Evaluation of a new Telemedicine System for Early Detection of Cardiac Instability in Chronic Heart Failure Patients: A Real-Life Out-of-Hospital Study

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Abstract

Background: For a decade, despite results from many studies, telemedicine systems have suffered from a lack of recommendations in chronic heart failure (CHF) care because of variable study results. Another limitation is the hospital-based architecture of most telemedicine systems. The TwoCan Pulse™ system marketed by e-Device uses an algorithm based on daily weight, transcutaneous oxygen measurement (TCOM) and heart rate to detect and treat acute heart failure (AHF) in CHF patients as early on as possible.

Objective: The aim of this study is to determine the efficacy of the TwoCan Pulse™ device in detecting clinical destabilization in real-life settings (out-of-hospital management) without generating too many false positive alerts.

Methods: All patients self-monitoring at home using the TwoCan Pulse™ system after a congestive acute heart failure event treated in a private cardiology clinic in Tours, France, between March 2020 and March 2021, with at least 75% compliance on daily measurements, were included retrospectively. A new-onset AHF was defined by the presence of at least one of the following criteria: transcutaneous oxygen saturation loss defined as TCOM under 90%, rise of cardiac frequency above 110 beats-per-minute (bpm), weight gain of at least 2 kilograms, and symptoms of congestive AHF described over the phone. An AHF alert was generated when criteria reached our definition of new-onset acute congestive heart failure.

Results: A total of 111 consecutive patients (70 men), with a mean age of 76.60 [69.5, 83.4] years, receiving TwoCan Pulse™ were included. Thirty-nine patients (35.1%) reached HF warning level, and 28 patients (25%) suffered from confirmed HF destabilization during follow-up. No patient suffered from AHF without being detected by TwoCan Pulse™. Among incorrect AHF alerts, 5 patients (45.4%) had taken inaccurate measurements, 3 patients (27.2%) suffered from supraventricular arrhythmia, one patient (9.1%) suffered from a pulmonary bacterial infection, and one patient (9.1%) contracted COVID-19. A weight gain of at least 2 kilograms within 4 days was significantly associated with a correct AHF alert ($p = 0.0038$), and a heart rate of more than 110 bpm was more significantly associated with an incorrect AHF alert ($p = 0.007$).

Conclusions: This single-center study highlighted the efficacy of the TwoCan Pulse™ telemedicine system in detecting and treating quickly cardiac instability complicating the course of chronic heart failure, by detecting new onsets of acute heart failure as well as of supraventricular arrhythmia, thus helping cardiologists provide better follow-up to ambulatory patients.

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~~A new paradigm in telemedicine: determinants of TWOCAN PULSE™ telemonitoring system performance in ambulatory heart-failure patients.~~

Evaluation of a new Telemedicine System for Early Detection of Cardiac Instability in Chronic Heart Failure Patients: A Real-Life Out-of-Hospital Study

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Impact statement:
We certify that this work is novel

Key Points:
telemedicine systems have suffered from a lack of recommendations in chronic heart failure (CHF) care because of variable study results.
We found the efficacy of the ~~TwoCan Pulse™~~ telemonitoring system in detecting and treating quickly cardiac instability complicating the course of chronic heart failure, by detecting new onsets of acute heart failure as well as of supraventricular arrhythmia, thus helping cardiologists provide better follow-up to ambulatory patients.

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Patrick Jourdain conceived the idea of the study, reviewed all the data, and wrote and edited the main manuscript, Emmanuelle Berthelot, Pierre Raphael and Jean Marie Urien reviewed all the data, and wrote and edited the main manuscript, Patrick Jourdain performed the statistical analysis, was responsible for tables and figures, Thomas Moine and Marie Emilie Lopes collected the data, and edited the manuscript.

