# Long-term impact of home-based monitoring after an admission for acute decompensated heart failure: a systematic review and meta-analysis of randomised controlled trials

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## Summary

**Background** Patients with heart failure have high rehospitalisation rates and poor cardiovascular outcomes. Home-based monitoring (HBM) has emerged with promising results in different settings. However, its long-term effects on patients recently admitted for acute decompensated heart failure (ADHF) remain uncertain.

**Methods** We systematically searched PubMed, Embase, and Cochrane Library for randomised controlled trials (RCTs) comparing HBM with usual care (UC) that were published between database inception and June 24, 2023. We included studies with patients admitted for ADHF in the previous 6 months and with a minimum follow-up of 6 months. We excluded studies with patients hospitalised for reasons other than ADHF and studies with disproportional education interventions between arms. Statistical analyses were performed using R software version 4.3.2. We pooled risk ratios (RR) and mean differences (MD) with 95% confidence intervals (CI) for categorical and continuous outcomes, respectively. Cochrane Collaboration's tool for assessing risk of bias in RCTs (RoB 2) was used to assess study quality. Publication bias was assessed via funnel plots and Egger's test, and heterogeneity was assessed through $I^2$ statistics and sensitivity analysis. The protocol for this systematic review and meta-analysis was registered in the International Prospective Register of Systematic Reviews (PROSPERO, CRD42023465359).

**Findings** We included 16 RCTs comprising 4629 patients, of whom 2393 (51.7%) were randomised to HBM and 3150 (68%) were men. Follow-up ranged from six to fifteen months. As compared with UC, HBM significantly reduced all-cause mortality (RR 0.75; 95% CI 0.61, 0.91; p = 0.005), all-cause hospitalisations (RR 0.82; 95% CI 0.70, 0.97; p = 0.018), cardiovascular (CV) mortality (RR 0.53; 95% CI 0.36, 0.79; p = 0.002), hospitalisations for heart failure (RR 0.75; 95% CI 0.62, 0.91; p = 0.004), and CV hospitalisations (RR 0.72; 95% CI 0.55, 0.95; p = 0.018). There were no significant differences in length of hospital stay (MD 0.97 days; 95% CI -0.90, 2.84; p = 0.308).

**Interpretation** In patients recently admitted with ADHF, HBM significantly reduces long-term all-cause mortality and hospitalisations, CV mortality and hospitalisations, and hospitalisations for heart failure, as compared with UC. This supports the implementation of HBM as a standard practice to optimise patient outcomes following admissions for ADHF. However, future studies are warranted to evaluate the efficacy and safety of implementing HBM in the real-world setting.

*Abbreviations:* ADHF, Acute decompensated heart failure; CI, Confidence Interval; CV, Cardiovascular; HBM, Home-based monitoring; HF, Heart failure; HHF, Hospitalisations for HF; LVEF, Left ventricular ejection fraction; MD, Mean difference; NYHA, New York Heart Association; PRISMA, Preferred Reporting Items for Systematic Review and Meta-Analyses; PROSPERO, International Prospective Register of Systematic Reviews; RCTs, Randomised controlled trials; RoB 2, Risk of Bias in Randomised Trials 2; RR, Risk Ratio; UC, Usual care

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## Research in context

### Evidence before this study

Patients with acute decompensated heart failure (ADHF) are at high risk for rehospitalisation and poor cardiovascular outcomes, especially within 6 months of the index hospitalisation. Home-based monitoring (HBM) has emerged with promising results in early detection of arrhythmias and device malfunction in patients with heart failure (HF). However, its long-term impact on reducing admissions for ADHF and mortality remains uncertain. In August 2023, Scholte and colleagues demonstrated a reduction in all-cause mortality and HF hospitalisations; however, the inclusion of patients with both stable and unstable HF resulted in a high heterogeneity. Herein we aimed to specifically focus on patients with unstable HF, who had a recent ADHF admission and therefore are at a greater risk of event recurrence, and to explore other outcomes of interest. We searched from database inception to June 24, 2023, with the following search terms: "heart failure", "cardiac failure", "HF", "CHF", "sensor", "monitor", "device", "wearable", "telecommunication", "telecardiology", "health information system", "wireless", "internet", "message", "call", "interactive voice response", "mobile", "mHealth", "telehealth", "telephone", "ehealth", "telemanagement", "monitoring", "telemedicine", "tele-home-care", "telehomecare", "tele-guidance", "telemonitoring", "telecare", "telemedical", "smartphone", "remote", "home", "outpatient", "discharge", "discharged", "hospitalized", "hospitalization", "admission", "admitted", "readmission", "usual care", "standard care", "clinical care", "control", "RCT", "random", "randomly", "randomized", "randomization". No language restrictions were used. We found 7812 results. After removing duplicate results and applying the eligibility criteria, 186 records were selected for full-text review. Finally, 16 RCTs were included.

### Added value of this study

We conducted a systematic review and meta-analysis of randomised controlled trials (RCTs) investigating the efficacy of long-term HBM compared with usual care (UC) in patients admitted for ADHF in the previous 6 months, with a minimum follow-up of 6 months. 16 RCTs were included. We further evaluated subgroups of patients hospitalised in the last month and patients with impaired left ventricular ejection fraction (LVEF). Our findings demonstrated a reduction in all-cause mortality, cardiovascular mortality, hospitalisations for heart failure, and hospitalisations for cardiovascular causes with HBM. In addition, our meta-regression reveals that the earlier HBM is implemented after an admission for ADHF, the greater the benefits in mortality.

### Implications of all the available evidence

Our findings provide a valuable and powerful perspective on telemedicine use in managing patients with HF, providing timely intervention and personalised healthcare. Further investigations should focus on refining HBM applications and assessing the sustained impact of its integration as a standard practice for enhancing outcomes in patients recently admitted for ADHF.

## Introduction

Heart failure (HF) is a leading cause of hospitalisation and mortality. Globally, it is estimated that over 64.3 million individuals had HF in 2023, and its prevalence continues to rise due to population ageing.[1] Patients recently discharged with a diagnosis of acute decompensated HF (ADHF) are at an increased risk of clinical worsening, recurrent hospitalisations, and multiorgan dysfunction, requiring close monitoring and management.[2–4]

In this sense, home-based monitoring (HBM) has emerged with promising results in improving patient care, reducing healthcare costs, and providing a non-invasive frequent and timely monitoring of clinical status.[5] Although the COVID-19 pandemic catalysed the transition from clinic-based care to remote monitoring, data on the use of HBM in patients with ADHF remains limited, especially in the long-term setting.

