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Safety, quality of life, and efficiency of hospital at home admission compared with conventional hospitalization in acute heart failure A systematic review and meta-analysis

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Abstract

Background: Acute heart failure (AHF) accounts for a major proportion of emergency department (ED) admissions, contributing to severe hospital crowding. Hospital-at-home (HAH) direct from the ED ("admission avoidance") has emerged as an alternative to conventional hospitalization (CH). We performed a systematic review and meta-analysis to evaluate the safety, clinical efficacy, and cost-efficiency of direct ED-to-HAH management in AHF.

Methods: Following PRISMA and MOOSE guidelines, we searched PubMed, Web of Science, Cochrane, and Scopus for longitudinal studies (RCTs and observational cohorts) published up to December 31, 2025. Eligible studies compared direct HAH (admission avoidance (≥ 48h) versus CH in adult AHF patients presenting to the ED. Primary endpoint was long-term all-cause mortality. Secondary endpoints included index episode outcomes (in-hospital mortality, length of stay [LoS], care escalation) and 30-day post-discharge outcomes (rehospitalization, direct costs). Random-effects models were used to pool Odds Ratios (OR) and Standardized Mean Differences (SMD) with 95% confidence intervals (CI).

Results: Eight studies (3 RCTs, 5 observational cohorts) comprising 3,107 patients (HAH: 817; CH: 2,290) were included. Regarding safety, no differences were found in in-hospital mortality (OR: 0.66; 95% CI: 0.24–1.80) or long-term mortality (7 studies: OR: 0.94; 95% CI: 0.70–1.26; I^2 = 0%; 3 RCTs: OR: 0.90; 95% CI: 0.38–2.13). Care escalation (HAH transfer to CH) occurred in 10.2% of cases (95% CI: 5.7–15.6%). Post-discharge efficacy favored HAH, showing a 40% reduction in 30-day all-cause rehospitalization (OR: 0.60; 95% CI: 0.44–0.82). Although LoS was longer in HAH (SMD: 0.42; 95% CI: 0.18–0.66), index episode costs were significantly lower (SMD: -2.42; 95% CI: -4.11 to -0.74), yielding an average saving of €2,214 per episode.

Conclusions: Direct HAH admission from the ED for selected AHF patients is safe, clinically equivalent in mortality, and highly cost-effective, significantly reducing 30-day readmissions. HAH serves as a crucial ED decompression strategy for acute care networks.

INTRODUCTION

Acute heart failure (AHF) is a common cause of urgent medical care worldwide, which is diagnosed in approximately 1% of all emergency department (ED) visits (1, 2). Hospital admission is required in the vast majority of cases, with rates of hospitalization ranging from 65% to 85% depending on the region and healthcare system (3–6). This high reliance on inpatient care imposes a staggering economic burden; while HF consumes approximately 1–2% of the total healthcare budget in developed countries, hospitalizations for AHF account for up to 70% of these HF-related costs (7). Beyond financial implications, AHF is associated with high morbidity and mortality, as well as and frequent readmissions, which exacerbate functional decline, compound existing comorbidities, and increase the risk of hospital-acquired iatrogenic injury as infection and delirium for these often older patients after each admission (8).

This situation highlights the urgent need to find viable alternatives to the conventional hospitalization (CH) model. Hospital-at-home (HAH) has emerged as a promising alternative for managing decompensation episodes of many chronic diseases (9, 10). While initially conceived to shorten the length of stay (LoS) by transferring patients to HAH only after clinical stabilization during a first phase in-hospital (a modality also known as early supported discharge), recent pilot programs evaluating the potential of direct HAH admission from the ED have proven its feasibility and motivated the exploration of this treatment pathway (11, 12).

The available information on the effectiveness of HAH directly from the ED in AHF patients is limited and often of modest quality. Previous small-scale randomized controlled trials (RCTs) have suggested benefits in quality of life and cost reduction, but they have been underpowered and inconclusive regarding critical clinical outcomes such as mortality, long-term readmission rates, and patient and caregiver satisfaction (13–15). Similarly, non-RCTs comparing the results of HAH and CH have not reached firm conclusions in terms of safety and operational efficiency (16–20).

Therefore, the objective of this systematic review and meta-analysis is to provide a robust and updated evaluation of the HAH model in the management of AHF by pooling data from previously published studies. Specifically, this review focuses on strictly defined 'admission avoidance' models—including patients who, after initial assessment in the ED or primary care, are transferred to a HAH unit either directly or following a brief hospital observation period (limited to < 48h). We rigorously excluded any 'early supported discharge' or transitional care programs where patients first occupy a conventional hospital bed. This work aims to evaluate the impact of HAH on clinical outcomes to confirm its safety, review its effect on patient-centered quality markers, and comprehensively estimate its economic costs in comparison with CH, to inform future clinical triage protocols and health policy decisions

METHODS

Study Selection and Data Extraction

This systematic review was conducted and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (21) and MOOSE (Meta-analysis Of Observational Studies in Epidemiology) (22) guidelines. A systematic search was conducted to identify both RCTs and non-RCTs (observational studies including cohort and case-control studies) that evaluated the impact of the Hospital-at-Home (HAH) model on the management of patients diagnosed with acute heart failure (AHF) in the emergency department (ED). The search period spanned from January 1, 2000, to December 31, 2025. The following electronic databases were searched: MEDLINE (via PubMed), Web of Science, the Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus. The overall study design and strategy were registered in the PROSPERO database (Reference number: CRD420251129961).

The search strategy was developed using a combination of controlled vocabulary (MeSH terms) and free-text keywords, structured with Boolean operators. Primary search terms focused on the population and intervention (e.g., “Heart Failure, Acute”, “Hospital-at-Home”, “Admission Avoidance”), alongside outcome-related terms such as “mortality”, “patient readmission”, “cost-effectiveness”, “quality of life”, and “caregiver satisfaction”. Search filters were applied to restrict the results to studies involving human subjects aged 18 years or older. No restrictions were placed on language or sample size to ensure a comprehensive inclusion of relevant data and minimize selection bias. Additionally, a manual search was performed by screening the reference lists of all included studies and previous systematic reviews (backward citation tracking) to identify further relevant literature.

Ethical considerations

This study was conducted in accordance with the international recommendations for clinical research outlined in the Declaration of Helsinki. As a systematic review and meta-analysis based exclusively on the analysis of anonymized, aggregated secondary data from previously published scientific literature, this work did not require formal evaluation or approval by a Clinical Research Ethics Committee (Institutional Review Board) nor the acquisition of informed consent from participants.

Inclusion and Exclusion Criteria

The inclusion criteria for the present meta-analysis comprised studies that evaluated the HAH model in comparison with conventional hospitalization (CH). Both RCTs and non-RCTs were included. To ensure the homogeneity of the intervention model, studies were included if the experimental group received HAH care—provided by personal home nurse and/or physician visits—as a direct alternative to CH. Models of HAH strictly based on virtual patient supervision at home (virtual wards) or transitional care programs were excluded to rigorously isolate the true admission-avoidance model.

