Original Research

DIGITAL HEALTH

Digital Health
Volume 9: 1–10

DOI: 10.1177/20552076231152178
journals.sagepub.com/home/dhj
SAGE

Bringing the hospital to home: Patient-reported outcome measures of a digital health-supported home hospitalisation platform to support hospital care at home for heart failure patients

Martijn Scherrenberg[1,2,3], Jobbe PL Leenen[4,5,6], Astrid E van der Velde[4], Josiane Boyne[7], Wendy Bruins[4], Julie Vranken[2,3], Hans-Peter Brunner-La Rocca[7], Ed P De Kluiver[4,8] and Paul Dendale[2,3]

Abstract

Background: Hospitalisations for heart failure are frequent and costly, linked with a lower quality of life, and lead to higher morbidity and mortality. Home hospitalisation interventions could be a substitute for in-hospital stays to reduce the burden on patients. The current study aims to investigate patient-reported satisfaction and usability in combination with the safety of a digital health-supported home hospitalisation intervention for heart failure patients.

Methods: We conducted an international, multicentre, single-arm, interventional study to investigate the feasibility and safety of a digital health-supported home hospitalisation platform. Patients with acute decompensation of known and well-assessed chronic heart failure with an indication for hospital admission were included. The primary outcome was patient satisfaction. Secondary outcomes were usability, adherence, and safety.

Results: A total number of 66 patients were included, of which the data of 65 patients (98.5%) was analysed. A total of 86.1% of patients reported being very satisfied or totally satisfied. No patients reported to be not satisfied with the home hospitalisation intervention. The patients reported a sufficient usability score (mean score: 75.8% of 100%) for the digital health-supported home hospitalisation platform. The adherence to the daily measurements of blood pressure and weight was very high, whereas the adherence to the daily interaction with the eCoach was lower (69.3%). In 7 patients (10.8%), a conversion from home hospitalisation to regular hospitalisation was needed. Furthermore, 6 patients (9.2%) had rehospitalisation within 30 days after the end of the home hospitalisation intervention.

Conclusion: A digitally supported home hospitalisation intervention is feasible. This study demonstrates high patient satisfaction and sufficiently high usability scores. The safety outcomes are comparable with traditional heart failure hospitalisations. This indicates that digitally supported home hospitalisation could be an alternative to in-hospital care for all age groups, yet further research is needed to prove the (cost-) effectiveness.

Keywords

Telemedicine, hospital to home transition, heart failure, home hospitalisation, digital health

Submission date: 19 April 2022; Acceptance date: 3 January 2023

[1]Heart Centre Hasselt, Jessa Hospital, Hasselt, Belgium
[2]Faculty of Medicine and Life Sciences, UHasselt, Diepenbeek, Belgium
[3]Mobile Health Unit, Faculty of Medicine and Life Sciences, Hasselt University, Hasselt, Belgium
[4]Isala Heart Centre, Isala, Zwolle, The Netherlands
[5]Connected Care Centre, Isala, Zwolle, The Netherlands
[6]Isala Academy, Isala, Zwolle, The Netherlands
[7]Maastricht University Medical Centre, Maastricht, The Netherlands
[8]Zuyderland Medical Center, Heerlen, The Netherlands

Corresponding author:
Martijn Scherrenberg, Heart Centre Hasselt, Jessa Hospital, Stadsomvaart 11, 3500 Hasselt, Belgium.
Email: martijn.scherrenberg@telenet.be

Introduction

Heart failure (HF) is a progressive disease characterised by recurrent episodes of symptom exacerbation that can lead to HF (re)hospitalisation and intravenous diuretic treatment. Research shows that up to 50% of patients with HF are readmitted to the hospital within one year.[1] These frequent rehospitalisations are linked with significant reductions in patients' quality of life (QoL).[2] Furthermore, HF patients frequently have multiple comorbidities and are older, indicating a significant risk of serious hospital-related complications,[3] which may result in longer hospital stays, higher rates of intensive care unit admissions, higher mortality rates, and irreversible loss of physical and/or mental condition.[3]

