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ORIGINAL RESEARCH

Exploring the effect of telemedicine on the control of blood pressure and lipid measurements in cardiovascular patients from rural Sweden: a before-and-after intervention study

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ABSTRACT

Introduction: Compliance with long-term secondary prevention guidelines in primary care settings is hampered, in part, by a shortage of health professionals in rural areas. Telemedicine has shown promise in supporting preventive care without requiring the physical relocation of professionals to underserved regions. Although many studies have shown positive outcomes with telemedicine, more evidence is needed. The aim of this study was to compare the effect of telemedicine on compliance to guidelines for blood pressure and lipid control in primary care in patients with ischaemic cardiovascular disease compared with traditional care in rural Sweden. In addition, the study investigated the effect of five years of telemedicine follow-up on improvements in blood pressure and lipid levels compared with a control health centre.

Methods: Two rural health centres in northern Sweden were included. The intervention group received regularly scheduled online video consultations between a cardiologist and the local nurses, while the control group received conventional centre-based monitoring. Patient-based registry information was collected for the period 2016-2020. Data included available measurements of systolic and diastolic blood pressure, LDL, HDL, total cholesterol and triglycerides. Compliance with the guidelines was assessed by recording the number of available blood pressure and lipid measurements from the list of eligible patients. Those with one or no measurements were considered non-compliant. Means of blood pressure and lipid measurements at two time points were estimated, followed by difference-in-difference analysis.

Results: The intervention group showed increased compliance to guideline recommendations. However, there were no statistically significant differences in blood pressure and lipid measurements over time compared with the control group.

Conclusion: The results highlight the potential of telemedicine to improve compliance to secondary cardiovascular prevention guidelines in rural primary care. This study serves as a successful model for integrating telemedicine into real-world health care and highlights the need for continued research and evaluation.

Keywords: telemedicine, cardiovascular prevention, compliance, blood pressure, cholesterol, rural, Sweden

Abstract in Español at the end of the article

INTRODUCTION

Compliance to long-term, comprehensive cardiovascular prevention guidelines in primary care, including regular patient follow-up and monitoring, is essential to reduce the risk of cardiovascular events and improve patient outcomes [1]. However, the implementation of well-established healthcare guidelines, particularly secondary prevention strategies, faces significant barriers due to persistent workforce shortages. This problem is particularly acute in rural areas, where it severely hampers the ability to maintain essential prevention and rehabilitation services, thereby affecting the quality and efficiency of care. In recent years, particularly in the wake of the COVID-19 pandemic, the use of telemedicine—the practice of delivering health services remotely using telecommunications technology—has demonstrated significant potential for improving access to healthcare [2-4]. This technological advance fills a critical gap by enabling healthcare professionals to provide services online, eliminating the need for physical presence and facilitating continuous patient care even in remote or underserved areas [5].

The systematic implementation of telemedicine has been particularly beneficial in the management of chronic diseases [6-7], including cardiovascular care [8]. This approach is consistent with the need to adhere to long-term cardiovascular prevention guidelines [9] and allows for regular follow-up and monitoring of patients, such as annual coronary heart disease check-ups and routine blood pressure and cholesterol measurements, without the need for the physical presence of specialized healthcare personal.

In the northern part of Sweden, where sparse population and long distances to healthcare facilities are the norm, the Västerbotten region has over the years implemented various strategies to improve access to healthcare for its population [10, 11]. In 2015, the Stenbergska Primary Care Centre, located in the town of Lycksele in southern Lapland, initiated a telemedicine collaboration programme. This programme, which lasted five years, involved a team consisting of an online specialist from Umeå and a local nurse from Stenbergska. They provided secondary prevention for patients with cardiovascular disease after discharge from hospital-based rehabilitation services through regular weekly online meetings. The hypothesis was that this programme would improve compliance to primary care guidelines for cardiovascular patients after discharge from hospital-based rehabilitation programmes.

