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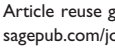

Impact of a telemonitoring intervention in patients with chronic heart failure in Germany: A difference-in-difference matching approach using real-world data

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Abstract

Introduction: The aim of this study was to evaluate the effects of a non-invasive telemonitoring intervention on mortality, healthcare costs, and hospital and pharmaceutical utilisation in patients with chronic heart failure (CHF) of a large statutory health insurer in Germany.

Methods: In a retrospective observational cohort study using real-world data, we assessed differences between 635 patients who received a telemonitoring intervention versus 635 receiving usual care covering 36 months after intervention. We used propensity score matching on a set of 102 parameters collected in the 24-month pre-intervention period to correct for observed differences, as well as difference-in-difference (DiD) estimators to account for unobserved differences. We analysed the effect of the intervention for up to three years on (i) all-cause mortality; (ii) costs (i.e. inpatient stays, ambulatory care, pharmaceuticals, and medical aids and appliances); and (iii) healthcare utilisation (i.e. length and number of hospital stays, number of prescriptions).

Results: DiD estimates suggest lower inpatient costs of the telemonitoring group of up to €1160 (95% confidence interval (CI): –2253 to –69) in year three. Ambulatory care costs increased significantly in all three years up to €316 (95% CI: 1267 to 505) per year. Telemonitoring had a positive effect on survival (hazard ratio = 0.71; 95% CI: 0.51 to 0.99) and increased the number of prescriptions for diuretics. Effects were more prominent for patients with severe CHF.

Discussion: The study suggests that the telemonitoring intervention led to a significant decrease in mortality and a shift in costs from the inpatient to the ambulatory care sector 36 months after intervention.

Keywords

Chronic heart failure, difference in difference, health economics, propensity score matching, telecardiology

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Introduction

Chronic heart failure (CHF) is a cardiovascular disorder with a high incidence worldwide (5–10 cases per 1000 persons/year).[1] It is one of the most frequent diagnoses in Germany[2] and the most common diagnosis during hospital admission in the developed world for patients aged 65+.[3] This leads to high costs, mostly due to repeated hospitalisations.[4] Reported mortality rates vary substantially, but are generally high,[5] especially after recent hospitalisations.[1,6]

Telemonitoring is one approach for tackling high costs and strengthening patient autonomy. It aims to

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facilitate disease management by frequently monitoring parameters such as weight or blood pressure, thereby detecting early changes in patients' condition that might warrant intervention. Home telemonitoring can be beneficial in other dimensions – for example, reducing physical contacts of vulnerable patient groups during the global COVID-19 pandemic.[7] It can also be used to detect possible emergencies, such as cardiac pulmonary oedema and facilitate their timely management. While not all studies report significant positive effects on all-cause mortality, several trails have shown that telemonitoring is beneficial, especially in reducing all-cause mortality and CHF-related hospitalisation.[8–11] Most studies have focused on mortality and hospitalisations, fewer have investigated costs or multiple outcomes. In those that have investigated costs, with few exceptions,[12] the intervention period has usually been short, limiting information about the long-term effects.[10]

In this study, we aim to address this gap by evaluating the effects of a non-invasive home telemonitoring intervention on all-cause mortality, healthcare costs, healthcare utilisation, and pharmaceutical prescribing in a large population over three years. We rely on individual-level data from a large statutory health insurer in Germany (IKK Südwest) and use a two-stage approach combining propensity score matching (PSM) with difference-in-difference (DiD) estimation to correct for observed and unobserved differences.[13,14] In total, we compare 635 individuals for 36 months after they started the telemonitoring intervention with 635 matched individuals who received usual care.

Methods

Design and sample

Using a retrospective cohort design, we compare patients with a history of CHF who had received either usual care as control group (CG) or usual care plus a telemonitoring intervention as intervention group (IG) in a real world setting. Usual care is the standard treatment delivered by the German healthcare system, which, compared to other countries, is very fragmented. The care for CHF patients is usually delivered by a general practitioner and a cardiologist, both in private practices, which are expected to deliver guideline concordant care.[15] The observation period of five years began with a baseline comparison 24 months before the intervention started and lasted for 36 months after the start (Figure 1). Enrolment was staggered in three-month increments between Q2/2012 and Q4/2014. We base our analysis on claims data from a large statutory health insurer in Germany comprising individual-level demographics, as well as data on all-cause mortality; costs to the payer; inpatient and ambulatory care visits including all diagnoses (ICD-10-GM); prescriptions of ambulatory care pharmaceuticals; and medical aids and appliances paid for by the insurer. We observed patients from Q1/2010 through Q2/2017.

