

# TELEMONITORING OF ELDERLY WITH HYPERTENSION AND TYPE 2 DIABETES AT THE PRIMARY CARE LEVEL: PROTOCOL FOR A MULTICENTRIC RANDOMIZED CONTROLLED PILOT STUDY

## TELEMONITORING STAREJŠIH BOLNIKOV S HIPERTENZIJO IN SLADKORNO BOLEZNIJO TIPA 2 NA PRIMARNI RAVNI: PROTOKOL MULTICENTRIČNE RANDOMIZIRANE KONTROLIRANE PILOTNE RAZISKAVE

Matic MIHEVC<sup>1,4\*</sup>, Črt ZAVRNIK<sup>1,4</sup>, Majda MORI LUKANČIČ<sup>1</sup>, Tina VIRTič<sup>1,2</sup>,  
Valentina PREVOLNIK RUPEL<sup>3</sup>, Marija PETEK ŠTER<sup>4</sup>, Zalika KLEMENC KETIŠ<sup>1,2</sup>, Antonija POPLAS SUSIČ<sup>1,4</sup>

<sup>1</sup>Ljubljana Community Health Centre, Primary Healthcare Research and Development Institute, Metelkova 9, 1000 Ljubljana, Slovenia

<sup>2</sup>University of Maribor, Faculty of Medicine, Department of Family Medicine, Taborska 8, 2000 Maribor, Slovenia

<sup>3</sup>Institute for Economic Research, Kardeljeva ploščad 17, 1000 Ljubljana, Slovenia

<sup>4</sup>University of Ljubljana, Faculty of Medicine, Department of Family Medicine, Poljanski nasip 58, 1000 Ljubljana, Slovenia

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### ABSTRACT

**Introduction:** Arterial hypertension (AH) and type 2 diabetes (T2D) represent a significant burden for the public health system, with an exceptionally high prevalence in patients aged  $\geq 65$  years. This study aims to test the acceptability, clinical effectiveness, and cost-effectiveness of telemonitoring in elderly patients with AH and T2D at the primary care level.

### Keywords:

mobile health, telemonitoring, blood pressure, blood glucose, HbA1c, aged, primary health care, costs

**Methods:** A multi-centre, prospective, randomized, controlled trial will be conducted. Patients aged  $\geq 65$  years with AH and T2D will be randomized in a 1:1 proportion to a mHealth intervention or standard care group. Patients in the intervention group will measure their blood pressure (BP) twice weekly and blood glucose (BG) once monthly. The readings will be synchronously transmitted via a mobile application to the telemonitoring platform, where they will be reviewed by a general practitioner who will indicate changes in measurement regimen or carry out a teleconsultation. The primary endpoint will be a change in systolic BP (SBP) and glycated haemoglobin (HbA1c) relative to standard care up to 12 months after inclusion. Secondary endpoints will be a change in other observed clinical variables, quality-of-life indexes, and costs.

**Expected results:** Telemonitoring will be an acceptable method of care associated with significant reductions in SBP and HbA1c levels and an increase in quality-of-life indexes in the intervention group. However, the cost-effectiveness threshold (incremental cost-effectiveness ratio below €25,000/quality-adjusted life year) might not be reached.

**Conclusion:** This study will provide new evidence for scaling up telemonitoring network at the primary care level and modifying telemonitoring protocols to achieve the best clinical and cost-effective outcomes.

### IZVLEČEK

**Uvod:** Arterijska hipertenzija (AH) in sladkorna bolezen (SB) tipa 2 predstavljata veliko breme javnozdravstvenemu sistemu. Njuna prevalenca narašča s starostjo in je še posebno visoka v skupini starejših bolnikov. Eno od metod za izboljšanje njune urejenosti predstavlja telemonitoring krvnega tlaka (KT) in krvnega sladkorja (KS). Namen raziskave je oceniti sprejemljivost telemonitoringa, njegovo klinično učinkovitost in učinkovitost glede na stroške v skupini starejših bolnikov z AH in SB tipa 2 na primarni ravni.