This study therefore aimed to compare the effect of telemedicine on compliance to primary care guidelines for blood pressure and lipid control in patients with ischaemic cardiovascular disease compared with traditional care in rural Sweden. In addition, the study examined the effect of five years of telemedicine follow-up on improvements in blood pressure and lipid levels compared with the control health centre.

METHODS

Study context

This region is known for its sparse population density, with communities often separated by long distances and natural landscapes such as forests and mountains. The two primary care centres have similar sociodemographic characteristics. The population is predominantly Swedish, with a small indigenous Sami presence. The age distribution is skewed towards middle-aged and older residents, reflecting a trend for younger people to move to urban areas for education and employment opportunities. The local economy is largely based on agriculture, forestry and small-scale industry. Educational levels vary, with a significant proportion of the population having completed basic education. Household composition often includes multi-generational families, which is common in rural areas [12].

Study setting

The intervention was carried out at Stenbergska Primary Care Centre in the municipality of Lycksele in Västerbotten region. The municipality covers an area of 5,636 km², has a population of 12,500 and is located approximately 130 km from the nearest university hospital in the city of Umeå. Another primary care centre in the rural municipality of Malå, also in Västerbotten, was selected for comparison. This municipality covers an area of 4,680 km², has a population of 2,800 and is 208 km from the nearest cardiologist in Umeå city. In Malå, patients needing secondary cardiovascular prevention are followed by the staff at the primary care centre without formal consultation with a specialist. Both primary care centres are located in the southern Lapland region of Sweden and have similar sociodemographic characteristics (Figure 1).

The intervention

Briefly, the operational model of this intervention was structured around weekly videoconferencing rounds between a cardiologist and the lead nurse to address all clinical queries collected during the week. In specific cases, the consultant arranged synchronous individual video consultations with selected patients. This intervention was applied consistently for five years, from 2016 to 2020.

The specialist communicated with staff and patients at the primary care centre using videoconferencing technology already implemented in the region. The cardiac nurse practitioner reviewed selected patients' medications, health records, and other relevant issues. The nurse also systematically checked that the patient had had their blood pressure and cholesterol measured at the prescribed time (once a year), as recommended in the guidelines, and when necessary, the specialist booked visits with patients via this videoconferencing system to discuss their clinical concerns and secondary prevention measures such as smoking, healthy eating and exercise.