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ABSTRACT

Background: For a decade, despite results from many studies, telemedicine systems have suffered from a lack of recommendations in chronic heart failure (CHF) care because of variable study results. Another limitation is the hospital-based architecture of most telemedicine systems. Some systems marketed by e-Device use an algorithm based on daily weight, transcutaneous oxygen measurement (TCOM) and heart rate to detect and treat acute heart failure (AHF) in CHF patients as early on as possible. The aim of this study is to determine the efficacy of the device in detecting clinical destabilization in real-life settings (out-of-hospital management) without generating too many false positive alerts.

Method: All patients self-monitoring at home using the ~~TwoCan Pulse™~~ system after a congestive acute heart failure event treated in a private cardiology clinic in Tours, France, between March 2020 and March 2021, with at least 75% compliance on daily measurements, were included retrospectively. A new-onset AHF was defined by the presence of at least one of the following criteria: transcutaneous oxygen saturation loss defined as TCOM under 90%, rise of cardiac frequency above 110 beats-per-minute (bpm), weight gain of at least 2 kilograms, and symptoms of congestive AHF described over the phone. An AHF alert was generated when criteria reached our definition of new-onset acute congestive heart failure.

Results: A total of 111 consecutive patients (70 men), with a mean age of 76.60 [69.5, 83.4] years, receiving ~~TwoCan Pulse™~~ the telemonitoring system were included. Thirty-nine patients (35.1%) reached HF warning level, and 28 patients (25%) suffered from confirmed HF destabilization during follow-up. No patient suffered from AHF without being detected by the telemonitoring system. Among incorrect AHF alerts, 5 patients (45.4%) had taken inaccurate measurements, 3 patients (27.2%) suffered from supraventricular arrhythmia, one patient (9.1%) suffered from a pulmonary bacterial infection, and one patient (9.1%) contracted COVID-19. A weight gain of at least 2 kilograms within 4 days was significantly associated with a correct AHF alert ($p = 0.0038$), and a heart rate of more than 110 bpm was more significantly associated with an incorrect AHF alert ($p = 0.007$).

Conclusion: This single-center study highlighted the efficacy of the ~~TwoCan Pulse™~~ telemedicine system in detecting and treating quickly cardiac instability complicating the course of chronic heart failure, by detecting new onsets of acute heart failure as well as of supraventricular arrhythmia, thus helping cardiologists provide better follow-up to ambulatory patients.

INTRODUCTION

~~In chronic heart failure (CHF) guidelines, telemonitoring systems[1] have suffered from a lack of recommendations to reduce delayed care and the need for hospitalization for diuretic therapy. Results of studies are highly variable, depending on protocols and countries, and they are mostly hospital-based. A new telemedicine system, TwoCan Pulse™, marketed by e-Device, is used to monitor ambulatory patients suffering from CHF. It measures daily weight, transcutaneous oxygen saturation (TCOM) and heart rate, so as to detect acute heart failure destabilization as early on as possible in outpatients, in order to treat them promptly by oral diuretics and avoid hospitalization. This device was specially designed to maximize the monitoring of patients at the highest risk of hospitalization for HF, without generating too many false positive alerts, to optimize the system's ergonomics and the possibility of deployment in small hospitals and private medical practices. The French national experimentation program for telemedicine in chronic heart failure has approved the possibility of using such devices to telemonitor CHF patients, in order to determine the usefulness of HF telemonitoring in real-life settings. The aim of this study is to determine the efficacy of this telemedicine system in detecting AHF in compliant ambulatory patients, and the characteristics of outpatients who experienced AHF alerts.~~

Chronic heart failure (CHF) remains a significant public health challenge, characterized by frequent destabilizations leading to hospitalizations, decreased quality of life, and increased mortality rates (1). Over the past decade, despite numerous studies exploring telemedicine systems, there remains a dearth of consensus on their recommendations for CHF care due to inconsistent findings (2). Moreover, most existing telemedicine systems are hampered by their hospital-based architecture, limiting their effectiveness in real-world, out-of-hospital settings (3).