### Ključne besede:

mobilno zdravje, krvni tlak, krvni sladkor, starostniki, primarna raven, stroški

**Metode:** Izvedli bomo multicentrično, prospektivno, randomizirano, kontrolirano raziskavo. Bolnike, stare  $\geq 65$  let z AH in SB tipa 2, bomo razvrstili naključno v razmerju 1 : 1 v skupino s telemonitoringom (intervencijska skupina) in standardno oskrbo (kontrolna skupina). Bolniki v intervencijski skupini bodo opravljali meritve KT 2-krat tedensko in meritve KS 1-krat mesečno. Opravljene meritve se bodo preko mobilne aplikacije sinhrono prenesle v telemedicinski portal, kjer jih bo pregledal telemedicinski koordinator. Ta bo indiciral spremembe v protokolu izvajanja meritev ali potrebo po telekonzultaciji z izbranim zdravnikom. Bolniki v kontrolni skupini bodo prejeli zgolj standardno oskrbo. Klinično učinkovitost bomo ocenili z oceno razlike v sistolnem KT (SKT) in vrednostih glikiranega hemoglobina (HbA1c) glede na standardno oskrbo po 12 mesecih spremljanja. Sočasno bomo ocenili tudi razlike v diastolnem KT, vrednostih KS na tešče, lipidnem profilu in indeksu telesne mase glede na standardno oskrbo po 12 mesecih spremljanja. Za oceno sprememb v kakovosti življenja bomo primerjali razlike v vrednostih na lestvici ADS, vprašalniku EQ-5D-5L in lestvici EQ-VAS glede na standardno oskrbo po 12 mesecih spremljanja. Učinkovitost telemonitoringa glede na stroške bomo ocenili z oceno razmerja prirastka stroškov glede na prirastek učinkovitosti (ICER) med obema skupinama po 12 mesecih spremljanja. Stroške bomo ocenili z oceno stroškov dela in materialnih stroškov. Učinkovitost bomo ocenili z oceno prirastka let življenja, uteženih s kakovostjo življenja (QALY), ki jih bomo ocenili s pomočjo vprašalnika EQ-5D-5L in lestvice EQ-VAS. Sprejemljivost intervencije bomo kvalitativno ocenili s pomočjo strukturiranih polodprtih intervjujev.

**Pričakovani rezultati:** Pričakujemo, da bo telemonitoring med bolniki sprejemljiva metoda oskrbe na daljavo in da bo povezan s pomembnim znižanjem vrednosti SKT ter HbA1c in izboljšanjem indeksov kakovosti življenja v intervencijski skupini. Obstaja verjetnost, da ne bomo uspeli dokazati, da je ICER  $< 25.000$  €/QALY, kar je v Sloveniji trenutno meja za stroškovno učinkovitost intervencije.

**Zaključek:** Raziskava bo zagotovila nove dokaze za širjenje mreže telemonitoringa na primarnem nivoju in spremembo protokolov vodenja kroničnih bolnikov na način, da bodo dosežene čim boljše klinična in stroškovna učinkovitost ter dobra aderenza bolnikov.

\*Corresponding author: Tel. + 386 7 3481 793 ; E-mail: mihevc.matic@zd-tr.si

## 1 INTRODUCTION

Arterial hypertension (AH) and type 2 diabetes (T2D) are leading chronic diseases that frequently co-occur, share the same risk factors, and together account for nearly 70% of all-cause deaths (1). The prevalence of their comorbidity increases with age and is particularly high in the elderly group. It is estimated that up to 75% of patients aged  $\geq 65$  years have AH, while 25% have T2D (2, 3). Despite the potential for successful treatment, their prevalence is steadily increasing (2, 3). Consequently, these global trends place a significant burden on population health and a financial burden on healthcare systems (2, 3).

One approach to reversing the rising trends, empowering chronic patients, and reducing the incidence of secondary complications from uncontrolled blood pressure (BP) and blood glucose (BG), could be integrated care supported by BP and BG telemonitoring (1, 4-6). Telemonitoring is a subset of telemedicine and refers to the transmission of physiological data, such as BP and BG values, via automated electronic means or via web-based or telephone data. The data received allows physicians to interpret the data synchronously and make timely decisions about the patient's treatment (5-7). Currently, telemonitoring is often combined with teleconsultations, which can be synchronous via videoconferencing devices or asynchronous via email, internet, or mobile phones (5-7). The combination of frequent BP/BG measurements and timely feedback/consultation from the registered nurse or physician is the main reason why telemonitoring has the potential to significantly improve clinical outcomes (5-8). In addition, telemonitoring indirectly promotes patient empowerment by increasing their engagement, knowledge, and skills needed to manage their disease (8).

