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Cost analysis of admitting nursing home residents to hospital at home: A Danish micro-costing approach

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ABSTRACT

Objectives: Hospital at Home (HaH) is a new care concept aimed at reducing hospital admissions by providing specialised healthcare to patients at home. The aim of this study was to compare the cost of a HaH model with traditional hospital admission for nursing home residents with acute illness in the Northern Region of Denmark.
Study design: This study employed a retrospective micro-costing approach based on initial findings from the early implementation of the HaH model. The analysis was conducted from a healthcare sector perspective.
Methods: A comprehensive framework for cost analysis was developed based on policy documents, clinical guidelines, and interviews with administrative and leading healthcare professionals. Data on resource usage was obtained from clinical experts and case notes. Costs for resource usage were valued using payroll data for different job categories and Danish DRG-tariffs. The estimated costs of care models were compared and deterministic sensitivity analysis identified important factors for the cost difference.
Results: The analysis showed that the HaH model is associated with cost savings of 40–45 % compared to traditional hospital admissions. Furthermore, the sensitivity analysis indicate that it is crucial to consider the extent of additional time healthcare professionals allocate to extra care, when a nursing home resident is admitted at home, as this parameter significantly influences the costs associated with HaH.
Conclusions: Based on the costing framework, we found that the HaH model was cheaper than traditional hospitalisations. These results were robust to variations in resource use of different activities in the HaH model.

1. Introduction

Hospital at Home (HaH) models represent a new and promising approach to hospitalisation, potentially addressing the imbalance between demand and capacity to deliver specialised healthcare to frail, elderly patients. In HaH models, patients with certain acute illnesses such as dehydration, lung and urinary tract infections are treated in their home by municipal care providers under the clinical supervision of hospital specialists. In Europe, several studies of HaH models have demonstrated that HaH is a safe alternative to traditional hospital admission.[1–4]

Different HaH models have been implemented in Denmark.[5,6] However, there has been limited focus on the costs and financial consequences of HaH. Such analyses are challenging to conduct especially due to the cross-sectorial nature of the intervention, where formal responsibility for patient care is shared between providers of hospital services (regional staff) and home nursing services (municipality staff). This organisational structure imposes challenges for the necessary cross-sectorial collaboration and formal sharing of financial responsibility of caring for frail, elderly patients in Denmark.

However, new models for collaboration, such as shared-care and home-based healthcare, are widely recognised for their potential to improve the quality of patient care, with evidence indicating that they can reduce the use of healthcare resources and decrease the financial

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burden of care.[1,14]

In Denmark there are robust registers with patient-level data documenting the resource use and costs of hospital admissions and ambulatory visits. However, similar detailed registries do not exist for municipal health care. Thus, when studying HaH, where collaborative patient care is provided across sectorial divisions, new methods to investigate the resource use and costs must be developed and applied.

The aim of this study was to develop a comprehensive framework to compare the cost of the early-stage implementation of HaH for acutely ill nursing home residents in the Northern Region of Denmark with traditional hospitalisation.

2. Methods

2.1. Framework for cost analysis

The cost analysis was carried out in accordance with the micro-costing strategy for health economic evaluation as described by Drummond et al.[7] The analysis applied a healthcare sector perspective and a time horizon of 10 days after the initial contact with hospital staff. The analysis proceeded with an identification of relevant resources, measurement of the resource use, and valuation of the included resources. The difference in total cost between the two alternatives - the incremental costs - was calculated as the difference in mean costs.[7] All included patients were physically admitted to HaH. Their treatment pathways were used as cases to estimate the hypothetical cost of a corresponding hospital admission, to allow a 1:1 comparison between the two alternatives.

2.2. Context for cost analysis

In Denmark, the healthcare sector, including care for the elderly, is tax-funded through block grants from the state. The care provision is divided into a primary (general practice, elderly care etc.) and secondary sector (hospitals etc.). At present, five geographically determined regions are responsible for the operation of hospitals and primary medical practices, while 98 municipalities within the five regions are responsible for the provision of nursing care.[8] In the current financial model, the patient's municipality should contribute to the funding of the regionally provided hospital care when the patient is admitted to hospital.[9]

This new HaH model aims to reduce hospital admissions by providing specialised healthcare at nursing homes for acutely ill nursing home residents and is an alternative to traditional hospitalisation. In this HaH model, the municipal nursing staff provide the physical treatment of the patients under the supervision and clinical responsibility of the hospital-based medical specialists. The current feasibility project included four nursing homes, of which only two contributed patients to the present analysis. These two centers were located in the same municipality and building, and the HaH model was implemented in the same way, making them largely homogeneous in provision of care. One was a regular nursing home and the other a transitional care center, which typically admits more complex residents. Residents at the participating nursing homes were eligible for HaH admission, if they required acute admission for conditions as dehydration, urinary tract infection, erysipelas, and chronic obstructive pulmonary disease.