HF poses not only a significant burden on patients' QoL, but it also has an impact on healthcare budgets.[4] It is estimated that approximately 2% of national healthcare budgets are spent on HF.[4] A significant portion of the cost for HF is due to frequent rehospitalisations.[4] The high costs, combined with the fact that the prevalence of HF is expected to further rise in the coming years, have increased the interest in innovative HF care pathways.[4] Therefore, telemonitoring in HF was researched to discover symptom exacerbation at an earlier stage and thereby prevent hospitalisations with promising results.[5]

There is increasing traction to explore the possibilities of providing clinical healthcare at home as a safe alternative to in-hospital admissions. Admitting HF patients at home is not only highly innovative but may also be a promising approach both from a healthcare and economic perspective. Home hospitalisation is already being investigated in a number of other conditions, including chronic obstructive pulmonary disease (COPD) and neuromuscular disease.[6] The general conclusions were that it is feasible and can be conducted safely. However, most of these previous trials researching home hospitalisation did not include any form of telemonitoring. The addition of remote monitoring provides the opportunity to monitor vital signs to improve safety, which is interesting in a complex and potentially deadly disease such as HF. Therefore, the Interreg NWE subsidised project NWE-Chance developed a digital health-supported home hospitalisation platform to support hospital-level care at home for HF patients. The current study aims to investigate patient-reported satisfaction and usability in combination with the safety of a digital health-supported home hospitalisation intervention for HF patients. We hypothesised that more than 75% of the patients would report high satisfaction scores (very satisfied and totally satisfied).

Methods

Design and setting

An international, multicentre, single-arm, interventional study was conducted for a 15-month period (October 2020–December 2021) in one Belgian hospital (Jessa Hospital) and two Dutch hospitals (Isala, Maastricht University Medical Center+ (MUMC+)). All patients signed an informed consent before participating in the study. The study complied with the Declaration of Helsinki, Google Cloud Platform, and General Data Protection Regulations. The full protocol is described previously.[7]

Participants

A total of 100 patients from three participating hospitals were planned to be included in this study. This decision was based on a feasible number of inclusions within one year in the three participating centres. Due to the ongoing COVID-19 pandemic, the inclusion rate has slowed down. Therefore, only 66 patients were included in the study before the end of the inclusion period.

The inclusion criteria for this were:

- Acute decompensation of known and well-assessed chronic HF with an indication for hospital admission.
- Age ≥18 years.
- Living independently and/or sufficiently supported at home and/or living in nursing homes within a proximity of <30 km of the hospital.

The main exclusion criteria were an indication for intensive care admission or the presence of severe comorbidity requiring simultaneous hospital care.[7]

For professionals, eligibility criteria were registration as a specialised (cardiac care) nurse or physician and being able to speak and read the Dutch language. *The full inclusion criteria were defined in* Appendix 1. *A consort diagram can be found in* Appendix 2.

Intervention

Patients participating in Isala and MUMC+ were directly transferred to their homes to get home hospitalisation treatment. At Jessa Hospital, the patients were first admitted to a hospital ward for a limited number of days until there was no need for intravenous diuretics before being transferred to their homes. All participating patients received, similar to in-hospital, treatment in combination with a digital health-supported home hospitalisation platform. The specialised HF nurses visited the patients daily at home to monitor their clinical status and to eventually adapt therapy. The HF nurses were always in close contact with the treating cardiologists about the evolution of the clinical status and potential therapy changes. The cardiologists did not visit the patient at home. In addition to the daily visits, all patients received the digital health-supported home

hospitalisation platform. This platform (powered by HC@Home, Zwolle, The Netherlands) integrated a portable blood pressure (BP) device, a weighing scale, and a wearable chest patch (powered by Sensium, Abingdon, UK) to monitor vital functions such as heart rate (HR), activity level, and posture, and an eCoach (powered by Sananet, Sittard, The Netherlands) for symptom assessment and to educate and guide the patient through the home hospitalisation period. The eCoach is a smartphone application where patients can find videos about HF, measurement of BP and home hospitalisation. Furthermore, the patient is asked to fill in a symptom assessment every morning during the home hospitalisation period. Lastly, the eCoach gives an overview to the patient of their BP, HR and weight measurements.