Previous studies have found that BP and BG telemonitoring combined with teleconsultations lasting 12 months or longer had the greatest effect on BP and BG reduction, while isolated interventions lasting 6 months or less were unsuccessful in the long term (1, 5, 7, 9). Meta-analyses of randomized clinical trials examining the clinical effectiveness of BP and BG telemonitoring found a 5-mmHg reduction in SBP and a 0.3% reduction in HbA1c compared with standard care 12 months after study inclusion (1, 5, 7, 9). More complex telehealth interventions may yield even better results, but are associated with higher costs (10).

In Slovenia the healthcare system is based on the Bismarck model, which provides equal and fair access to health care for all patients (4). In 2011, a new working model was introduced in Slovenian family medicine practices. A registered nurse was added to the team consisting of a family physician and a practice nurse. A registered nurse took over the preventive activities and management of patients with stable chronic diseases (including AH and T2D), providing standardized and integrated care at the

level of screening, treatment, education, and quality control (11). Patients with AH or T2D are seen by their family physician and registered nurse at least once a year. The physician examines patients, refers them to the laboratory, assesses disease control and the need for titration of therapy, while the registered nurse screens patients for AH/T2D complications, assesses their psychosocial status, educates them about non-pharmacological measures, and refers them to additional health promotion activities within the health education centre, including nutritionists, psychologists or psychotherapists, as appropriate (11, 12). A general problem with previous research is that it has neglected the central role of primary care in the management of chronic diseases, such as AH and T2D. Clinical pathways have generally been designed to be conducted in clinical settings rather than small healthcare centres. Studies were conducted in younger, motivated patients with either AH or T2D, rather than in older, multimorbid patients with little knowledge about the use of modern technologies. The latter have the highest risk of cardiovascular mortality and could benefit significantly from telemonitoring interventions (13). Furthermore, a high threshold for clinical significance in relation to BP and BG reduction calls into question the clinical relevance of telemonitoring. Currently, a 10-mmHg decrease in systolic BP (SBP) and a 0.5% reduction in glycated haemoglobin (HbA1c) are considered clinically relevant (14, 15). Moreover, there is a need for additional evidence on the acceptability of telemonitoring in the elderly group.

From the perspective of the Slovenian healthcare system, there is currently a lack of self-management support for patients with AH and T2D (4, 16). In addition, the challenges of the ageing population and the shortage of primary care physicians require the testing of care models that shift responsibility for their health vertically to patients to a greater extent (16).

Finally, there is insufficient evidence on the cost-effectiveness of telemonitoring interventions to drive our research. Previous studies have found telemonitoring to be more cost-effective in patients with T2D, while cost-effectiveness was achieved in a group of patients with AH assuming a lifetime telemonitoring effect (17, 18). This was found with an incremental cost-effectiveness ratio (ICER) of £20,000 per quality-adjusted life year (QALY) (17). Currently, a higher ICER threshold of €25,000/QALY is considered cost-effective in Slovenia (19). A cost-effectiveness analysis in a group of elderly patients with AH and T2D at the primary care level has not yet been published.

This study thus aims to test the acceptability, clinical effectiveness, and cost-effectiveness of telemonitoring in elderly patients with AH and T2D at the primary care level. The specific goals of the study are: (a) to assess the effect of telemonitoring on observed clinical variables

and quality of life indexes up to 12 months after inclusion, (b) to compare the difference in costs relative to the difference in QALY between telemonitoring and standard care group 12 months after inclusion, and (c) to assess acceptability of telemonitoring among elderly patients and healthcare workers.

## 2 METHODS

### 2.1 Study design

A multi-centre, prospective, randomized controlled pilot study will be conducted.

### 2.2 Study duration

The study will be conducted from March 2021 to June 2023.

### 2.3 Setting

The study will be conducted in three primary healthcare centres (PHC) in Slovenia. The PHC Ljubljana will reflect the urban population, while two peripheral PHCs (Trebnje, Slovenj Gradec) will reflect the rural population.

### 2.4 Study population

The population will comprise patients aged  $\geq 65$  years with AH and T2D. Demographic characteristics are expected to reflect the general population in this age group, with a mean age of over 70 years and a slightly higher proportion of women than men.