We considered only CHF patients (≥18 years) with an existing diagnosis to be eligible and, therefore, screened all individuals two years before the start of the intervention in both the claims data for CHF-related hospitalisations and additionally related ambulatory diagnoses. Newly CHF-diagnosed patients are not included. Patients with severe terminal illnesses or conditions that made telemonitoring impractical or impossible, such as dementia or dialysis, were excluded. Online Appendix A provides the full criteria list.

The health insurer identified eligible patients in the claims data via pre-defined ICD-10 diagnoses. These were randomly assigned to either IG or CG. Those in the IG were contacted by the health insurer and given information on the programme to decide on participation. The health insurer covered all costs of the programme. Before final enrolment, participating

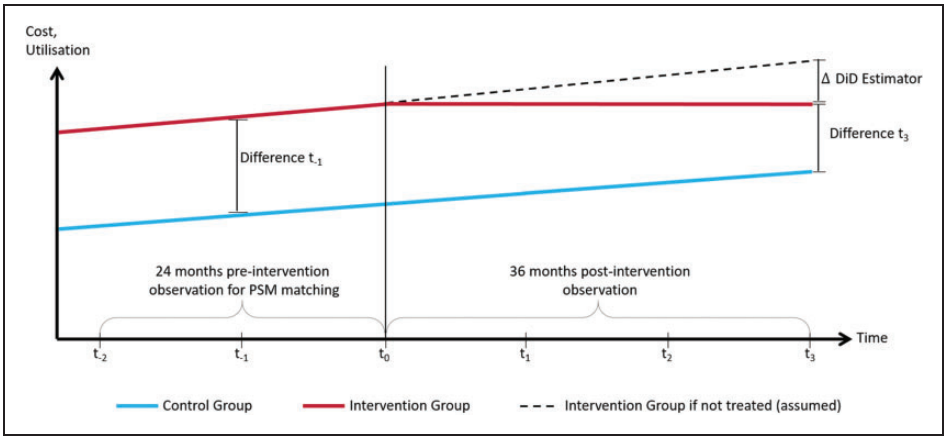

Figure 1. Research design, with a 24-month pre-intervention observation used for the PSM matching and the 36-month follow-up.

physicians re-assessed the IG candidates for eligibility and applied exclusion criteria that could not be observed in the claims data – for example, if the patients lack German language skills. All participants in the IG provided written consent, while the CG continued usual care. Universität Hamburg granted ethical approval.

Telemonitoring intervention

The telemonitoring intervention, which was provided on top of usual care, was non-invasive and designed to help CHF patients manage their disease by regularly monitoring relevant parameters within their usual physician network. At a minimum, patients who received the telemonitoring intervention were equipped with an electronic scale that reminded them to weigh themselves daily. Depending on patients' comorbidities, patients also receive a blood pressure monitor (hypertensive heart disease, daily transmission), a 12-channel electrocardiogram (ischemia or arrhythmia, monthly transmission or on-demand), or both. Data from all devices were transmitted automatically to the telemonitoring centre. If patients were non-compliant (e.g. not transmit measures), they were contacted.

The backbone of the telemonitoring system was an electronic patient record that was updated in real time and made available to patients' physicians. The dedicated telemonitoring centre, run by an external organisation and staffed with at least one physicians and several nurses, contacted patients or their physicians in case the measured data was not transmitted or deviated from the pre-set boundary (defined by default as 1.5 kg or 2% weight deviation to the day before, systolic blood pressure >160 mmHG or <90 mmHG, diastolic blood pressure >100 mmHg or <50 mmHg, or a heart frequency >100 bpm or <50 bpm). Both the patients and the physicians could seek advice 24/7 from the centre's specialists. Additionally, the telemonitoring centre performed standardised follow-up calls with the patient every four to six weeks to provide education on CHF-related topics and advice on self-management.