All data was sent automatically to a caregiver dashboard where the nurses and cardiologists could follow up with patients remotely. The data in the caregiver dashboard, in combination with the home visits, was intended to follow the patients' clinical evolution. Individual alerts for weight and BP could be set to optimise monitoring. Alerts were only visible when opening the caregiver dashboard. The incoming data was checked at least once every day. There was no active monitoring of the incoming data during the night.[7]

Procedures

Before the start of the trial, patients and informal caregivers were instructed on how to use the digital health-supported home hospitalisation platform at the moment of inclusion and during the first home visit by the nurse. Patients received a smartphone with a pre-installed eCoach application. The decision to end the home hospitalisation intervention or convert the home hospitalisation was made by the treating cardiologist. Like with normal hospitalisation, no criteria were defined to end the home hospitalisation. Figure 1 gives a schematic overview of the intervention.

Data collection

Baseline patient demographic and clinical characteristics were collected by the research nurses and investigators. Satisfaction was measured by a questionnaire adapted from the satisfaction questionnaire used by Utens et al.[8] The questionnaire consisted of 18 questions regarding the different aspects of the home hospitalisation intervention. Usability was measured by the System Usability Scale (SUS).[9] This questionnaire contains 10 questions based on the Likert five-point scale; questions 1, 3, 5, 7, and 9 are positive and questions 2, 4, 6, 8, and 10 are negative. The intervention was considered usable if the average SUS score was ≥68%.[9] Smartphone or tablet ownership and user frequency were assessed to study the influence of digital experience on patient-reported outcomes. The caregiver strain index[10] was used to assess how burdensome home hospitalisation was for the patient's primary caregiver. The caregiver strain index consists of 13 questions. A score of 7 or higher is associated with increased caregiver burden.

All questionnaires were delivered directly after the home hospitalisation intervention. The questionnaires can be found in the Supplementary material.

Adherence was defined as the percentage of days patients transmitted at least one BP measurement and one weight per day. All measurements were automatically

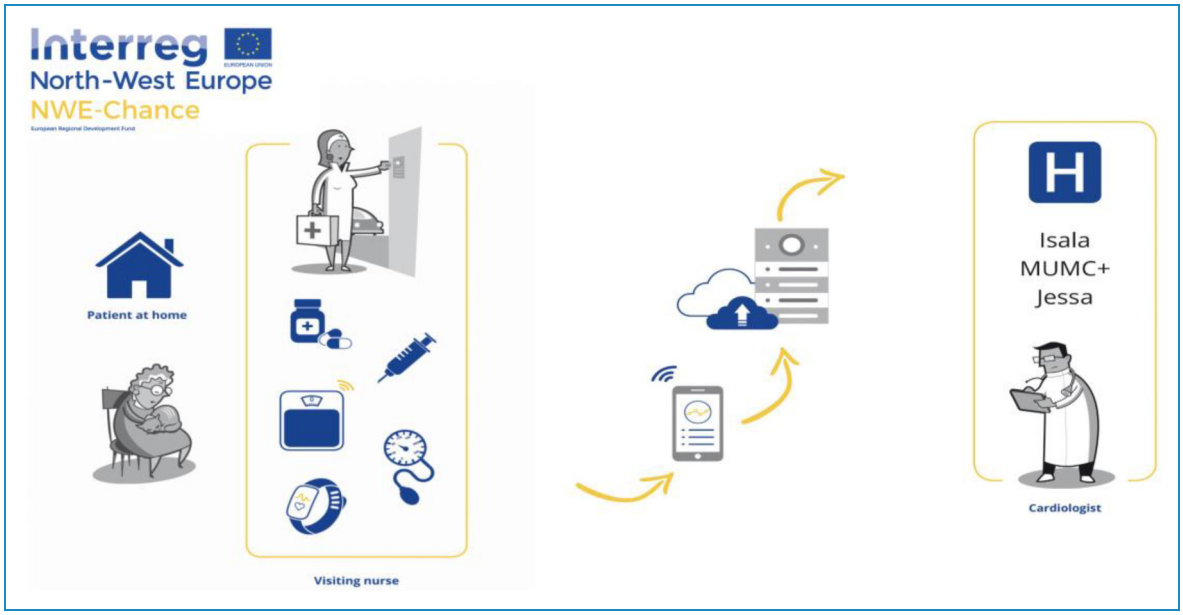

Figure 1. Schematic overview of the home hospitalisation intervention.

stored in the platform. This data was provided by HC@Home to the researchers at the end of the study. Safety was measured by two parameters: the number of conversions from home hospitalisation to regular hospitalisation due to stagnating or worsening clinical status, and the number of rehospitalisations in 30 days.