### 2.5 Inclusion and exclusion criteria

Inclusion criteria will be: (a)  $\geq 65$  years of age, (b) confirmed diagnosis of AH with a 7-day mean home BP values  $\geq 135/85$  mmHg or with 24-hour blood pressure monitoring mean  $\geq 130/80$  mmHg (20), (c) confirmed diagnosis of T2D with fasting BG value  $\geq 7.0$  mmol/l or venous plasma glucose  $\geq 11.1$  mmol/l 2 hours after glucose tolerance test with 75 g glucose intake or any random opportunity (21), (d) diagnosis of AH and T2D for at least one year, and (e) ability to use telemonitoring equipment.

Exclusion criteria will be: (a)  $< 65$  years of age, (b) T2D requiring insulin treatment at inclusion, (c) gestational diabetes or type 1 diabetes, and (d) cognitive impairment, (e) inability to use telemonitoring equipment for any reason.

### 2.6 Selection of patients

Eligible patients will be invited to participate in the study by their GPs. Patients will receive an explanation of the study's goals, which will be additionally described on the participant information sheet. Patients who will decide to participate in the study will sign the informed consent form.

### 2.7 Randomisation

After consenting to participate, patients will be randomized to either the telemonitoring (intervention) group or the standard care (control) group using simple 1:1 randomization (22). The randomization list will be generated by an independent project manager. To avoid randomization bias, patient identification numbers will be used instead of names. The first patient on the list will be randomized to the intervention group, the second patient to the control group, and so on.

### 2.8 Intervention group

#### 2.8.1 Telemonitoring package and education of patients

At baseline, patients in the intervention group will receive a telemonitoring package that will include an Android smartphone (LG K22®), a validated BP monitor (A&D 651 BLE®), a validated BG monitor (Contour Next One®), and instructions for use. Each patient will receive one hour of training with a nurse on the measurement protocol and how to use the telemonitoring package.

#### 2.8.2 Telemedicine infrastructure

The telemedicine infrastructure will comprise medical sensors (BP and BG monitors), a hub (a smartphone with a mobile application), and a telemedicine platform. First, the results from the medical sensors will be transmitted to the mobile application using Bluetooth wireless technology. The mobile application will serve as a hub from where measurement results will be transferred to the telemedicine cloud platform via a 4G or 5G mobile standard. Patients will communicate with the telemedicine centre coordinator through the application (via messages or video calls). The telemedicine cloud platform will serve as the central data processing point. The platform cloud will be hosted by a third-party provider and will be available to end-users via the internet. The data received will be encrypted and compliant with the General Data Protection Regulation.

#### 2.8.3 Blood pressure measurement

Patients will be instructed to measure their BP twice weekly in the morning and evening in a quiet room after resting for 5 minutes in a seated position with their back and arm supported (Figure 1). Two measurements will be taken, with a programmed 1 minute pause between the first and second measurements. If indicated, patients will perform a 7-day profile of morning and evening BP measurements (20).

#### 2.8.4 Blood glucose measurement

Patients will be instructed to measure their BG value once a month (Figure 2). They will take two measurements: the morning measurement on an empty stomach and

the measurement 90 minutes after lunch. If indicated, patients will perform a one-day BG profile (values on an empty stomach, 90 minutes after breakfast, before lunch, 90 minutes after lunch, before dinner, 90 minutes after dinner) (21).

### 2.8.5 Management of patients in telemedicine centre

The telemedicine centre will be coordinated by a GP who will review the recorded values and act as a link between other GPs and the included patients. Patients will be treated according to the latest guidelines, which recommend aiming for BP in the home setting <135/85 mmHg, maintaining fasting BG <7 mmol/l and postprandial BG <10 mmol/l (20, 21). However, as the studied population will have T2D and will be  $\geq 65$  years old, target home SBP will be 125-135 mmHg and DBP 70-79 mmHg (20). Transmitted values will be marked with three colours indicating normal, derailed, or extremely derailed values (Figure 1 and Figure 2). Green (shown as white) will reflect normal values and suggest no changes in monitoring regimen. Yellow (shown as grey) will reflect derailed values and indicate a change in the telemonitoring regimen. Red (shown as black) will reflect extremely derailed values and indicate the need for immediate teleconsultation with a GP, further workup, or a change in the treatment regimen.

### 2.9 Control group

The control group will receive standard care, described in more detail in the introduction, and will be treated according to the latest guidelines (20, 21).