In Malå, the control arm, cardiovascular secondary

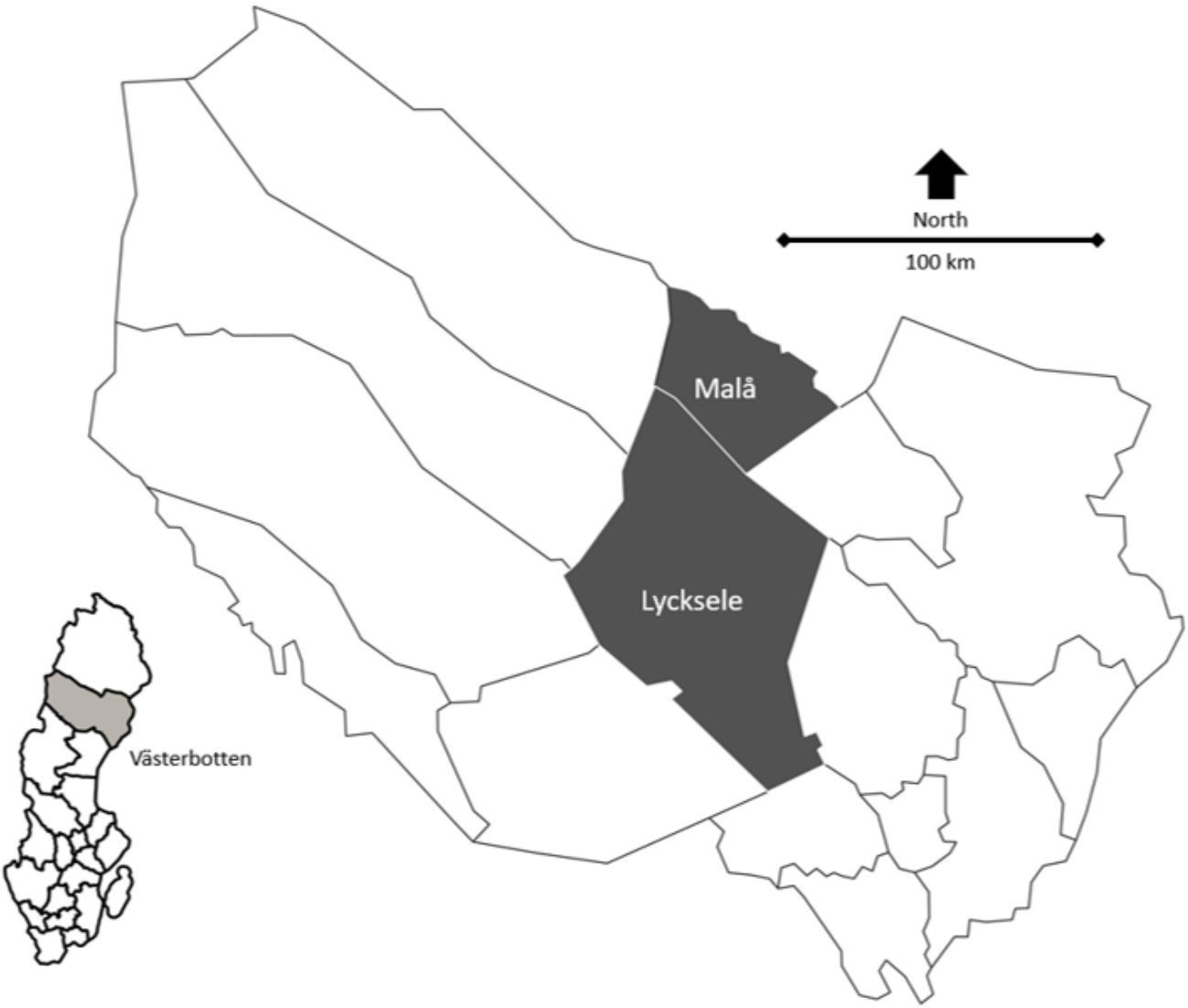

Figure 1. Location of Västerbotten county in Sweden and the two study municipalities within the county.

prevention was managed by primary health centre staff without formal specialist consultations.

Study design and data sources

A retrospective cohort study design was used, with individual data extracted from patient records with the help of the Västerbotten County Clinical Research Centre (KFC). Data analysed included systolic and diastolic blood pressure, low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol and triglycerides. Information on the diagnosis code, age and sex of the patients was also obtained. All patients with one of the ICD-10 diagnoses (i.e. chronic ischaemic heart disease not otherwise specified [I25.9], previous myocardial infarction [I25.2], atherosclerotic heart disease [I25.1] and sequelae of cerebral infarction [I69.3]) registered between 2016 and 2020 were included in the study. Inclusion criteria were that each person had (i) a matching diagnosis number and (ii) at least two measurements at two different time points.

Data analysis

All measurements had a unique ID number corresponding to a patient, as well as the time and date of collection. Only the first and last measurements during the period January 2016 to December 2020 for each patient were included in the analysis. This pragmatic approach was taken, firstly, because the primary interest was in comparing changes over time between groups rather than modelling individual trajectories and, secondly, because the enormous variation in the number of measurements observed between patients, as well as the timing of measurements between participants in both groups, would add complexity to the analysis and interpretation.

Compliance was assessed by recording the number of available blood pressure and lipid measurements from the list of eligible patients. Those with one or no measurements were considered non-compliant.

The mean of each measurement at the two time points was then calculated for all patients in each health

centre. The mean difference between the two groups of health centres at each time point was then estimated, followed by a difference-in-difference (DiD) analysis by adding time as an interaction variable. A DiD analysis is one of the most commonly used methods in impact evaluation studies based on a combination of before-after and treatment-control group comparisons [13].

