ESC European Society of Cardiology

European Journal of Cardiovascular Nursing (2024) **23**, 188–196
https://doi.org/10.1093/eurjcn/zvad059

ORIGINAL RESEARCH

Usability of a digital health platform to support home hospitalization in heart failure patients: a multicentre feasibility study among healthcare professionals

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Received 29 October 2022; revised 1 June 2023; accepted 5 June 2023; published 9 June 2023

Aims Heart failure (HF) is a common cause of mortality and (re)hospitalizations. The NWE-Chance project explored the feasibility of providing hospitalizations at home (HH) supported by a newly developed digital health platform. The aim of this study was to explore the perceived usability by healthcare professionals (HCPs) of a digital platform in addition to HH for HF patients.

Methods and results A prospective, international, multicentre, single-arm interventional study was conducted. Sixty-three patients and 22 HCPs participated. The HH consisted of daily home visits by the nurse and use of the platform, consisting of a portable blood pressure device, weight scale, pulse oximeter, a wearable chest patch to measure vital signs (heart rate, respiratory rate, activity level, and posture), and an eCoach for the patient. Primary outcome was usability of the platform measured by the System Usability Scale halfway and at the end of the study. Overall usability was rated as sufficient (mean score 72.1 ± 8.9) and did not differ between the measurements moments ($P = 0.690$). The HCPs reported positive experiences ($n = 7$), negative experiences ($n = 13$), and recommendations ($n = 6$) for the future. Actual use of the platform was 79% of the HH days.

Conclusion A digital health platform to support HH was considered usable by HCPs, although actual use of the platform was limited. Therefore, several improvements in the integration of the digital platform into clinical workflows and in defining the precise role of the digital platform and its use are needed to add value before full implementation.

Registration ClinicalTrials.gov NCT04084964.

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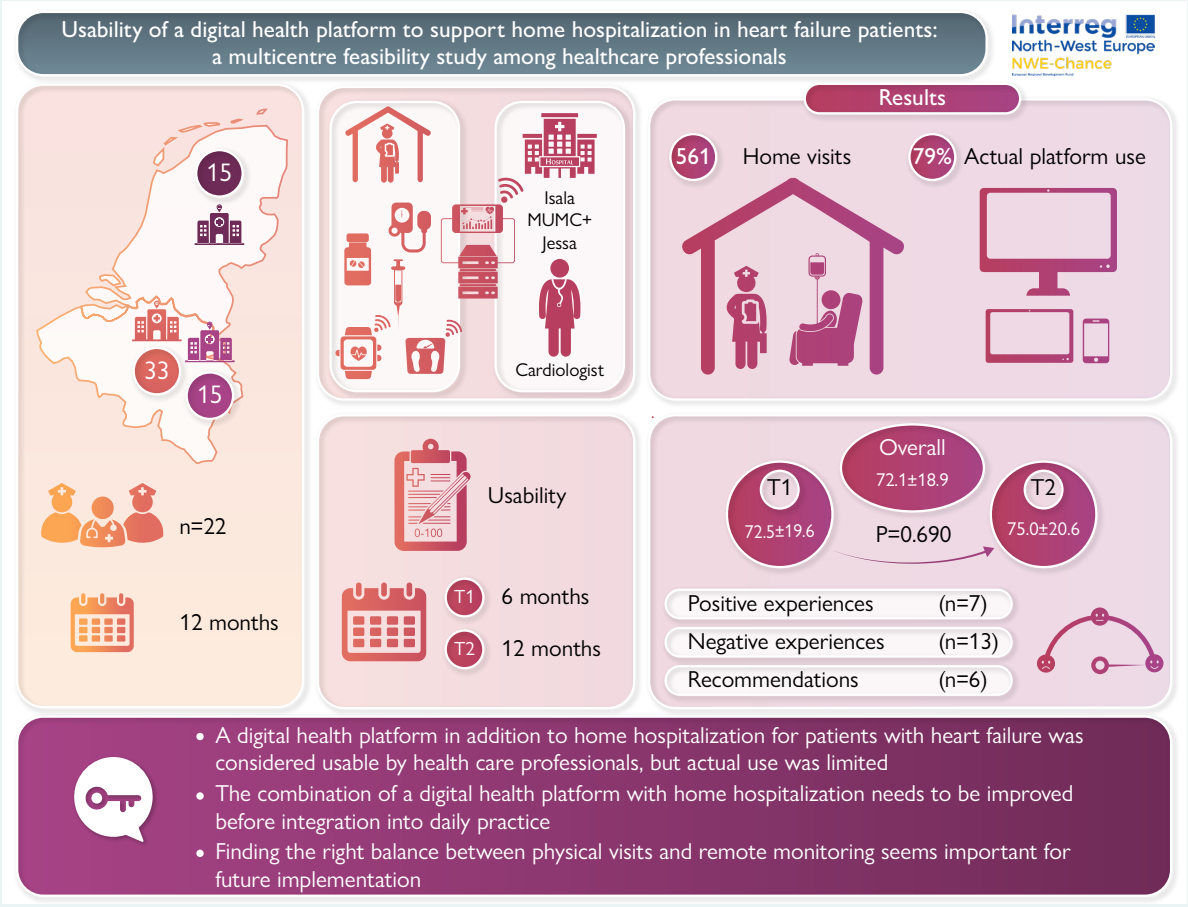
Graphical Abstract