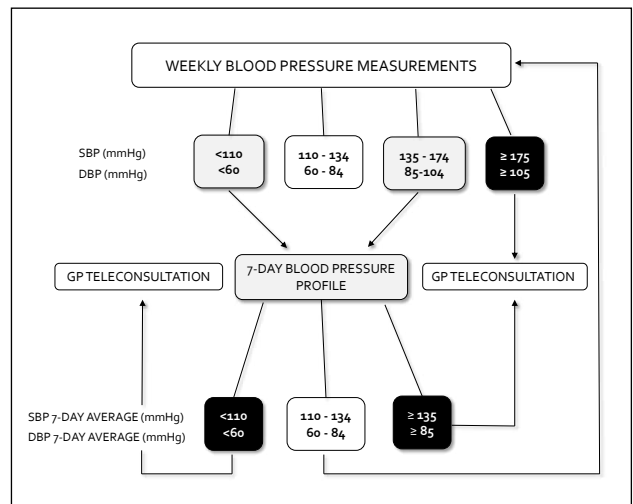
### 2.10 Data collection

We will collect various variables from different categories (Table 1). The data sources will be medical records, the telemedicine platform, questionnaires, and interviews conducted at enrolment and at the end of the study.

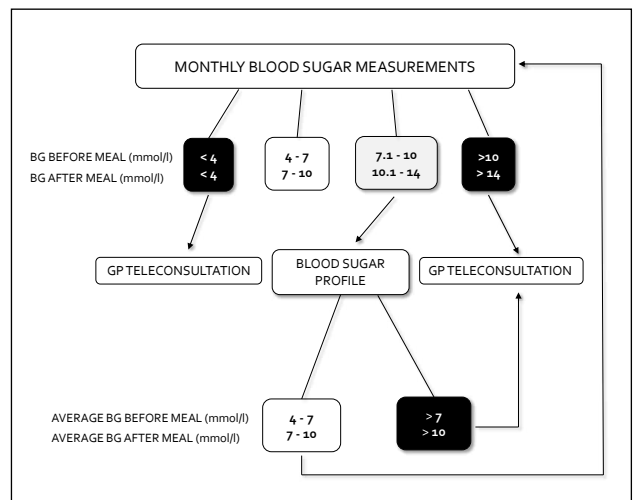
#### 2.10.1 Behavioural risk factors

We will assess daily activity by weekly high- or moderate-intensity physical activity duration. More than 150 minutes of moderate-intensity or more than 75 minutes of high-intensity physical activity per week will be considered adequate (23).

Eating habits and behaviours will be assessed using a structured questionnaire regularly used in Slovenian model practices. We will determine four components of healthy eating habits and behaviours: the daily number of meals, frequency of vegetable consumption, salting food at the table, and type of fat intake. Eating fewer than 3 meals per day, consuming less than one serving of vegetables per day, salting food at the table, and using margarine, butter, cream, and pork fat will be considered unhealthy (24).



**Figure 1.** Arterial hypertension telemedicine management algorithm (SBP - systolic blood pressure; DBP - diastolic blood pressure; GP - general practitioner).



**Figure 2.** Diabetes mellitus type 2 telemedicine management algorithm (BG - blood glucose; GP - general practitioner).

We will assess alcohol use with the Alcohol Use Disorders Identification Test (AUDIT-C). We will use the Slovenian validated version, which suggests 6 points for men and 5 points for women as cut-offs for identifying hazardous or harmful drinkers (25).

#### 2.10.2 Systolic and diastolic blood pressure values

SBP and DBP values will be checked at baseline, after 6 months, and after 12 months using validated BP monitors. SBP and DBP values will be defined as 7-day averages of morning and evening measurements, as recommended by the European Society of Cardiology (20).

**Table 1.** Study data collection list (AH - arterial hypertension; T2D - type 2 diabetes; CVD - cardiovascular disease; HbA1c - glycated haemoglobin; BG - blood glucose; BMI - body mass index; AUDIT-C - Alcohol Use Disorders Identification Test; ADS - Appraisal of Diabetes Scale; EQ-5D - EuroQol 5-Dimension; QALY - quality adjusted life year).

