Evaluation of the effect of a multifunctional telemedicine device on healthcare use and costs – a non randomized pragmatic trial

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Abstract

Background:

Telemedicine health insurance models are highly prevalent in the Swiss healthcare system. Nevertheless, the potential of telemedicine is only partly being achieved, since current telemedicine health insurance models are limited to an initial contact by telephone and a gatekeeper role that organizes access to health care providers such as GPs, specialists, or hospitals. Against this background, a telemedicine device with diverse visual and auscultatory examination functions was made available to 2,000 telemedicine-insured clients. This device allowed diagnostic information to be sent to a medical care provider and used for telemedical consultation.

Objective:

To determine whether the additional implementation of a multifunctional telemedicine examination device resulted in fewer physical consultations, reduced service utilization, and lower healthcare expenditures among telemedicine-insured clients.

Methods:

Our analysis is based on claims data from 135,636 clients insured in a telemedicine call center model covering the years 2019 and 2020. We compare the use of healthcare and healthcare costs of clients that received a telemedicine device to those without such a device, using multivariable regression to adjust for group differences due to self-selection.

Results:

We found lower total healthcare expenditures of -229 (Swiss Francs) and lower inpatient costs of -160 (Swiss Francs) on the part of clients with the telemedicine device. However, the implementation of the telemedicine device did not lead to a statistically significant reduction in service utilization.

Conclusions:

The treatment of telemedicine-insured clients was on average more cost-effective when they received the multifunctional telemedicine device. Accordingly, complementing the existing telemedicine model with telemedicine devices that allow for improved telemedical consultations has the potential to increase the cost-saving potential of the existing telemedicine call center models.

1 Introduction

As in most other countries, the increase in health care expenditure in Switzerland is considered to be one of the greatest challenges facing the health system and health policy.[1] Integrated care models are seen as a viable strategy to cushion the cost increase. However, these models are only one among several options for those insured under the basic health insurance. In integrated care models, insured persons usually accept a restriction in their choice of provider and, in exchange, receive a premium reduction, which serves as an incentive for enrollment.[2] Integrated care models have already become well established in the Swiss healthcare system, with over 70% of insured persons choosing such a model in 2018.[3]

At the core of all these models is some gatekeeping, i.e., the insured persons are obligated to consult their chosen gatekeeper, a general practitioner, a group of GPs, a GP network or a telemedicine call center, before turning to other medical providers.[4] Gatekeeping is thus intended to prevent unnecessary specialist and inpatient services use and reduce costs.[5,6] Such effects have already been demonstrated in a variety of studies[7-9], with savings also achieved in the more recent telemedicine call center models.[10]

In the case of the medical call centers, a medical professional in a call center acts as a gatekeeper who carries out the initial assessment and then decides on referral to the next level of care.[11] This is done by answering patient requests with computer assistance and referring those in need of a hospital or a physician. In this context, the general benefits of telemedicine are seen in the preservation of a certain level of care security and the reduction of costs by avoiding unnecessary treatments.[12,13] Expert groups see telemedicine as an approach to efficiently addressing the current challenges facing the healthcare system.[14]

Nevertheless, certain barriers remain in the current utilization of telemedicine. Because it generally does not allow a comprehensive assessment of patients, there are a variety of requests from insured persons who cannot be conclusively treated by telemedicine.[12] This is why the potential of telemedicine treatments cannot be fully exploited.[15] However, once options exist to perform examinations via digital tools, an improved diagnosis will be possible and examining physicians will be able to initiate further treatments instantly without the need for the patient to consult a medical professional in person.[16,17]

One such device is the multifunctional telemedicine device TytoHome. It is designed for use by private individuals and was approved for use in the European Union and on the American market (certification of the Food and Drug Administration).[18]

TytoHome combines several medical instruments such as stethoscope, dermatoscope, and otoscope, which can be used to conduct examinations at home.[1] This is unique in that to this point, only single digital diagnostic devices such as a digital stethoscope and otoscope have been established as solutions in clinical practice in many cases.[19-21]

Until 2020 TytoHome was mostly used in Israel and the USA, with TytoCare in Israel cooperating with the country's largest hospital group, Clalit.[22,23] In 2020, SWICA health insurance, one of the largest health insurers in Switzerland and which has its own operated telemedicine call center santé24, became the first health insurer in Europe to make the telemedicine device available to 2,000 of its clients.[24]

The participating insured persons are therefore able to conduct the various examinations at home and send results digitally to the medical call center.[1] Thus, for symptoms that previously required physical consultations, examinations can now be sent in advance by the device.[25] The medical staff then reviews the examination information and uses it for the assessment of the patients. According to the gatekeeping principle, the medical professional then decides the extent to which the patient should be referred to further medical providers or whether the treatment can already be completed at this level.