In August 2023, a comprehensive meta-analysis by Scholte and colleagues showed a significant overall reduction in mortality and hospitalisation events among patients with stable and unstable HF.[6] However, herein we restricted criteria to patients recently hospitalised, targeting a high-risk population. Similarly, while previous meta-analyses evaluated HBM in patients with HF, none has assessed the role of HBM specifically in ADHF focusing on long-term outcomes.[7–12] Therefore, we performed a systematic review and meta-analysis of randomised controlled trials (RCTs) comparing HBM versus usual care (UC) for long-term efficacy outcomes in patients hospitalised for ADHF within the last 6 months.

## Methods

### Ethics

Our study did not require informed consent or Institutional Review Board, given that we incorporated data from publicity available studies approved by ethics committees or institutional review boards. We did not have access to individual patient data and all patients provided written consent before enrollment in the individual studies.

### Search strategy and selection criteria

This systematic review and meta-analysis was conducted following Cochrane recommendations and Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines.[13,14] The protocol for this study was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) database under protocol number 42023465359. We systematically searched published studies in PubMed, Embase, and Cochrane Library from database inception to June 24, 2023, with the following search terms: "heart failure", "cardiac failure", "HF", "CHF", "sensor", "monitor", "device", "wearable", "telecommunication", "telecardiology", "health information system", "wireless", "internet", "message", "call", "interactive voice response", "mobile", "mHealth", "telehealth", "telephone", "ehealth", "telemanagement", "monitoring", "telemedicine", "tele-home-care", "telehomecare", "tele-guidance", "telemonitoring", "telecare", "telemedical", "smartphone", "remote", "home", "outpatient", "discharge", "discharged", "hospitalized", "hospitalization", "admission", "admitted", "readmission", "usual care", "standard care", "clinical care", "control", "RCT", "random", "randomly", "randomized", "randomization". No language restrictions were used. We further performed a backward snowballing search using references from included studies and previous systematic reviews.

We restricted inclusion to the following eligibility criteria: (1) RCTs; (2) comparing HBM with UC; (3) enrolling patients admitted for ADHF in the previous 6 months; (4) with a minimum follow-up of 6 months; and (5) reporting any of the outcomes of interest. We considered secondary analyses of included RCTs as one single index study. We excluded: (1) observational studies; (2) studies with patients previously hospitalised for reasons other than ADHF or when the reason for hospitalisation was unclear; (3) follow-up period of less than 6 months; (4) studies focused on nurse/patient education; (5) studies with disproportional education interventions between arms—only intervention arm underwent health education sessions while UC arm does not; and (6) conference abstracts. Title/abstract and full-text screening were conducted in duplicate by two independent reviewers (M.R.C.C. and M.A.P.B.). Disagreements were resolved through consensus, including a third author (N.F.).

### Data analysis

Data were independently extracted by three authors (M.R.C.C., D.D.P.N., and M.A.P.B.), following predefined search criteria. A template was developed for data extraction of relevant items, including study details (author, year of publication, time of follow-up, study design, and sample size), participants (population characteristics, sex, New York Heart Association (NYHA) class, left ventricular ejection fraction (LVEF), and blood pressure), intervention (type of HBM and specific characteristics) and relevant outcomes.

Our outcomes of interest were as follows: (1) all-cause mortality; (2) all-cause hospitalisations; (3) cardiovascular (CV) mortality; (4) hospitalisations for HF (HHF); (5) CV hospitalisations; and (6) length of hospital stay. We further performed between-trial subgroup analyses in (1) patients hospitalised for ADHF within a month prior to randomisation versus hospitalised over a month; (2) patients with HF with impaired LVEF at baseline (as per individual studies definitions, with an LVEF of less than 50%); and (3) according to the HBM modality, in order to compare potential variations in monitoring strategies, including vital signs measurement, use of hemodynamic monitor, telephone calls or digital weight scale between groups; and (4) according to UC modality, comparing potential variations in standard care management.

We pooled risk ratios (RR) and mean differences (MD) with 95% confidence intervals (CI) for categorical and continuous outcomes, respectively. To account for heterogeneity in methodology and demographics across studies, we applied a random-effects model, as per Cochrane's recommendations.[14] Heterogeneity was assessed through $I^2$ statistics. Sensitivity analyses for all-cause mortality and HHF were performed using the leave-one-out method to evaluate the impact of each study on the pooled analysis. Sensitivity analysis using hazard ratio (HR) was performed in the outcomes of CV hospitalisation, all-cause hospitalisation, all-cause mortality, and HHF. Subgroup analysis checking for interaction between trials grouped per time from index hospitalisation and HBM strategy was considered statistically significant if p for interaction was <0.05. All statistical analyses were performed using R software version 4.3.2 (R foundation, Vienna, Austria).

To assess whether key clinical and methodological factors impact the comparative efficacy of HBM versus UC, we further conducted meta-regression analyses. The dependent variables were the log RRs for all-cause mortality, all-cause hospitalisations, and HHF. Predictor variables considered included publication year, mean age, LVEF, and time to intervention. Consistency was maintained by employing the same method to estimate the between-study variance in meta-regressions as in meta-analyses. Results of the meta-regressions are presented in terms of betas intercepts, as well as their

corresponding standard errors and p-values, indicating the magnitude and statistical significance of the effects of each predictor.

Quality assessment was performed by three authors (E.P., R.O.M.F., and T.A.C.) using Cochrane Collaboration's tool for assessing risk of bias in randomised trials (RoB 2), which categorises each RCT as low, some concerns, or high risk for bias in 5 domains: selection, performance, detection, attrition, and reporting biases.[15]

### Role of the funding source

There was no funding source for this study. All authors confirm that they had full access to all the data in the study and accept responsibility for the decision to submit for publication.

## Results

### Study description

The initial search found 7812 results on June 24, 2023. After removing duplicate results and applying the eligibility criteria, 186 records were selected for full-text review, as detailed in Fig. 1. Sixteen RCTs were included in this systematic review and meta-analysis, comprising 4629 patients, of whom 2393 (51.7%) were randomised to receive HBM and 3150 (68%) were men. Follow-up ranged from six to fifteen months. Mean age of patients ranged from 56 to 80.9 years. Mean LVEF ranged from 21.6%–59%. Individual studies characteristics are displayed in Table 1. Definitions of HBM and UC across included studies are presented in Table 2, as UC definitions varied among included studies with regards to the frequency of scheduled visits and the type of follow-up, with some of them being referred to general practitioners. Only one study had hemodynamic monitoring as the HBM strategy.[16]

### Main outcomes

There was a significant reduction in all-cause mortality (RR 0.75; 95% CI 0.61, 0.91; p = 0.005; $I^2$ = 21%; Fig. 2) and all-cause hospitalisations (RR 0.82; 95% CI 0.70, 0.97; p = 0.018; $I^2$ = 70%; Fig. 3). The subgroup of patients monitored through vital signs measurements and telephone calls exhibited a significant difference in all-cause hospitalisations (RR 0.66; 95% CI 0.52, 0.85; p = 0.001; $I^2$ = 58%; Fig. 3) compared with other HBM strategies, and treatment effects did not reach statistical significance ($p_{interaction}$ = 0.01; Fig. 3).