Addressing these limitations, some systems offers a novel approach to CHF management. Utilizing a proprietary algorithm integrating daily weight, transcutaneous oxygen measurement (TCOM), and heart rate, the system aims to detect and treat acute heart failure (AHF) episodes in CHF patients at the earliest stages. By facilitating early intervention, this system holds the promise of reducing the burden of hospitalizations and improving patient outcomes (4–6).

Despite its potential, there remains a need to evaluate the efficacy of this kind of system in real-life settings. Specifically, it is crucial to assess its ability to detect clinical destabilization in out-of-hospital environments while minimizing false positive alerts. Therefore, the primary objective of this study is to investigate the performance of the TwoCan Pulse™ device in detecting AHF episodes and supraventricular arrhythmias in CHF patients undergoing out-of-hospital monitoring.

In this retrospective analysis, we present findings from a cohort of CHF patients who underwent self-monitoring at home using the TwoCan Pulse™ system following a congestive AHF event. By analyzing data collected over a one-year period, we aim to elucidate the system's ability to accurately identify AHF episodes

and its impact on clinical outcomes. Additionally, we explore factors associated with both correct and incorrect AHF alerts, shedding light on the system's strengths and limitations in real-world use.

Through this investigation, we seek to provide valuable insights into the role of telemedicine systems, in enhancing the management of CHF patients in ambulatory settings. By demonstrating its effectiveness in early detection and intervention, we aim to support the integration of such technologies into routine clinical practice, thereby improving the care continuum for CHF patients.

METHOD

Study population

This study consists of a retrospective single-center observational cohort of patients hospitalized with congestive heart failure during the previous 3 months, at high risk of further AHF, included in the ETAPES national telemedicine experimentation program, who were provided with the telemonitoring system upon discharge to home from Nouvelle Clinique Tourangelle of Tours, France, regardless of age, sex, social status and left ventricular ejection fraction at inclusion.

All consecutive patients using the telemonitoring sustem (TwoCan Pulse™) for early detection of AHF and presenting sufficient compliance, with a follow-up of at least one year with TwoCan Pulse™ between March 1, 2020, and March 1, 2021, were included. As required by the ETAPES program, inclusion criteria were clinical decompensation of heart failure in the last 12 months, plus symptomatic HF with NYHA 2 or above and BNP greater than 100 pg/mL. Exclusion criteria were: patients who dropped out during follow-up because of telephone network difficulty or discomfort, patients with insufficient compliance defined as daily measurements below 75% of the study period, uncontrolled supraventricular arrhythmia, in particular if the heart rate is above 100 bpm, unstable patient state ruling out home discharge, or life expectancy under 1 year.

Chronic Heart Failure, telemonitoring system compliance and education

Chronic heart failure (CHF) was defined according to the ESC 2021 Heart Failure Guidelines criteria[2], including HF with reduced ejection fraction (HFrEF) and HF with preserved ejection fraction (HFpEF). Duration of HF was arbitrarily divided into new-onset HF if more recent than one year and into long-duration HF if longer than one year.

Sufficient compliance was defined by daily use of telemonitoring system at least 75% of the time in the defined period of this study. Every hospitalized HF patient meeting the criteria was offered a TwoCan Pulse™ device before being discharged to home. Patients who accepted the offer were instructed on use of the device and received personalized therapeutic and educational support from trained nurses. Only 5% of screened patients turned down the offer and were excluded from the study.

HF destabilization alert

Weight, transcutaneous oxygen measurement (TCOM) taken on a finger, and cardiac frequency were self-monitored by the patient once daily. The data was sent instantly by Bluetooth transmitter to a secured website, and a medical team, composed of a nurse and two cardiologists, monitored patients' status and alerts six days a week.