Outcomes

The primary endpoint of this study is patient satisfaction. The intervention was considered as linked to high satisfaction if ≥75% of the patients report being very satisfied or totally satisfied.

The secondary outcomes were:

- Usability.
- Adherence to the daily measurements.
- Safety of the home hospitalisation intervention.

Lastly, the influence of baseline characteristics, being a frequent smartphone user and adherence to the daily measurements, was assessed on satisfaction, usability, and safety.

Statistical analysis

Data analysis was performed using SPSS (version 26). All available data was used; no data imputation was performed for missing values. Numbers and percentages were used to characterise categorical data. Shapiro–Wilk tests were used to assess the distribution of the data. Normally distributed continuous data was characterised by mean ± standard deviation. Continuous data that was not normally distributed was characterised as median and interquartile ranges. A stepwise multiple logistic regression was used to determine the factors that were associated with satisfaction, usability, and safety. Chi-square and Kruskal–Wallis testing were performed to detect significant trends between the three hospitals. A p-value of <0.05 (2-tailed) was considered statistically significant.

Results

Baseline characteristics

In total, 66 patients were included, whereas 65 patients were included in the analysis. The data from one patient was excluded because the home hospitalisation could not be organised due to practical issues. Participants were predominately male (67.7%). The mean age of the included patients was 72.8 years. *A total of 45 patients had an ejection fraction below 50%*. Most patients were classified as New York Heart Association (NYHA) 2 or 3 at the moment of inclusion. The majority of patients were retired (76.9%), owned a smartphone or tablet (63.1%), and report regular use of those devices (55.4%). Significant differences in patients' profiles were observed between the three hospitals. MUMC+ had significantly older patients. Furthermore, patients from Isala and MUMC+ had higher NYHA scores, lower kidney function, and a higher prevalence of diabetes mellitus.

Table 1 provides an overview of the baseline characteristics.

Satisfaction

Most patients preferred either home hospitalisation (41.5%) or a combination of home hospitalisation and regular hospitalisation (43.1%). Furthermore, patients predominantly reported worrying not at all or a little bit. Furthermore, all patients felt safe during the home hospitalisation, and overall satisfaction was very high. A total of 86.1% of patients reported being very satisfied or completely satisfied, whereas no patients reported dissatisfaction with the home hospitalisation intervention. Logistic regression analysis did not identify any predictors for the reported satisfaction. More information about satisfaction can be found in Table 2.

Usability

The patients reported a good usability score for the digital health-supported home hospitalisation platform. The mean score was 75.8 ± 9.16%. A total of 66.6% reported a usability score of 68% or higher. A linear regression model could not identify baseline characteristics predictive of the usability score.

Adherence

Adherence to BP and weight measurements was high (respectively, 96.2% and 93.6%), whereas adherence to symptom registration in the eCoach was lower (69.3%). Furthermore, adherence to the daily measurements and frequent use of a smartphone or tablet was not linked with the usability of the digital health-supported home hospitalisation platform.

Safety

The median duration of the home hospitalisation intervention was 8 days. In 7 patients (10.8%), a conversion from home hospitalisation to regular hospitalisation was needed. The main reasons for conversion were stagnating HF conditions at home ($n = 5$) or the occurrence of severe infection (pneumonia ($n = 1$) and pleuropericarditis ($n = 1$)), which required further treatment in the hospital. Furthermore, 6 patients (9.2%) were readmitted to the hospital within 30 days of the end of the home hospitalisation intervention. In all cases, the reason for rehospitalisation was a new episode of HF decompensation. The median

Table 1. Baseline characteristics.