In this context, the visual and auscultatory complementarity should enhance the possibilities of telemedicine consultations. Accordingly, compared to the previous telemedicine call center model more diagnoses should be possible by telemedical service provider without referral to other medical professionals. As a result, the demand for outpatient and inpatient services on the part of the insured should be reduced compared to the previous telemedicine call center model. Ultimately, using the comprehensive telemedicine device should result in cost savings compared to the previous telemedicine call center model.

Such reductions as a result of implementing the telemedicine service have already been described in the context of international implementations of the device.[26,27] Nevertheless, at the current stage there is no evidence concerning the impact of implementing the multifunctional telemedicine device among insured patients in the European context.

This paper therefore looks at the extent to which the establishment of a multifunctional telemedicine device can lead to a more cost-effective provision of healthcare for clients already enrolled in a telemedicine call center model. We investigate whether the implementation of a multifunctional telemedicine device leads to a reduced number of physical consultations, reduced service utilization and lower healthcare expenditures among telemedicine-insured clients.

If there are savings to be generated from the implementation of the telemedicine device, it could become a module of an enhanced telemedicine call center model.

2 Materials and Methods

2.1 Data

We performed a cross-sectional study and compared health insurance clients ("insureds") who received the multifunctional device with those without such a device.

Our analysis is based on claims data from one of the largest Swiss health insurers (SWICA), which covers 0.831 million individuals with compulsory health insurance (approx. 10% of the Swiss population).[28] The utilized data sample includes 135,636 Swiss residents who had uninterrupted compulsory health insurance coverage based on a telemedicine model during the years 2019 to 2020.

2.2 Participants

Our study population included clients who were enrolled in the telemedicine model in 2020 and 2019. Clients in the telemedicine model are obliged to consult the medical call center free of charge prior to turning to other medical providers.

We excluded clients without at least one physical consultation and healthcare expenditures in each year to narrow our analysis to people with some basic need for health services. At the same time, we were able to ensure, that the insureds conducted at least one consultation with the medical center or, for those who owned the telemedicine device, had the most likely use of the telemedicine device.

At the beginning of 2020, SWICA insureds were invited to opt for participation in the pilot project and to receive a telemedicine device. Insureds were informed about the project via mailings and press releases. All clients were eligible to participate.

Ultimately, the treatment group with the multifunctional telemedicine device included 943 telemedicine insureds and the control group included 134,693 telemedicine insureds who had not opted for the device.

2.3 Outcome measures

Our main outcome is the total annual amount of health care expenditure (excluding maternity), which we broke down into outpatient and inpatient costs. Additional outcomes were outpatient service utilization (none vs. one or more), the number of outpatient consultations and the number of inpatient stays.

As controls we use age (minors <18, young adults 18-26, adults 27+) and gender, the existence of private supplementary insurance or private supplementary hospital insurance, the selected deductible

rate, the residence of the insured person based on the official regions of the Swiss Federal Statistic Office and the size of the family. In addition, the pharmaceutical cost groups (PCGs) were used to identify the morbidity of the insured. PCGs make it possible to extrapolate the morbidity of the respective insured persons from the accounting data of drug purchases and are also included in the Swiss risk equalization framework.[29]

The variable selection for the model was based on previously published studies of efficiency gains in integrated care models. These analyses showed that variables including the morbidity of the insured, hospital stay in the previous year, and gross costs in the previous year had a large impact.[4]

Ultimately, in addition to sociodemographic characteristics of the insured and the PCGs for the ascertainment of morbidity, the total costs (in Swiss francs) in the previous year, which are considered to be one of the central explanatory variables for the estimation of health care expenditures, were also included.[30]

2.4 Statistical Methods

We report descriptive statistics for both the treatment and control groups using means and medians for continuous variables and absolute and relative frequencies for categorical variables.