Statistical analysis

We used a matching DiD approach[13,14,16] to address selection bias into the program by patients or physicians. First, we applied PSM[17] and matched on pre-intervention observables to eliminate bias arising from factors that predicted participation in the intervention. We used nearest neighbour (1:1) matching, within a caliper width of 0.01, to align the IG and CG over 102 observable baseline characteristics for year one and two before the enrolment, to follow disease progression. We matched on variables observed 24 months before the start for the IG or, for the CG, 24 months before 1 January 2013. We matched for age, sex, months since last hospital stay, retirement status, and residence. For comorbidity, we used the 16 Charlson comorbidity groups,[18,19] 22 pharmaceutical groups, based on the Anatomical Therapeutic Chemical (ATC) Classification System, shown to be relevant in the treatment of heart diseases (see online Appendix C)[15,20] and CHF severity based on the coded New York Heart Association (NYHA) classes. Furthermore, we considered healthcare costs and utilisation before the start of the intervention. In our main specification, we excluded patients who died during the observation period from the DiD analysis before the matching because costs escalate before the end of life and may disturb the results if the intervention has an effect on survival.[21]

Using the best matching approach is of utmost importance to avoid bias. Therefore, we applied two sensitivity analyses: including deceased patients and entropy balancing.[22]

To avoid bias, we analysed healthcare costs and utilisation using an additional DiD approach to account for unobservable differences.[23,24] We compared the difference in costs and utilisation one year before the start of the intervention between CG and IG with the difference in costs and utilisation between the two groups in year one, year two, and year three after enrolment to determine the effect of the intervention (Figure 1). DiD allows us to take account for unobserved differences between the groups that could not be captured by PSM, such as physical activity and smoking behaviour. We measured costs from the payer perspective in Euros at 2015 values, categorised as inpatient, ambulatory, pharmaceutical, and medical aid and appliance. Inpatient costs were winsorised at €100,000 per year to limit distortion by outliers.

To analyse whether any effect of the intervention might differ depending on whether patients had mild or severe CHF, we stratified between different NYHA groups, defining CHF in patients coded with NYHA III–IV as severe, and with NYHA I, II and unknown as mild.

We performed the survival analysis on the full sample with a similar matching using Kaplan–Meier estimates and tested differences in survival with a log-rank test and a Cox proportional hazard model. We used SAS 9.4 for data processing and STATA 15.1 for statistical analysis.

Results

Table 1 and online Appendix C give an overview of the two groups before matching. In total, 738 patients were in IG and 869 in the CG. Patients in the IG were, on

Table 1. Pre- and post-matching characteristics of the study population.