Variable	All ($N = 65$)	Jessa ($N = 35$)	Isala ($N = 15$)	MUMC+ ($N = 15$)	*P*-value
Age	72.8 ± 12.8	70.1 ± 14	72.2 ± 10.5	81 ± 7.8	**0.013**
Gender (female)	21 (32.3%)	9 (25.7%)	7 (46.7%)	5 (33.3%)	0.322
Smoking					0.299
No	29 (44.6%)	16 (45.7%)	5 (33.3%)	8 (53.3%)	
Current	9 (13.8%)	6 (17.1%)	1 (6.7%)	2 (13.3%)	
Ex	23 (35.4%)	13 (37.1%)	8 (53.3%)	2 (13.3%)	
Unknown	4 (6.2%)	0 (0%)	1 (6.7%)	3 (20%)	
Ischemic heart disease	39 (60%)	15 (42.8%)	12 (80%)	12 (80%)	**0.002**
History of atrial fibrillation	36 (55.4%)	18 (51.4%)	12 (80%)	6 (40%)	0.116
NYHA					**0.011**
2	29 (44.6%)	21 (60%)	5 (33.3%)	3 (20%)	
3	31 (47.7%)	14 (40%)	10 (66.7%)	7 (46.7%)	
4	2 (3.1%)	0 (0%)	0 (0%)	2 (13.3%)	
Unknown	3 (4.6%)	0 (0%)	0 (0%)	3 (20%)	
Diabetes mellitus	23 (35.4%)	6 (17.1%)	11 (73.3%)	6 (40%)	**<0.001**
Beta-blocker	46 (70.7%)	26 (74.3%)	13 (86.7%)	7 (46.7%)	0.144
ACE-inhibitor or sartans	30 (46.2%)	19 (54.3%)	8 (53.3%)	3 (20%)	0.138
ARNI	13 (20%)	9 (25.7%)	1 (6.7%)	3 (20%)	0.303
Mineralocorticoid receptor antagonist	38 (58.4%)	30 (85.7%)	2 (13.3%)	6 (40%)	**<0.001**
Diuretics	57 (87.7%)	29 (82.8%)	15 (100%)	13 (86.7%)	0.070
BMI	28.4 ± 5.7	27.5 ± 4.6	31.3 ± 8.2	27.9 ± 3.8	0.377
eGFR	52.5 ± 24.3	60.9 ± 25.6	42.6 ± 17.8	41.6 ± 19	**0.008**
Potassium	4 ± 0.5	3.9 ± 0.5	4.2 ± 0.5	4 ± 0.5	0.178
LVEF	38.8 ± 14.9	39.1 ± 15.9	36.4 ± 14.5	39.3 ± 14.6	0.526
Systolic blood pressure	121.2 ± 21.2	117.9 ± 20.3	122.3 ± 20.5	131.8 ± 22.5	0.158
Diastolic blood pressure	70.6 ± 11.9	71.2 ± 10.3	68.1 ± 10.1	72.8 ± 17.3	0.571
Education					0.500
Primary school	12 (18.5%)	7 (20%)	2 (13.3%)	3 (20%)	

(continued)

Table 1. Continued.

Variable	All ($N = 65$)	Jessa ($N = 35$)	Isala ($N = 15$)	MUMC+ ($N = 15$)	*P*-value
Secondary school	23 (35.4%)	10 (28.6%)	7 (46.7%)	6 (40%)	
Secondary professional level	4 (6.2%)	3 (8.6%)	0 (0%)	1 (6.7%)	
Higher professional level	17 (26.2%)	9 (25.7%)	5 (33.3%)	3 (20%)	
University level	5 (7.7%)	5 (14.3%)	0 (0%)	0 (0%)	
Unknown	4 (6.2%)	1 (2.9%)	1 (6.7%)	2 (13.3%)	
Employment					0.160
Employee	6 (9.2%)	6 (17.1%)	0 (0%)	0 (0%)	
Self-employed	1 (1.5%)	0 (0%)	1 (6.7%)	0 (0%)	
Retired	50 (76.9%)	27 (77.1%)	11 (73.3%)	12 (80%)	
Unemployed	5 (7.7%)	2 (5.7%)	2 (13.3%)	1 (6.7%)	
Unknown	3 (4.6%)	0 (0%)	1 (6.7%)	2 (13.3%)	
Possession of a smartphone or tablet	41 (63.1%)	23	10	8	0.420
Regular user	36 (55.4%)	21	10	5	0.141
Travel time between home and hospital (min)	17.5 ± 7	18.3 ± 6.8	19.1 ± 7	11.8 ± 3.2	**0.002**

Note: Bold values indicate significant value.
NYHA: New York Heart Association; ARNI: angiotensin-nepryselin-inhibitor; BMI: body mass index; eGFR: estimated glomerular filtration rate; LVEF: left ventricular ejection fraction; MUMC+: Maastricht University Medical Center+.

time to rehospitalisation was 12 days. A univariate logistic regression model identified the presence of diabetes mellitus (OR = 5.95; *p*-value = 0.009) as the sole predictor for the combination of conversion to regular hospitalisation or rehospitalisation in 30 days. No link was found between adherence to the measurements and safety outcomes. More information can be found in Table 3.