Keywords Heart failure (MeSH) • Hospital to home transition (MeSH) • Telemedicine (MeSH) • Home hospitalization • Digital health platform • Usability • Acceptability • Professionals

Novelty

- A digital health platform in addition to home hospitalization for patients with heart failure was considered usable by healthcare professionals, but actual use was limited.
- The combination of a digital health platform with hospitalization at home needs to be improved before integration into daily practice.
- Finding the right balance between physical visits and remote monitoring seems important for future implementation.

Introduction

Despite guideline-based and remote management of patients with heart failure (HF), the number of hospitalizations for severe HF remains significant.[1] Heart failure is the most common cause of hospitalization in patients over the age of 65 in developed countries.[2] Moreover, HF has a great impact on patients' wellbeing and is associated with high mortality, frequent (re)hospitalizations, and reduced quality of life.[2–4] Especially, rehospitalization's, that occur in up to 50% of patients have a great impact on patients and healthcare systems.[5–7] With the increasing prevalence of HF and to prevent rehospitalizations, there is a substantial need to explore innovative hybrid care models. Therefore, hospitals are increasingly exploring the possibilities of providing hospitalization at home (HH) and remote monitoring.[8–12]

The HH interventions consist of treatment delivered to patients who present with an acute condition; a healthcare professional provides this treatment in the patient's home for a condition that would normally require hospitalization.[13] The HH has been evaluated for other diseases, mostly in pilot settings or with a small number of patients. The general conclusion of all these studies was that HH is feasible and can be conducted safely for specific diseases such as HF, chronic obstructive pulmonary disorder, and community-acquired pneumonia.[14,15] Also, a meta-analysis of six studies concluded that HH for HF seems to increase time to readmission, improve health-related quality of life (QoL), and

reduce HF-related costs.[8] In addition to HH, remote monitoring, such as daily non-invasive measurements and structured phone calls, showed a decrease in all-cause mortality, HF rehospitalizations, and increase in QoL.[9–11,16–19] However, these results were in outpatient setting, and the evidence on all-cause mortality is considered low.

A combination of HH and remote monitoring may help to reduce this burden. It is, however, unclear if it is also useful in providing HH to HF patients. One of the benefits of remote monitoring technologies in HH is the opportunity to continuously monitor the vital signs of the patient, which could improve their safety.[16] However, no previous studies combined hospitalization at home and remote monitoring. Therefore, the subsidized project NWE-Chance developed a digital health-supported HH platform to support hospital-level care at home for HF patients from three hospitals.[20] This study investigated whether the experience of HH for HF patients with the addition of digital health-supported HH platform is feasible. One of the key challenges for successful implementation may be the attitude and acceptance of healthcare professionals (HCPs) who provide this innovative form of care.[21] Therefore, the aim of this study was to explore the perceived usability by HCPs of a digital platform in addition to HH for HF patients.

Methods

Design and setting

An international, multicentre, single-arm, interventional study was conducted for a 15-month period (October 2020–December 2021) in three hospitals. Participating centres were two Dutch hospitals: Maastricht University Medical Centre (MUMC+) and Isala, a tertiary teaching hospital, and one Belgian hospital: Jessa Hospital, a non-university secondary referral hospital. The full study protocol and patient-reported outcomes are described previously.[20,22] This study is reported in concordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[23]

Participants

Patients with an acute decompensation of known and well-assessed chronic HF with an indication for hospital admission were eligible for participation in the study. For professionals, eligibility criteria were registration as a (cardiac care) nurse or physician, providing care for the included patients during the study, and able to speak and read the Dutch language. Full in- and exclusion criteria are previously described.[20]

Intervention

All participating patients received, similar to in-hospital, HH treatment in combination with a digital health-supported platform. In Isala, HH was already standard-of-care since 2009; both Jessa and MUMC implemented HH and the platform simultaneously in the study. Specialist HF nurses visited patients at home every day to monitor their clinical status, take blood samples, and, if necessary, adjust their (intravenous) drug 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 cardiologist was in charge of the policy of the patient. Patients participating in Isala and MUMC+ were directly transferred to their homes to get the home hospitalization 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 IV diuretics before being transferred to their home.