CATEGORY	DATA VARIABLE	MEASUREMENT DESCRIPTION
Demographic data	Age	In full years
	Gender	Male or female
	Education	Primary school, high school graduate, vocational school, bachelor's degree, master's degree, doctoral degree
Clinical history	Marital status	Married, divorced, widowed, single
	Duration of AH and T2D	In full years
	Current therapy	Name of drug and dose
	Family history of CVD	Yes or no
	Associated diseases	Name of disease
Behavioural risk factors	Smoking	Yes or no
	Daily activity	Adequate or inadequate
	Eating habits and behaviours	Healthy or unhealthy
	Alcohol use	Score on the AUDIT-C questionnaire
Clinical characteristics	SBP and DBP	7-day average of morning and evening measurements
	HbA1c	Laboratory value
	Fasting BG	Laboratory value
	Lipid profile	Laboratory values
	BMI	Measured value
Quality of life	Quantitative	Score on the ADS and EQ-5D scales
	Qualitative	Semi-structured interviews
Acceptability of intervention	Qualitative	Semi-structured interviews
Cost-effectiveness	Costs	Labour costs and material costs per patient
	Effect	Change in QALY per patient

### 2.10.3 Glycaemic control and lipid profile

HbA1c level, fasting BG value, and lipid profile values will be determined from peripheral venous blood sampling at baseline and after 12 months. Additionally, fasting BG value will be checked after 6 months using a validated finger-stick BG monitor.

### 2.10.4 Quality of life

A change in quality of life from baseline up to 12 months will be assessed with two scales. First, the patient's adjustment to diabetes, psychological burden of self-management, and behaviour modifications will be assessed using the Appraisal of Diabetes Scale (ADS) (26). ADS is a 7-item self-report scale in which respondents rate each statement on a 5-point Likert scale. The smaller the total score, the more positive the appraisal strategy. The related questionnaire will be validated independently of this study.

Second, for the purpose of cost-effectiveness analysis we will assess changes in QALY using the EQ-5D-5L (EuroQol 5-Dimension 5-Level) and EQ VAS (EuroQol Visual Analogue

Scale) instruments, which are a standardized, valid, and reliable tools for measuring patients' health-related quality of life. To calculate the utilities, the value set for Slovenia will be used (27).

### 2.10.5 Acceptability of intervention

Acceptability of the intervention will be qualitatively assessed through semi-structured interviews with patients, nurse practitioners, and GPs. The initial standardized interview guide will be based on previous evidence and principles of the latest theoretical framework of acceptability (TFA) (28). The TFA describes acceptability as a construct with seven domains, including affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy (28). Furthermore, interview guides will cover the health context, recruitment process, coping with technology, telemonitoring routine, change in self-management skills, impact on mental health, and change in patient-doctor relationship. Initial guides might be modified after piloting the first 10 interviews.

### 2.10.6 Costs

To measure costs, a human capital approach will be used. The costs will include material and labour costs. Material costs will be determined by depreciation of the equipment. Labour costs will be determined by the following factors: time spent by the telemedicine centre coordinator reviewing data and communicating with patients and their GPs, time spent training patients to use the telemonitoring package, frequency of additional patient teleconsultations with GPs, frequency of additional outpatient visits and time spent by patient on the additional tasks needed. As the study period will be 1 year, no discounting will be applied.

### 2.11 Endpoints

The primary endpoint will be a change in SBP and HbA1c relative to the standard care up to 12 months after inclusion.

Secondary endpoints will be a change in diastolic BP (DBP), fasting BG, lipid profile, body mass index, ADS score, EQ-5D-5L score, and EQ VAS score relative to the standard care up to 12 months after inclusion.

### 2.12. Sample size and power of the research

Because of limited telemonitoring equipment, our sample size is limited to 60 patients in the intervention group, altogether 120 patients with the control group included. Therefore, instead of calculating the sample size to demonstrate a 10-mmHg reduction in SBP and a 0.5% reduction in HbA1c, we calculated the expected minimum detectable difference between groups with the planned sample size. We considered multiple studies to estimate the expected standard deviation (SD) of a change in SBP and HbA1c in the intervention and control groups 12 months after inclusion (29-32). Power calculations were performed using a two-tailed independent equal-variance t test in PASS 14 power analysis software.

For a change in SBP, the planned sample size of 120 achieves a power of 80% to reject the null hypothesis of equal means with a significance level of 0.05 when the population mean difference between groups is at least 6.2 mmHg (if SD is equal to 12 for both groups) or 10.8 mmHg (if SD is 21). For the change in HbA1c, this is possible when the population mean difference between groups is at least 0.7% (if SD is equal to 1.3 for both groups) or 1.2% (if SD is 2.4).

### 2.13 Statistical analysis

Data will be analysed using the R statistical software. Numeric variables will be summarized with means and standard deviations or medians and interquartile ranges. Categorical variables will be presented with absolute and relative frequencies. Differences between groups in numeric variables will be tested using a two-tailed independent samples t-test or the Mann-Whitney U-test.