Burden on informal caregivers

The burden on informal caregivers was assessed with the Caregiver Strain Index.[10] The median score of the Caregiver Strain Index was 2.5. Only 10% of the informal caregivers had a score of 7 or higher, which corresponds with caregiver overload.

Discussion

This study is, to our knowledge, one of the first that investigated a digital platform to support home hospitalisation for HF patients. The novelty of the study stems from the use of a digital health-supported home hospitalisation platform in a home hospitalisation intervention for acute HF. Our findings prove that a digitally supported home hospitalisation intervention is feasible and highly liked by patients. Age or being a frequent user of technology was not associated with satisfaction and usability outcomes. This indicates that the intervention may be feasible for all age groups and patients with different levels of experience in using digital health. There was a clear interest among patients in transferring at least a part of hospital care to the home setting.

Similar findings regarding satisfaction were reported in home hospitalisation intervention for other chronic diseases.[9,11] Leff et al.[11] demonstrated that hospital care at home was associated with greater satisfaction than acute hospital inpatient care for patients with chronic diseases and their family members. This corresponds with the high satisfaction scores in this study. Arsenault-Lapierre et al.[6] concluded in a recent meta-analysis that home hospitalisation interventions are a viable alternative to in-hospital stays for patients with chronic diseases. The study demonstrated that mortality did not differ between the hospital-at-home and the in-hospital care groups. Moreover, the risk of readmission was lower and the length of treatment was longer in the hospital-at-home group than in the in-hospital group. However, it is important to acknowledge that only 9 studies with 956 patients were

Table 2. Patient satisfaction.

Variable	All ($N = 65$)
Preference	
At home	27 (41.5%)
At hospital	7 (10.8%)
Combination	28 (43.1%)
No preference	3 (4.6%)
How worried at the start?	
Extremely worried	4 (6.2%)
Very worried	7 (10.8%)
Worried	15 (23.1%)
Little bit worried	16 (24.6%)
Not worried at all	20 (30.8%)
No answer	3 (4.6%)
How safe did you feel during the day?	
Extremely safe	21 (32.3%)
Very safe	27 (41.5%)
Safe	14 (21.5%)
Not safe	0 (0%)
Completely unsafe	0 (0%)
No answer	3 (4.6%)
How safe did you feel during the night?	
Extremely safe	15 (23.1%)
Very safe	27 (41.5%)
Safe	18 (27.7%)
Not safe	0 (0%)
Completely unsafe	0 (0%)
No answer	5 (7.7%)
Overall satisfaction	
Totally satisfied	35 (53.8%)
Very satisfied	21 (32.3%)
Satisfied	4 (6.2%)
Not satisfied	0 (0%)
Not satisfied at all	0 (0%)
No answer	5 (7.7%)

Table 3. Safety outcomes.

	30-day rehospitalisations
All ($N = 65$)	6 (9.2%)
Jessa Hospital ($n = 35$)	1 (2.9%)
MUMC+ ($n = 15$)	3 (20%)
Isala ($n = 15$)	2 (13.2%)
Variable	All ($N = 65$)
Conversions	7 (10.8%)
Jessa Hospital	3 (8.6%)
MUMC	1 (6.7%)
Isala	3 (20%)
Variable	All ($N = 65$)
30-day rehospitalisations	6 (9.2%)
Jessa Hospital	1 (2.9%)
MUMC	3 (20%)
Isala	2 (13.3%)

MUMC: Maastricht University Medical Center.

included. The studies investigated home hospitalisation for COPD ($n = 4$), chronic HF ($n = 2$), ischemic stroke ($n = 1$), neuromuscular disease ($n = 1$), and a combination of chronic diseases ($n = 1$).[6]

Only the study by Levine et al.[12] used remote monitoring technology in a home hospitalisation intervention for patients with COPD, chronic HF, infection, or asthma. A skin patch for continuous monitoring of HR, respiratory rate, telemetry,

movement, falls, and sleep was used. This randomised controlled trial included 91 patients. The authors reported reduced costs, healthcare use, and readmissions while increasing physical activity compared with usual hospital care. The meta-analysis[6] and the study by Levine et al.[12] highlight the potential of reimaging the current way of delivering hospital-level care. However, it is clear that more and larger trials are needed because most of the evidence is based on very heterogeneous trials with small sample sizes.