At the time of the analysis, only three HaH admissions corresponding to two unique patients had taken place, as the pilot project was still in its early stages. For the HaH group, all patients who received HaH were included in the analysis to model their treatment pathways. Due to the limited sample size and GDPR considerations, the exact observation period is not provided.

2.3. Identification of relevant resources

We identified the resource use for HaH based on a description of the intervention provided by the project manager of the HaH-intervention and experts from the project group. Resource use for a hospital admission was identified using the official clinical guidelines for the hospitals in the Northern Region of Denmark[10,11] and knowledge provided by clinical experts.

Based on the identified resources for both alternatives, a comprehensive framework was developed to quantify the resource use and costs of the two alternatives. Activities occurring in both alternatives (e.g. adjustment phase after admission, venous blood sampling) were included, if it was believed that they would differ in costs.

2.4. Measurement of resource use

We obtained information regarding time usage for included activities from interviews with several healthcare professionals, including doctors, nurses, social and health care assistants, pharmacologists, and others. The majority of the time usages were collected via interviews with the employees in the different professions, and e-mails when interviews were not possible. These interviews provided quantitative measures of approximate time spent on different care-related tasks and were used to validate that all relevant resources were considered in the analysis. In addition to the information obtained from staff interviews, staff at nursing homes had prospectively registered their time usage for activities related to treating patients at home using patient-specific time-tracking forms. Google Maps was used to determine transport time between different locations. An overview of all measures of time usage for the two alternative treatments is provided in Tables 1 and 2 in Appendix 1.

Often time usage was reported as a specific time estimate. When the time usage was provided as intervals, the midpoint of the interval was used to calculate the mean resource use and cost. Some of the included activities could be handled by different health care professionals. In these cases, the cost of activities was calculated as a weighted average of the relevant salaries as shown in Table 2 in Appendix 2. For example, the

Table 1
Valuation of unit costs.

	Activity	Source
Hospital at Home	Salaries	The Danish Regional Salary and Tariff Board[16] Danish Medical Council's catalogue of unit costs[17] Municipalities and Regions Payroll Data Office[18]
	Materials for the medicine cabinet	Project manager of the Hospital at Home intervention
	Education of nurses in venous blood sampling	
	Connection to LABKA[a]	
	Epoc-machine[b]	Employee at the pre-hospital company
	Utensils for venous blood sampling	
	Utensils for capillary blood sampling	Municipal acute nurse
Hospitalisation	Salaries	Danish Medical Council's catalogue of unit costs[17] Municipalities and Regions Payroll Data Office[18]
	Bed day tariff X-ray tariff	The Danish DRG-tariffs by the Danish agency for health data[19]

***Note*:** Table 1 shows which sources contributed to the valuation of unit costs.

[a] LABKA is Laboratory Information System for Hospital Laboratories, Clinical Biochemistry Department.

[b] Epoc is a machine used in municipal 1 to analyse blood samples outside a lab. A connection is made from the epoc-machine to LABKA, which means the test results are available for the medical specialist.

Table 2
Total costs of HaH and traditional hospitalisation.

	Total costs per admission	Incremental costs per admission	Total cost per day	Incremental costs per day
Hospitalisation	16,301 DKK (US$ 2359)	–	5434 DKK (US$ 786)	–
Hospital at Home (municipality 1)	8840 DKK (US$ 1280)	−7461 DKK (US$ −1080)	2947 DKK (US$ 427)	−2486 DKK (US$ −360)
Hospital at Home (municipality 2)	9728 DKK (US$ 1409)	−6573 DKK (US$ −951)	3243 DKK (US$ 470)	−2190 DKK (US$ −317)

Note: Table 2 shows the total average cost of a three-day admission and cost per day in both HaH and hospitalisation. The incremental cost is also shown in the table. Costs are reported in Danish Krone (DKK) and converted to US dollars using the 2024 exchange rate of 1 US$ = 6.86 DKK.[20].

cost related to taking a blood sample in municipality 1 was weighted between a municipal general nurse (83 %) and a municipal acute nurse (17 %).

2.5. Unit costs

Unit costs of different resources and activities were determined from multiple sources, including official price lists and annual salaries. The sources of information for different unit costs are shown Table 1. Resource use valuation grouped by activity is presented in Tables 4, 5 and 6 in Appendix 3. For hospital admission, a DRG bed day tariff was applied as a proxy for baseline inpatient costs. Costs related to blood samples and ECG measurements were calculated using a micro-costing approach, while X-ray examinations were valued using the relevant DRG tariff.