New-onset acute congestive heart failure (AHF) alert criteria were based on a predefined clinical algorithm involving the presence of at least one criterion among transcutaneous oxygen saturation loss defined as TCOM under 90%, rise of cardiac frequency above 110 beats-per-minute (bpm), weight gain of at least 4 kilograms or presence of at least two criteria among transcutaneous oxygen saturation loss defined as TCOM under 92%, a rise of cardiac frequency to above 90 bpm, and weight gain of at least 2 kilograms within 4 days. Stable patients were defined as patients without any of these criteria. The alarm triggers if one of the following 4 conditions is reached: heart rate above 110/min, oxygen saturation < 90%, weight gain > 4 kg compared to baseline weight, weight gain of > 4 kg in four days, or two of the following conditions are met: heart rate above 90/min and below 110/min, oxygen saturation < 92% and ≥ 90%, weight gain > 2 kg in 2 days. The alarm is sent to the small central device provided to the patient and to the cardiologist, either via email if they prefer or on the TwoCan server. To our knowledge, no other remote monitoring system uses an algorithm that takes into account these different values. Compliance measurement: patients were selected if they recorded at least 75% of their three values each day.

In order to encourage patient engagement and self-care, patients were informed of their status by a green light in the absence of any AHF alert, and a red light and an alarm in the event of an AHF alert.

In the event of an alert signal on their device, patients were to call their cardiologist within 72 hours to assess the need for diuretic treatment adjustment, an emergency doctor's appointment or, if more indicated, admission to the cardiology unit. If patients did not call their cardiologist as expected, the medical team called them within 48 hours. In the absence of any referring cardiologist, patients were to call the emergency number of their referring center, allowing for an answer from a cardiologist 7 days a week. Every alert was checked over the phone by a nurse or a cardiologist, based on breathlessness symptom evaluation or onset of edema, and was classified retrospectively as acute heart failure (AHF) if the patient's state stabilized after diuretic dose adjustment.

Baseline assessment and follow-up

Baseline data, including demographics, cardiomyopathy characteristics, treatment plan, chronic renal impairment and/or chronic obstructive pulmonary disease, and left ventricular ejection fraction (LEVF) at inclusion, were collected from hospital medical charts for all enrolled patients. The in-hospital data collected included the presence and type of alert (weight gain, transcutaneous oxygen loss, or excessive heart rate), and clinical response (call, emergency doctor's appointment and/or hospitalization). Every patient received a

standard follow-up visit at one year following inclusion, whether there was any AHF alert or not, to check on any AHF occurrence since inclusion that may not have been detected by TwoCan Pulse™.

Study aims

The aim of the study was to analyze patient phenotype, rate and types of alerts, and the efficacy of the telemonitoring system algorithm in detecting any destabilization of HF in CHF outpatients.

Statistical analysis

Qualitative variables were expressed as numbers (percentages); continuous data as mean ± standard deviation or median (interquartile range, IQR) depending on their distribution. T test was used as continuous variable and Chi-square test for comparing percentages. $P < 0.005$ was considered as significant. Survival rates were summarized using Kaplan–Meier estimates, and log-rank tests were used to compare groups. All tests were two-sided at a significance level of 0.05. Statistical analyses were conducted using the R++ ® device (Paris, France).

Ethical consideration

The study was compliant with Helsinki rules and was approved by the local ethics committee (Commission éthique et déontologie de la Faculté de Médecine Paris-Saclay #20181128163709). Informed consent was obtained for all the participants.

Statement regarding human subject research ethics review, exemptions, and approvals were obtained.

All patients have completed an informed consent form. This study is part of research involving human subjects and is subject to rigorous regulation in France.

Anonymization in studies involving human subjects in France involves removing or coding directly identifiable personal data, aggregating data where possible, generalizing specific details to prevent identification, and having anonymized data reviewed by an ethics committee before publication.

Compensation for participation in studies includes reimbursement for travel expenses, compensation for time spent participating, or provision of medical care or services related to the study.

There was no identification of individual participants/users in any images of the manuscript or supplementary material

RESULTS

Patient’s characteristics are summarized in tables 1, 2 and 3.