In addition to the daily visits, all patients received the Digital Health platform (*Figure 1*).[19] The integrated digital platform consists of a portable blood pressure (BP) device, weight scale, pulse oximeter (HC@Home, Zwolle, The Netherlands), a wearable chest patch to monitor vital signs like heart rate, respiratory rate, activity level, and posture (Sensium, Abingdon, UK), and an eCoach on a mobile application (Sananet, Sittard, The Netherlands). The eCoach consisted of HF-related educational videos about HF, performing BP measurements and the HH intervention itself. In addition, it consisted of a daily symptom check about overall wellbeing, shortness of breath, fatigue, oedema, dehydration symptoms, dizziness, irregular or rapid heartbeat, and chest pain.

Patients and the informal caregivers were instructed about how to use the digital health platform at the moment of inclusion during the first home visit by the nurse. Patients received a smartphone with a pre-installed application to receive reminders for measurements of BP and weight and to track the evolution of their BP and weight values. The smartphone also contained the eCoach.

All data were sent automatically to a caregiver dashboard where the nurses and cardiologists could follow-up patients remotely. The data in the caregiver dashboard, in combination with the home visits, were intended to follow the patients' clinical evolution. Individual alerts for weight and blood pressure could be set to optimize monitoring, and the measurements of the wearable sensor were presented per hour. Alerts were only visible when opening the caregiver dashboard. The incoming data were checked at least once every day. There was no active monitoring of the incoming data during the night. A full description of the intervention procedures and components of the digital health platform is reported previously.[20]

Data collection

The primary outcome was perceived usability of the digital health platform by the HCPs. Secondary outcomes were perceived acceptability, appropriateness, feasibility, and satisfaction. All questionnaires were retrieved after 6 months (T1) and 12 months (T2) to describe potential variations over time.

For the primary outcome, usability was measured by the 10-item five-point Likert-scale questionnaire System Usability Scale (SUS).[24] An aggregated SUS score of ≥68 (scale 0–100) indicated the intervention was sufficient usable. In addition to the questionnaire, a seven-item open-end questionnaire (see Supplementary material online, *Material S1*) was provided to further clarify their experience with the HH in combination with the digital health platform at the end of the study (T2).

For the secondary outcomes, appropriateness and feasibility were assessed by the four-item five-point Likert-scale Appropriateness of Intervention Measure and Feasibility of Intervention Measure questionnaires.[25] A median sum score from 1.0 to 3.0 was considered as disagree, a score from 3.0 to 3.5 as neutral, and a score of ≥3.5 was defined as agreed. Furthermore, acceptability was measured by the 19-item Likert-scale Service User Technology Acceptability Questionnaire (SUTAQ) covering six domains: benefits (nine items), privacy (four items), personal care skill (two items), substitution (three items), and satisfaction (one item).[26] No total score could be generated from the six domains. Last, satisfaction was measured by a self-developed six-item Likert-scale questionnaire. The items were statements about their role (clear and satisfaction), reduction in workload, overall satisfaction, quality of care, and continuity of care. No total score was generated from the six statements.

Statistical analysis

All available data were used; no data imputation was performed for missing values. Descriptive statistics were performed. For continuous data, medians and interquartile ranges (IQR), or means and standard deviations (SD) were calculated based upon normal distribution. Every parameter was checked for normality by the Shapiro–Wilk test and visually by a histogram. For categorical data, frequencies and percentages were reported.

For analysing of the open-end usability questionnaire, a framework analysis was conducted.[27] The analytical framework consisted of positive and negative experiences and recommendations for future use. The statements about experiences were categorized in overall, BP/weight measurements, vital sign patch, and the eCoach. The process of data familiarization, framework identification, indexing, charting, mapping, and interpretation was independently conducted by JL and MS.

The measurement moments T1 and T2 were considered as independent measurement, and for determination of difference between moments, Mann–Whitney U tests were used. A $P < 0.05$ was considered as statistically significant. All analyses were performed with IBM SPSS Statistics 25.0 for Mac (IBM Armork, New York, USA).