Models were estimated using Bayesian inference, with coefficients (β) as measures of effect and 95% credible intervals (95% CrI) to estimate inferences; this allowed uncertainty to be expressed as the 95% probability that the true (unknown) estimate would lie within the interval, given the evidence provided by the observed data. The Bayesian approach allowed us to better deal with the small sample size of the study. All analyses were performed using the free software R (rstanarm package). The priors used in the models were based on normal distributions defined by default in the package (see Appendix).

Ethical approval

This study was approved by the Swedish Ethical Review Authority (Dnr 2021-00115). The research group had only access to de-identified patient information.

RESULTS

Participants´ compliance

In the Stenbergska intervention group, 99 patients had a matching diagnosis of cardiovascular disease and 98 had measurements of cardiovascular-related risk factors (blood pressure and lipids) during the study period. Of the 99 patients, 91 (92%) were eligible for blood pressure measurements (4 were excluded because they had no blood pressure measurements and 4 because they had only one measurement) and 96 (97%) for blood lipid measurements (HDL, LDL, total cholesterol and triglycerides) (2 were excluded because they had only one measurement).

In the Malå control group, there were 80 patients with a diagnosis and 67 with measurements, with all the measurements having a matching diagnosis. Of the 80 patients, 39 (49%) were eligible for blood pressure measurements (37 were excluded because they had no measurements and 4 because they had only one measurement) and 46 (58%) were eligible for blood lipid measurements (18 were excluded because they had no measurements and 16 because they had only one measurement).

Of the total eligible population, 130 (74% men and 26% women) participants were included for blood pressure outcomes and 142 (72% men and 28% women) for blood lipids. The mean age was 74.9 years in the blood pressure group and 73.8 years in the lipid group.

In the Stenbergska group, the population consisted of 65 men (71%) and 26 women (29%) for the blood pressure analysis and 67 men (70%) and 29 women (30%) for the blood lipid analysis. The mean age in the Stenbergska group was 74.0 years in the blood pressure group and 73.5 years in the lipid group.

In the Malå control group, 31 men (79%) and 8 women (21%) were included for the blood pressure analysis and 35 men (76%) and 11 women (24%) for the blood lipid analysis. The mean age in the Malå group was 76.9 years in the blood pressure group and 74.5 years in the lipid group.

DiD results

Table 1 shows the means of the individual measurements at baseline and follow-up for each health centre, as well as the DiD estimates. All these results are also shown in Figure 1S (Supplement 1).

For the systolic blood pressure, baseline means of 134.96 in the intervention group and 134.38 in the control group were found. At the follow-up, the means decreased to 130.02 and 128.64 in the intervention group and control group, respectively, with a non-statistically significant DiD of 0.80 (95% CI: -8.97, 10.58). For the diastolic blood pressure, the baseline mean was 79.71 for the intervention group and 77.77 for the control group. At follow-up, they changed to 77.22 and 74.77, giving a non-statistically significant DiD of 0.50 (95% CI: -5.46, 6.47). The mean LDL-cholesterol was 2.72 for the intervention group and 2.78 for the control at baseline. At follow-up, it decreased in both groups to 1.84 and 1.97, respectively, giving a DiD of -0.07 (95% CI: -0.60, 0.47). For the HDL cholesterol, the mean was 1.37 for the intervention group and 1.28 for the control at baseline, decreasing to 1.34 in the intervention group but increasing to 1.29 in the control at the follow-up, giving a non-statistically significant DiD of -0.04 (95% CI: -0.22, 0.14).

For the total cholesterol, the mean baseline was 4.74 for the intervention group and 4.87 for the control group, lowering later at follow-up to 3.77 and 3.98, respectively, with a non-statistically significant DiD of -0.07 (95% CI: -0.64, 0.50). Finally, for the triglycerides, the mean for the intervention and control groups was 1.42 and 1.79, respectively, changing at follow-up to 1.32 for the intervention group and 1.79 for the control group, resulting in a non-statistically significant DiD of -0.09 (95% CI: -0.50, 0.30).