Study population

Between March 1st, 2020 and March 1st, 2021, a total of 111 consecutive patients were included in the study. Baseline characteristics of these patients are presented in Table 1. In summary, 63% were male, aged 76.6 [69.49, 83.41] years. The underlying cardiomyopathy was coronary artery disease in 53 patients (47.7%), and primary dilated cardiomyopathy in 30 patients (27%). Forty-four patients (39.64%) had a history of atrial fibrillation. The underlying HF type with reduced left ventricular ejection fraction was found in 82 patients (73,8%), with an optimal underlying treatment in HFrEF in 57 (55.34%) of those patients and a median duration of HF of 1179 [61.5, 4391.5] days.

Characteristics of ambulatory follow-up (Patient characteristics in table 1 and 2)

As detailed in table 1 and table 2, in one year, 39 patients (35.1%) presented at least one AHF alert, of which 28 (71.7%) because of a confirmed AHF alert, and 11 (28.3%) because of an unconfirmed AHF alert. No statistical differences were found between the confirmed AHF alert group and the unconfirmed AHF alert group in terms of medical characteristics, such as ejection fraction or age.

As summed up in table 3, among unconfirmed AHF alerts, 5 patients (45.4%) had taken inaccurate measurements (especially for weight), 3 patients (27.2%) suffered from supraventricular arrhythmia, one patient (9.1%) suffered from a pulmonary bacterial infection, and one patient (9.1%) contracted COVID-19 disease. Median time from inclusion to AHF alert was 100 days [36.00, 205], with a significative difference between the confirmed AHF alert group and the unconfirmed AHF alert group (150.5 days [72.5, 254.5] vs 75.3 days [69.06, 83.73], p = 0.01).

As detailed in table 4, telemonitoring system sensitivity was 100%, and its specificity was 86.7%. Positive predictive value was 71,7% and negative predictive value was 100%.

To resolve AHF alerts, a medical consultation by phone sufficed in 22 cases (56.4%), an emergency medical appointment was required for 14 patients (35.8%) and hospitalization was required for 3 patients (7.6%). A weight gain of 4 kilograms or more within 4 days was significantly associated with a confirmed AHF alert (p = 0.0038) and a resting heart rate faster than 110 bpm was more significantly associated with an unconfirmed AHF alert (p = 0.007). No patient suffered from AHF in the absence of any AHF alert.

Discussion

The effectiveness of telemonitoring system in detecting patients presenting heart failure seems to have been established by the fact that no patient suffered from AHF within the year of follow-up without being detected by the telemonitoring system algorithm.

Our algorithm based on the analysis of three constants appears to be able to detect every AHF in our study. It also detects other diseases requiring prompt care, such as community-acquired bacterial pneumonia (CABP) and (supraventricular) arrhythmia, as proven by the isolated higher heart rate found in three patients with unconfirmed AHF alerts.

Therefore, the telemonitoring system system may help cardiologists detect patients at risk of destabilization of their underlying cardiopathy beyond AHF, and treat them as promptly as possible to avoid significant complications such as stroke in atrial fibrillation. This study is in line with many others studies(4,7–11), which have proven the efficacy of telemedicine systems in helping avoid unplanned hospitalizations and improving HF self-management by patients (12–14).

The main advantages of telemonitoring system are simplicity of data acquisition and ease of handling for patients, making it broadly available to all patients, even in old age. In fact, telemonitoring system only requires a phone plug to send daily measurements. A team of two cardiologists, supported by a nurse, on a direct phone line is enough to ensure the follow-up, and an AHF alert is easily analyzed when a patient record turns red on the telemonitoring system medical website. In the coming years, with a growing older population, simple methods of following elderly HF patients will become necessary (15–18), and telemonitoring system appears to be useful for that purpose, as proven in our study by the low rate of inaccurate measurements and the need for a land line only.