HBM significantly reduced CV mortality in patients monitored through vital signs measurements plus telephone calls (RR 0.53; 95% CI 0.36, 0.79; p = 0.002; $I^2$ = 0%; Fig. 4), and results remained consistent in the subgroup of patients within one month of the ADHF index admission (RR 0.53; 95% CI 0.36, 0.79; p = 0.002; $I^2$ = 0%; Supplementary Fig. S1). There was a significant reduction in HHF (RR 0.75; 95% CI 0.62, 0.91; p = 0.004; $I^2$ = 53%; Fig. 5), and CV hospitalisations rates (RR 0.72; 95% CI 0.55, 0.95; p = 0.018; $I^2$ = 34%; Fig. 6). Moreover, there was a significant interaction according to time in CV hospitalisations, favouring a more pronounced benefit within one month of the ADHF admission (RR 0.63; 95% CI 0.49, 0.81; p < 0.001; $I^2$ = 0%; Fig. 6) compared with a strategy implemented after one month of the index admission ($p_{interaction}$ = 0.04; Fig. 6). However, there was no significant difference between HBM and UC in length of hospital stay (MD 0.97 days; 95% CI -0.90, 2.84; p = 0.308; $I^2$ = 48%; Supplementary Fig. S2).

### Subgroup analyses

Definitions of impaired LVEF are presented in Supplementary Table S1. Results remained consistent in patients with impaired LVEF at baseline, as HBM significantly reduced all-cause mortality (RR 0.59; 95% CI 0.46, 0.75; p < 0.001; $I^2$ = 0%; Supplementary Fig. S3), all-cause hospitalisations (RR 0.82; 95% CI 0.72, 0.94; p = 0.004; $I^2$ = 0%; Supplementary Fig. S4), and HHF (RR 0.66; 95% CI 0.53, 0.83; p < 0.001; $I^2$ = 0%; Supplementary Fig. S5).

Subgroup analyses based on the type of UC revealed significant differences in the outcomes of all-cause hospitalisation ($p_{interaction}$ < 0.01; Supplementary Fig. S6) and HHF ($p_{interaction}$ = 0.02; Supplementary Fig. S7), favouring HBM over UC for UC defined as clinic visits plus telephone calls and clinic visits plus self-monitor bio-measures approaches. Additionally, HBM demonstrated a benefit over clinic visits alone for the outcome of HHF (RR 0.65; 95% CI 0.50, 0.84; p = 0.001; $I^2$ = 0%; Supplementary Fig. S7). There was no significant effect modification in all-cause mortality, CV mortality, and CV hospitalisation (Supplementary Figs. S8–S13).

No significant effect modifications were noted in the endpoints of all-cause mortality, HHF, CV mortality, and length of hospital stay according to time from index hospitalisation or HBM strategy (Supplementary Figs. S14–S17).

### Meta-regressions

Supplementary Table S2 displays results of the meta-regressions for the outcomes of all-cause mortality, all-cause hospitalisations, and HHF. In the outcome of all-cause mortality, there was a significant association between higher time from randomisation to the intervention and a lower magnitude of benefit of HBM versus UC (p = 0.02; Supplementary Table S1).

For the outcome of HHF, there were no significant linear associations between publication year (p = 0.57), mean LVEF (p = 0.50), mean age (p = 0.99), or follow-up duration (p = 0.90). We also found no significant differences between publication year in the outcomes of all-cause mortality (p = 0.19) or all-cause hospitalisation (p = 0.66).

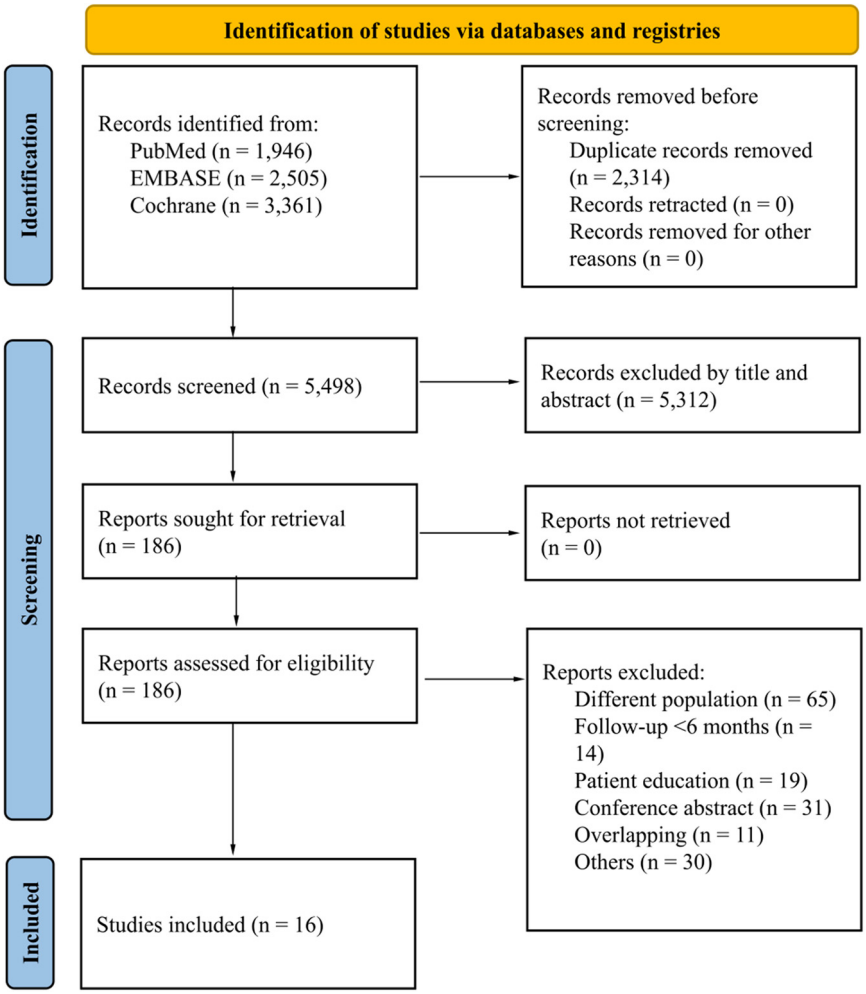


***Fig. 1:*** PRISMA diagram.

### Risk of bias assessment

Individual RCTs appraisal using the RoB 2 tool is depicted in Supplementary Fig. S18 of the Supplementary Material. The only study considered with high risk of bias was Kulshreshtha et al. (2010) due to bias arising from the randomisation process, as patients were prospectively randomised on a week-on and week-off basis (quasi-randomised) (Supplementary Figs. S18 and S19).[17]

