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**HOSPITAL-AT-HOME COMPLEX INTERVENTION
TAILORED TO OLDER PATIENTS WITH
DISABLING ACUTE PROCESSES: EVALUATION
OF CLINICAL FACTORS FOR EFFECTIVENESS
ON EARLY DISCHARGE AND ADMISSION
AVOIDANCE STRATEGIES**

Doctoral Thesis / Tesi Doctoral

Miquel Àngel Mas Bergas
2018



**Universitat Autònoma
de Barcelona**

Programa de Doctorat en Medicina
Departament de Medicina

Hospital-at-home complex intervention tailored to older patients with disabling acute processes: evaluation of clinical factors for effectiveness on early discharge and admission avoidance strategies

(Intervenció complexa d'hospitalització domiciliària adaptada a pacients d'edat avançada amb processos aguts discapacitants: avaluació de factors d'efectivitat clínica en les estratègies d'alta precoç i evitació d'ingrés)

Doctoral Thesis/Tesi Doctoral

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Línia de recerca: Investigació clínica multidisciplinària: Síndromes geriàtriques, fragilitat i discapacitat: aspectes epidemiològics i clínics.

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Thesis submitted by Miquel À. Mas to the Universitat Autònoma de Barcelona for the degree of PhD.

September 2018 / Setembre 2018

“Corre, home entre els homes.

Tresca.

Salta muntanyes,

i no deixis d'estirar la corda de l'estel”

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List of abbreviations

AA: Admission Avoidance
ACEU: Acute Care of the Elderly Unit
ADL: Activities of Daily Living
BI: Barthel Index
BBU: Bed Based Unit
CGA: Comprehensive Geriatric Assessment
CNS: Canadian Neurological Scale
COPD: Chronic Obstructive Pulmonary Disease
ED: Emergency Department
ESD: Early Supported Discharge
GP: General Practitioner
GRU: Geriatric Rehabilitation Unit
HaH: Hospital-at-Home
HaH-ICP: Hospital-at-Home Integrated Care Programme
HBU: Home Based Unit
HHU: Hospital-at-Home Unit
ICGU: Intermediate Care Geriatric Unit
MDT: Multidisciplinary team
MMSE: Mini Mental State Examination
NIHSS: National Institute of Health Stroke Scale
OT: Occupational Therapy
PS: Propensity Score
RCT: Randomised Controlled Trial
SALT: Speech and Language Therapy
SPMSQ: Short Portable Mental Status Questionnaire
SSS: Scandinavian Stroke Scale
SU: Stroke Unit

Table of contents

13	Abstract
19	Chapter 1. Introduction
21	1.1. Research context
21	1.2. Intermediate Care as a key element for an integrated care system
23	1.3. Intermediate Care in the Catalan Health System
27	Chapter 2. The hospital-at-home: literature review
29	2.1. Hospital-at-home schemes to older adults: review of evidence
32	2.2. Hospital-at-home in the Catalan Health System: gaps and opportunities
37	Chapter 3. Aim and methods
39	3.1. Objective and hypothesis of the PhD research
40	3.2. Methods of the PhD research
45	Chapter 4. Development of the complex intervention
47	4.1. Development of the Hospital-at-Home Integrated Care Programme (HaH-ICP)
50	4.2. The paradigm of Early Supported Discharge in stroke patients
53	Chapter 5. Main results
55	5.1. Analysis in orthopaedics processes (papers 1 and 2)
65	5.2. Analysis in acute medical crises (paper 3)
69	5.3. Analysis in frail stroke patients (paper 4)
73	5.4. Evaluation of the effectiveness in disabling processes (papers 5 and 6)
83	Chapter 6. Discussion
85	6.1. Summary of results
87	6.2. Comparison with previous studies
94	6.3. Strengths and limitations
97	Chapter 7. Conclusions
101	Chapter 8. Considerations for future implementation and future research lines
107	References
121	Appendixes

Abstract

In the last decades, an international movement worldwide has developed different schemes in the community to provide care to older adults in complex health crises based on complex interventions.