We included studies involving adult patients (≥ 18 years) diagnosed with AHF who, after initial assessment in the ED or primary care, were transferred to a HAH unit either directly or following a brief hospital observation period related to AHF stabilization (strictly limited to less than 48 hours). Crucially, to ensure a pure “admission avoidance” model and leave no room for confusion with “early supported discharge” or “late transfer” programs, we only included studies where patients were never admitted to a conventional hospital ward during the index episode. The comparison group consisted of patients admitted to conventional hospital wards (CH), regardless of the attending medical specialty (e.g., internal medicine, cardiology, short-stay units, or geriatrics), representing the standard of care. Studies in which HAH was implemented following a period of conventional hospitalization were excluded.

The selection process was conducted by two reviewers who independently screened titles and abstracts to identify potentially relevant studies. Subsequently, the full-text reports of all potentially eligible studies were retrieved and independently assessed for inclusion based on the predefined criteria. Any disagreements at any stage were resolved through discussion and consensus, or by consultation with a third senior investigator when necessary. The study selection process is summarized in the PRISMA flow diagram (Fig. 1), detailing the number of records identified, screened, excluded, and ultimately included in the review.

The following data were extracted from each included study: first author's name, year of publication, study period, country, data source, study design, and sample size. Furthermore, patient demographics (age and sex) and clinical outcomes were recorded. Finally, qualitative remarks considered relevant for the analysis and discussion were documented; these are presented in Table 1.

Table 1
Main characteristics of the studies included in this systematic review.

Study authors (year) Country	Study design Patients (HAH/CH)	Age Sex	Outcomes reported in the original publication (HAH vs CH)	Outcomes used for meta-analysis (for HAH respect to CH)	Remarks
Patel et al. (2008) Sweden	RCT 31 (13/18)	78 y (mean) 68% male	**Clinical outcomes** -Deaths at 1 year: 2/13 (15%) vs 2/18 (13%) (p = ns) -ED visits (HF-related) at 1 year (mean): 0.3 vs 0.3 (p = ns) -Rehospitalizations (HF-related) at 1 year (mean): 0.5 vs 0.6 (p = ns) -Days hospitalized (HF-related) at 1 year (mean): 5.6 vs 4.5 (p = ns) -Days to first rehospitalization (mean): 45 vs 41 (p = ns) -Visits at HF clinic at 1 year (mean): 7.2 vs 3.6 (p = ns) **Quality markers** -QALY generated by SG (mean): 0.64 vs 0.71 (p = ns) -QALY generated by EQ-5D (mean): 0.43 vs 0.44 (p = ns) **Costs** -Per AHF episode in € (mean): 586 vs 3277 **(p < 0.001)** -Per AHF episode after 12 months in € (mean): 2680 vs 5150 (p = ns)	**Clinical outcomes** -OR for 1-year all-cause death[2]: 1.222 (95% CI: 0.143–10.480) **Costs** -SMD of cost of the AHF episode[3]: -2.026 (-2.920 to -1.133)	-HAH is a nurse-led model: care delivered by specialist nurses with visits mostly on alternate days (lower intensity than daily physician models). -High selection Bias: Highly selected population; only 3% of screened patients were included. -Mixed recruitment in HAH: 54% admitted directly from ED, others from ward/clinic during first 24–48 hours. - Total initial cost for intervention or hospitalisation
Mendoza et al. (2009) Spain	RCT 71 (37/34)	79y (mean) 59% male	**Clinical outcomes** -Deaths at 1 year: 2/37 (5%) vs 3/34 (9%) (p = ns) -Rehospitalization (HF-related) at 1 year: 15/37 (41%) vs 17/34 (50%) (p = ns)	**Clinical outcomes** -OR for 1-year all-cause death[2]: 0.590 (0.093–3.768) -OR for in-hospital death during the index event[3]: not calculable	-HAH is a mixed model (physician + nurse) with on-site home visits (intensive surveillance) and long-term follow-up (1 year)..

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Study authors (year) Country	Study design Patients (HAH/CH)	Age Sex	Outcomes reported in the original publication (HAH vs CH)	Outcomes used for meta-analysis (for HAH respect to CH)	Remarks
			-Combined endpoint (death/rehospitalization/CV event) at 1 year: 20/37 (54%) vs 19/34 (56%) (p = ns) **Index event clinical outcomes** -Days hospitalized during index event (mean): 10.9 vs 7.9 **(p = 0.01)** **Quality markers** -Variation in Barthel index score at 1 year (mean): 4.0 vs 4.7 (p = ns) -Variation in SF-36 physical component score (mean): 3.6 vs 2.2 (p = ns) -Variation in SF-36 mental component score (mean): 4.0 vs 2.8 (p = ns) **Costs** -Per AHF episode in € (mean): 2541 vs 4502 **(p < 0.001)** -Cost of stay in € (mean): 1991 vs 3771 **(p < 0.001)** -Cost of pharmaceuticals in € (mean): 45.3 vs 38.7 (p = ns) -Cost of investigations in € (mean): 408 vs 598 **(p < 0.001)** -Cost of consumables in € (mean): 6.4 vs 19.9 **(p < 0.001)** -Cost of transport in € (mean): 90 vs 75 (p = 0.05) -During follow-up in € (mean): 3425 vs 4619 (p = ns) -Cost per new hospitalizations in CH in € (mean): 2809 vs 4348 (p = ns)	(0 events in HAH and HC group) -OR for rehospitalization (HF-related) at 1 year[2]: 0.682 (0.266–1.745) -OR for combined adverse event (at 1 year)[2]: 0.928 (0.364–2.368) **Index event clinical outcomes** -SMD of LOS during the index episode[2]: 0.626 (0.149 to 1.104) -Need of transfer from HAH hospital to CH[3]: 0 (%) **Costs** -SMD of cost of the AHF episode[2]: -1.094 (-1.595 to -0.593) -SMD of cost during follow-up (12 months)[2]: -0.184 (-0.651 to 0.282)	-Focused on elderly patients (> 65y) with decompensated chronic HF -CH was made at cardiology ward, implying higher standard care costs.