There was no evidence of small study effects (publication bias) by visual appraisal of the funnel plot for the outcome of all-cause mortality, since studies with similar weights were symmetrically distributed against their standard errors. This conclusion is further substantiated by results of Egger's regression test ($p = 0.21$; Supplementary Fig. S20).

### Sensitivity analyses

Leave-one-out sensitivity analyses for the outcomes of all-cause mortality and HHF revealed no study dominance after omitting each individual RCT (Supplementary Figs. S21 and S22).[16–31] Sensitivity analysis using HR revealed no significant differences in the outcomes of CV hospitalisation, all-cause hospitalisation, all-cause mortality, and HHF (Supplementary Figs. S23–S26), although this analysis was likely underpowered due to the smaller number of studies (n = 6).

## Discussion

In this systematic review and meta-analysis of 16 RCTs and 4629 patients, we assessed the long-term effects of HBM in patients admitted for ADHF in the previous 6 months. Our main findings were as follows: HBM significantly reduced (1) all-cause mortality; (2) all-cause hospitalisations; (3) HHF; (4) CV mortality; and (5) CV hospitalisations rates. There were no significant differences between HBM and UC in length of hospital stay.

| Study | Follow-up | Study population, n | Age (years)[a] | Men (%) | NYHA III or higher (%) | LVEF (%)[a] | SBP (mmHg), mean | DBP (mmHg), mean |
|---|---|---|---|---|---|---|---|---|
| Jiménez-Marrero, 2018 | 6 months | 50/66 | 77/78 | 54/51.5 | 52/46 | 56/59 | 122/126 | 70/68 |
| Chaudhry, 2010 | 6 months | 826/827 | 61/61 | 56.5/59.3 | 57.7/56.7 | NA | 121.5/120.3 | 71.1/70.6 |
| Kotooka, 2018 | 15 months | 90/91 | 67.1/65.4 | 56.6/61.5 | 22.2/20.9 | 40.5/39.2 | NA | NA |
| Cleland, 2005 | 15 months | 341/85 | 67/68 | 75.9/81.1 | 31.9/42.3 | 25/24 | 114/115 | 69/69 |
| Kulshreshtha, 2010 | 6 months | 42/68 | 65/70.2 | 61.9/64.7 | NA | 39/37 | NA | NA |
| Antonicelli, 2008 | 12 months | 28/29 | 77/79 | 57/66 | 46.4/37.9 | 35/37 | 130/135 | 80/83 |
| Giordano, 2009 | 12 months | 230/230 | 58/56 | 84/86 | 46/35 | 28/26 | 107/109 | NA |
| Olivari, 2018 | 12 months | 229/110 | 79.6/80.9 | 61.1/65.4 | 51.9/51.8 | NA | 127.7/125.9 | 74/71.9 |
| Dendale, 2012 | 6 months | 80/80 | 75.9/75.6 | 62/67 | NA | 34.9/35.9 | 125/124 | 73/70 |
| Bourge, 2008 | 6 months | 134/140 | 58/58 | 66/64 | 100/100 | NA | NA | NA |
| Souza, 2014 | 6 months | 123/129 | 62/63 | 61/64.3 | 53.6/58.1 | 29.2/30.1 | NA | NA |
| Goldberg, 2003 | 6 months | 138/142 | 57.9/60.2 | 69.6/65.5 | 95.6/99.3 | 21.6/21.8 | NA | NA |
| Jerant, 2001 | 6 months | 25/12 | 68.8/72.7 | 44/50 | 32/41.7 | NA | NA | NA |
| Leventhal, 2011 | 12 months | 22/20 | 76.7/77.6 | 59.1/65 | NA | 45/42 | 124.1/129.7 | 72.3/71.6 |
| Lynga, 2012 | 12 months | 166/153 | 73.7/73.5 | 75.9/73.9 | 100/100 | NA | NA | NA |
| Scherr, 2009 | 6 months | 54/54 | 65/67 | 74/72 | 87/87 | 25/29 | NA | NA |

Significant interaction between groups; HBM/UC. HBM, home-based monitoring; UC, usual care; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; SBP, systolic blood pressure; DBP, diastolic blood pressure; NA, not available. [a]Mean or median.

***Table 1:*** **Baseline characteristics of included studies.**

Results remained consistent in subgroup analysis of patients with impaired LVEF at baseline. Meta-regression analysis found a significant association between time from index ADHF admission and initiation of HBM, with a greater benefit when HBM was implemented earlier. This finding indicates that a delay in intervention was associated with a smaller benefit of HBM in reducing mortality. Meta-regression in the outcome of HHF implies that year of publication, higher mean age, lower LVEF, or higher follow-up duration do not seem to influence the relative comparison of HBM with UC.

ADHF is a leading cause of hospitalisations and is associated with high mortality and rehospitalisation rates.[32] Considering that patients require close monitoring after an HF hospitalisation, HBM has shown promising results as an intervention for remote clinical surveillance.[32–34] The COVID-19 pandemic played a role in catalysing transition to telemedicine and optimising this approach as an alternative to frequent in-person visits.[5] In this sense, our meta-analysis stands out as it shows substantial benefits of HBM in patients admitted for ADHF in the previous 6 months, reducing mortality and rehospitalisation rates in a high-risk population that places a high burden on healthcare systems in the long-term setting. Therefore, HBM should be considered as an alternative to UC in patients with a recent hospitalisation for ADHF.