Sample size

Since a formal power calculation was impossible due to the lack of preliminary data with similar HH programmes, a sample size of 20 professionals was estimated to yield sufficient data for determination of feasibility.[28] This was based on the yearly number of eligible patients and the number

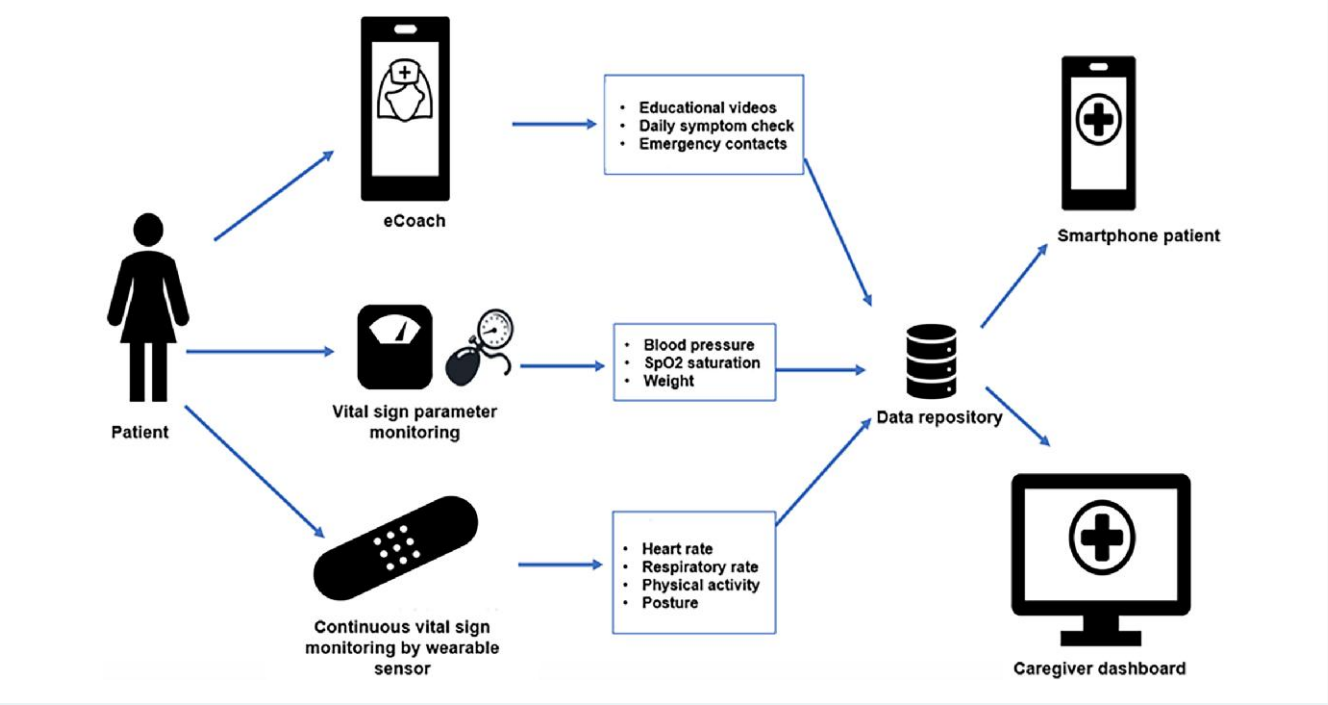


Figure 1 Overview of the digital health-supported home hospitalization platform.[19]

Table 1 Characteristics of the professionals

Characteristic ($n = 22$)	
Age in years, median (IQR)	44 (29–58.5)
Gender, *n* (%)	
Male	4 (18)
Female	18 (82)
Job position, *n* (%)	
Cardiac care nurse	19 (86.4)
Nurse practitioner	1 (4.5)
Cardiologist	1 (4.5)
Cardiologist in training	1 (4.5)
Work experience in years, median (IQR)	25 (5.5–40)

MUMC+, Maastricht University Medical Centre; HH, home hospitalization; *n*, frequency; SD, standard deviation.

of HCPs in each centre ($n = 10$ for MUMC+, $n = 15$ for Isala, and $n = 5$ for Jessa Hospital, respectively). Due to the small sample size per centre, data were not stratified and analysed by centre.

Results

Study characteristics

A total of 63 patients participated in the study of which 15 (23.8%) in the MUMC+, 15 (23.8%) in Isala, and 33 (52.4%) in Jessa Hospital. The HH days were in total 561, whereas 530 days (94.5%) a healthcare provider provided care for the patients (*Tables 1 and 2*). Remote monitoring by the use of the digital health platform was performed in 445 days (79.3%) during HH. The use varied between centres: 253 h (93.4%) in Jessa Hospital, 137 h (76.0%) in the MUMC+, and 55 h (50.5%) in Isala, respectively.

A total of 22 professionals responded (response rate 76%) to the questionnaires with a median age of 44 years (IQR29-59), and median work experience was 25 years (IQR5.5–40); the majority was female ($n = 18$) and nurses ($n = 19$) (*Table 2*).