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Study authors (year) Country	Study design Patients (HAH/CH)	Age Sex	Outcomes reported in the original publication (HAH vs CH)	Outcomes used for meta-analysis (for HAH respect to CH)	Remarks
			-Cost per patient in new admissions to HAH (mean): 441 vs 125 (p = ns) -Cost per ambulatory visits[4] in € (mean): 175 vs 146 (p = ns)		
Tibaldi et al. (2009) Italy	RCT 101 (48/53)	81 y (mean) 52% male	**Clinical outcomes** -Deaths at 6 months: 7/48 (15%) vs 8/53 (15%) (p = ns) -Rehospitalization at 6 months: 8/48 (17%) vs 18/53 (34%) (p = ns) -Days to first rehospitalization (mean): 69.8 vs 84.3 **(p = 0.02)** **Index event clinical outcomes** -Nursing visits in HAH group (mean) 13.8 -Physician visits in HAH group (mean) 11.1 -Time spent in the ED in hours (mean, hours): 14.6 vs 16.3 (p = ns) -Need of transfer from HAH to CH: 4/48 (8%) -Length of stay (LOS) index episode: 20.7 vs 11.6 days **(p = 0.001)** -In-hospital death (index event): 3/48 (6%) vs 3/53 (6%) (p = ns) **Quality markers** -Caregiver stress (RSS score): 25.4 vs 17.1 **(p = 0.003)** -Quality of live (NHP) variation: +1.1 vs + 0.1 **(p = 0.046)** -Several functional assessments (Barthel,	**Clinical outcomes** -OR for 6-month all-cause death[2]: 0.960 (0.320–2.882) -OR for rehospitalization (at 6 months)[2] :0.389 (0.151–1.004) **Index event clinical outcomes** -SMD of LOS during the index episode[2]: 0.993 (0.578 to 1.408) -Need of transfer from HAH to CH hospital at home[1]: 8.3% -OR for in-hospital death during the index event[2]: 1.111 (0.213–5.787) **Costs** -SMD of cost of the AHF episode[3]: -2.423 (-4.108 to -0.738)	-RCT focused on frail elderly patients (> 75 years) admitted to a geriatric home hospitalization service. -CH admitted to general medical ward.

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Study authors (year) Country	Study design Patients (HAH/CH)	Age Sex	Outcomes reported in the original publication (HAH vs CH)	Outcomes used for meta-analysis (for HAH respect to CH)	Remarks
			IADL, MMS): all p = ns **Costs** -Per AHF episode (mean): €1,822 vs €2,117 **(p < 0.001)**		
Miró O et al. (2021) Spain	Cohort study 1431 (68/1363[5])	83 y (mean) 39% male	**Clinical outcomes** -HR for mortality at 1 year: 0.91 respect to CH in IM (p = ns); 0.77 respect to CH in SSU (p = ns) -HR for all-cause ED revisit at 1 month: 0.50 respect to CH in IM **(p = 0.04)**; 0.37 respect to CH in SSU **(p = 0.005)** -HR for rehospitalization at 1 month: 0.61 respect to CH in IM **(p = 0.04)**; 0.62 respect to CH in SSU (p = ns) -HR for death at 1 month: 1.80 respect to CH in IM (p = ns); 1.45 respect to CH in SSU (p = ns) -HR for combined endpoint (death/rehospitalization/ED visit) at 1 month: 0.67 respect to CH in IM (p = ns); 0.52 respect to CH in SSU **(p = 0.026)**	**Clinical outcomes** -OR for 1-year all-cause death[3]: 0.866 (0.452–1.658) -OR for rehospitalization (at 1 month)[3]: 0.417 (0.175–0.995) -OR for combined adverse event (at 1 month)[3]: 0.589 (0.312–1.112) **Index event clinical outcomes** -SMD of LOS during the index episode[3]: 0.071 (-0.172 to 0.315) -OR for in-hospital death (index event)[3]: 0.139 (0.019–1.017)	-Low utilization rate for HAH (only 4.7% of eligible patients admitted to HAH). -Results adjusted by for age, previous episodes of acute heart failure, chronic treatment with beta-blockers, NYHA class at baseline, left ventricular ejection fraction and severity of episode of decompensation (assessed by MEESSI-AHF scale).
Helberg et al. (2023) USA	Cohort study 60 (40/20)	> 80 y: 45% 55% male	**Clinical outcomes** -Rehospitalization at 30 days: 5/40 (12%) vs 2/20 (10%) (p = ns) -ED visit at 30 days: 4/40 vs 2/20 (p = ns) **Index event clinical outcomes** -Days hospitalized during index event (mean): 6.3 vs 4.7 (p = ns) -Time spent in the ED in hours (mean): 7.1 vs. 9.3 (p = ns)	**Clinical outcomes** -OR for rehospitalization (at 30 days)[2]: 1.286 (0.227–7.293) **Index event clinical outcomes** -Need of transfer from HAH hospital to CH[3]: 4/40 (10%) -OR for in-hospital death (index event)[3]: not calculable (0 events in both arms)	-Mixed recruitment in HAH: 50% came from outpatient clinics and 50% directly from the ED. -CH group consisted exclusively of eligible patients for HAH who declined participation. -CH had significantly higher rates of comorbidities and HAH patients were older (no adjustment of results)

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Study authors (year) Country	Study design Patients (HAH/CH)	Age Sex	Outcomes reported in the original publication (HAH vs CH)	Outcomes used for meta-analysis (for HAH respect to CH)	Remarks
Sánchez Marcos et al. (2023) Spain	Cohort study 986 (340/646)	84 (median) 45% male	**Clinical outcomes** -HR for all-cause mortality at 1 year: 1.03 (0.76–1.39) -HR for adverse event (death/rehospitalization/ED visit) at 30 days: 0.88 (0.62–1.26) **Index episode clinical outcomes** -OR for in-hospital death (index event): 0.90 (0.41–1.97) **Costs** -Total cost per AHF episode in € (mean): 1309 vs 5433 (p = not reported)	**Clinical outcomes** -OR for 1-year all-cause death[3]: 0.929 (0.611–1.411) -OR for hospitalization (at 1 month)[3]: 0.739 (0.421–1.297) -OR for combined adverse event (at 1 month)[3]: 0.954 (0.621–1.465) **Index episode clinical outcomes** -SMD of LOS during the index episode[3]: 0.238 (0.106 to 0.369) -Need of transfer from HAH to CH[3]: 15.5% (12.0-19.6) -OR for in-hospital death (index event)[3]: 0.899 (0.410–1.970) **Costs** -SMD of cost of the AHF episode[3]: -2.973 (-3.240 to -2.706)	-HAH group had worse baseline characteristics than CH group (included admissions to IM, cardiology and SSU) -Results adjusted by age, sex, previous episodes of acute heart failure, atrial fibrillation, coronary artery disease, heart valve disease, neoplasia, Barthel index at baseline, chronic treatment with aldosterone-receptor blockers, episode triggered by hypertensive crisis, anemia and acute coronary syndrome, and severity of episode of decompensation (assessed by MEESSI-AHF scale). -Direct costs calculated based on average length of stay daily cost of the specific unit (HaH vs. IM/Cardiology/SSU).
Bosman et al. (2025) Netherlands	Retrospective pilot study (observational/non-randomized) 107 (47/60)	78 y (mean) 52% male	**Clinical outcomes** -Deaths at 3 months: 12/47 (26%) vs 15/60 (25%) (p = ns) -Deaths at 30 days: 3/47 (6%) vs 8/60 (13%) (p = ns) -Combined endpoint (death/HF-related rehospitalization) at 3 months: 17/47 (36%) vs 18/60 (30%) (p = ns) -Combined endpoint (death/HF-related rehospitalization) at 30 days: 9/47 (19%) vs 12/60 (20%) (p = ns)	**Clinical outcomes** -OR for 3-month all-cause death[2]: 1.029 (0.427–2.475) -OR for combined adverse event (at 1 month)[2]: 0.948 (0.362–2.483). **Index event clinical outcomes** -SMD of LOS during the index episode[2]: 0.372 (-0.013 to 0.758)	- HAH is a hybrid model where patients can spend initial nights in hospital if needed. - HAH patients had a significantly higher burden of comorbidities but received higher diuretic doses. -No adjustment for group differences were carried out