Despite improvements in the pharmacological management of HF over time, morbidity and mortality remain high and demand for healthcare continues to rise.[32,35,36] In this sense, non-pharmacological interventions have been increasingly implemented to improve patient care through health education and close monitoring of clinical status.[37] Importantly, our meta-regression revealed that the earlier implementation of HBM after an admission for ADHF results in a greater benefit in mortality. We also found a significant effect modification for time since ADHF and the outcome of CV hospitalisations, demonstrating a favourable effect in patients treated within one month of the ADHF index admission. Pandor and colleagues analysed 21 RCTs, including 6317 patients who underwent remote monitoring after admission with ADHF in the last 28 days. They found that structured telephone support, provided by human-to-human interaction, and home telemonitoring (either by patient self-input of data and/or by automatic data transfer from implanted devices), were beneficial in reducing all-cause mortality in this high-risk population, similarly to our findings.[38] Overall, these findings reinforce the importance of timely initiation of interventions to improve outcomes for patients discharged after admission for ADHF. As demonstrated by reductions in mortality and hospitalisation rates, HBM strengthens the quality of healthcare and ensures that patients receive prompt and personalised attention.

LVEF is an important criterion for assessing HF phenotypes and treatment. The TIM-HF2 trial studied the management of patients across LVEF categories and found no significant interaction in the treatment effect of HBM with LVEF subgroups (preserved, reduced, and mildly reduced).[39] Similarly, we found no significant association between treatment effect on HHF and LVEF on meta-regression. This suggests that the results are significant irrespective of the LVEF phenotype.

| Study | Home-based monitoring | Usual care | Patient management in case of decompensation | Health education |
|---|---|---|---|---|
| Antonicelli, 2008 | Daily vital signs measurement[a] + once a week telephone calls + weekly electrocardiogram +24 h urine output on the previous day. | Scheduled clinic visits every four months + monthly telephone calls. | Additional visits whenever changes in signs, symptoms, and clinical status related to worsening of cardiac insufficiency or dyspnea are detected. | Training course to patients and home caregivers to apply the home study protocol and explain the importance of therapeutic adherence and maintaining a suitable lifestyle. |
| Bourge, 2008 | Hemodynamic monitor[b] + daily weight + weekly telephone calls + clinic visits at 1,3 and 6 months. | Random call schedules + clinic visits at 1,3 and 6 months. | Changes in patients' symptoms and medications were documented and notified to clinicians. | NA |
| Chaudhry, 2010 | Daily telephone calls. | Educational material.[c] | Contact any patient whose response of signs and symptoms generated variances + Contact clinicians directly in case of any urgent concerns. | Developed by the Heart Failure Society of America.[c] |
| Cleland, 2005 | Twice daily vital signs measurement[a] + monthly telephone calls + electrocardiogram + research clinic every 4 months. + patient management plan.[d] | Patient management plan[d] + research clinic every 4 months. | Values of vital signs out of preset limits automatically notified study nurses + contact primary care doctor or ambulance service in case of urgency. | NA |
| Dendale, 2012 | Daily vital signs measurement[a] + telephone calls[c] + outpatient clinic 2 weeks after discharge, 3, and 6 months. | Outpatient clinic 2 weeks after discharge + follow-up with general practitioners. | Values of vital signs out of preset limits automatically notified the general practitioner and HF clinic + contacted by general practitioner. | Standard course discussing the cause and consequences of heart failure, medical treatment, the importance of close monitoring of body weight and symptoms, and advice about diet and exercise. |
| Giordano, 2009 | Daily vital signs measurement[a] + weekly or every 15 days telephone calls + electrocardiogram. | Outpatient clinic 2 weeks after discharge + follow-up with a cardiologist at 12 months. | Occasional teleassistance in the presence of signs or symptoms of decompensation + contact general practitioner or cardiologist if signs of hemodynamic instability. | Education about heart failure, including advice on daily self-measurement, rate of conducting blood examinations, dietary restrictions, including sodium and fluid, and signs and symptoms of a heart failure decompensation. |
| Goldberg, 2003 | Twice daily vital signs measurement[c] + Twice daily telephone calls + follow-up with cardiologist at discharge, 2 weeks, 3 months, and 6 months. | Home weight record + follow-up with primary care physician + follow-up visits with cardiologist at discharge, 2 weeks, 3 months, and 6 months. | Values of vital signs beyond the limit were promptly reported to physicians by nurses. | Advice on daily weights, dietary restrictions including sodium and fluid, and signs and symptoms of a heart failure decompensation. |
| Jerant, 2001 | Schedule video conference + telephone calls + integrated electronic stethoscope. | In-person visits with a primary care provider. | Emergency contact numbers. | NA |
| Jiménez-Marrero, 2018 | Daily vital signs measurement[c] + scheduled telephone calls or videoconferences. | Self-monitor bio-measures on daily basis[c] + face-to-face structured follow-up. | In the case of mild decompensation, nurses performed diuretic dose adjustments themselves or with the support of a heart failure physician specialist. | Complete psychosocial, self-efficacy and health-related quality of life evaluation, including health education.[c] |
| Kotooka, 2018 | Daily vital signs measurement[a] + body composition + daily telephone calls. | Body weight measurement + follow-up with primary care physician. | Physician determined the vital signs warning threshold for each patient. If the acquired data exceeded, the monitoring nurses notified the patient's physician. | NA |
| Kulshreshtha, 2010 | Daily vital signs measurement[a] + daily telephone calls. | Standard care.[c] | Vital ranges were established for each patient by their physician. In case of worsening conditions, physicians were notified, and patient referred to an emergency department. | NA |
| Leventhal, 2011 | 17 telephone calls in decreasing intervals over the next 12 months. | Follow-up with primary care physician. | Identification of signs and symptoms of decompensation + consultation with a physician. | Heart failure educational booklet published by the Swiss Heart Failure Foundation.[c] |
| Lynga, 2010 | Daily digital weight scale + daily telephone support + follow-up visits 6–8 weeks after randomization and after 12 months. | Self-monitor weight daily + follow-up visits 6–8 weeks after randomization and after 12 months. | Contact heart failure clinic if weight gain > 2 kg from the target weight or in 3 days and/or worsening symptoms. | NA |
| Olivari, 2018 | Daily vital signs measurement[a] + electrocardiogram. | Schedule visits after the first month from discharge, 3–6 months and after 12 months + telecare service. | Telecare service + Personal alarm in case of sudden worsening of health condition or accident. | NA |
| Scherr, 2009 | Daily vital signs measurement[a] + daily telephone calls. | Pharmacological treatment only.[c] | If transmitted values went outside limit, physicians received an email alert + Teleassistance. | NA |

(Table 2 continues on next page)

| Study | Home-based monitoring | Usual care | Patient management in case of decompensation | Health education |
|---|---|---|---|---|
| (Continued from previous page) | | | | |
| Souza, 2014 | Four telephone calls.[e] | Follow-up with general practitioners. | Early contact with the heart failure team + clinical cardiologist. | Revision of self-care behaviour, and adherence to the prescribed recommendations. Specific information about the expected effects, side effects, and regular posology of heart failure drugs. Importance of weight control, hydro-saline restriction, physical activity, and annual vaccination. |

NA, Not available. [a]Vital signs measurement: weight, heart rate, and blood pressure. [b]Monitoring of body temperature, patient activity, right ventricular systolic and diastolic pressure, maximal positive and negative rate of change in right ventricular pressure (dP/dt), right ventricular pre-ejection and systolic time intervals, and estimated pulmonary arterial diastolic pressure (ePAD). [c]No further details available. [d]The investigator described what pharmacologic treatment patients should receive, in what order and how it should be monitored. [e]Four home visits by trained nurses (10, 30, 60, and 120 days after discharge).