A 20 % overhead was added to staff salaries for municipal acute nurses, paramedics, ambulance attendants and ambulance assistants as an approximate for the cost of vehicles and equipment.[12] As the time horizon of the analysis was less than one year, the costs were not discounted. For the fixed capital costs, a linear depreciation annuity method was used with an annual discount rate of 3.5 % to calculate the equivalent annual costs of major acquisitions including epoc-equipment and establishment of medicine cabinets.[13]

2.6. Total average costs

The average cost of a patient admitted to either hospital or at home, was calculated as the accumulation of costs related to required resources including staff time, use of equipment and consumables. The cost per patient varied depending on the type of treatment required based on patient diagnosis. The total average cost was estimated based on the cost of individual resource use of each patient pathway. Cost for the HaH model was calculated individually for the two municipalities due to use of different methods for blood sampling and reported as an average for each municipality.

Major capital expenditures, i.e. purchase of epoc and establishment of a medicine cabinet were included as a cost per admission with the assumption of 100 annual home admissions.

The details behind the cost calculations are shown in Appendix 4.

2.7. Sensitivity analysis

In sensitivity analysis, we examined the robustness of the cost calculation and impact of different assumptions on the mean cost difference. After calculating the average cost of an activity, we calculated the lower and upper limit of costs for each activity. We chose to focus on parameters with the largest variability including venous and capillary blood sampling, initial rounds, subcutaneous fluid therapy and additional time usage for nursing care related to admission at home and adjustment phase after admission. Further information about the sensitivity analysis can be found in Appendix 5.

3. Results

3.1. Framework for resources and cost analysis

We developed the comprehensive framework as shown in Fig. 1. The flowchart illustrates different activities included in the cost analysis. The patient pathway was divided into four phases: onset of illness, diagnosis, treatment, and recovery. The onset of illness was assumed to be identical for the HaH and hospital admission. The nursing staff observed the resident's illness and contacted the general practitioner, who then consulted with the Medical Emergency Coordination Center (MECC).

The treatment pathway branched after referral to the MECC. The MECC referred patients eligible for HaH to the hospital-based medical specialist at the medical department. The medical specialist decided, if the patient should be admitted at home or admitted to hospital. When hospital admission was decided, the MECC coordinated transport for the patient from the nursing home to the hospital.

In the diagnostic phase of HaH, the medical specialist requested diagnostic tests from venous and capillary blood samples and used video consultation with the patient to determine if the patient is eligible for HaH. When admitted to hospital, the patient was transported to the emergency department where a medical doctor examined the patient by e.g. ECG, blood samples and X-ray (if indicated by symptoms). Based on these tests, the patient was referred to the appropriate clinical department for further care.

During the treatment phase of HaH, the patient remained at the nursing home during the whole treatment. Rounds were carried out online (via Microsoft Teams) by a municipal general nurse and the medical specialist. Rounds in hospitals were carried out by a medical doctor or medical specialist and a nurse from the clinical department.

During the recovery phase, patients in HaH were discharged through online rounds. Patients admitted to hospital were discharged and transported back to the nursing home where nursing staff took over the care of the patients. Existing literature indicates that patients discharged from hospital may experience confusion for several days after discharge.[15]

3.2. Assessment of cost difference

Table 2 summarises the results of the cost analysis. The average cost per patient in the HaH model ranged from 8840 to 9728 DKK and the cost per patient in the traditional hospitalisation model was 16,301 DKK. This implies that the HaH model provides an incremental cost saving of 6573 to 7461 DKK per admission corresponding to 40 %–45 % less costs compared to traditional hospitalisation. The data on time usage collected for this analysis did not indicate a prolonged post-discharge time usage for patients admitted to hospital compared to patients discharged from HaH.

An important cost driver for the traditional hospital model was the acute examination package, which included an ECG, a blood test and in many cases an X-ray. These diagnostic tests were only provided in the traditional hospital model. Another important cost driver for traditional hospital admission was the bed day cost based on Danish tariffs for Diagnostic Related Groups (DRG). An important cost driver for the HaH model was the additional staff time required to care for the patient at the nursing home. The sensitivity analysis showed that this parameter had a large impact on the HaH cost. Further information about the sensitivity analysis can be found in Appendix 5.