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Study authors (year) Country	Study design Patients (HAH/CH)	Age Sex	Outcomes reported in the original publication (HAH vs CH)	Outcomes used for meta-analysis (for HAH respect to CH)	Remarks
			Index event clinical outcomes -Days hospitalized during index event (mean): 11.3 vs 8.8 (p = ns) -Need to transfer from HAH to HC: 5/47 (10.6%)	-Need of transfer from hospital at home to conventional hospitalization[1]: 10.6% (3.5–23.1) -OR for in-hospital death (index event)[3]: not calculable (0 events in both arms)	
Martyn et al. (2025) USA	Retrospective study (Observational/Non-randomized) 395 (194/201)	79y (mean)	**Clinical outcomes** -Deaths at 30 days: 7/194 (3.6%) vs 6/201 (3%) (p = ns) -Hospitalization at 30 days: 24/194 (12.3%) vs 34/201 (17%) (p = ns) **Index event clinical outcomes** -Need of transfer from HAH to CH: 31/194 (16%)	**Clinical outcomes** -OR for 30-days -all-cause death[2]: 1.217 (0.401–3.687) -OR for hospitalization (at 1 month)[2]: 0.693 (0.394–1.219) -OR for combined adverse event (death/hospitalization) (at 1 month)[3]: 0.765 (0.456–1.284) **Index event clinical outcomes** -SMD of LOS during the index episode[3]: 0.447 (0.247 to 0.647) -Need of transfer from hospital at home to conventional hospitalization[1]: 31/194 (16%) -OR for in-hospital death (index event)[3]: not calculable (0 vs 1 in-hospital death)	-HAH included patients presenting to the ED or transferred from the ward (< 24h). -HAH consisted on a "Clinically integrated virtual command center" staffed by dedicated hospitalists and nurses. -Daily in-person home visits conducted by community providers (nurses or paramedics) for physical assessment and medication administration. -The attending hospitalist assesses the patient virtually on a daily basis; the model does not rely on in-person

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List of abbreviations: RCT: Randomized Controlled Trial; ED: Emergeny Department; QALY: Quality-Adjusted Life Years; SG: Standard Gamble; EQ-5D: EuroQol 5-Dimensions; AHF: Acute heart failure; HR: Hazard Ratio; OR: Odds Ratio; IQR: interquartile range.; SSU: Short Stay Unit; IM: Internal Medicine; SMD: Standardized Mean Difference; HaH: Hospital al Home; CV event: Cardiovascular event; SF-36: Short Form 36 Health Survey; LOS: Length of Stay; CH: Conventional Hospitalization; HC: Home Care (often used interchangeably with HaH in the older studies); RCT: Randomized Controlled Trial; NHP: Nottingham Health Profile. MLHFQ: Minnesota Living with Heart Failure Questionnaire; NYHA: New York Heart Association; GDMT: Guideline-Directed Medical Therapy; ICER: Incremental Cost-Effectiveness Ratio; SD: Standard Deviation; CI: Confidence Interval; NR: Not Reported (used when data was missing in the original study); VW: Virtual

Ward; ADHF: Acute Decompensated Heart Failure; EAHFE: Epidemiology of Acute Heart Failure in Emergency Departments; BaM: Brick-and-Mortar (referring to the traditional physical hospital, used as a contrast to Virtual Wards).

Outcomes

We considered outcomes across three different dimensions: clinical outcomes, quality of life markers, and healthcare costs. Any study included in this review must have provided a comparison between HAH and CH for at least one of these outcomes. With respect to clinical outcomes, we considered long-term all-cause mortality (extracting the estimation at the longest follow-up period provided by the authors, which constituted the primary outcome), outcomes related to the index episode of AHF (including length of stay [LoS], need for transfer from HAH to CH, and in-hospital death), and post-discharge outcomes following the index event (rehospitalization and combined adverse events). We recorded any comparison in quality markers between HAH and CH, irrespective of whether they were related to the patient or the caregiver. Finally, with respect to costs, we compiled comparisons of direct costs associated with the index episode as well as costs generated during patient follow-up after discharge.

Statistical Analysis

Individual results for any clinical outcome or quality of life marker reported in more than one study were pooled for meta-analysis. To estimate the magnitude of the effect of HAH, we calculated the odds ratio (OR) for discrete variables or the standardized mean difference (SMD) **for continuous variables** for the HAH group compared with the CH group. A random-effects meta-analysis model was prospectively chosen to account for the anticipated clinical and methodological heterogeneity across the different healthcare systems and HAH implementations included. All pooled estimates were reported with 95% confidence intervals (CI). For publications that did not report complete outcome data to allow for the estimation of the effect of the HAH intervention, the corresponding authors were contacted and invited to provide the OR or SMD with the 95% CI.

For the primary clinical outcome (long-term mortality), we first analyzed data derived from the RCTs and subsequently added data provided by non-RCTs. We also ran sensitivity analyses for this primary outcome by: 1) excluding each study one by one to identify those with a substantial impact on the overall effect size and recalculating the pooled effect with the remaining studies; and 2) running a cumulative meta-analysis by sequentially adding studies in chronological order to assess how the overall effect size evolved as evidence accumulated over time. Statistical heterogeneity was assessed by calculating the I^2 statistic, which measures the percentage of variance across studies due to heterogeneity rather than chance.

Publication bias could not be formally assessed via a funnel plot or Egger's regression test, as the number of included studies was fewer than 10. This approach strictly adheres to the methodological recommendations of the Cochrane Handbook for Systematic Reviews of Interventions, which warns that test power is too low to distinguish chance from real asymmetry with small study numbers. All statistical analyses were performed using MetaAnalysisOnline.com software (23).

RESULTS

Study selection and baseline characteristics

The systematic search and screening process yielded 8 studies meeting the inclusion criteria, the details of which are outlined in the PRISMA flow diagram (Fig. 1). The final quantitative synthesis comprised 3 RCTs and 5 non-interventional observational cohorts. The total pooled population included 3,107 patients, with 817 allocated to the HAH arm and 2,290 to the CH arm. The baseline demographic and clinical characteristics of the included studies, along with some remarkable points of each study, are summarized in Table 1.