Differences between groups in categorical variables will be tested using the chi-squared test or Fisher's exact test. In the case of significant differences between groups at baseline, regression methods will be used. We will consider a p-value of <0.05 as statistically significant.

### 2.14 Qualitative analysis

Qualitative analysis will be conducted using an inductive thematic analysis approach (33). The semi-structured interviews will be recorded, transcribed verbatim and transcriptions will later be checked for accuracy. Two independent researchers will analyse data in three steps: open coding, formation of subthemes and themes, abstraction. Sample size will be determined by inductive thematic saturation. After independent coding, the final thematic analysis will be compiled through a triangulation process among coders. If consensus between two coders on the grouping of codes will not be achieved, an experienced supervisor will be consulted (33).

### 2.15 Cost-effectiveness analysis

Cost-effectiveness will be expressed as an ICER, in which the difference in costs between the two approaches (telemonitoring vs. standard care) and the difference in QALYs will be compared. Difference in QALYs will be measured using the EQ-5D-5L and EQ VAS instruments, difference in costs will be estimated from calculated material and labour costs (27). Currently, an ICER in Slovenia is set to €25,000/QALY (19). This threshold will be considered to determine whether the intervention is cost-effective.

## 3 DISCUSSION

This is the first study to investigate the feasibility, clinical effectiveness, and cost-effectiveness of BP and BG telemonitoring in elderly patients with comorbid AH and T2D at the primary care level.

In previous studies, older multimorbid patients were often excluded because they could not use modern technologies, were not motivated to participate in the study, or needed additional support from family members (1, 5, 7). According to recent projections, the global population of people over 65 years of age will more than double by 2050, while the proportion of elderly people in the global population will increase from 9% to 16% (34). Therefore, exploring novel approaches such as telemonitoring to promote patient-centred care focused on quality of life and self-management support is essential.

The reason for the slow integration of telemonitoring into daily practice could be its unconvincing clinical and cost-effectiveness (5, 7, 17, 18). From the healthcare workers' perspective, the main barriers are the lack of adaptation

to workflows within practices, concerns about creating anxiety and dependency, and fear of additional workload (35). All these concerns should be taken into account when developing future models of care.

The strength of this pilot study lies in the sufficient follow-up time, the multi-centre randomized controlled nature, the complexity of the observed outcomes, and the originality of the population observed. Moreover, we designed the inclusion criteria to include not only patients with derailed BP (>150/100 mmHg) and HbA1c (>7.5%) values, but also those with relatively well-controlled parameters. This was done to capture the population that would otherwise be treated at the primary care level. This could result in lower observed differences, but will give us diversity in the observed population, which will also be reflected in the results of the qualitative content analysis. Due to multimorbidity, intensive BP measurement regimen, and difficulty in completing regular check-ups with their GPs and specialists in the control group during the COVID-19 pandemic, we expect to observe larger differences between groups compared to previous studies (1, 5, 7). In terms of cost-effectiveness, we expect an increase in EQ-5D-5L and EQ VAS index scores. However, based on previous evidence, the threshold for cost-effectiveness may not be reached (17, 18).

Finally, there might be limitations in our study design. Due to the pilot nature of the study and the relatively small sample size, the power of the study will be low. In addition, we defined SBP and DBP values at baseline and follow-up as 7-day BP averages of morning and evening readings, although the gold standard is still the 24-hour average of BP monitoring (20). This was done for practical reasons, and is more reliable than in previous studies where the mean of the second and third ambulance readings was used as the primary outcome (29). Furthermore, there are some common risks of randomized controlled trials, such as loss to follow-up, the risk that randomized patients are not representative of the population studied, and imbalance between groups in baseline variables, which may affect the results.

#### 4 CONCLUSION

This study will provide new evidence for scaling up a telemonitoring network at the primary care level and modifying telemonitoring protocols to achieve the best clinical and cost-effective outcomes, and good patient adherence. Further studies should examine a larger population and follow patients for at least 5 years to assess long-term outcomes. However, without recognition of telemonitoring as an essential component of chronic patient care by policymakers, further large-scale and long-term expansion is questionable.

#### CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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#### ETHICAL APPROVAL AND REGISTRATION

The study was approved by the National Medical Ethics Committee (reference number 0120-219/2019/4) and is registered in the ISRCTN registry (<https://doi.org/10.1186/ISRCTN31471852>).

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