Adherence to the daily measurements of BP and weight was very high, which supports the conclusion that the platform was very feasible and usable. The lower adherence to the eCoach could potentially be explained by the fact that patients found the symptom assessment unnecessary due to the daily visits by a nurse who also performed a symptom assessment. In the future, the digital platform could be used to lower the number of home visits. Incoming data can be used to determine if a home visit is warranted. The lower number of home visits could potentially improve the cost-effectiveness of home hospitalisation and ease the implementation on a large scale. We hypothesise that a reduction in home visits will make the eCoach more useful.

The median duration of the home hospitalisation intervention was 8 days. However, in MUMC+ a longer duration was found. A potential explanation could be the fact that patients are older and have a higher NYHA classification. Nevertheless, both satisfaction and safety measures were similar among the three hospitals. This may indicate that home hospitalisation is also a feasible and safe alternative even for older patients with severe HF.

Safety measures were also similar to regular HF hospitalisations. This study showed a conversion rate to regular hospitalisation of 10.8% and a 30-day rehospitalisation rate of 9.2%. This was comparable with regular hospitalisation, where studies have demonstrated a 30-day rehospitalisation rate of 18% to 23%.[13,14] Some differences in the conversion rate between the difficult hospitals were observed. Potential explanations could be the fact that more patients had ischemic heart disease, diabetes mellitus, and low renal function. However, due to the fact that this is a feasibility no strong conclusion about the differences in conversion rates could be made.

Limitations

Since this is a feasibility study, statements on the effectiveness are lacking. Randomised controlled trials are needed in the future. The ongoing COVID-19 pandemic led to shifts in healthcare organisation and a lower number of HF admissions. This led to a lower total number of patients than expected. No validated questionnaires exist to determine patient satisfaction in a home hospitalisation intervention. Therefore, a satisfaction questionnaire was developed based on the study of Utens et al.[8] Finally, we did not collect data on the number of patients that were unwilling to participate. Therefore, the patient preference regarding home hospitalisation is likely overestimated. In a later phase, implementation studies are needed to understand the percentage of patients willing to participate in home hospitalisation.

Conclusion

This study demonstrates the potential of digitally supported home hospitalisation intervention for HF. Our findings prove that home hospitalisation is feasible in three hospitals with different levels of experience in delivering home care. The ongoing COVID-19 pandemic highlighted again the need to search for innovative approaches to increase hospital bed availability.[15,16]

A digitally supported home hospitalisation intervention is feasible. This study demonstrates high patient satisfaction and sufficiently high usability scores. The safety outcomes are comparable with traditional HF hospitalisations. This indicates that digitally supported home hospitalisation could be an alternative to in-hospital care for all age groups, yet further research is needed to prove the (cost-) effectiveness.

Acknowledgements: The authors would like to thank all colleagues from the Isala Hospital, Jessa Hospital, and Maastricht University Medical Center+. Furthermore, we would like to thank all the NWE Chance consortium members.

Contributorship: All authors contributed to the development and design of the paper. MS wrote the paper. All authors provided feedback and advice on the final version of the paper.

Conflict of interest: The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: E.P. de Kluiver has an indirect interest in one of the SME partners (HC@Home). The other authors have no conflicts of interest to declare.

Ethical approval: The study was approved by the ethical committees of Jessa Hospital, University of Hasselt, Isala, MUMC +. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Funding: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This project has received funding from the Interreg NWE Programme under grant agreement number 661.

Availability of data: Data is available on request.

Guarantor: PD.