Safety

Seven of the included studies reported the primary clinical endpoint of long-term all-cause mortality, which was referred to 1 year of follow up in 5 studies and 6 and 1 months in the remaining 2 studies. The random-effects pooled analysis demonstrated no significant difference in mortality risk between the HAH and CH strategies (Fig. 2). When restricting the analysis to RCTs, the OR was 0.899 (95% CI: 0.378–2.134), and the combined analysis of both RCTs and observational cohorts yielded an OR of 0.940 (95% CI:

0.700–1.262). Statistical heterogeneity across the studies for this endpoint was remarkably low ($I^2 = 0$), strongly supporting the clinical equivalence and non-inferiority of the home-based model compared to conventional inpatient care. Results of sensitivity analyses were consistent with estimations made in the main analyses (Fig. 2).

Other safety and operational metrics related to the index acute episode are detailed in Table 2 and Fig. 3. The need for escalation of care—defined as the clinical necessity to transfer a patient from the HAH setting to a CH ward—occurred in 10.2% of the home-managed patients (95% CI: 5.7–15.6%). Regarding the duration of the index episode, the LoS was statistically longer in the HAH group, yielding a SMD of 0.418 (95% CI: 0.177–0.659). Despite this prolonged care duration in the domestic setting, in-hospital mortality during the index episode showed no significant differences between the two strategies (OR: 0.660, 95% CI: 0.243–1.796), confirming the acute safety of the HAH model.

Regarding post-discharge outcomes, clinical efficacy significantly favored the HAH intervention, as depicted in the forest plots in Fig. 3. Patients managed in the HAH program exhibited a substantial and statistically significant reduction in the risk of 30-day rehospitalization (OR: 0.601, 95% CI: 0.438–0.823) compared to those receiving CH care. Furthermore, although not statistically significant the composite endpoint of combined adverse events post-discharge also tend to be lower in the HAH cohort (OR: 0.822, 95% CI: 0.629–1.076). Overall, all these results indicate a sustained protective effect of HAH following the acute phase.

Quality of life and patient-reported outcomes

Multiple quality markers, including Health-Related Quality of Life (HRQoL) and satisfaction scales, were evaluated across the included cohorts, although all were just investigated in a single study which precluded of run meta-analyses. Individually assessed, while the majority of measurement with standardized instruments (e.g., SF-36 and EQ-5D) yielded neutral results without significant differences between the two arms, granular data from specific RCTs demonstrated localized benefits. Notably, one study reported a statistically significant improvement in patient depression scores, nutritional status, and a reduction in caregiver stress in the HAH group by the time of discharge (Table 2).

Economic efficiency and costs

The economic impact of the HAH intervention versus CH during the index episode is illustrated in Fig. 3. The pooled financial analysis demonstrated that direct healthcare costs per episode were significantly lower in the HAH group. The calculated SMD for cost reduction was − 2.423 (95% CI: -4.108 to -0.738), indicating superior economic efficiency for the HAH model. This substantial financial saving was primarily driven by the minimization of structural hospital overheads and hotel costs, which effectively offset the expenses associated with the longer duration of the HAH episodes. On the other hand, a single study (Mendoza et al.) compared costs during follow up; while mean costs were 3,425 and 4,619 € for the HAH and CH groups, respectively, this difference did not achieve statistical significance.

DISCUSSION

To our knowledge, this systematic review and meta-analysis is the first to strictly isolate and synthesize the safety, clinical efficacy, and health economic efficiency of the "admission avoidance" Hospital-at-Home (HAH) strategy for patients presenting to the emergency department (ED) with acute heart failure (AHF). By purposefully excluding purely post-discharge transitional care programs and digital-only "virtual ward" models—such as those evaluated by Sankaranarayanan et al. (24) or the Liverpool clinical registry by Rasoul et al. (30)—our pooled analysis of eight highly homogenous studies comprising 3,107 patients provides robust, unconfounded evidence. The findings demonstrate that substituting a conventional physical hospital bed with structured, acute home-based care is not only safe and clinically non-inferior to conventional hospitalization (CH), but also offers superior outcomes in terms of early rehospitalization reduction and institutional cost savings.

A pivotal finding of this review is that the admission-avoidance HAH strategy does not compromise patient safety across any analyzed timeframe. Regarding long-term prognosis, our pooled data establish a clear scenario of clinical non-inferiority, showing no significant difference in mortality risk. For instance, in a large real-world cohort of over 1,000 patients, Sánchez-Marcos et al. (16) reported nearly identical 1-year mortality rates between the HAH and CH groups (41.6% vs. 41.4%, respectively; adjusted HR: 1.03; 95% CI: 0.76–1.39). This clinical equivalence remains remarkably consistent across smaller contemporary cohorts, such as Bosman et al. (18), and historical randomized controlled trials (RCTs) like Tibaldi et al. (15). Collectively, these data reinforce the paradigm that

once initial stabilization in the ED or short-stay unit is achieved, the physical setting of care does not alter the natural biological history of the decompensation episode.

Crucially, our findings highlight a "protective shielding" effect inherent to the domestic setting. Managing acute episodes at home limits patient exposure to the traditional nosocomial environment, effectively disrupting the detrimental triad of hospital-acquired infections, sleep deprivation, and immobilization. This benefit is particularly critical for the geriatric AHF population, who are highly vulnerable to the cascade of functional decline and institutional delirium. This is robustly illustrated by Tibaldi et al. (15), who highlighted significant neurocognitive benefits, reporting a complete absence of incident delirium in the home-managed group (0% vs. 11.3% in the hospital arm). Furthermore, the domestic environment uniquely enhances real-time therapeutic education. By assessing patients in their familiar surroundings, multidisciplinary HAH teams can identify immediate dietary barriers (e.g., sodium intake) and fluid management issues, fostering sustainable self-care behaviors that are difficult to replicate in an artificial hospital ward.

Regarding post-discharge efficacy, our meta-analysis revealed a striking 40% reduction in 30-day readmission rates favoring the HAH strategy (OR: 0.60; 95% CI: 0.44–0.82). This protective effect is particularly noteworthy given the baseline characteristics of the included cohorts; as reported by Sánchez-Marcos et al. (16), patients assigned to HAH frequently presented with a higher comorbid burden, older age, and poorer baseline functional status compared to those in CH. The fact that HAH is associated with superior post-discharge outcomes even in these high-risk phenotypes suggests that the intensive, individualized transitional discharge planning embedded within the acute HAH model effectively mitigates the "post-hospital syndrome" described in the literature.