	Before matching			After matching		
Patient characteristics	CG	IG	Std diff	CG	IG	Std diff
Age (years)	64.7	63.8	7.1	64.5	64.4	1.4
Age^2 (years)	4390.0	4212.0	10.8	4321.2	4294.0	1.7
Sex (1 = female)	67.1	71.0	–8.3	66.8	69.3	–5.4
Pensioner (1 = pensioner)	63.7	63.2	1.0	64.4	64.6	–0.3
Urban	20.7	21.4	–1.9	23.6	21.9	4.1
Rural	60.1	59.6	0.9	56.9	59.4	–5.1
Month since last hosp.	16.3	10.5	60.6	12.1	12.0	1.3
Disease severity (NYHA classification)						
Class not coded	37.4	34.4	6.3	34.0	36.7	5.5
NYHA Class unspecified	16.1	15.4	2.0	18.3	16.9	3.7
NYHA Class I	2.8	4.6	9.6	3.8	3.9	0.8
NYHA Class II	18.0	18.1	0.2	18.6	18.4	0.4
NYHA Class III	13.7	15.7	5.6	15.0	14.6	0.8
NYHA Class IV	11.9	11.8	0.3	10.4	9.4	3.1
Costs in t_{-1} (EUROS)						
Ambulatory care	730.1	807.4	–12.8	858.6	811.4	7.4
Inpatient	3142.1	7668.3	–50.0	4845.7	5077.7	–3.0
Pharmaceuticals	1265.5	1368.3	–4.8	1316.0	1338.6	–1.3
Medical aids and appliances	309.9	318.3	–0.9	293.4	303.2	–1.3
Costs in t_{-2} (EUROS)						
Ambulatory care	715.5	692.3	4.0	757.7	749.6	1.2
Inpatient	4941.8	4271.6	8.6	5055.8	4793.7	3.3
Pharmaceuticals	1232.8	1092.3	5.8	1166.3	1200.7	–1.8
Medical aids and appliances	217.3	237.5	–2.9	220.4	231.1	–1.7
Utilisation in t_{-1}						
Number of hospital visits	0.76	1.52	–56.0	1.20	1.19	0.5
Length of stay (days)	5.61	12.34	–47.1	9.16	8.74	3.4
Utilisation in t_{-2}						
Number of hospital visits	1.17	0.92	19.8	1.14	1.07	5.5
Length of stay (days)	9.06	7.10	15.0	8.98	8.08	6.8
Comorbidity and Pharmaceutical groups in t_{-1}						
Charlson groups	4 of 17 with std diff > 10			0 of 17 with std diff > 10		
Pharmaceutical groups	9 of 22 with std diff > 10			0 of 22 with std diff > 10		
Comorbidity and Pharmaceutical groups in t_{-2}						
Charlson groups	0 of 17 with std diff > 10			0 of 17 with std diff > 10		
Pharmaceutical groups	10 of 22 with std diff > 10			0 of 22 with std diff > 10		
N	738	869		635	635	

Note: unless specified otherwise, numbers are in percent. Deceased patients are excluded. All costs (ambulatory, inpatient, pharmaceuticals, medical aids and appliances) reported are 2015 Euros and refer to all costs (not just CHF-related) reimbursed by the health insurer. Details on the Charlson and Pharmaceutical groups can be found in online Appendix C.

Std diff: standardised difference; CG: control group; IG: intervention group; NYHA: New York Heart Association. Pharmaceutical groups follow Koehler et al.[20]

average, younger (63.8 vs 64.7 years) and more likely female (71.0% vs 67.1%), but had similar NYHA classes. Disease progression before the intervention differed substantially between the two groups: patients in the IG had more (1.5 vs 0.8) and longer (12.3 vs 5.6 days) hospital visits in the year before the intervention compared to the CG. We used risk adjustment for each of the two years before the start of the intervention to account for differences in morbidity, costs, and disease progression.

Matching

PSM successfully decreased the pre-intervention differences between the IG and CG in the 635 matched pairs (Table 1). A detailed list of matching variables can be found in the online Appendix C. We assessed the quality of matching using the standardised difference[17] and defined a negligible difference as <10%.[25] Before matching, mean standardised difference over all variables was 10.0%, and 32 variables had values >10%.

Matching reduced mean standardised difference to 3.4%, and yielded standardised differences <10% for all variables. Stratifying the overall sample into different NYHA classes lead to 157 matched pairs in the severe and 478 in the mild group.

Survival

The results of the Kaplan–Meier survival estimates and a Cox proportional hazard model are shown in Figure 2 and Table 2.

Kaplan–Meier estimates suggest that the survival of individuals in the IG was better than in the CG (stratified logrank test $p = 0.029$). This is reflected in the results of the Cox proportional hazards model, which shows a statistically significant 29% lower risk of dying in the IG (hazard ratio: 0.71; 95% confidence interval (CI): 0.51 to 0.99; $p = 0.04$). We corrected for potential confounding effects by entering age and the NYHA class in the Cox model, which both had also a significant effect.

Comparing the Kaplan–Meier survival estimates in the subgroup analysis, we found that patients with severe CHF had a higher mortality rate compared to those with mild CHF, and that the intervention appeared to have a greater effect in the former than the latter (Figure 3).