Usability

Overall usability was rated as sufficient (mean 72.1 ± 18.9) during the study and did not differ between the measurements moments ($P = 0.690$) (*Table 3*) (see Supplementary material online, *Material S2*). The majority found the platform easy to use ($n = 27$; 82%), not unnecessarily complex ($n = 22$; 67%), and would use it again ($n = 25$; 76%). Furthermore, a slight majority of the HCPs felt confident in using the platform ($n = 20$; 60.6%). Also, HCPs found the platform functions well integrated ($n = 20$; 61%) and did not think there were inconsistencies ($n = 18$; 55%). After analysis of the open-end questionnaire, seven positive experiences and 14 negative experiences were found. Also, six recommendations for the future were done by HCP (*Table 4*).

Overall, HCPs were positive about the ease of use of the platform and providing them more insight in clinical trends and in preparation of the home visits. Also, they thought it provided a safer feeling for patients at home. However, there were several negative experiences. The HCPs mentioned that the platform was less relevant because of the frequent home visits and sometimes led to not using of the platform in providing care. Additionally, they found it was only applicable for a subset of patients because of the lack of self-management in performing the measurements of several patients. A nurse reported about this: 'It was convenient to use. The usefulness was somewhat limited because we daily visited the patient. (…) However, it was still a useful platform for patient follow-up and to get an objective view of the patient's clinical evolution.' (Nurse, Jessa Hospital).

Table 2 Study characteristics

	MUMC + ($n = 15$)	Isala ($n = 15$)	Jessa Hospital ($n = 33$)
Number of patients, *n* (%)	15 (23.8)	15 (23.8)	33 (52.4)
HH length of stay, mean (SD)	12.7 ± 3.7	7.2 ± 5.3	7.3 ± 2.8
Total number of HH days, *n* (%)	181 (100)	109 (100)	271 (100)
Days providing physical care, *n* (%)	161 (89)	105 (97)	264 (97)
Remote monitoring in days, *n* (%)	137 (76.0)	55 (50.5)	253 (93.4)

IQR: interquartile range' *n*, frequency

Table 3 Outcomes of the questionnaires

Outcome	Overall ($n = 33$)	T1 ($n = 18$)	T2 ($n = 15$)	*P*-value
Usability, mean (SD)	72.1 ± 18.9	72.5 ± 19.6	75.0 ± 20.6	0.690[a]
Appropriateness, median (IQR)	3.63 (3–4)	4 (3–4)	3.25 (3–4)	0.448[b]
Feasibility, median (IQR)	4 (3.1–4)	4 (3–4)	3.75 (3.1–4)	0.339[b]

T1, Mid of the study (6 months); T2, End of the study (12 months); IQR, interquartile range; *n*: frequency.
[a]Unpaired *T*-test.
[b]Mann–Whitney *U* test.

Considering BP and weight measurements, several HCPs did not experience technical issues when using these devices. Also, some of them thought it could be a stimulant for self-management of patients because they were able to perform the measurements themselves. On the contrary, HCPs mentioned that independently performing the measurements by the patient was not possible for all patients due to insufficient self-management, and therefore, the help of the nurse was still necessary. One nurse of the MUMC+ reported: 'For me as caregiver it was easy to use the BP monitor and weight scale, however, I think using these measurement instruments is not that easy for a lot of patients'. Also, some HCPs found configuration of the Bluetooth connection between the devices and mobile phone difficult.

Considering the vital signs patch, HCPs found it useful as a supportive tool for caregiving. However, several HCPs mentioned that they did not experience any added value by insight of vital signs trends because of the lack of support in clinical decision making. Other negative experiences mentioned were technical problems with the connection between the patch and the router, and finding the battery life of 5 days too short. They also mentioned that some patients experienced skin irritation or erythema from the patch and dislocation from wearing it during HH. Finally, nurses missed the presentation of patch readings as feedback to the patient, which was available for BP, weight, and eCoach.

With regard to the eCoach, it is noteworthy that no positive experiences were reported by HCPs. Several of them did not see any benefit in using the eCoach during HH, which may be related to the aforementioned lack of rationale and need for using the eCoach during HH. In addition, HCPs reported that completing the eCoach for twice a day was too much of a burden for patients. A nurse from the university medical centre reported: 'Filling in the questionnaire twice a day is too much for the patient. I think once a day sufficient. Eventually, a nurse visits the patients and discusses all their symptoms with them again.' (Nurse, MUMC+)

For future use, HCPs reported six recommendations. They found diagnostic measurements such as a point-of-care test for renal function or a 12-lead electrocardiogram could be beneficial in providing care. Thereafter, patient education and feedback could be further developed and integrated in the platform. Finally, the nurses felt that the cardiologist's knowledge of the digital platform was a potential facilitating factor, given its important role in the patient care process.