To analyze whether the multifunctional telemedicine device leads to a reduced number of physical consultations and lower healthcare expenditures among telemedicine-insured clients, we apply multivariable regression to adjust for differences between treatment and control group due to self-selection.

Multivariable linear regression models were used for healthcare expenditures, logistic regression for having at least one outpatient service utilization and, since it is count data, Poisson regression for the number of outpatient consultations and number of hospitalizations. We additionally report average marginal effects (AME) for the logistic and Poisson models. Other than the logit coefficients, AMEs allow for a direct interpretation of effects in terms of probabilities (logistic regression) or counts (Poisson regression).

Our regression equation has the following form:

$$(1)\ TC_i = \beta_0 + \beta_1 Tyto_i + \beta_j X_{ij}$$

with TC_i being the total costs 2020 for individual i, and $Tyto_i$ a dummy-variable taking the value of 1 for members of the treatment group and 0 for the control group. X_{ij} stands for the various control variables j. Equations for the other outcome variables are analogous.

Because the verification of the regression assumptions for linear regression analyses revealed a violation of the independent and identically distributed error terms assumption, we calculated robust standard errors (Hubert-White estimators).

Analysis was performed with the statistical software R (version 4.1.0).

2.5 Data Protection/Ethics

The analysis was performed in accordance with the Swiss Federal Data Protection Act (DSG). All data were de-identified and anonymized before the analysis was performed.

In accordance with national ethical and legal regulations and the 'Good Practice in Secondary Data Analysis (GPS)', no ethical approval was required because the data were pre-existing and de-identified. Since the data were anonymized, patient consent was not required.

Therefore, the authors considered that ethical approval and informed consent were not necessary.

3 Results

Descriptive statistics for the samples are presented in *Table 1*. With the exception of gender, the groups differ with regard to all socio-demographic characteristics considered. Clients who opted for the telemedicine device are younger, have more family members, choose supplementary insurance more often, and exhibit fewer PCGs, indicating lower morbidity.

As expected, health expenditures and the utilization of services in the treatment group were lower than in the control group (without the multifunctional telemedicine device).

Table 1: Sample characteristics for the control group and treatment group (mean and median for numeric, proportions for dummy variables)

Variable	Without telemedicine device	With telemedicine device	Total	Test for difference
Sample size	134,693 (99.4 %)	943 (0.6 %)	135,636 (100.0 %)	
Male (0/1)	56,622 (42.0 %)	392 (41.6 %)	57,014 (42.0 %)	[a]
Age	42.2 (44)	30.1 (35)	42.1 (44)	*** [a]
Adult (0/1)	109,785 (81.5 %)	561 (59.5 %)	110,364 (81.4 %)	*** [a]
Family size	2.5 (2)	3.5(4)	2.5 (2)	*** [a]
Place of residence				
Zurich (0/1)	49,613 (36.8 %)	417 (44.2 %)	50,030 (36.9%)	*** [a]
Eastern Switzerland (0/1)	29,455 (21.9 %)	249 (26.4 %)	29,704 (21-9 %)	*** [a]
Northwestern Switzerland (0/1)	14,812 (11.0 %)	112 (11.9 %)	14,924 (11.0 %)	
Mittelland (0/1)	17,718 (13.2 %)	108 (11.5 %)	17,826 (13.1%)	[a]
Central Switzerland (0/1)	6,750 (5.0 %)	28 (3.0 %)	6,778 (5.0 %)	** [a]
Lake Geneva (0/1)	7,791 (5.8 %)	17 (1.8 %)	7,808 (5.8 %)	*** [a]
Ticino (0/1)	8,554 (6.4 %)	12 (1.3 %)	8,566 (6.3 %)	*** [a]
Health insurance				
Deductible class (>500 Swiss Francs) (0/1)	45,989 (34.1 %)	318 (33.7 %)	46,307 (34.1 %)	[b]
Supplementary insurance (0/1)	118,340 (87.9 %)	926 (98.2 %)	119,266 (87.9 %)	*** [a]
Supplementary hospital insurance (0/1)	41,301 (30.7 %)	322 (34.1 %)	41,623 (30.7 %)	* [a]
Indicator for morbidity				