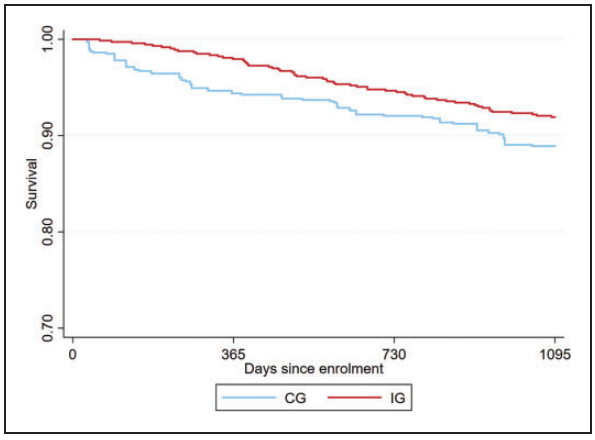

Figure 2. Kaplan–Meier survival estimates after PSM differentiating between IG and CG, and the stratified logrank test on equality of survival curves.

Table 2. Cox proportional hazard model.

Cox regression	HR
Intervention	0.710 (2.01)*
Age	1.057 (7.11)**
NYHA Class	1.254 (4.53)**
N	1460

HR: hazard ratio; NYHA: New York Heart Association. Z-statistic in parenthesis.
*$p < 0.05$.
**$p < 0.01$.

Healthcare costs

We analysed the effect of the telemonitoring intervention on four cost categories using the matching DiD approach (Table 3). The model compares the difference between the IG and CG in the baseline period (i.e., one year before the intervention) with the difference between both groups for each year of the three-year intervention period (defined as year one, two, or three after intervention). The difference in inpatient costs between the IG and CG in year one and two of the intervention did not differ significantly from the difference observed in the year before the intervention (−216€; 95% CI: −1273 to 841; $p = 0.69$, and 54€; 95% CI: −877 to 985; $p = 0.91$). However, we did observe a significant difference for year three of the intervention (−1161€; 95% CI: −2252 to −69, $p = 0.04$). Compared to the year before the invention, the difference in ambulatory care costs between the IG and CG was significantly higher for each of the three years, on average by €284. Compared to baseline, the difference in pharmaceutical costs between the IG and CG increased, with significant results in year two. For medical aids and appliances, the differences were small and insignificant.

Table 4 shows the results for patients with mild or severe CHF. The effect of the intervention on costs appears to have been greater in the latter group, resulting in a higher reduction of inpatient costs compared to the CG and the baseline period; however, only significant for year two. In contrast, significant higher cost differences in year two compared to the baseline difference were seen in patients with mild CHF compared to

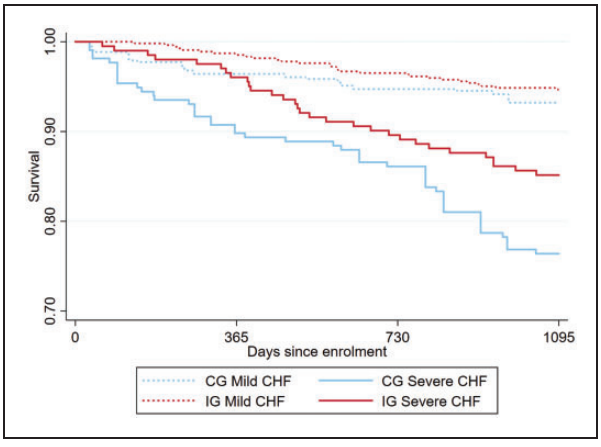

Figure 3. Kaplan–Meier survival estimates for subgroups after PSM differentiating between IG and CG for mild (NYHA class I–II and unspecified) and severe heart failure (NYHA class III–IV).

Table 3. Difference-in-difference (DiD) estimates after propensity score matching.

	t_1	t_2	t_3
Cost (Euros)			
Inpatient	–216 (539)	53 (475)	–1161** (557)
Ambulatory care	275*** (42)	261*** (69)	316*** (97)
Pharmaceuticals	162 (102)	216** (98)	46 (146)
Medical aids and appliances	1 (50)	36 (74)	–76 (73)
Utilisation (days)			
Number of hospital stays	0.07 (0.079)	0.04 (0.09)	–0.10 (0.09)
Length of stay	0.35 (0.93)	1.49* (0.77)	–0.25 (1.18)
Pharmaceutical prescriptions			
Diuretics	0.75*** (0.16)	1.08*** (0.18)	1.00*** (0.18)
Beta-blockers	0.16 (0.14)	0.00 (0.15)	0.20 (0.15)
Agents affecting RAS	0.23 (0.15)	0.08 (0.16)	0.10 (0.17)
N	1270	1270	1270