***Table 2:*** **Definitions of HBM and UC across included studies.**

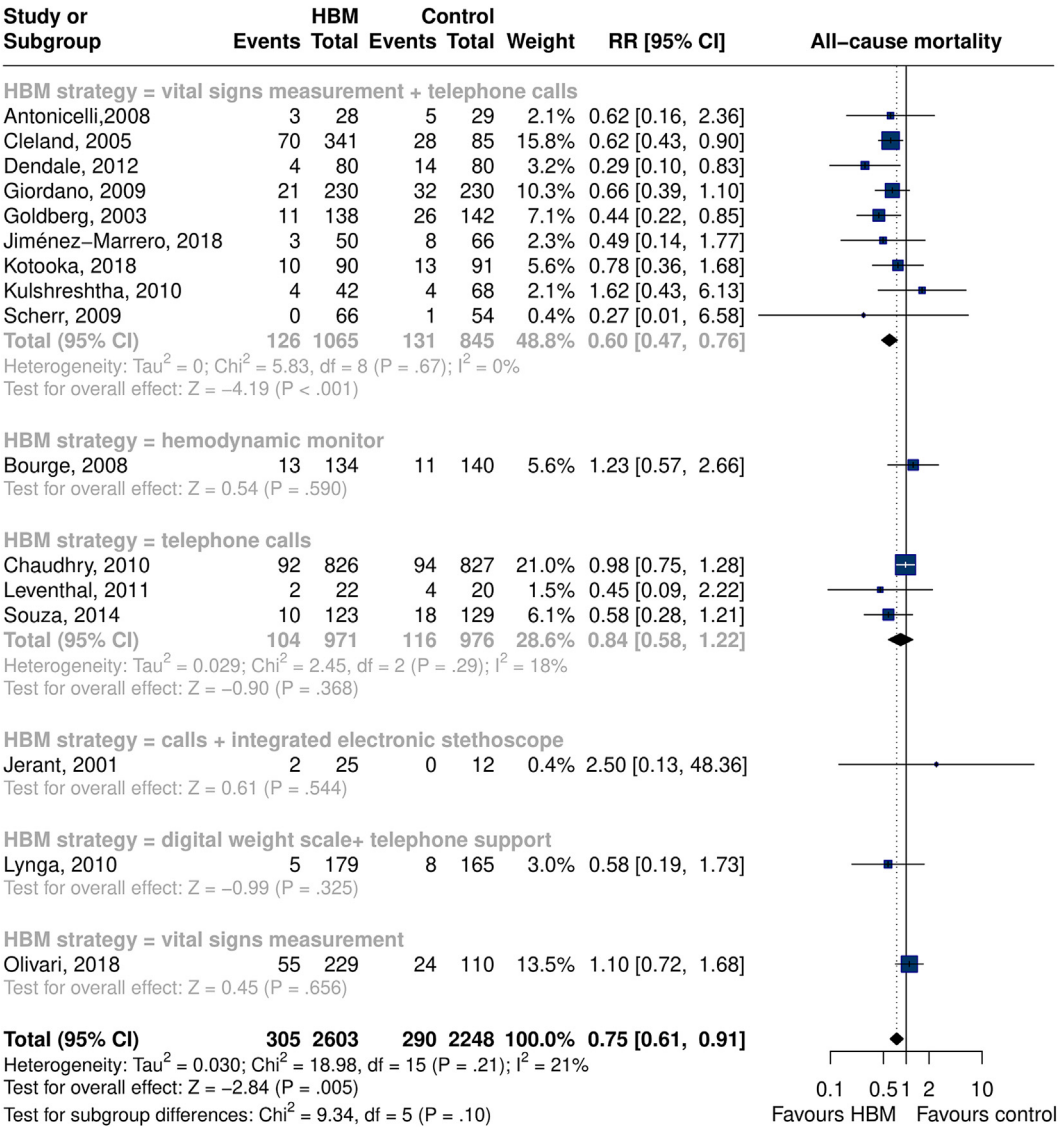


***Fig. 2:*** Home-based monitoring (HBM) significantly reduced all-cause mortality (p = 0.005) compared with usual care (UC).