Number of pharmacy-based cost groups	0.2 (0)	0.1 (0)	0.2 (0)	*** [a]
Health expenditures and utilization				
Total costs 2020	3,792.35 (1'368)	2,177.22 (933)	3,781.12 (1'363)	***[b]
Total costs 2019	3,671.78 (1'395)	2,197.45 (979	3,661.53 (1'390)	***[b]
Outpatient costs 2020	2,731.82 (1'188)	1,749.89 (863)	2,724.99 (1'185)	***[b]
Inpatient costs 2020	636.7 (0)	238.4 (0)	633.9 (0)	***[b]
Number of outpatient consultations 2020	6.1 (4)	5.1(4)	6.1 (4)	** [a]
Number of outpatient consultations 2019	6.3(4)	5.6 (4)	6.3(4)	*** [a]
Number of hospitalizations 2020	0.0 (0)	0.0 (0)	0.0(0)	[a]

0/1: Dummy variables

[A]t-test, [B]Welch's t-test

**p<0.05, **p<0.01, ***p<0.001*

3.1 Impact of the multifunctional telemedicine device

3.1.1 Health care expenditures

The implementation of the multifunctional telemedicine device is associated with lower health care expenditures (*Table 2*). Opting for the telemedicine device led to lower health care expenditures and outpatient expenditures as compared to the solely telemedicine call center model. The implementation did not lead to a statistically significant reduction in gross outpatient costs. The full model is presented in the annex.

Table 2: Effect of the telemedicine device use on healthcare costs – results of multivariable linear regression models (Observations in treatment group: 943 – Control group: 134,693)

Outcomes	
Total health care costs (Swiss Francs)	−228.997*
Outpatient costs (Swiss Francs)	−108.239
Inpatient costs (Swiss Francs)	−159.889***

0/1: Dummy variables

**p<0.05, ***p<0.001*

Control variables included: age, gender, private supplementary insurance or supplementary hospital insurance, selected deductible rate, the residence of the insured person based on the official regions of the Swiss Federal Statistic Office, the size of the family and number of PCGs (full model in Table 4)

3.1.2 Utilization of services

Estimations of the results for healthcare use are presented in *Table 3.* The implementation did not lead to a statistically significant reduction in service utilization, measured as probability for at least one outpatient utilization, number of outpatient consultations, or number of hospital stays. The full model is presented in the annex.

Table 3: Effect of telemedicine device use on healthcare use – results of logistic regression and Poisson regression (Observations in treatment group: 943 – Control group: 134,693)

Outcomes	Logit coefficient	Average marginal effects
At least one outpatient service utilization (0/1)	0.146	0.011
Number of outpatient consultations	−0.017	−0.105
Number of hospital stays	−12.683	−0.073

0/1: Dummy variables

Control variables: age, gender, private supplementary insurance or supplementary hospital insurance, the deductible rate selected, the residence of the insured person based on the official regions of the Swiss Federal Statistical Office, the size of the family and amount of PCG (Table 5)

4 Discussion

To the best of our knowledge, this publication is the first that examines the effect of introducing a multifunctional telemedicine device for telemedicine insured individuals in Europe. Previous surveys concerning the telemedicine device describe the establishment of the service in an international context or refer to the quality of the examinations of the telemedicine device.[18,26,27,31,32]

Overall, our study shows that the care of telemedicine-insured patients was more cost-effective if they received the multifunctional telemedicine device. Total costs in the treatment group are lower by 229 (Swiss Francs), which corresponds to 6% of the average health care costs in our sample. Thus, the additional implementation of the multifunctional telemedicine device reduces costs compared with enrollment in the telemedical model alone.

Our results seem to show that the additional visual and auscultatory capabilities of the multifunctional telemedical device lead to a strengthening of the telemedical consultations provided and enhance the possibilities of concluding telemedicine consultations by the telemedicine center. Therefore, the gatekeeping function of the telemedicine center could be strengthened through the additional offering of the telemedicine device to insureds.