Another important finding of this study is that devices do not serve to improve the underlying treatment of chronic HF, but only to treat new onsets of congestive HF as promptly as possible, to avoid long-stay hospitalizations and associated costs. This system is integrated in the overall management of HF patients, providing daily monitoring and ready access to a cardiologist.

In our study, the median time from inclusion to 1st AHF alert was 100 days [36.00, 205], with a shorter median time for unconfirmed AHF alerts than confirmed AHF alerts. This difference could be explained by the rate of inaccurate measurements in the unconfirmed AHF alert group, which seemed to occur soon after inclusion, because of misunderstanding or misuse, which are easily corrected by further instruction.

Our study suffers from several limitations. Firstly, the limited number of patients included, in a single center, which can lead to a lack of breadth for the study. Another limitation is the duration of this retrospective study, only one year. In fact, the telemonitoring system system has actually been used in Nouvelle Clinique Tourangelle since 2017, but no study was conducted to check the efficacy of telemedicine in AHF. In a decade of rise of telemedicine systems, telemonitoring system could play a part in HF monitoring after home discharge, but should undergo a prospective clinical trial to determine its effectiveness statistically. Many clinical trials have proven the efficacy of telemedicine systems in reducing length of stay and rate of hospitalization(15,19,20). The telemonitoring system should undergo a clinical trial to confirm its efficacy and possibly its ability to reduce length of hospital stay for AHF.

CONCLUSION

Thus, our study has shown the potential benefit in home healthcare of the telemonitoring system telemedicine system, based on daily measurements of weight, TCOM and cardiac frequency, on detecting and treating quickly cardiac instability complicating the progression of chronic heart failure, by detecting new-

onset acute heart failure, but also new onset of supraventricular arrhythmia, in ambulatory patients, thus helping cardiologists provide closer follow-up.

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Table 1: Population characteristics of patient included in the study with the device.

	Total (N = 111)	Patients with AHF alert (N= 39)	Patients without AHF alert (N= 72)	p Value
AHF within a year after inclusion	28	28	0	0.0001
Age (years)	76.60 [69.49, 83.41]	76.93 [69.71, 82.86]	75.3 [69.06, 83.73]	0.92
Male, n (%)	70 (63%)	29 (74.3%)	41 (56.9%)	0.1
Weight (kg)	75.00 [64.00, 89.00]	72.5 [61.75, 80.25]	79 [72, 96]	0.02
Cardiovascular risk factors - Hypertension - Diabetes mellitus - Dyslipidemia - History of smoking - Family history of CVD	 50 (45.05%) 22 (19.82%) 77 (69.37%) 23 (20.72%) 3 (2.70%)	 33.0 (45.8%) 10.0 (13.9%) 51.0 (70.8%) 15.0 (20.8%) 3.00 (4.17%)	 17.0 (43.6%) 12.0 (30.8%) 26.0 (66.7%) 8.00 (20.5%) 0 (0%)	 0.84 0.05 0.67 1 0.55
Cardiomyopathy, n (%) - CAD - DCM - HCM - Hypertensive cardiopathy - AVS - CAD + AVS - CAD + MR - Valvular prothesis - Amylosis	 53 (47.7%) 30 (27%) 4 (3.6%) 7 (6.3%) 7 (6.3%) 3 (2.7%) 2 (1.8%) 1 (0.9%) 4 (3.6%)	 36 (50%) 20 (27.5%) 2 (2.7%) 7 (9.7%) 2 (2.7%) 0 2 (2.7%) 1 (1.3%) 2 (2.7%)	 17 (43.5%) 10 (27.6%) 2 (5.1%) 0 5 (12.8%) 3 (7.6%) 0 0 2 (5.1%)	0.71
Duration of heart failure - Median duration (days) - New onset of HF - HF lasting for at least 1 year	 1179 [61.5, 4391.5] 49 (44.1%) 62 (56.9%)	 706 [23.75, 2359.75] 15 (38.4%) 24 (61.6%)	 804 [24, 2897.5] (47.2%) 38 (52.8%)	 0.14 0.43
History of atrial fibrillation (n, %)	44 (39.64%)	11.0 (28.2%)	33.0 (45.8%)	0.1
Chronic renal insufficiency (n, %)	10 (9.01%)	8.00 (11.1%)	2 (5.13%)	1
COPD (n, %)	3 (2.70%)	2.00 (2.78%)	1 (2.56%)	0.49
Treatment (n, %) - Betablockers - ACEi/ARB - ARNI - MRA - Ivabradine - Furosemide • Dose (mg/day)	 99 (89.1%) 66 (59.4%) 17 (15.3%) 36 (32.4%) 3 (2.7%) 87 (78.4%) 104	 35 (89.7%) 17 (43.5%) 6 (15.3%) 13 (33.3%) 1 (2.5%) 30 (76.9%) 104	 64 (88.8%) 47 (65,2%) 11 (15.2%) 23 (31.9%) 2 (2.7%) 57 (79.1%) 93	 1 0.02 1 1 1 0.81
Optimal medical treatment in HFrEF (n, %)	57 (55.34%)	16.0 (48.5%)	41.0 (58.6%)	0.12
Heart Failure (n, %) - HFrEF - HFpEF - LEVF at inclusion (%)	 82 (73.8%) 29 (25.2%) 40.00 [31.50, 50.00]	 29 (74.4%) 10 (25.6%) 40 [30, 48.12]	 53 (73.6%) 19 (26.4%) 41 [35.5, 50]	 1