In the first part of this thesis, a literature review was done in order to analyse the main characteristics of several models of hospital-at-home care in older adults, based on two main modalities/strategies: Admission Avoidance (for providing hospital admission substitution and preventing hospital-related morbidities) and Early Supported Discharge (for shortening length of hospitalisation and facilitating community reinsertion after an acute admission).

After knowing that there is a strong international evidence on hospital-at-home interventions for several processes of care in older populations, both on Early Supported Discharge and Admission Avoidance modalities, we designed a patient-centred complex intervention, by using Comprehensive Geriatric Assessment (CGA), based on the reviewed literature, to provide care of health crises in vulnerable older patients in need of hospital care.

The Hospital-at-Home Integrated Care Programme (HaH-ICP) was piloted and evaluated in an urban area in the north of Barcelona, by a geriatrician-led multidisciplinary team. The programme was analysed using a quasi-experimental design, by comparing the results of the intervention provided in a hospital-at-home unit, linked to a department of geriatrics, with the results of contemporary matched patients that were attended by the same department in a hospital-based trajectory for several disabling health processes (medical, orthopaedics and stroke).

In both, Early Supported Discharge and Admission Avoidance modalities, the home-based scheme was found efficient based on clinical outcomes of health crisis resolution and functional resolution, in several trajectories (medical, orthopaedic and stroke processes). Overall, the clinical results were comparable to the hospital-based trajectory. In the rehabilitation process of the disabling health crises, the intervention was found associated with favourable crisis resolution, compared to usual care. In the Early Supported Discharge trajectory, in medical and orthopaedics crises, the intervention led to shortening of acute stay. In Admission Avoidance in medical crises, better functional results at discharge were evidenced, and a non significant trend in lower readmission rates up to 30-day follow-up was observed. In orthopaedic processes, a significant reduction in direct costs was evidenced.

The HaH-ICP was an adaptation of geriatrician-led hospital-at-home models of care to a local older adult population in Southern Europe. Several clinical factors from CGA at admission, such as suffering an orthopaedic process, having Barthel Index score higher than 40 points at admission, and not having pressure ulcers at admission, were found factors related with favourable crisis resolution.

The clinical research presented in this Doctoral Thesis pretends to contribute to future implementation of the geriatrician-led multidisciplinary hospital-at-home model in the Catalan integrated care system, based on future research lines summarised in the discussion section.

Resum

En les últimes dècades, un moviment internacional provinent de diversos països ha desenvolupat diferents recursos comunitaris per l'atenció de persones grans amb crisis complexes de salut a partir d'intervencions complexes.

En la primera part de la tesi, s'ha realitzat una revisió de la literatura per tal d'analitzar les principals característiques de diversos models d'hospitalització domiciliària en les persones grans, basada en dues modalitats/estratègies principals: Evitació d'Ingrés (per tal de proveir atenció substitutiva a l'hospitalització i prevenir complicacions relacionades amb l'hospitalització) i Facilitació d'Alta (per tal d'escurçar la durada de l'hospitalització i facilitar la reinserció comunitària després d'un ingrés hospitalari agut).

Després de comprovar que disposem de sòlides evidències en intervencions d'hospitalització domiciliària en poblacions d'edat avançada, tant per la modalitat de Facilitació d'Alta com per la d'Evitació d'Ingrés, es va dissenyar, en base a la literatura revisada, una intervenció complexa centrada en la persona a partir de l'Avaluació Geriàtrica Integral (AGI), per a la provisió d'atenció de crisis de salut en persones grans vulnerables que necessitin atenció hospitalària.

Un programa integrat d'atenció, anomenat d'Hospitalització Domiciliària Integral (HDI), es va pilotar i avaluar en una àrea urbana del nord del Barcelona, per un equip multidisciplinari de base geriàtrica. El programa va ser analitzat per mitjà d'un disseny quasi experimental, amb comparació dels resultats de la intervenció realitzada en una unitat d'hospitalització domiciliària vinculada a un servei de geriatria, amb els dels pacients aparellats atesos contemporàniament pel mateix servei en la trajectòria convencional d'hospitalització, en diferents processos de salut (mèdics, ortopèdics i ictus).