Note: DiD estimates including all covariates of the matching approach of intervention group (usual care + telemonitoring intervention) vs control group (usual care), comparing one year before with year 1–3 after the intervention. All costs (ambulatory, inpatient, pharmaceuticals, medical aids and appliances) reported are 2015 Euros and refer to all costs (not just CHF-related) reimbursed by the health insurer.
PSM: propensity score matching; RAS: renin–angiotensin system.
Robust standard errors in parenthesis.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

Table 4. Difference-in-difference (DiD) estimates after propensity score matching for patients with mild and severe chronic heart failure (CHF).

	(A) DiD "mild CHF" (NYHA I–II + unspecified)			(B) DiD "severe CHF" (NYHA III–IV)		
	t_1	t_2	t_3	t_1	t_2	t_3
Costs (EUR)						
Inpatient	–327 (612)	806* (490)	–884 (620)	88 (1144)	–2227* (1178)	–2018 (1225)
Ambulatory care	244*** (49)	225*** (83)	238** (109)	365*** (76)	365*** (106)	546*** (202)
Pharmaceuticals	156 (106)	118 (77)	96 (132)	190 (260)	518 (327)	–95 (421)
Medical aids/appliances	–55 (52)	30 (67)	–101 (83)	169 (120)	49 (207)	–1.2 (144)
Utilisation						
Number of hospital stays	0.02 (0.09)	0.06 (0.10)	–0.13 (0.10)	0.19 (0.17)	–0.03 (0.20)	–0.02 (0.18)
Length of stay	0.01 (1.1)	2.56*** (0.83)	0.14 (1.17)	1.27 (1.91)	–1.83 (1.77)	–1.48 (3.15)
Prescriptions						
Diuretics	0.64*** (0.16)	0.84*** (0.18)	0.81*** (0.19)	1.09*** (0.40)	1.78*** (0.40)	1.58*** (0.40)
Beta-blockers	0.15 (0.16)	0.06 (0.17)	0.35** (0.17)	0.19 (0.29)	–0.18 (0.30)	–0.27 (0.31)
Agents affecting RAS	0.14 (0.18)	–0.09 (0.19)	–0.06 (0.19)	0.47* (0.27)	0.55* (0.29)	0.58* (0.30)
N	956	956	956	314	314	314

Note: DiD estimates for subgroups of mild CHF (NYHA I–II +unspecified) and severe CHF (NYHA III–IV) including all covariates of the matching approach of intervention group (usual care + telemonitoring intervention) vs control group (usual care), comparing one year before with year 1–3 after the intervention. All costs (ambulatory, inpatient, pharmaceuticals, medical aids and appliances) reported are 2015 Euros and refer to all costs (not just CHF-related) reimbursed by the health insurer.
RAS: renin–angiotensin system: NYHA: New York Heart Association.
Robust standard errors in parenthesis.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

the CG. Furthermore, the magnitude of the increase in the differences of ambulatory care costs was higher in each of the three years for the IG with severe CHF, compared to the baseline difference.

Healthcare utilisation

Table 3 presents the DiD estimates of the intervention on the patients' use of inpatient care and the

prescription of CHF-relevant pharmaceuticals.[26] Neither the number of hospital stays nor their length appeared to be consistently affected by the intervention over the three-year period. Only a significant increase in the length of stay of 1.5 days (95% CI: –0.01 to 3.00; $p = 0.05$) could be observed for the IG in year two after the intervention.

The difference in the number of pharmaceuticals prescribed according to the relevant guidelines increased for the IG in each of the three years of the intervention compared to the baseline, especially for diuretics (ATC class: C03). Differences in the number of diuretic prescriptions increased significantly by 0.8 prescriptions per year (95% CI: 0.44 to 1.01; $p < 0.01$) in year one for the IG, followed by an additional increase to 1.1 prescriptions in year two (95% CI: 0.73 to 1.42; $p < 0.01$), and 1.0 prescriptions in year three (95% CI: 0.65 to 1.4; $p < 0.01$). The difference in the number of prescriptions of beta-blockers (ATC class: C07) and agents acting on the renin–angiotensin system (ATC class: C09) increased insignificantly in the IG over the observation period.