Secondary outcomes

Overall, perceived appropriations and feasibility was agreeable for HCPs during the whole study (*Table 3*). Perceived appropriateness was considered agreeable during (T1) the study, yet decreased to a median neutral score at the end of the study (T2). This difference was not statistically significantly different ($P = 0.448$).

Regarding acceptability (*Table 5*), more HCPs agreed with the statement that they could easier get in touch with the patient by the HH hospitalization halfway the study than at the end of the study, 82% vs. 44%, respectively ($P = 0.032$). None of the other statements differed between measurements. Moreover, HCPs disagreed about their involvement with the patients' health (65%) during HH and were evenly divided (50%) at the end of the study. Still 71% and 63% of HCPs, respectively, found the platform contributing to a better treatment. Also, 88% agreed that the platform could be a good addition to a regular hospitalization halfway the study and 68% at the end of study. The majority of HCPs (88% resp. 94%) did not find the platform invaded the privacy. Remarkably, 88% and 75% found the platform can be trusted to work appropriately with, and they were dominantly satisfied about their delivered care with the platform (88% and 81%). Finally, 59% and 56% of HCPs found the platform could be a substitute for a normal hospital admission.

Regarding overall satisfaction, 54% at T1 and 46% at T2 of the HCPs were satisfied (*Table 6*). Furthermore, HCPs were satisfied about their role and found their role clear. Moreover, 54% of HCPs found the platform resulted in a higher workload during the study and 73% at the end of the study. The HCPs were satisfied about the quality of care 75% during the study and at the end of study.

Table 4 Analysis of open-end usability questionnaire

Positive experiences	Negative experiences
Overall	
Easy to use	Less relevant because of frequent home visits
Useful for preparation of consultation	Applicable for only a subset of patients
Providing a safe feeling for patients	
More insight in clinical trends	
Blood pressure and weight measurements	
Did not experience technical issues	Bluetooth connectivity is comprehensive
Stimulation of the self-management process	Difficult to use for some patients
Vital signs patch	
Useful as supportive tool	Did not experience added value
	Problems with connectivity
	Skin irritation
	Short battery life
	Dislocation of the patch
	No insight into the measurements for the patient
eCoach	
None	Rationale and necessity not clear
	No benefits experienced
	Symptom check registration too burdensome for patients
Recommendations	
Point-of-care test for renal function	
Better integration with home hospitalization	
12-lead electrocardiogram	
More acquaintance of the cardiologist	
Patient education and feedback	
Dashboarding of alarms on population level	

Discussion

To the best of our knowledge, this is the first paper exploring HCPs perspective about a digital health platform in addition to a HH intervention for HF patients. The novelty of the study stems from the use of a digital health-supported home hospitalization platform in a home hospitalization intervention for acute HF. Our findings prove that a digitally supported home hospitalization intervention was considered usable, although actual use overall was only 79% of the HH days and several concerns about the elements of the digital health platform were raised by HCPs. Moreover, perceived appropriateness and feasibility of the intervention were sufficient. Although, the majority was satisfied about the intervention, the majority also found that it resulted in a higher workload.

The adoption of digital health technology by HCPs is crucial for successful implementation in clinical workflows.[29,30] In general, the digital health platform in combination with HH was adopted by HCPs; however, the role of the digital health platform within the HH clinical workflow needs to be better defined and established further. The HH entails several procedures, which cannot be completely digitized; therefore, the combination of digital tools with traditional methods should be carefully determined.[31] In our study, HCPs generally experienced the digital health platform as an increase in workload. This may indicate that the chosen study set-up (adding the digital health platform on top of existing clinical workflows, instead of replacing part of the existing clinical workflows) was not ideal. This issue was explicitly mentioned in the remarks questionnaire and also reflected in the limited use of the platform, 79% during all visits. Basing the decision for home visits by the nurse on the incoming data from the remote monitoring technology may increase the relevance for of the digital platform in the clinical workflow. For example, home visits may be reduced to every other day for stable hospitalized HF patients but increased to daily visits when necessary. This could help to make the intervention even more cost-effective. Other studies also found that for successful implementation, the barrier of incompatibility of eHealth with existing clinical workflow processes, in our study the daily home visits and digital health platform, should be overcome.[32,33]