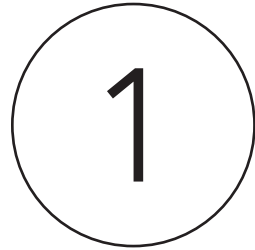
En les dues modalitats, Facilitació d'Alta i Evitació d'Ingrés, el programa domiciliari es va comprovar que era eficient en la consecució de resultats clínics de resolució de crisis i de recuperació funcional, per les diferents trajectòries (mèdica, ortopèdica i ictus).

Globalment, els resultats clínics foren comparables als de la trajectòria d'hospitalització convencional. En rehabilitació de processos aguts discapacitants, la intervenció s'associà a favorable resolució de la crisi, comparant-la amb l'atenció habitual. En la modalitat de Facilitació d'Alta, en crisis mèdiques i ortopèdiques, la intervenció es va associar amb una estada hospitalària més curta. En la modalitat d'Evitació d'Ingrés en crisis mèdiques, es van evidenciar millors resultats al finalitzar la intervenció, a més

d'una tendència no significativa a tenir taxes més reduïdes de reingrés als 30 dies. En l'atenció dels processos ortopèdics, es va evidenciar una reducció significativa en els costos directes de l'atenció.

La creació del programa integrat d'HDI va suposar l'adaptació dels models d'hospitalització domiciliària geriàtrics a una població local adulta en el Sud d'Europa. Van identificar-se diversos factors clínics, provinents de l'AGI feta a l'ingrés a la unitat d'hospitalització domiciliària, com a relacionats amb resolució favorable de les crisis de salut ateses, com ara que el diagnòstic principal sigui ortopèdic, presentar una puntuació de més de 40 en l'índex de Barthel d'ingrés, o no presentar nafres per pressió.

La recerca clínica presentada en aquesta tesi pretén contribuir a la implementació d'un model d'hospitalització domiciliària geriàtric, adaptat al sistema d'atenció integrat català, a partir de diferents consideracions de recerca futures que es descriuen en la discussió.



INTRODUCTION

1.1. Research context

The PhD project presented is the result of the work of nearly a decade of effort in the evaluation of available evidence and in pragmatic research in order to develop specialised interventions to promote the transfer of the care for the older population from the hospital to the community within the Catalan health system.

My research interest on home-based integrated care started about ten years ago, in 2008, with a visit performed to **Llandough Hospital**, Cardiff, Wales, UK, with Dr Tony Bayer, who served as my mentor during the visit. During my visit to the National Health Service (NHS), I had the chance of knowing the work of different geriatric teams that developed their work outside the hospital, both at an outpatient level (Day Hospital schemes monitoring patients at risk of readmission due to frailty or comorbidity) and in the community. Regarding home-based resources, I had the opportunity to study two schemes, established in the British health system, such as the *hospital-at-home* (active treatments at home) and *reablement* (rehabilitation treatment at home). Noticing that intense home interventions, provided by multidisciplinary teams could be done in an *equivalent way* that in the hospital geriatrics wards, let to several thoughts. On one hand, it fascinated me due to the capacity of these services of providing specialised geriatric care tailored to patient's needs and centred on person values, and on the other, it urged a clinical research question about the viability of developing these kinds of specialised schemes in our country, by adapting it to Catalans older citizens.

After the UK visit, I had the opportunity to join a local integrated care project within **Badalona Serveis Assistencials**. This institution provides social and health care in the town of Badalona, the third largest city in Catalonia, in an urban area in the north of Barcelona. Being able to work in a small territory and having the leadership of clinical interventions developed at micro-level as alternative to inpatient care from a department of geriatric medicine and palliative care, has been an excellent opportunity to carry out the research described in this doctoral thesis.

1.2. Intermediate Care as a key element for an integrated care system

Advances in older people's health and life expectancy in recent decades, leading to an aging population, the increasing number of hospital admissions, combined to a decline in the number of hospital acute beds, and the increasing number of older citizens with complex needs, are some of the factors that urge the health system to be readapted to older people with multiple chronic conditions, worldwide (1,2). Several strategies, supported by the **World Health Organization**, include: empowering and engaging people and communities, strengthening governance and accountability, reorienting the model of care, coordinating services within and across sectors and creating an enabling environment (3).