We see in Table 4 that patients in the IG with severe CHF appeared to be more affected than patients with mild CHF, leading to a shorter length of stay in the former in years two and three, whereas the group with mild CHF had a longer length of stay in year two compared to baseline. Again, hospital visits seem not to be affected. Looking at the prescriptions shows an increase in the difference of the number of diuretics (ATC C03) prescribed to patients in the IG in both severity groups. We observe higher differences in prescription rates for beta-blockers in patients with mild CHF and for agents affecting the renin–angiotensin system in patients with severe CHF compared to the baseline year differences.

The results of the entropy balancing approach and the analysis including the deceased were comparable in size and magnitude, with few exceptions (online Appendix B).

Discussion

In this retrospective observational cohort study using real-world data, we analysed the impact of a telemonitoring intervention in 635 matched patients with CHF on all-cause mortality, healthcare costs and utilisation, and guideline-concordant ambulatory care prescribing over 36 months. We found a significant positive impact of the intervention on mortality. The risk of dying in the IG was 29% lower than in the CG, an effect similar in magnitude to that reported in a meta-analysis of several international randomised controlled trials (RCTs), a Cochrane review,[8,11] and two large German observational studies.[27,28]

In terms of costs, our study revealed two principal effects: whereas the costs of inpatient care were lower in the IG, especially in the third year of the intervention, the costs of ambulatory care were significantly higher in the IG in each observation year. The lower inpatient costs we observed compared to the CG in year three offset the higher ambulatory care costs over the full observation period. Similar to other observational studies,[29] our findings suggested that the intended shift from inpatient to ambulatory care was successful.

Regarding healthcare utilisation, we did not find any significant effects, unlike most RCTs.[8] However, our findings were in line with other observational studies.[28,30]

Our study advances the current literature in several aspects. Our two-stage approach to risk adjustment corrects for observed and unobserved characteristics. Although this is highly suitable for analysing the effects of complex interventions in real-world conditions,[14,16] it has been used rarely to date.[28,30] For observed characteristics, we matched on a large set of 102 pre-intervention variables to correct for a wide range of observable characteristics. We accounted for unobserved differences by using a DiD approach. Most studies use fewer variables for matching and did not correct for unobserved characteristics, potentially leading to biased results.

Furthermore, the combination of the four outcomes and a comparably large observational period is unique given that most studies focus on either clinical outcomes, such as mortality, or a single cost category. This implies that these studies cannot show the interrelationships between the different dimensions while focussing on short-term results, which may lead to wrong decisions at the health policy level. Finally, we complement evidence from RCTs by providing real-world evidence, which is important to show external validity.[31]

This study is not without limitations. Chief among these is its reliance on claims data, which provide a rich dataset but do not allow analysing factors, such as clinical parameters (e.g. left ventricular ejection fraction), if patients already have implanted medical devices (e.g. pacemakers) and differentiate between healthcare providers. While the IG was additionally screened for eligibility for telemonitoring, the CG could not be screened, which may bias enrolment. While the external validity of our findings is relatively high due to our use of real-world data and a large IG, randomisation would further improve internal validity.

Further research may add to our findings by combining clinical with claims data as this can add a number of important clinical or surrogate endpoints.

Conclusion

We evaluated the impact of a telemonitoring intervention on all-cause mortality, healthcare costs, healthcare

utilisation, and pharmaceutical prescribing. Using PSM and DiD, we followed 635 matched pairs of patients with CHF during a three-year intervention. We were able to show that telemonitoring can have substantial positive effects on mortality and guideline-concordant pharmaceutical prescribing even in the first year of intervention and may help shift care from the inpatient to the ambulatory care sector, especially in year three. Our findings suggest that the benefits of the telemonitoring intervention were greater for severe CHF patients and underscore the need to supplement RCTs with studies that use real-world data to capture the everyday reality of health services.

Declaration of conflicting interests

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Supplemental material

Supplemental material for this article is available online.

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