypertension: a cluster-randomized trial. *Curr Med Res Opin* 2019; 35: 167–173.
56. Levine DM, Dixon RF, and Linder JA. Association of structured virtual visits for hypertension follow-up in primary care with blood pressure control and use of clinical services. *J Gen Intern Med* 2018; 33: 1862–1867.
57. Nicolucci A, Cercone S, Chiriatti A, et al. A randomized trial on home telemonitoring for the management of metabolic and cardiovascular risk in patients with type 2 diabetes. *Diabetes Technol Ther* 2015; 17: 563–570.
58. Stone RA, Rao RH, Sevvick MA, et al. Active care management supported by home telemonitoring in veterans with type 2 diabetes: the DiaTel randomized controlled trial. *Diabetes Care* 2010; 33: 478–484.
59. Karhula T, Vuorinen AL, Rääpysjärvi K, et al. Telemonitoring and mobile phone-based health C-coaching among Finnish diabetic and heart disease patients: randomized controlled trial. *J Med Internet Res* 2015; 17: e153.
60. Ramallo-Fariña Y, García-Bello MA, García-Pérez L, et al. Effectiveness of internet-based multicomponent interventions for patients and health care professionals to improve clinical outcomes in type 2 diabetes evaluated through the INDICA study: multiarm cluster randomized controlled trial. *JMIR Mhealth Uhealth* 2020; 8: e18922.
61. Weinstock RS, Teresi JA, Golland R, et al. Glycemic control and health disparities in older ethnically diverse underserved adults with diabetes: five-year results from the informatics for diabetes education and telemedicine (IDEATel) study. *Diabetes Care* 2011; 34: 274–279.
62. Fortmann AL, Gallo LC, Garcia MI, et al. Dulce digital: an mHealth SMS-based intervention improves glycemic control in hispanics with type 2 diabetes. *Diabetes Care* 2017; 40: 1349–1355.
63. Warren R, Carlisle K, Mihala G, et al. Effects of telemonitoring on glycaemic control and health-care costs in type 2 diabetes: a randomised controlled trial. *J Telemed Telecare* 2018; 24: 586–595.
64. Vaughan EM, Hyman DJ, Naik AD, et al. A telehealth-supported, integrated care with CHWs, and medication-access (TIME) program for diabetes improves HbA1c: a randomized clinical trial. *J Gen Intern Med* 2021; 36: 455–463.
65. Christensen JR, Laursen DH, Lauridsen JT, et al. Reversing type 2 diabetes in a primary care-anchored eHealth lifestyle coaching programme in Denmark: a randomised controlled trial. *Nutrients* 2022; 14: 3424.
66. Tang PC, Overhage JM, Chan AS, et al. Online disease management of diabetes: engaging and motivating patients online with enhanced resources-diabetes (EMPOWER-D), a randomized controlled trial. *J Am Med Inform Assoc* 2013; 20: 526–534.
67. Iljaž R, Brodnik A, Zrimec T, et al. E-healthcare for diabetes mellitus type 2 patients – a

- randomised controlled trial in Slovenia. *Zdr Varst* 2017; 56: 150–157.
68. Leong CM, Lee T-I, Chien Y-M, et al. Social media-delivered patient education to enhance self-management and attitudes of patients with type 2 diabetes during the COVID-19 pandemic: randomized controlled trial. *J Med Internet Res* 2022; 24: e31449.
69. Steventon A, Bardsley M, Doll H, et al. Effect of telehealth on glycaemic control: analysis of patients with type 2 diabetes in the whole systems demonstrator cluster randomised trial. *BMC Health Serv Res* 2014; 14: 334.
70. Lee JY, Chan CKY, Chua SS, et al. Telemonitoring and team-based management of glycemic control on people with type 2 diabetes: a cluster-randomized controlled trial. *J Gen Intern Med* 2020; 35: 87–94.
71. Parsons SN, Luzio SD, Harvey JN, et al. Effect of structured self-monitoring of blood glucose, with and without additional telecare support, on overall glycaemic control in non-insulin treated type 2 diabetes: the SMBG study, a 12-month randomized controlled trial. *Diabet Med* 2019; 36: 578–590.
72. Lum ZK, Chang KL, Tsou KY, et al. Enhancing diabetes care with community pharmacist-involved collaborative care model: a multi-centre randomised controlled trial. *Diabetes Res Clin Pract* 2022; 185: 109238.
73. Naik AD, Hundt NE, Vaughan EM, et al. Effect of telephone-delivered collaborative goal setting and behavioral activation vs enhanced usual care for depression among adults with uncontrolled diabetes: a randomized clinical trial. *JAMA Netw Open* 2019; 2: e198634.
74. Gerber BS, Biggers A, Tilton JJ, et al. Mobile health intervention in patients with type 2 diabetes. *JAMA Netw Open* 2023; 6: e2333629.
75. Odnoletkova I, Goderis G, Nobels F, et al. Optimizing diabetes control in people with type 2 diabetes through nurse-led telecoaching. *Diabet Med* 2016; 33: 777–785.
76. Liou JK, Soon MS, Chen CH, et al. Shared care combined with telecare improves glycemic control of diabetic patients in a rural underserved community. *Telemed J E Health* 2014; 20: 175–178.
77. Lim SL, Ong KW, Johal J, et al. Effect of a smartphone app on weight change and metabolic outcomes in Asian adults with type 2 diabetes. *JAMA Netw Open* 2021; 4: e2112417.