There is a need to develop **new integrated care systems** (4-6) tailored to vulnerable patients with complex chronic conditions, such as multimorbidity, chronic disabilities or frailty (7-8). Integrated Care is an approach to overcome care fragmentation, promoting health and wellbeing, improving care experiences and care outcomes. It can take several forms, and different conceptual frameworks and taxonomies have been developed to help manage our understanding.

In recent decades, several health strategies have developed novel resources, supported by evidence-based interventions, to keep patients at home (9) or to encourage their return at home efficiently after hospitalisation (10). The experience of the National Health System in the United Kingdom is a paradigmatic example of this kind of provision of care. Based on the National Service Framework for Older People (11) older people could access to a range of **intermediate care services** at home or in designated care settings, to promote their independence by providing enhanced services to prevent unnecessary hospital admission, and effective rehabilitation services to enable early discharge from hospital. Intermediate care services comprise a brief period (normally no longer than six weeks) of intensive rehabilitation and/or acute treatment, responding to or averting a crisis or supporting hospital discharge, to bridge the gap between acute hospital and primary and community care.

Following a **British Geriatrics Society Guidance to Commissioners and Providers of Health and Social Care** (12), Intermediate Care should be regarded as describing services that meet the following criteria (**Table 1**):

Table 1. What are Intermediate Care services?

- A.** Services targeted at people who would otherwise face unnecessarily prolonged hospital stays or inappropriate admission to acute inpatient care, long-term residential care, or continuing NHS inpatient care.
- B.** Services provided on the basis of a comprehensive assessment, resulting in a structured individual care plan that involves active therapy, treatment and opportunity for recovery.
- C.** Services which have a planned outcome of maximising independence and typically enabling patients/users to resume living at home.
- D.** Services which are time limited, normally no longer than six weeks, and frequently as little as one to two weeks or less.
- E.** Services which involve cross-professional working, with a single assessment framework, single professional records and shared protocols.

Thus, an intermediate care service should have a clear function (admission prevention and/or post-acute care), incorporate comprehensive (multi-disciplinary) assessment, have an enablement process, offer time-limited contact and involve multi-agency working. Common examples of Intermediate Care in the UK include: community hospitals, hospital-at-home schemes, rapid response teams, Community Assessment and Rehabilitation Schemes or hospital supported discharge teams, including stroke rehabilitation teams (12).

According to the British approach, intermediate care resources can be separated into two levels: intermediate care hospital wards (**bed-based Intermediate Care** including acute care and post-acute care units), and the specialised care in the patient's own environment (**home-based Intermediate Care**) (13).

1.3. Intermediate Care in the Catalan Health System

In Catalonia, that has one of the leader public health systems in Europe, government plans to develop services *between Primary Care and acute hospitals* started in the 80s of last century, with policies focusing on people with complex needs. In 1986, the Department of Health and Social Security of the Government of Catalonia created the **Programa Vida Als Anys** (14). The aim of this programme was to provide care to older adults with chronic conditions or people with terminal diseases. Since then, the number of resources has increased, constituting a universal coverage public network of health and social care centres (15). In 1990, there were established regulations aimed at defining the standards of the facilities of this network. Since then, several home-based schemes have been created to focus care on end-of-life patients, and in supporting GPs in the continuum of care of patients with complex chronic disabling conditions. In 2006, the Catalan Government created the **Pla Director Sociosanitari**, as a specific plan that acts as a tool for healthcare information, study and proposal whereby the Department of Health determines the guidelines to promote, plan, coordinate and evaluate the actions to be taken in the areas of geriatric care, palliative care, Alzheimer disease and other dementias, care for people with neurodegenerative diseases and brain damage (16). This plan centred bed-based intermediate care as one of the main actors of the care plans for people suffering chronic conditions, set up by the **Health Plan for Catalonia 2011–2015**, on the **integrated care strategy** of the Catalan government (17).