If the issue of the telemedicine device were to be established as standard practice, this could lead to an increase in the efficiency gains of telemedicine models presented in various publications.[4,10] The overall cost savings identified in this study are in line with the results of various case studies on the use of the same telemedicine device in an international context, although decidedly in the lower range, which is not unexpected due to the differences in study design and the different european context.[26,27]

The second finding is that there are no significant differences in "outpatient costs" and in the secondary outcomes of service utilizations. In our view, there are a number of explanations for this. The available data did not allow differentiation of outpatient consultations between general practitioner and specialized consultations. As a result of the examination spectrum of the telemedicine device, the expectation would be that the enhanced telemedical consultations would mostly serve as an alternative to an in-person consultation with a general practitioner, but perhaps less so for outpatient consultations overall.

A limitation of this study is that we were not able to examine the actual use of the telemedicine device, but only the effect of participating in the pilot project, that is, of having received the device. Nevertheless, insureds were encouraged to use the device. Participants were reminded by periodic

reminder mailings to use the device when appropriate. Also, a technical consultation service was available to answer questions about the telemedicine device and the respective facility.

Having said that, participants were not obligated to use the device when contacting the telemedical center, and an internal analysis showed that only 132 persons, i.e., 14% of the treatment group, used the device at least once and contacted the telemedical call center during the one-year observation period. This certainly places certain limits on the effects found.

Since the device was offered to all clients, a randomized allocation to treatment and comparison group was not feasible. To account for a possible selection effect and a varying risk structure of treatment and control group, a variety of control variables were included in the regression analyses. In particular, the total costs of the previous year that we included are a main predictor of total costs.[30] Regression analyses as control strategy have been shown to provide insights in efficiency gains of integrated care models.[4] Nevertheless, as with all real-world studies, this study has a risk of bias due to unobserved and unaccounted variables, which could have an impact on our estimates.

Also, the observation period of our study was the first year of the coronavirus pandemic. This means, for instance, that significantly fewer infectious diseases besides Covid-19 were reported as a result of the public health interventions to reduce social contacts and the spreading of the coronavirus.[33,34] Considering the fact that the telemedicine device is particularly suited for diagnosing these infectious diseases, the pandemic might have led to less use of the device. On the other side, the pandemic might have led to an increase in the use of telemedical services relative to regular consultations, and with that, of the telemedical device.

Due to the mandatory deductible rate, insured persons might not have submitted all services used to the insurer for reimbursement; this would mean that using claims data would result in an underestimation of services use. Reich et al., however, report that only about 1.5% of all bills are paid directly and not claimed by the insured due to the deductible.[35] The population of telemedicine-insured persons we analyzed may differ from those of other insurers with regard to morbidity and insurance coverage. Additionally, the structures of the telemedicine models differ between individual insurers: for example, the telemedical center considered here, santé24, is operated exclusively by one insurer.[36] Accordingly, the results cannot be readily transferred to other health insurers and telemedical centers.

Furthermore, it was not possible within the present study design to ascertain the reasons why the establishment of the telemedicine service led to a reduction in the total gross costs of the insured. It can only be assumed that, because of the provision of the device, supplementary medical information was available to the caregivers of the medical center and this led to a strengthening of their pilot function. Qualitative studies could be conducted to investigate the expectations and motivations of

the insured for using the telemedicine device. These could potentially differ from the persons in the telemedical call center model of the insurance company. Results that showed this would certainly be an indicator of lower efficiency gains attributable to the telemedicine device.

At the same time, the medical concerns of the insureds that were able to be solved by the medical staff of santé24 without the involvement of registered physicians should certainly be analyzed. Santé24 would be able to see for which patient symptoms the use of the telemedicine device led to a strengthening of the pilot function of the specialist staff. The findings of such an analysis should be considered when designing an extended telemedicine care model. As soon as a new integrated care model with the telemedicine device and mandatory contact to the telemedicine center is established, the efficiency gains of the model compared to standard care with free choice of the medical staff can be assessed. The findings can be classified in the spectrum of the efficiency gains of telemedicine models already surveyed.