A specific focus on safety requires analyzing the "escalation of care" phenomenon. In our pooled analysis, 10.2% of home-managed patients required transfer back to a conventional hospital ward. This rate is highly consistent with contemporary data from US-based acute home programs (26). Rather than representing a failure of the home-based intervention, these timely transfers underscore the rigorous safety protocols and objective clinical criteria inherent to the model. As advocated by Bosman et al. (18), these events should be viewed within a "hybrid care" framework, where the home functions as a flexible, seamless extension of the hospital capable of escalating intensity when biological complexity dictates it.

From a health economics perspective, our pooled analysis demonstrates that HAH provides a decisive competitive advantage, yielding a statistically significant mean saving of €2,214 per index episode (SMD: -2.423; 95% CI: -4.108 to -0.738). This benefit is strongly corroborated by individual registries; Sánchez-Marcos et al. (16) reported a 76% reduction in direct costs, and Mendoza et al. (14) observed a 44% reduction. Mechanistically, these savings are driven by the minimization of hospital overheads and "hotel costs" (e.g., night-shift staffing, ward maintenance), which effectively offset the expenses associated with the longer duration of HAH care.

Importantly, while these economic data primarily arise from European public health systems, they provide crucial clinical validation for the ongoing expansion of the *Acute Hospital Care at Home* waiver promoted by the Centers for Medicare & Medicaid Services (CMS) in the United States. Transitioning eligible AHF patients directly from the ED to an acute home setting aligns perfectly with the mandates of value-based care ecosystems, acting as a strategic "decompression valve" to optimize physical bed capacity during periods of peak hospital demand.

Finally, the implementation of acute HAH models frequently raises ethical concerns regarding the potential "transfer of burden" to informal caregivers. However, empirical data portray a more nuanced reality. Tibaldi et al. (15) observed that although caregivers of HAH patients initially presented with higher stress levels, they experienced a significant and distinct reduction in stress by the time of discharge—a mitigating trend not observed in the CH group. As emphasized by recent reviews of clinical guidelines (33), home-based acute models uniquely facilitate structured "patient and partner participation." By providing directed education in the home, the intervention transitions the caregiver's role from a passive observer of hospital care to an empowered, active partner in disease management, thereby mitigating long-term anxiety and burnout.

Limitations

Several limitations merit careful consideration when interpreting these findings. First, selection bias remains inherent to the HaH model and is not evaluated in the studies included in this systematic review. Stringent eligibility criteria—requiring hemodynamic stability, absence of uncontrolled acute comorbidities, and adequate home support—result in the enrollment of only a small fraction of screened patients in the ED. While this rigor is essential for patient safety, it restricts the generalizability of the findings to the broader AHF population. Furthermore, eligibility is frequently bound by geographic catchments and the requirement for a stable home environment, potentially introducing a socioeconomic bias that systematically excludes highly vulnerable populations, such as those

experiencing precarious housing or social isolation. Second, despite inclusion and exclusion criteria tried to provide homogenous studies, some heterogeneity in interventions persist and limit direct comparability across studies. The included cohorts span from traditional "high-touch" models relying on physical physician visits to contemporary "virtual wards" managed remotely via digital command centers and providing on-site care by community physicians and nurses. In this regard, a specific methodological limitation must be acknowledged: studies evaluating fully virtual models—such as the large cohorts by Sankaranarayanan et al. (24) and Achanta et al. (27) —did not meet the stringent eligibility criteria for this systematic review. However, given their critical insights into telemetric care, escalation pathways, and health economics, they have been purposefully integrated into discussion. Consequently, while our comprehensive discussion captures the cutting-edge of digital health, our pooled statistical effect sizes primarily reflect traditional or hybrid HAH models, highlighting the need for future standardized RCTs in purely virtual settings. Finally, while the healthcare system achieves substantial direct cost savings, the potential "transfer of caregiving burden" to the domestic sphere raises ethical concerns. Although data reported in the present systematic review suggest that families are empowered rather than burdened with the HAH stragegy, recognizing and hidden costs for relatives and care-givers through robust social policies remains critical for the model's ethical sustainability.

Finally, in accordance with the SAGER guidelines, potential sex and gender biases were considered. Although sex distribution was systematically recorded across all included studies (with female representation properly reflecting the real-world epidemiology of acute heart failure in emergency settings), the lack of sex-disaggregated outcome data in the primary studies precluded subgroup meta-analyses by sex for clinical efficacy, safety, or economic endpoints.

Conclusion

HAH for patients with AHF is a safe, effective, and economically advantageous strategy that serves as a viable and scalable alternative to CH for patients. The evidence gathered in this meta-analysis demonstrates that this model ensures clinical non-inferiority regarding the risk of mortality or readmissions, offering comparable clinical outcomes across all analyzed timeframes. Furthermore, HAH is associated with superiority in some patient and care-givers satisfaction levels. From a health system perspective, HAH represents a strategic decompression tool that optimizes acute clinical capacity and drastically reduces direct costs per episode. Ultimately, the successful scalability and operational sustainability of this paradigm shift require rigorous patient phenotyping, standardized selection protocols, and a holistic, proactive approach to informal caregiver integration.

Clinical Perspectives

Competency in Medical Knowledge: Implementing a direct "admission avoidance" hospital-at-home strategy for appropriately selected patients with acute heart failure presenting to the emergency department is a safe and highly efficient alternative to conventional hospitalization. This model maintains comparable long-term mortality rates while significantly reducing early rehospitalizations and index episode costs, providing a critical value-based tool to mitigate hospital overcrowding.

Translational Outlook: Although current evidence strongly supports the clinical and economic viability of home-based acute care, it relies heavily on observational registries and small-scale randomized data. Future large-scale, multicenter randomized controlled trials are urgently needed to confirm these findings, refine triage algorithms, and determine the differential impact of this model across specific heart failure phenotypes (e.g., HFrEF vs. HFpEF) and baseline frailty levels.

Declarations

Conflicts of Interest: Dr. Martyn serves as an advisor or receives consulting fees from, Fire1, Edwards LifeSciences, Novo Nordisk, Dyania Health, Acorai, Bayer, BridgeBio, Pfizer, Ensho Health, has equity in Apricity Robotics, and Kilele health and receives grant support from Ionis Therapeutics, AstraZeneca and the Heart Failure Society of America (HFSA).

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Table 2

Table 2 is available in the Supplementary Files section.