Also, the experienced usability of the different elements of the platform varied and therefore may need improvement as perceived ease of use is an important factor for successful adoption of technology.[34] Overall, dashboarding of the data in the platform may be more intuitive for HCPs by determination of thresholds and alerts when trends are deteriorating or missing data are present. The BP and weight measurements were experienced positively by the HCPs in contrast to the vital sign patch and the eCoach. Potential explanation is that those measurements are essential in administration of drugs during the HH visits, one of the key elements of care for HF patients. Furthermore, the vital signs patch was used as a supportive tool but did not directly have an influence on the care the nurses gave to patients and clinical decision making. The lack of clear follow-up protocols of trend data was probably the main reason why several HCPs mentioned that it did not even have an added value for them. This is in line with previous studies, which determined the feasibility of continuous monitoring by patch devices, but underlined the need for large well-controlled studies in patients at risk for deterioration to evaluate the impact of remote continuous vital sign monitoring.[35,36] In addition, the lack of clear added value in the current clinical workflows, the several technical and practical issues such as short battery life, connectivity, and dislocation may influence their perception about the vital sign patch. Moreover, no HCPs reported any benefits of the use of the eCoach in combination with HH visits. Most likely, this is because HCPs examine the patients daily. Therefore, such form of remote monitoring may only have an impact if there are no daily direct contact with the patients.[37] Moreover, like patients, HCPs could be more satisfied with human contact than digitally.[38] Considering the improvement of the digital health platform, HCPs mentioned the need for integration of a point-of-care test for renal function and electrocardiogram measurements. This is in line with a previous study, which integrated this as parameters in the HH group.[39]

In addition, patient and organizational factors may influence the successful use of such platforms in providing HH for HF patients. First, the characteristics of patients may be important because the follow-up of the more stable HF patients could be done by the digital health platform instead of the home visits. Likewise, for the more critically ill patients, daily visits alone could be beneficial. So, finding the right balance between digital and physical or a hybrid form of contact between the patient and HCPs may be important. Moreover, low digital literacy is one of the main barriers for the use of Digital Health from a patient perspective and is linked with older age, low health literacy and low socioeconomic, and health status.[29,40] However, age and frequent technology were not associated with satisfaction and usability outcomes in this study.[22]

Also, the level of expertise of HH for HF patients of the three hospitals may be another organizational factor influencing the perceived added value of a digital health platform. For two Dutch centres, HH

Table 5 Outcomes of the acceptability questionnaire

	T1 ($n = 17$)		T2 ($n = 16$)		*P*-value[a]
	Agree (1–3)	Disagree (4–6)	Agree (1–3)	Disagree (4–6)	
Perceived benefit (*n*, %)					
The platform I received has increased the access to care	12 (71)	5 (29)	11 (69)	5 (31)	1.000
The platform I received has helped me to improve my patients health	14 (82)	3 (18)	10 (63)	6 (37)	0.259
The platform has made it easier to get in touch with the patient for asking questions	14 (82)	3 (18)	7 (44)	9 (56)	0.032*
The platform has made me more actively involved in my patients health	6 (35)	11 (65)	8 (50)	8 (50)	0.491
The platform allows me to looking after, to better monitor the condition of the patients	12 (71)	5 (29)	10 (63)	6 (37)	0.721
The platform can be/should be recommended to patients in a similar condition	14 (82)	3 (18)	13 (81)	3 (19)	1.000
The platform can certainly be a good addition to the patients regular health or social care	15 (88)	2 (12)	11 (69)	5 (31)	0.225
The platform makes me less concerned about the patient	7 (41)	10 (59)	7 (44)	9 (56)	0.494
The platform has allowed me to be less concerned about the patients' health and/or social care	9 (53)	8 (44)	9 (56)	7 (44)	0.724
Privacy (*n*, %)					
The platform has made me feel uncomfortable, e.g. physically or emotionally	1 (6)	16 (94)	2 (13)	14 (87)	0.601
The platform I received has invaded my privacy	2 (12)	15 (88)	1 (6)	15 (94)	1.000
The platform I received has interfered with my everyday routine	16 (94)	1 (6)	16 (100)	0 (0)	1.000
The platform makes me worried about the confidentiality of the private information being exchanged	1 (6)	16 (94)	1 (6)	15 (94)	0.601
Care personnel skills (*n*, %)					
I am concerned that the person who monitors the patient status, through the platform, does not know the personal health/social care history	3 (18)	14 (82)	3 (19)	13 (81)	1.000
I am concerned about the level of expertise of the individuals who monitor the patients' status via the platform	5 (29)	12 (71)	4 (25)	12 (75)	1.000
Satisfaction (*n*, %)					
The platform has been explained to me sufficiently	16 (94)	1 (6)	14 (88)	2 (12)	0.601
The platform can be trusted to work appropriately	15 (88)	2 (12)	12 (75)	4 (25)	0.398
I am satisfied with the platform I received	15 (88)	2 (12)	13 (81)	3 (19)	0.656
Substitution (*n*, %)					
The platform could be a substitution for a regular hospital admission	10 (58.8)	7 (41.2)	9 (56.3)	7 (43.7)	1.000

T1, Mid of the study (6 months); T2, End of the study (12 months); *n*, frequency.
[a]Fisher's exact tests.
*Statistically significant with $P < 0.05$.

was already a well-established standard-of-care for several years, which may underline the experienced increase in work load by the digital health platform but also the limited use of both centres (50.5% and 76.0%, respectively) in contrast to the Jessa Hospital (93.4%).[29] Besides competence, abilities, and experiences,[21] culture differences regarding digital health innovations may exist, influencing the limited use.[32] Furthermore, the difference between direct HH treatment or HH treatment after early discharge may be of influence on the perception of HCPs, and given the higher inclusion rates of Jessa Hospital, HH after early discharge may also be easier to integrate in clinical practice.