5 Conclusions

The study shows that the establishment of a multifunctional telemedicine device can be considered effective in enhancing the cost-saving potential of existing telemedicine care models by allowing for enhanced telemedical consultations and thus contributing to curbing cost increases in the healthcare system.

From our perspective, we recommend that health policy makers take the results into account in discussions on the design of an extended telemedicine call center model in the future. Thus, the telemedicine device offers potential to, on the one hand, improve the cost efficiency of telemedicine care models and, on the other, to contribute to the safeguarding of care structures.

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7 Authorship confirmation statement

SB, MH, DM, OR designed the study. DM and SB prepared the claims data.

The claims data was provided by the SWICA Health Insurance Company, Winterthur, Switzerland. It is not publicly available due to privacy concerns.

SB analyzed the data and wrote the first manuscript draft. SB, MH, OR, and DM wrote the final manuscript. All authors were involved in the manuscript preparation and read and approved the final manuscript. This article has not been published elsewhere.

8 Authors' disclosure (Conflict of interest) statement(s), even if not applicable

SB and DM were employed from SWICA Health Insurance Company at the time of initiating this research.

OR is the current head of santé24.

All authors declare no conflict of financial interests.

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11 Annex

Table 4: Effect of telemedicine device use on health expenditures – results of multivariate Linear regressions

Coefficients	Total costs	Outpatient costs	Inpatient costs
CONSTANT	609.985***	601.882***	153.447***
Telemedicine device (0/1)	−228.997*	−108.329	−159.889***
Female (0/1)	−72.161	157.632***	−177.158***
Young adults 19 to 25 (0/1)	609.921***	453.424***	153.280***
Adults 26+ (0/1)	1,260.919***	957.243***	324,.05***
Deductible class (>500 Swiss francs) (0/1)	−931.991***	−745.418***	−220.646***
Number of pcgs	1,234.632***	653.456***	289.419***
Supplementary insurance (0/1)	−202.591**	−79.312	−94.107*
Supplementary hospital insurance (0/1)	109.643*	56.632	98.846***
Eastern Switzerland (0/1)	−76.539	−141.337***	129.379***
Northwestern Switzerland (0/1)	−25.938	−189.407***	−7.230
Lake of Geneva (0/1)	264.318**[*]	-6.015	−74.048
Mittelland (0/1)	−59.949	−253.208***	31.508
Ticino (0/1)	−130.059	−354.633***	−113.992**
Central Switzerland (0/1)	−191.042*	−88.964	−13.790
Total costs 2019	0.674***	0.429***	0.104***

0/1: dummy variables

**p<0.05, **p<0.01, ***p<0.001*

Table 5: Effect of telemedicine device use on utilization of services – results of logistic regression and Poisson regression

Coefficients	Outpatient service utilization (none vs. One or more)	Number of outpatient consultations	Number of inpatient stays
CONSTANT	1.927***	1.298***	−6.390***
Telemedicine device (0/1)	0.146	−0.017	−12.683
Female (0/1)	0.571***	−0.197***	−0.204***
Young adults 19 to 25 (0/1)	−0.191***	0.221***	1.465***
Adults 26+ (0/1)	0.101***	0,.570***	1.527***
Deductible class (>500 Swiss Francs) (0/1)	−0.656***	−0.487***	−0.675***
Number of pcgs	0.065*	0.217***	0.385***
Supplementary insurance (0/1)	0.129***	−0.041*	−0.269*
Supplementary hospital insurance (0/1)	0.167***	0.078***	0.430***
Eastern Switzerland (0/1)	−0.112****	−0.066***	0.076
Northwestern Switzerland (0/1)	−0.159***	−0.025***	-0.069
Lake of Geneva (0/1)	−0.244****	−0.033***	−0.309
Mittelland (0/1)	−0.257***	−0.115***	0.025
Ticino (0/1)	−0.013	0.043***	0.157
Central Switzerland (0/1)	0.020	−0.034***	0.250
Total costs 2019	0.000***	0.000***	0.000***

0/1: dummy variables

**p<0.05, ***p<0.001*

Results of logistic regression for outpatient service utilization (none vs. one or more) and results of Poisson regressions for number of outpatient consultations and number of inpatient stays.