ACEi: Angiotensin-converting-enzyme inhibitor, ARB: Angiotensin II type I receptor blocker, ARNI: Angiotensin receptor neprilysin inhibitor, AVS: Aortic valvular stenosis, CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease, DCM: Dilated Cardiomyopathy, HCM: Hypertrophic cardiomyopathy, HF: heart failure, HFpEF: heart failure with preserved ejection fraction, HFrEF: heart failure with reduced ejection fraction, LFVE: Left ventricular ejection fraction, MRA: Mineralocorticoid receptor antagonist, MR: Mitral regurgitation.

Table 2: Characteristics of patients with confirmed AHF alert

	Patients with confirmed AHF alert (N= 28)	Patients without confirmed AHF alert (N= 83)	p Value
Age (years)	81.27 [72.41]	75.5 [69.04, 82.48]	0.05
Male, n (%)	22.0 (78.6%)	48.0 (57.8%)	0.07
Weight (kg)	77 [67.5, 92.25]	74 [62.5, 87.5]	0.33
Cardiovascular risk factors - Hypertension - Diabetes mellitus - Dyslipidemia - History of smoking - Family history of CVD	 14.0 (50.0%) 7.00 (25.0%) 10.0 (35.7%) 5.00 (17.9%) 3.00 (3.61%)	 36.0 (43.4%) 15.0 (18.1%) 24.0 (28.9%) 18.0 (21.7%) 0 (0%)	 0.66 0.42 0.49 0.79 0.57
Cardiomyopathy, n (%) - CAD - DCM - HCM - Hypertensive cardiopathy - AVS - CAD + AVS - Amylosis	 11.0 (39.3%) 6.00 (21.4%) 1.00 (3.57%) 2.00 (7.14%) 2.00 (7.14%) 4.00 (14.3%) 2.00 (2.41%)	 42.0 (50.6%) 24.0 (28.9%) 3.00 (3.61%) 5.00 (6.02%) 5.00 (6.02%) 2.00 (2.41%) 2.00 (7.14%)	0.21
Duration of heart failure - Median duration (days) - New onset of HF - HF lasting for at least 1 year	 708.5 [78.75, 4524.5] 11.0 (39.3%) 17.0 (60.7%)	 883 [24, 2816.5] 38.0 (45.8%) 45.0 (54.2%)	 0.31 0.66
History of atrial fibrillation (n, %)	21.0 (75.0%)	46.0 (55.4%)	0.08
Chronic renal insufficiency (n, %)	2.00 (7.14%)	8.00 (9.64%)	1.00
COPD (n, %)	1.00 (3.57%)	2.00 (2.41%)	1.00
Treatment (n, %) - Betablockers - ACEi/ARB - ARNI - MRA - Ivabradine - Furosemide • Dose (mg/day)	 24.0 (85.7%) 13.0 (46.4%) 9.00 (32.1%) 3.00 (10.7%) 1.00 (3.57%) 21.0 (75.0%)	 76.0 (91.6%) 53.0 (63.9%) 27.0 (32.5%) 14.0 (16.9%) 1.00 (1.20%) 67.0 (80.7%)	 0.46 0.12 1.00 0.55 1.00 0.59
Optimal medical treatment in HFrEF (n, %)	11.0 (39.3%)	46.0 (55.4%)	0.19
Heart Failure (n, %) - HFrEF - HFpEF - LEVF at inclusion (%)	 19.0 (67.9%) 9.00 (32.1%) 44 [39.25, 51.25]	 63.0 (75.9%) 20.0 (24.1%) 40 [30, 47.25]	0.46 0.06