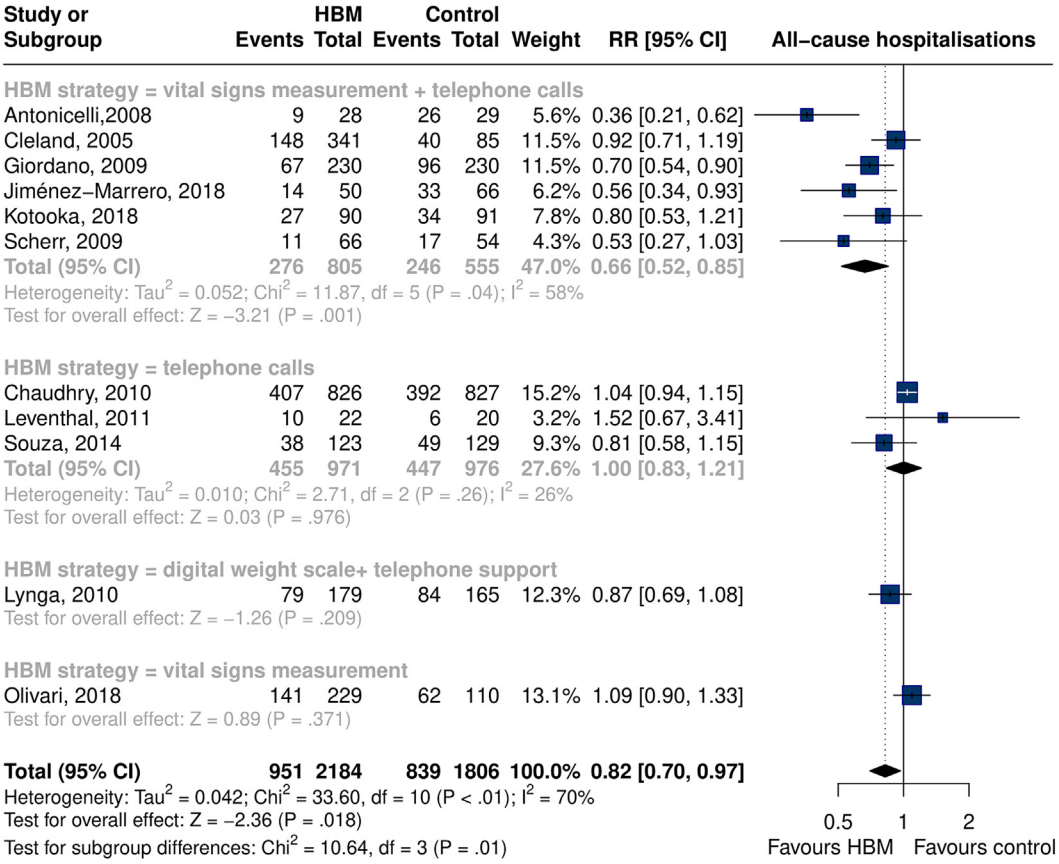


*Fig. 3:* Home-based monitoring (HBM) significantly reduced all-cause hospitalisation (p = 0.018) compared with usual care (UC). There was a significant interaction, favouring the vital signs measurement plus telephone calls approach ($p_{interaction}$ = 0.01).

Results stratified by HBM modality highlighted significant benefits in studies using vital signs measurements plus phone calls monitoring, particularly in the outcome of all-cause hospitalisation, and results remained consistent in CV mortality. This aligns with a previous network meta-analysis which stated that structured telephone support delivered by human-to-human interaction and home telemonitoring with medical support showed beneficial effects in reducing all-cause mortality.[38] This may be attributed to the

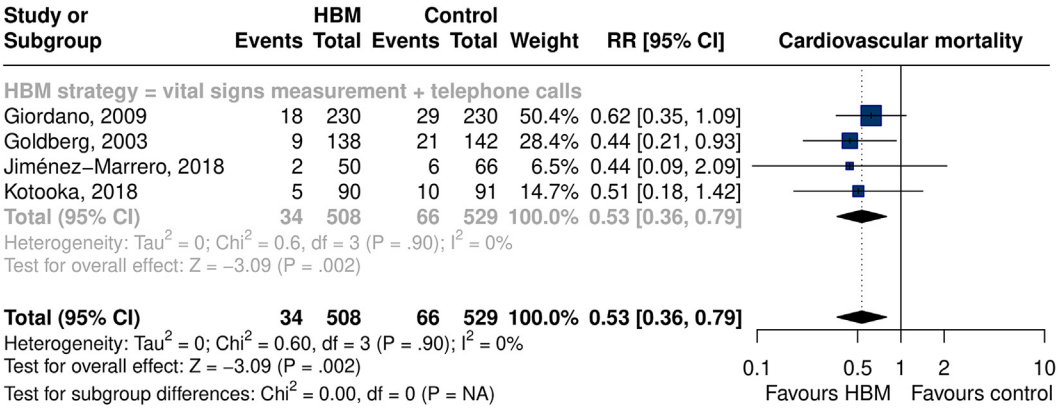


*Fig. 4:* Home-based monitoring (HBM) significantly reduced cardiovascular (CV) mortality (p = 0.002) compared with usual care (UC).

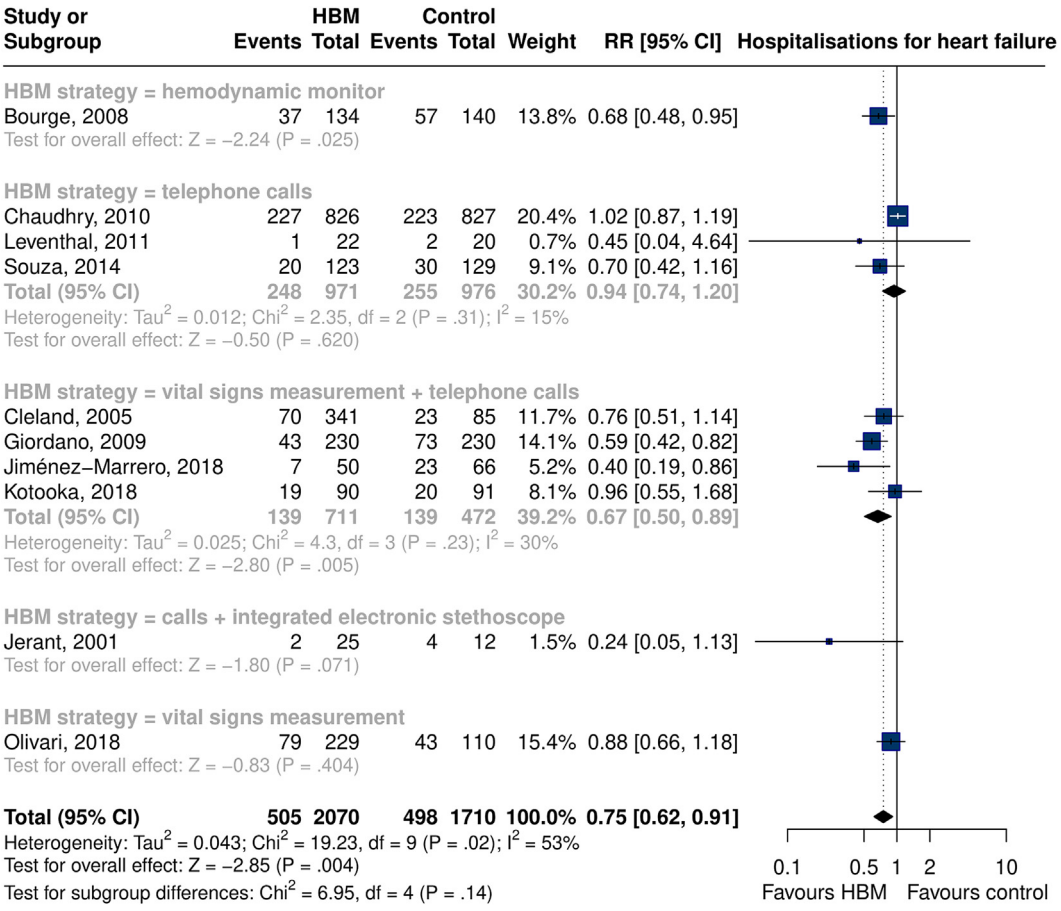


*Fig. 5:* Home-based monitoring (HBM) significantly reduced hospitalisations for heart failure (HHF) (p = 0.004) compared with usual care (UC).