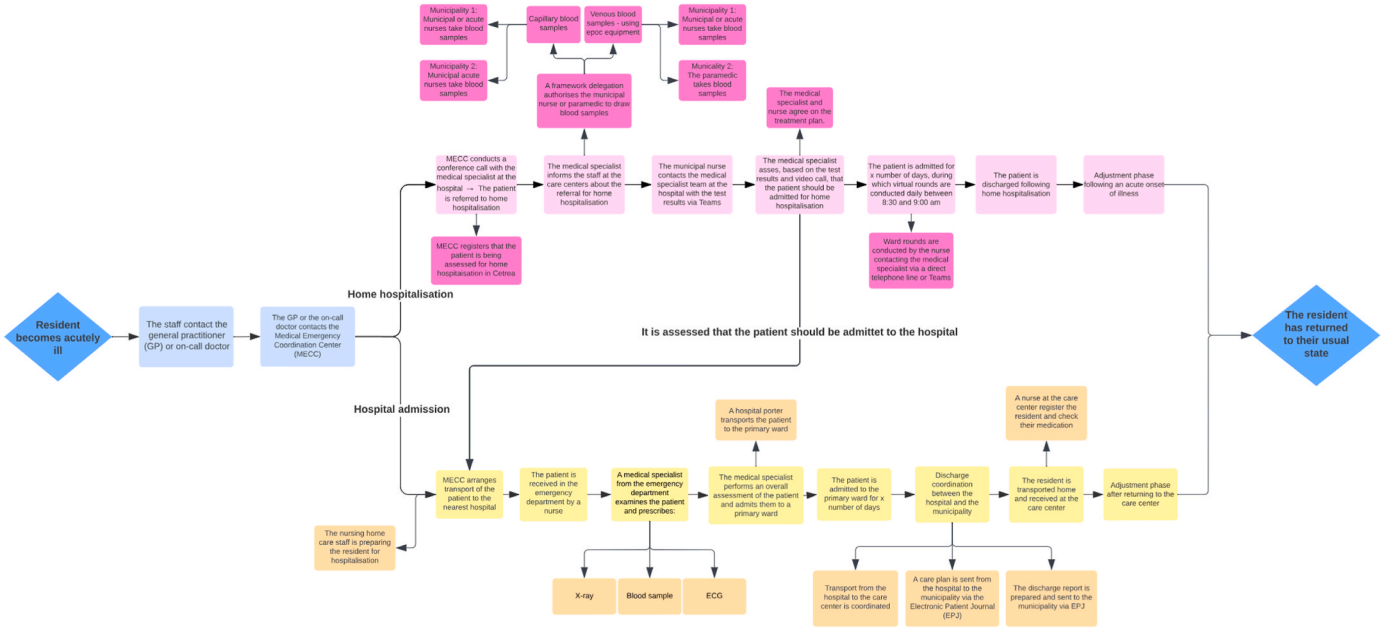

Fig. 1. Comprehensive framework of the activities that differ between HAH and traditional hospital admission in a patient pathway. *Note: GP = General practioner, MECC = Medical Coordination Center, ECG = Electrocardiogram, EPJ = Electronic Patient Journal.*

4. Discussion

This study applied a micro-costing approach to develop a comprehensive framework for comparing the resource use and costs for admission to HaH compared to traditional hospital admission for elderly, nursing home residents in the Northern Region of Denmark. The framework allowed for a detailed comparison of the resource usage and associated costs of the HaH model with traditional hospitalisation. The result shows that the HaH model is associated with a cost saving of 40–45 % compared to traditional hospitalisation.

A systematic review conducted in 2023 evaluates the cost-effectiveness of home hospitalisation compared to traditional hospital admission across 14 studies. Four of these studies examined home hospitalisation models with similarities to the model under investigation in this article.[14] Two of the studies, Patel et al.[21] and Jones et al.[22], found that home hospitalisation was cost saving when compared to hospital admission. Singh et al.[23] concluded that home hospitalisation was cost-effective with 97 % certainty.[14] In contrast, Kalra et al.[24] reported that, while home hospitalisation was less expensive than hospital care, the latter was more effective. If decision-makers were unwilling to pay more for additional QALYs gained, home hospitalisation had a 59 % probability of being cost-effective compared to hospital care. Notably, the likelihood of home hospitalisation being cost-effective decreased as willingness to pay increased.[14] As this analysis is a cost analysis rather than a full economic evaluation, findings are not directly comparable with cost-effectiveness results; the systematic review is referenced only to provide broader context. Different organisational structures for different HaH models, as well as differences in healthcare systems and contexts may have substantial impact on the observed difference in resource use and costs.