ACEi: Angiotensin-converting-enzyme inhibitor, ARB: Angiotensin II type I receptor blocker, ARNI: Angiotensin receptor neprilysin inhibitor, AVS: Aortic valvular stenosis, CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease, DCM: Dilated Cardiomyopathy, HCM: Hypertrophic Cardiomyopathy, HF: Heart failure, HFpEF: Heart failure with preserved ejection fraction, HFrEF: Heart failure with reduced ejection fraction, LFVE: Left ventriculaire ejection fraction, MRA: Mineralocorticoid receptor antagonist

Table 3: Acute heart failure : alert characteristics

	Total AHF alert (N = 39)	Confirmed AHF alert (N = 28)	Unconfirmed AHF alert (N = 11)	P Value
Days after inclusion	100 [36.00, 205]	150.5 [72.5, 254.5]	49 [18, 64]	0.01
Duration of HF - HF lasting for at least 1 year - New onset of CHF	 15 (38.4%) 24 (61.6%)	 17.0 (60.7%) 11.0 (39.3%)	 7.00 (63.6%) 4.00 (36.4%)	1.00
Type of AHF alert (n, %) - Weight gain - Loss of oxygen - Increased heart rate - Weight gain + Loss of oxygen - Weight gain + Increased heart rate - Loss of oxygen + Increased heart rate - Weight gain + Loss of oxygen + Increased heart rate	 25 (64.1%) 5 (12.8%) 4 (10.2%) 3 (7.6%) 0 1 (2.5%) 1 (2.5%)	 21 (75%) 3 (10.7%) 0 3 (10.7%) 0 0 1 (3.5%)	 4 (36.3%) 2 (18.2%) 4 (36.3%) 0 0 1 (9%) 0	 0.0038 NS 0.02
Medical response (n, %) - Call - Emergency consultation - Hospitalization	 22 (56.4%) 14 (35.8%) 3 (7.6%)	 17 (60.7%) 7 (25%) 3 (10.7%)	 5 (45.4%) 7 (63.6%) 0	 NS NS NS
Type of unconfirmed AHF alert (n, %) - Supraventricular arrhythmia - Inaccurate measurements - CABP - COVID19			 3 (27.3%) 5 (45.4%) 1 (9%) 1 (9%)	
CABP: Community-acquired bacterial pneumonia, COVID-19: Coronavirus Disease 2019, AHF: Acute heart failure				

Table 4: Performance table of telemonitoring system

	Global	Weight gain	Loss of oxygen	Increased heart rate
Sensitivity	100%	84%	3.5%	0%
Specificity	86.7%	94.7%	96%	98.6%
Positive predictive value	71.7%	84.6%	60%	0%
Negative predictive value	100%	83.7%	74.2%	65.5%