Figures

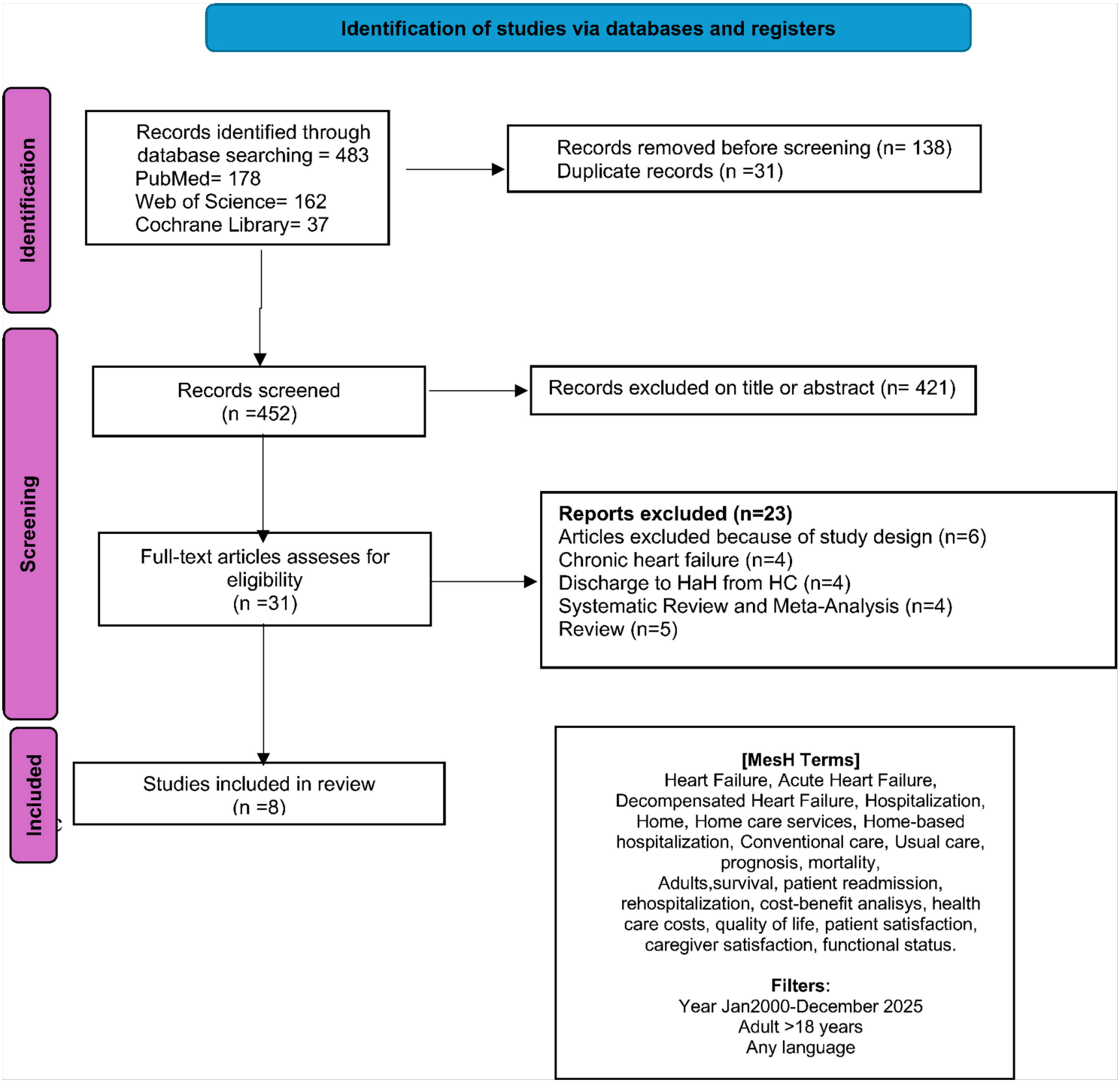


Figure 1

Selection process for articles included in the meta-analysis

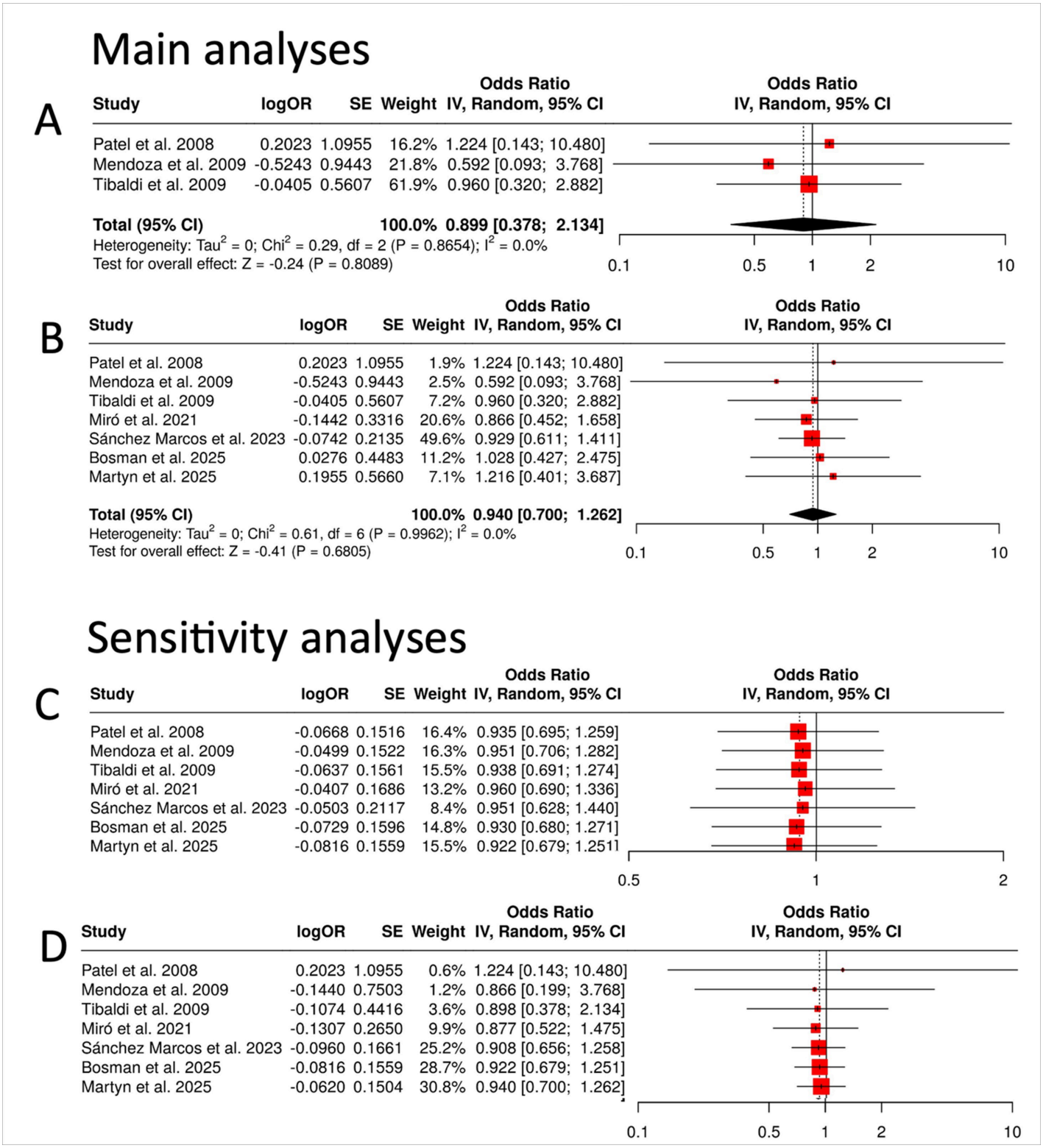


Figure 2

Forest plots of the main analysis of association between hospital at home and primary clinical outcome (long-term all-cause mortality*). Panel A shows the meta-analysis including the 3 randomized controlled trials and panel B shows the meta-analysis after including the 4 additional observational studies that provided data on this regard to the 3 randomized controlled trials (7 studies in total). Panel C represents the sensitivity analysis after excluding each study once and repeating the pooled estimations of the association between hospitalization at home and all-cause mortality using the remaining studies, and panel D depicts the results of the cumulative meta-analysis over time in the sequence the studies were published. Squares indicate study-specific odds ratio