DISCUSSION

It is widely recognised that compliance with the clinical practice guidelines in primary care can significantly reduce long-term morbidity and mortality in patients with established cardiovascular disease [14]. This study has shown that the introduction of online specialist consultations in primary care can potentially improve compliance with recommended primary care guidelines for cardiovascular patients [1].

Specifically, the primary finding of this study was that individuals in the intervention group had higher levels of compliance with guideline recommendations for monitoring common cardiovascular key risk factors,

such as blood pressure and lipids, compared to the control group. This finding is likely to be a direct result of the more stringent monitoring practices implemented in the intervention group throughout the study.

Table 1. Medians of the different outcomes at baseline and follow-up for the control and intervention health centres and difference-in-difference estimates with their 95% credible intervals (95% CrI).

	BASELINE			FOLLOW-UP			
Out-come	Intervention	Control	Difference	Intervention	Control	Difference	Difference-in-difference (95% CrI)
SBP	134.96	134.42	0.54	129.98	128.66	1.32	0.64 (-9.09, 9.97)
DBP	79.70	77.78	1.92	77.21	74.77	2.44	0.46 (-5.44, 6.54)
LDL	2.72	2.78	-0.06	1.84	1.97	-0.13	-0.07 (-0.62, 0.46)
HDL	1.37	1.28	0.09	1.34	1.29	0.05	-0.04 (-0.22, 0.14)
TCOL	4.73	4.87	-0.14	3.77	3.98	-0.21	-0.07 (-0.65, 0.48)
TRIG	1.41	1.79	-0.38	1.32	1.79	-0.47	-0.09 (-0.50, 0.30)

*SBP=systolic blood pressure, DBP= diastolic blood pressure, LDL= LDL cholesterol, HDL=HDL cholesterol, TCOL= total cholesterol, TRIG= triglycerides.

In addition, there were no statistically significant differences in blood pressure and lipid levels between the intervention and control groups. A possible explanation for the lack of association could be the significant number of patients who were excluded due to missing values in the control group (noncompliance), which could have affected the results and possibly led to an underestimation of the differences. However, although the results may not have reached statistical significance, the study's approach of integrating telemedicine for cardiovascular disease management remains promising and offers a potential avenue for improved patient care in the future.

In general, long-term secondary prevention in primary care has emerged as a prominent area of study in the context of telemedicine implementation, and the use of home monitoring and remote patient consultations has shown positive results [15], particularly in the aftermath of the COVID-19 pandemic [16]. However, the effective integration of telemedicine into traditional clinical settings remains limited, in part due to the lack of operational and successful workflow models within healthcare provider organisations that facilitate the seamless implementation of telemedicine [17]. For this reason, the demonstration of successful telehealth interventions is essential to translate current research findings into health policy and to encourage widespread adoption by both patients and health care providers.

Methodological considerations

When interpreting the results of this study, it is important to bear in mind that, firstly, the measurements were extracted from electronic patient records, which may have omitted information from the paper-based clinical histories; and secondly, the analysis focused only on the initial and final measurements, disregarding those taken in between. All health centres in Västerbotten have access to the same equipment and practical guidelines for monitoring and data management of CVD patients. We therefore assume that there should be no bias in this respect in the two health centres studied. There are other methodological issues related to the analytic (DiD) approach that need to be considered. The validity of DiD relies heavily on the parallel trend assumption, which states that in the absence of treatment, the treatment and control groups would have followed the same trend over time. If the treatment and control groups have different underlying time trends (for reasons unrelated to the treatment), the DiD estimates may be biased. This could be due to factors such as differences in baseline characteristics, regional economic conditions or other external influences. To some extent related to this issue, as we could not assess whether the groups differed systematically, the DiD estimates may have reflected these pre-existing differences. However, as our results were not statistically significant, these potential biases become less relevant. One possibility could be that the results were not significant due to the small study sample. The use of a Bayesian framework in our analysis largely excluded this possibility.