ORCID iD: Martijn Scherrenberg https://orcid.org/0000-0001-9483-3828

References

1. Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics-2017 update: A report from the American

Heart Association. *Circulation* 2017; 135: e146–e603. Epub 25 January 2017. Erratum in: Circulation. 2017;135(10): e646. Erratum in: Circulation. 2017;136(10):e196.
2. Heo S, Lennie TA, Okoli C, et al. Quality of life in patients with heart failure: Ask the patients. *Heart Lung* 2009; 38: 100–108.
3. Geraci JM, Ashton CM, Kuykendall DH, et al. In-hospital complications among survivors of admission for congestive heart failure, chronic obstructive pulmonary disease, or diabetes mellitus. *J Gen Intern Med* 1995; 10: 307–314.
4. Jackson SL, Tong X, King RJ, et al. National burden of heart failure events in the United States, 2006 to 2014. *Circ Heart Fail* 2018; 11: e004873.
5. Yun JE, Park JE, Park HY, et al. Comparative effectiveness of telemonitoring versus usual care for heart failure: A systematic review and meta-analysis. *J Card Fail* 2018; 24: 19–28.
6. Arsenault-Lapierre G, Henein M, Gaid D, et al. Hospital-at-home interventions vs in-hospital stay for patients with chronic disease who present to the emergency department: A systematic review and meta-analysis. *JAMA Netw Open* 2021; 4: e2111568.
7. Scherrenberg M, Storms V, van der Velde AE, et al. A home hospitalisation strategy for patients with an acute episode of heart failure using a digital health-supported platform: A multicentre feasibility study – a rationale and study design. *Cardiology* 2021; 146: 793–800.
8. Utens CM, Goossens LM, van Schayck OC, et al. Patient preference and satisfaction in hospital-at-home and usual hospital care for COPD exacerbations: Results of a randomised controlled trial. *Int J Nurs Stud* 2013; 50: 1537–1549.
9. Brooke J. SUS: A 'quick and dirty' usability scale. In: Jordan PW, Thomas B, Weerdmeester BA, etal (eds) *Usability evaluation in industry*. London: Taylor and Francis, 1986.
10. Sullivan MT. Caregiver strain index. *J Gerontol Nurs* 2002; 28: 4–5.
11. Leff B, Burton L, Mader S, et al. Satisfaction with hospital at home care. *J Am Geriatr Soc* 2006; 54: 1355–1363.
12. Levine DM, Ouchi K, Blanchfield B, et al. Hospital-level care at home for acutely ill adults: a randomized controlled trial. *Ann Intern Med* 2020; 172: 77–85.
13. Bergethon KE, Ju C, DeVore AD, et al. Trends in 30-day readmission rates for patients hospitalized with heart failure: findings from the get with the guidelines-heart failure registry. *Circ Heart Fail* 2016; 9: e002594.
14. Madanat L, Saleh M, Maraskine M, et al. Congestive heart failure 30-day readmission: descriptive study of demographics, co-morbidities, heart failure knowledge, and self-care. *Cureus* 2021; 13: e18661.
15. Baigent C, Windecker S, Andreini D, et al. European Society of Cardiology guidance for the diagnosis and management of cardiovascular disease during the COVID-19 pandemic: part 1-epidemiology, pathophysiology, and diagnosis. *Eur Heart J* 2022; 43: 1033–1058. Erratum in: Eur Heart J. 2021.
16. Baigent C, Windecker S, Andreini D, et al. ESC Guidance for the diagnosis and management of cardiovascular disease during the COVID-19 pandemic: part 2-care pathways, treatment, and follow-up. *Eur Heart J* 2022; 43: 1059–1103. Erratum in: Eur Heart J. 2021. DOI: 10.1093/eurheartj/ehab697.

Appendix 1

Inclusion criteria	Exclusion criteria
Patients with known and well-assessed chronic HF.	Indication for IC/CCU admission.
Age >18 years.	Mental impairment leading to inability to cooperate.
(Indication for) hospital admission for acute decompensated HF.	Severe comorbidity requiring simultaneous hospital care.
Living independently and/or sufficiently supported at home and/or living in nursing homes (or other supported living modalities).	History of severe liver/kidney disease.
Eligible for a hospital-at-home intervention based on the decision of a cardiologist.	Systolic BP <90 mmHg.
Living within wide proximity of the hospital ○ <30 km for Jessa Hospital and Isala ○ Within the region Maastricht Heuvelland for MUMC+.	Clinically significant tachycardia (in case of sinus rhythm, HR >110/min, in case of atrial fibrillation >150/min).
	Need for intravenous inotropic medication.
	Hypoxia (sO_2 <90% without additional O_2).

HF: heart failure; IC: intensive care; CCU: critical care unit; BP: blood pressure; HR: heart rate; MUMC+: Maastricht University Medical Center.

Appendix 2