4.1. Strengths and limitations

An important strength of this study is the robust cost-analysis, which included the identification, detailed measurement of resource usage and valuation of unit costs. This comprehensive approach ensured that all relevant costs were considered and provided a robust cost comparison between the HaH model and traditional hospitalisations. As demonstrated in Fig. 1, this comprehensive framework not only allowed for the precise identification of relevant costs but also contributed to the development of a more accurate and reliable cost calculation.

This study used a micro-costing approach, which offers good precision in estimating resource utilisation.[7] The micro-costing method is an alternative to a so-called gross-costing method where a deterministic cost is assigned to hospitalisations for example some form of "case-mix" system like the Diagnostic Related Groups. Gross-costings are generally considered less accurate in estimating resource use.[7] Therefore, the micro-costing approach was predominantly used for both HaH and traditional hospitalisation to ensure the most accurate estimation of resource consumption, with the exception of the use of a DRG-based bed-day tariff and a DRG tariff for x-ray in traditional hospitalisation. The strength of the micro-costing approach lies in its ability to provide a highly detailed and precise accounting of resource use, which is particularly valuable when local stakeholders are the primary users of the analysis. However, due to the context specific aspects, this approach may limit the generalisability to other settings.[7]

When evaluating resource utilisation, it is essential to consider appropriate data collection methods. The current data collection had several challenges because some resource items in the HaH-model was measured through patient-specific time-tracking forms with predetermined activity categories. These forms were completed by nursing staff at the nursing homes for each home hospitalisation. Accurately time recording of certain activities proved challenging, especially when the predefined categories were not aligned with the identified resource use. Certain activities were recorded improperly in the forms, resulting in incomplete data. Efforts were made to address these issues through interviews with care staff to obtain more precise time estimates for each activity. Nonetheless, this approach introduced the potential for recall and other biases, given the interviews were conducted after the home hospitalisations. Data collected through expert interviews was an important source for the measurement of relevant resources used in the traditional hospital admissions. This retrospective approach without patient-specific data assessed the resource use for an average patient and thereby introducing a degree of uncertainty.

A limitation of this study is that data were derived from a small number of patients at an early stage of the intervention. This implies that individual differences have a significant influence on the cost estimates. Cost estimates derived from a small, initial patient population must be

interpreted with caution. It is necessary to conduct further research that focus on the cost of a larger study population, where regression-based methods could be applied to adjust for heterogeneity across settings and patients.

Another limitation is that potential reductions in nursing home resource use when residents are admitted to hospital were not accounted for. This may imply a risk of overestimating the relative cost of hospital admission; however, such savings are unlikely to translate directly into lower expenditures, as staffing levels are usually fixed.

A methodological reflection is the average length of stay of the two alternatives. In this study length of stay was assumed to be the same in both alternatives. However, several European studies have indicated that the average length of stay for home-based hospitalisation is longer compared to traditional hospital admission.[2,4] This represents a limitation of the study's findings, as the duration of hospitalisation can significantly influence the cost associated with home hospitalisation. Nevertheless, efforts have been made to address this limitation through the sensitivity analysis, which demonstrated that home hospitalisation remained the less costly alternative, even when the average length of stay was 1.4 days longer compared to traditional hospital admission. This scenario analysis is presented in Figure 2 and 4 in Appendix 5. Furthermore, the results of a deterministic sensitivity analysis indicated that it is important to consider how much more time nursing staff use when the patient is admitted at home. This parameter has substantial impact on the costs associated with home hospitalisation.

The current organisational and financing structure of the Danish healthcare system is characterised by a sectorial division between the primary sector, which covers expenses related to nursing homes and home care, and the secondary sector, which encompasses specialised hospital treatment. This structure poses significant challenges when conducting economic evaluation of interventions, such as "Hospital at Home" which assumes close collaboration between care providers from both sectors. The two sectors manage their own budget, and some of the savings associated with the intervention may not belong to the sector that bears the expenses. This financial challenge increases the need for additional budget impact analyses to inform decisions.

Based on this and previous studies, future research may systematically investigate the proposed economic benefits and clinical outcomes of HaH through robust study designs - ideally prospective randomised controlled trials. By refining the methods applied in this study, future research can enhance the precision and applicability of economic evaluations of HaH models.

4.2. Conclusion

This study showed that the implemented HaH model was 40–45 % less costly compared with traditional hospitalisation in treating acutely ill nursing home residents from the Northern Region in Denmark. The cost analysis was conducted using a micro-costing approach and the conclusion was robust to changes in resource use in different activities in HaH.

Ethical statement

Ethical Approval was not necessary for this study.

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Declaration of competing interest

The authors declare that there is no conflict of interests.

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Appendix A. Supplementary data

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