estimates (the size of the square reflects the study-specific statistical weight); horizontal lines indicate the 95% confidence interval; black diamond indicates the pooled hazard ratio.

OR: odds ratio; CI: confidence interval; SE: standard error; IV: inverse variance; df: degrees of freedom.

**All data are referred to 1-year mortality, except the Tibaldi et al. and Martyn et al. studies that reported 6-month and 1-month mortality, respectively.*

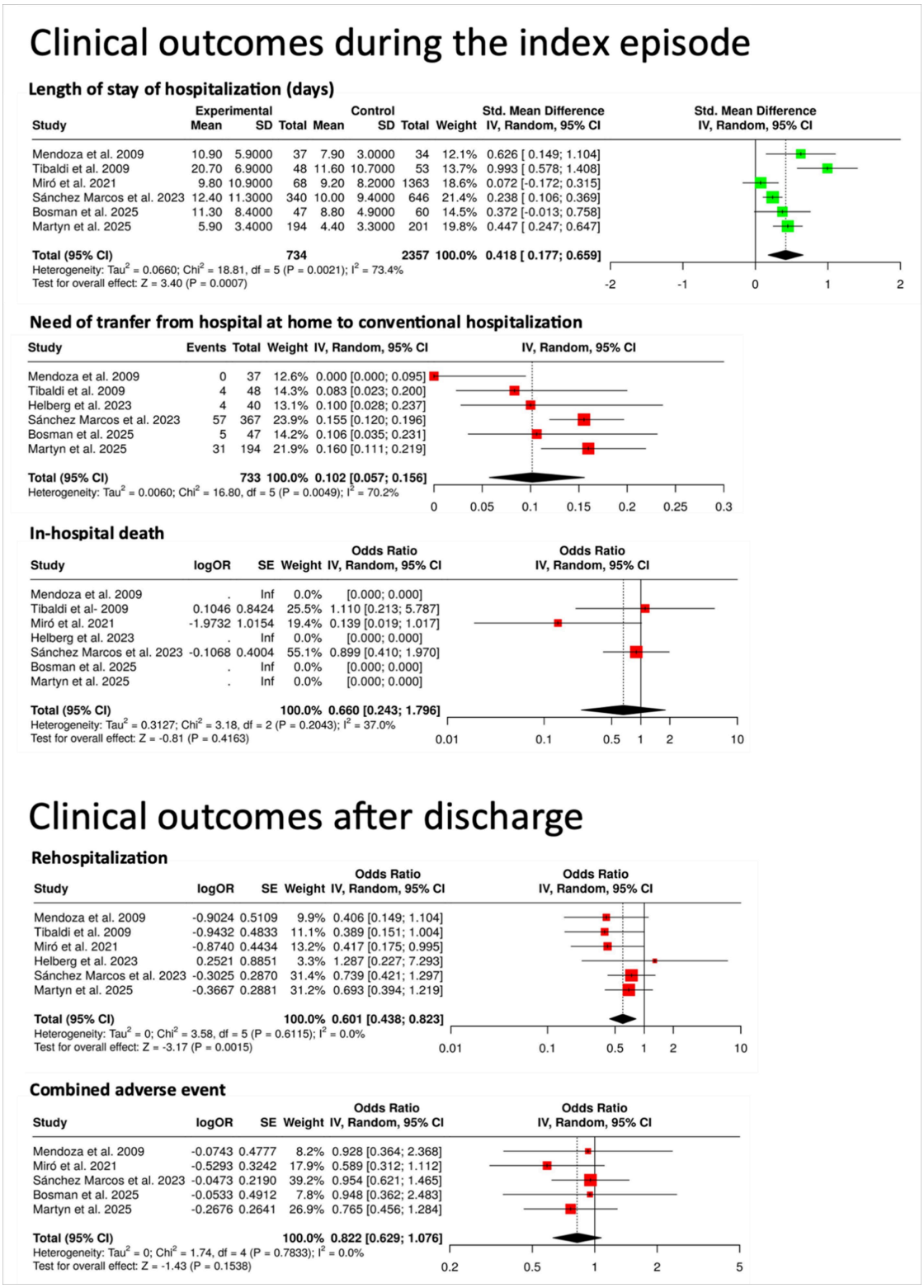


Figure 3

Forest plots of association between hospital at home and secondary clinical outcomes

OR: odds ratio; CI: confidence interval; SE: standard error; IV: inverse variance; df: degrees of freedom.

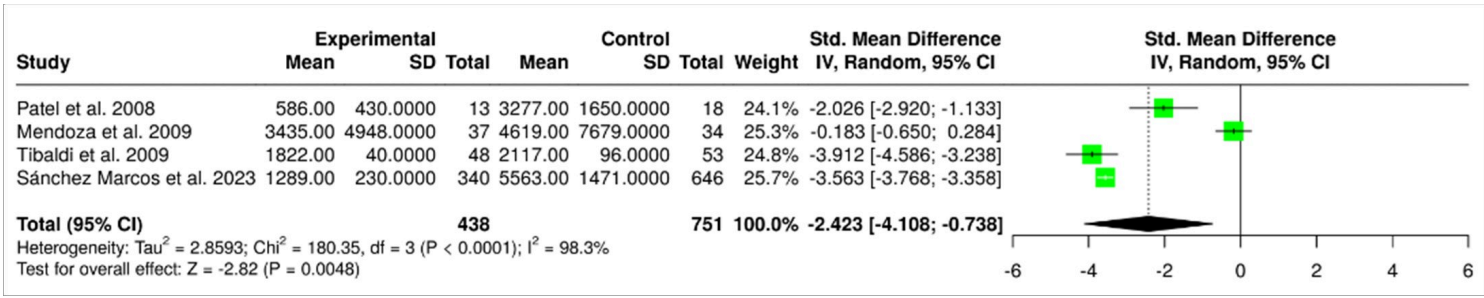


Figure 4

Forest plot of association between hospital at home and costs of the index episode (primary efficiency outcome).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table2.docx