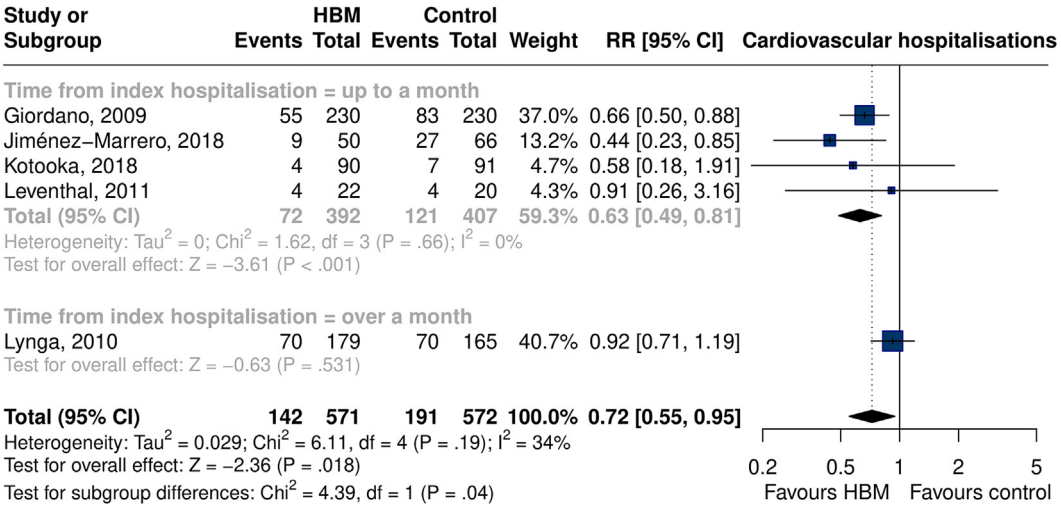


*Fig. 6:* Home-based monitoring (HBM) significantly reduced CV hospitalisations (p = 0.018) compared with usual care (UC). There was a significant interaction according to time, favouring patients hospitalised within one month of the acute decompensated heart failure (ADHF) index admission ($p_{interaction}$ = 0.04).

objectivity and ease of tracking early signs of decompensation, potentially leading to improved adherence.

Scholte and colleagues conducted a meta-analysis including 92 studies and more than 36,000 patients with a diagnosis of chronic HF. They observed that the implementation of HBM (either non-invasive or invasive) reduced all-cause mortality, the first episode of HHF and all HHF events, corroborating our findings.[6] However, our study differs from the above as our targeted population were patients with a recent admission for ADHF 6 months prior to randomisation as we intended to analyse the impact of HBM in preventing adverse outcomes specifically in this high-risk setting. We also provided data on different outcomes such as CV mortality, CV hospitalisations, and all-cause hospitalisations with data extracted only from RCTs.

Recent meta-analyses focusing on patients with stable HF present conflicting results regarding mortality and hospitalisation rates. Umeh and colleagues observed that HBM reduced all-cause mortality, CV mortality, all-cause hospitalisation, and HHF in this population.[8] A network meta-analysis observed a reduction in all-cause mortality, all-cause hospitalisation, CV hospitalisation, and HHF with no significant difference in CV mortality.[12] In contrast, Toro and colleagues found a reduction in HHF with the use of mobile telemonitoring applications, but without a significant effect in all-cause hospitalisations and mortality.[7]

Drews and colleagues in a previous meta-analysis including patients recently admitted for ADHF yielded substantially different results, with no significant differences between groups in all-cause mortality and hospitalisations.[9] However, besides the higher heterogeneity between the included studies, in two of the largest trials included it was not possible to perform direct medication titration by telehealth monitoring in the intervention group as well as the patients had poor adherence to this approach, which was likely the driving factor of the neutral effect of HBM. In three trials with positive results for the HBM approach, the population was on higher doses of guideline-directed medical therapy and had good adherence to this strategy. Lastly, our findings may also be explained by the larger pooled population, and hence higher statistical power, and our focus on longer-term outcomes (over 6 months), which reduces heterogeneity arising from comparisons at different follow-ups.

Our study has limitations. First, the lack of patient-level data prevented more granular subgroup analyses, such as sex differences and stratifications according to HF phenotype. Second, UC definitions varied among included studies, depending on centre-specific practice and protocol. Even so, pooling all studies together provided a closer look into real-world data accounting for locally different clinical approaches. In the subgroup analysis based on HBM definitions, one of the approaches appeared to be superior but the relevance of those findings is uncertain due to the lack of representation of other modalities of HBM. Third, there was also heterogeneity in HBM definitions. To address this limitation, we explored stratified subanalyses of key outcomes according to adopted strategies, which retrieved no significant interactions and pointed to more generalisable results from different interventions that can be ultimately conceived as remote patient monitoring strategies. Fourth, we had limited data on the outcomes of CV mortality and CV hospitalisation, thereby limiting the scope for comprehensive conclusions on these outcomes. Fifth, our follow-up duration ranged from six to fifteen months. However, we recognise that in a chronic condition such as HF, longer-term monitoring should ideally extend beyond this timeframe. Of note, we included the longest follow-up available for each study. Finally, direct comparisons between individuals with impaired LVEF and patients with preserved LVEF were not feasible due to a lack of discrimination regarding LVEF classification in the available studies.

In summary, HBM significantly reduced all-cause mortality, all-cause hospitalisation, CV mortality, HHF, and CV hospitalisations and early adoption of HBM strategies is implicated in favourable outcomes. This supports the incorporation of HBM as standard care to improve patient outcomes following admissions for ADHF.

#### Contributors

MRCC and NF contributed to study conception and design. Material preparation, data collection, and analysis were performed by MRCC, NF, EP, ROMF, DDPN, MAPB, TAC, AN, and ADM. The first draft of the manuscript was written by MRCC, NF, AN, and DDPN. ROMF, EP, and AF reviewed and commented on previous versions of the manuscript. AF supervised the process. MRCC, NF, and AF accessed and verified the underlying data. All authors read and approved the final manuscript. All authors confirm that they had full access to all the data in the study and accept responsibility for the decision to submit for publication.

#### Data sharing statement

The authors confirm that the data supporting the findings of this study are available within the article and its Supplementary materials.

#### Declaration of interests

We declare no competing interests.

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#### Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.eclinm.2024.102541.

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