Limitations

Several limitations should be considered. First, the three participating hospitals all had a different expertise in HH for HF patients, and the start of HH varied between hospitals (direct HH or HH after early discharge), which possibly had an influence on the inclusion rate per centre, the perceived workload of HH, and the perceived usability of the platform. The relatively extensive platform might be perceived as less relevant in HF patients without IV treatment, as in Jessa Hospital. However, we did not observe any significant differences between the hospitals, but the sample was too small to perform a formal sub analysis to determine differences per centre in this study. Second, the majority of patients were enrolled at Jessa Hospital, which may skew the perceived usability by HCPs for all centres, as this centre became more routine in using the digital platform during the HH. In addition, the HCPs included in this study were mainly nurses, which limits the applicability of our findings to physicians. However, given the objectives of the feasibility study, we considered it important to report. Thirdly, we used an invalidated Dutch version of the SUTAQ questionnaire, and therefore, the total score based on the constructs was not calculated, which may affect the interpretation of the acceptability. However, we

Table 6 Satisfaction questionnaire

		T1			T2			
	Response (*n*)	Disagree (1–2)	Neutral (3)	Agree (4–5)	Response (*n*)	Disagree (1–2)	Neutral (3)	Agree (4–5)
Role: clear (*n*, %)	9	1 (11)	2 (22)	6 (67)	4	0 (0)	0 (0.0)	4 (100)
Role: satisfied (*n*, %)	13	1 (8)	1 (8)	11 (84)	11	0 (0)	4 (36)	7 (64)
Reduced workload (*n*, %)	13	7 (54)	4 (31)	2 (15)	11	8 (73)	3 (27)	0 (0)
Satisfaction (*n*, %)	13	3 (23)	3 (23)	7 (54)	13	2 (15)	5 (39)	6 (46)
Quality of care (*n*, %)	12	1 (8)	2 (17)	9 (75)	11	2 (18)	3 (27)	6 (55)
Continuity of care (*n*, %)	13	1 (8)	0 (0)	12 (92)	11	1 (9)	2 (18)	8 (73)

presented and discussed the individual items, and no further validated questionnaires were available. Thereafter, there was a somewhat higher unexplainable non-response on the satisfaction questionnaire, which may limit these findings. Fourth, the digital health platform was not integrated in the Electronic Medical Record but was a web-based platform, which may influence the experiences of HCPs.

Conclusion

A digital health platform to support HH was considered usable by HCPs, although actual use of the platform and overall satisfaction was limited, probably due to the lack of integration into clinical workflows. Therefore, several improvements in the integration of the digital platform into clinical workflows and in defining the precise role of the digital platform and its use are needed to add value before full implementation.

Supplementary material

Supplementary material is available at *European Journal of Cardiovascular Nursing* online.

Author contributions

Jobbe PL Leenen (Conceptualization, Data curation, Formal Analysis, Investigation, Visualization, Writing—original draft), Martijn Scherrenberg (Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing—review & editing), Wendy Bruins (Conceptualization, Methodology, Project administration, Resources, Software, Supervision, Writing—review & editing), Josiane Boyne (Conceptualization, Methodology, Project administration, Resources, Software, Supervision, Writing—review & editing), Julie Vranken (Conceptualization, Methodology, Formal Analysis, Project administration, Writing—review & editing), Hans-Peter Brunner la Rocca (Conceptualization, Methodology, Funding acquisition, Supervision, Writing—review & editing), Paul Dendale (Conceptualization, Methodology, Funding acquisition, Supervision, Writing—review & editing), and Astrid E van der Velde (Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing—review & editing).

Funding

This project has received funding from the Interreg NWE Programme under grant agreement number 661.The authors would like to thank all participating patients, HCPs and technical partners.

Conflict of interest: The authors declare that there is no conflict of interest.

Data availability

Data are available upon reasonable request at the corresponding author.

Ethics

All patients signed an informed consent before participating in the study. The study complies with the Declaration of Helsinki, GCP and GDPR regulations. Ethical approval was granted by The Medical Ethics Review Committee of Isala (protocol no. 190903) and registered at ClinicalTrials.gov (NCT04084964).

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