Conclusion

This study investigated the use of a long-term online specialist consultation to address important gaps in health care in rural areas. The results underline the effectiveness of telemedicine specialist consultations in reaching primary care patients in rural Sweden who need secondary cardiovascular prevention. Although there were no differences in clinical measures between the intervention and control health centres, the intervention centre showed better compliance with primary care guidelines for cardiovascular patients after discharge from hospital-based services.

Therefore, the integration and expansion of telemedicine services as a standard component of post-discharge care for cardiovascular patients is recommended, especially in rural areas. In fact, this model of

digital rounds with specialists in referral centres and nurses in health centres has been extended by the local health authority across the region. Further research could focus on understanding the challenges faced by both patients and providers in following recommended guidelines for secondary cardiovascular prevention, and the implementation of stronger methodological designs could help to better elucidate the potential impact of this type of intervention.

DECLARATIONS

Publication Consent
Not applicable.

Competing interests
EXSS and MSS declare no conflict of interest. MG was the medical specialist involved in the delivery of the intervention.

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Author contributions
MG was responsible for the initial conceptualization of the research idea, EXSS and MSS conducted the analysis and drafted a first version of the manuscript. MG provided a critical input during the revision process significantly improved the clarity and coherence of the final document. Each author has read and approved the final manuscript.

Data availability
Data cannot be shared publicly because of the sensitive nature. Data are available from Umeå University (contact via the correspondent author) for researchers who meet the criteria for access to confidential data.

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Explorando el efecto de la telemedicina en el control de la presión arterial y las mediciones de lípidos en pacientes cardiovasculares de la Suecia rural: un estudio de intervención antes y después

RESUMEN

Introducción: El cumplimiento de las directrices de prevención secundaria a largo plazo en los centros de atención primaria se ve dificultado, en parte, por la escasez de profesionales sanitarios, sobre todo en las zonas rurales. La telemedicina se ha mostrado prometedora para apoyar la atención preventiva sin necesidad de que los profesionales se desplacen físicamente a regiones desatendidas. Aunque muchos estudios han mostrado resultados positivos con la telemedicina, se necesitan más evidencias. El objetivo de este estudio fue comparar el efecto de la telemedicina en el cumplimiento de las directrices para el control de la presión arterial y los lípidos en la atención primaria en pacientes con enfermedad cardiovascular isquémica en comparación con la atención tradicional en las zonas rurales de Suecia. Además, el estudio investigó el efecto de cinco años de seguimiento con telemedicina sobre las mejoras en la presión arterial y los niveles de lípidos en comparación con un centro de salud de control.
Métodos: Se incluyeron dos centros de salud rurales del norte de Suecia. El grupo de intervención recibió videoconsultas en línea programadas periódicamente entre un cardiólogo y las enfermeras locales, mientras que el grupo de control recibió un seguimiento convencional en el centro. Se recopiló información de registro basada en pacientes para el período 2016-2020. Los datos incluyeron las mediciones disponibles de presión arterial sistólica y diastólica, LDL, HDL, colesterol total y triglicéridos. El cumplimiento de las directrices se evaluó registrando el número de mediciones de presión arterial y lípidos disponibles de la lista de pacientes elegibles. Se consideraron no conformes aquellos en los que no se había realizado ninguna o ninguna medición. Se calcularon las medias de las mediciones de la presión arterial y los lípidos en dos momentos y se realizó un análisis de diferencias en diferencias.
Resultados: El grupo de intervención mostró un mayor cumplimiento de las recomendaciones de las directrices. Sin embargo, no hubo diferencias estadísticamente significativas en las mediciones de la presión arterial y los lípidos a lo largo del tiempo en comparación con el grupo de control.
Conclusiones: Los resultados destacan el potencial de la telemedicina para mejorar el cumplimiento de las directrices de prevención cardiovascular secundaria en la atención primaria rural. Este estudio sirve como modelo de éxito para la integración de la telemedicina en la atención sanitaria del mundo real y pone de relieve la necesidad de seguir investigando y evaluando.

Palabras clave: telemedicina, prevención cardiovascular, cumplimiento, presión arterial, colesterol, rural, Suecia

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