78. Yang Y, Lee EY, Kim H-S, et al. Effect of a mobile phone-based glucose-monitoring and feedback system for type 2 diabetes management in multiple primary care clinic settings: cluster randomized controlled trial. *JMIR Mhealth Uhealth* 2020; 8: e16266.
79. Bujnowska-Fedak MM, Puchała E, and Steciwko A. The impact of telehome care on health status and quality of life among patients with diabetes in a primary care setting in Poland. *Telemed J E Health* 2011; 17: 153–163.
80. Bohingamu Mudiyansele S, Stevens J, Watts JJ, et al. Personalised telehealth intervention for chronic disease management: a pilot randomised controlled trial. *J Telemed Telecare* 2019; 25: 343–352.
81. McFarland M, Davis K, Wallace J, et al. Use of home telehealth monitoring with active medication therapy management by clinical pharmacists in veterans with poorly controlled type 2 diabetes mellitus. *Pharmacotherapy* 2012; 32: 420–426.
82. Jia W, Zhang P, Zhu D, et al. Evaluation of an mHealth-enabled hierarchical diabetes management intervention in primary care in China (ROADMAP): a cluster randomized trial. *PLoS Med* 2021; 18: e1003754.
83. Anzaldo-Campos MC, Contreras S, Vargas-Ojeda A, et al. Dulce wireless tijuana: a randomized control trial evaluating the impact of project Dulce and short-term mobile technology on glycemic control in a family medicine clinic in northern Mexico. *Diabetes Technol Ther* 2016; 18: 240–251.
84. Basudev N, Crosby-Nwaobi R, Thomas S, et al. A prospective randomized controlled study of a virtual clinic integrating primary and specialist care for patients with type 2 diabetes mellitus. *Diabet Med* 2016; 33: 768–776.
85. Benson GA, Sidebottom A, Hayes J, et al. Impact of ENHANCED (diEtitiaNs helping pAtieNts CarE for diabetes) telemedicine randomized controlled trial on diabetes optimal care outcomes in patients with type 2 diabetes. *J Acad Nutr Diet* 2019; 119: 585–598.
86. Choudhry NK, Isaac T, Lauffenburger JC, et al. Effect of a remotely delivered tailored multi-component approach to enhance medication taking for patients with hyperlipidemia, hypertension, and diabetes: the STIC2IT cluster

- randomized clinical trial. *JAMA Intern Med* 2018; 178: 1182–1189.
87. Frias J, Virdi N, Raja P, et al. Effectiveness of digital medicines to improve clinical outcomes in patients with uncontrolled hypertension and type 2 diabetes: prospective, open-label, cluster-randomized pilot clinical trial. *J Med Internet Res* 2017; 19: e246.
 88. Wild SH, Hanley J, Lewis SC, et al. Supported telemonitoring and glycemic control in people with type 2 diabetes: the Telescot diabetes pragmatic multicenter randomized controlled trial. *PLoS Med* 2016; 13: e1002098.
 89. Wakefield BJ, Holman JE, Ray A, et al. Effectiveness of home telehealth in comorbid diabetes and hypertension: a randomized, controlled trial. *Telemed J E Health* 2011; 17: 254–261.
 90. Bosworth HB, Olsen MK, Grubber JM, et al. Racial differences in two self-management hypertension interventions. *Am J Med* 2011; 124: 468.e1–468.e8.
 91. Shea S, Kothari D, Teresi JA, et al. Social impact analysis of the effects of a telemedicine intervention to improve diabetes outcomes in an ethnically diverse, medically underserved population: findings from the IDEATel study. *Am J Public Health* 2013; 103: 1888–1894.
 92. Chiaranai C, Chularee S, Saokaew S, et al. Effectiveness of telehealth on the glycemic control of patients with type 2 diabetes mellitus during the COVID-19 pandemic: a systematic review and meta-analysis of randomised controlled trials. *Int J Nurs Stud Adv* 2024; 6: 100169.
 93. Kim Y, Park JE, Lee BW, et al. Comparative effectiveness of telemonitoring versus usual care for type 2 diabetes: a systematic review and meta-analysis. *J Telemed Telecare* 2019; 25: 587–601.
 94. Andersson NW, Corn G, Dohlmann TL, et al. LDL-C reduction with lipid-lowering therapy for primary prevention of major vascular events among older individuals. *J Am Coll Cardiol* 2023; 82: 1381–1391.
 95. Chiaranai C, Chularee S, Prawatwong W, et al. Two-way SMS reminders for medication adherence and quality of life in adults with type 2 diabetes: a randomized controlled trial. *Pac Rim Int J Nurs Res Thail* 2023; 27: 457–471.
 96. Cai X, Qiu S, Luo D, et al. Mobile application interventions and weight loss in type 2 diabetes: a meta-analysis. *Obesity* 2020; 28: 502–509.
 97. Omboni S, McManus Richard J, et al. Evidence and recommendations on the use of telemedicine for the management of arterial hypertension. *Hypertension* 2020; 76: 1368–1383.
 98. Zhang W, Cheng B, Zhu W, et al. Effect of telemedicine on quality of care in patients with coexisting hypertension and diabetes: a systematic review and meta-analysis. *Telemed J E Health* 2021; 27: 603–614.
 99. Thijs L, Asayama K, Maestre GE, et al. Urinary proteomics combined with home blood pressure telemonitoring for health care reform trial: rational and protocol. *Blood Press* 2021; 30: 269–281.