Based on data of the Results Centre of the Agency for Health Quality and Assessment of Catalonia (AQuAS) (18), from 135 centres of all the regions of the country, in 2015 more than 68,300 episodes of inpatient care were attended by this network. Of these, 14% were acute hospitalisations (admission avoidance strategy, as alternative to acute hospital care), 46% post-acute care and geriatric rehabilitation admissions (early dis-

charge strategy, shortening acute hospital stays), and the rest were mainly long term care admissions. In the same year, 72 home-based teams focused their activities on the care at home a total of 15,337 people in situations of chronic complexity, particularly in advanced chronic disease or cancer, attending patients in need of any kind of palliative care/end-of-life approach.

From an integrated care perspective (17-18) we can affirm that there is a strong bed-based intermediate care network, covering both step-up and step-down strategies, with a capacity to respond to the increasing needs of the system. More recently, it was urged a new stage, with a change of paradigm from early discharge to admission avoidance due to the creation of bed-based step-up units. In contrast, the system does not have the same resources in the community to provide the same admission avoidance provision and early discharge facilitation in health crises to older patients with complex chronic conditions, as frailty, chronic disability and multimorbidity. There is a necessity to develop a validated home-based intermediate care model in our country.

2

THE HOSPITAL-AT-HOME: LITERATURE REVIEW

2.1. Hospital-at-home schemes to older adults: review of evidence

Since the end of the 90s, with the publication of the first RCTs of **hospital-at-home/hospital in the home/home hospitalisation/Early Supported Discharge** pioneering services in Europe, Australia, New Zealand, and North-America, the literature on home-based interventions, that act as alternative to hospital care admission, has been increasing. In an essential work published in 2012, Caplan et al. (19) designed a meta-analysis to assess the effect of RCT of international hospital in the home services, that significantly substitute in-hospital care, by including replacement of both acute and subacute hospitalisation, in patients aged >16 years with medical, surgical, disabling and psychiatric processes. They hypothesised that replacing hospital care with home-based care for 7 days or for 25% of the duration of the control hospital admissions would produce better clinical outcomes and would result in reduced costs of care. In their work, these pioneer trialists about this topic found that hospital in the home schemes reduces mortality, readmission rates and cost, and increases patient and carer satisfaction, but does not affect carers' burden, compared with in hospital care.

In order to corroborate the existence of a strong and validated home-based intermediate care model of care which could be adapted to our context and healthcare system, we performed a scoping review, published in the **Revista Española de Geriatria y Gerontología** (20), analysing several evidence-based **hospital-at-home models attending older patients** from the literature. We included data from a previous paper in which we had critically reviewed different methodological and organisational aspects of the available randomised controlled trials (RCT) studies in selected older patients early discharged after a stroke, which we had published in the **International Journal of Stroke** (21), and we added data from RCTs on medical and surgical processes. The main objectives of our reviews were to find evidence-based clinical schemes tailored to older patients with complex conditions due to acute illness and an associated disability and use them to build our own model. We proposed several questions: What role do these resources play in the continuity of care of older adults with complex conditions? Are these schemes adapted to the oldest patients? What are the main characteristics of these schemes? Can we consider these interventions as complex? What was the role of Comprehensive Geriatric Assessment based multidisciplinary work on demonstrating efficacy/efficiency of interventions in these patients? We also tried to find the gaps in evidenced trials (as exclusion criteria or more research needed in different processes and patient profiles).

Our scoping review was conducted on articles including RCT, systematic reviews and meta-analysis in PubMed and Cochrane Library, from January 1990 to July 2013. Search terms were: hospital-at-home, Early Supported Discharge, hospital in the home and home hospitalization. An analysis was performed to include: the interven-

tion model (admission avoidance or early discharge), age, diagnosis, main inclusion criteria and intervention characteristics (disciplines involved, duration of intervention, main outcomes and objectives). From an initial number of 202 papers, we selected 38 original RCT-based articles including patients ≥ 65 -year-old, with different medical and surgical processes, as heart failure or COPD exacerbations, medical acute illness in patients suffering dementia, stroke, or orthopaedics processes as hip fracture and other fractures, among others. From the final selection of articles, 11 were considered **Admission Avoidance schemes** (22-32), 24 were considered **Early Supported Discharge schemes** (33-56) and 3 were considered as mixed (**Early Supported Discharge and Admission Avoidance**) schemes (57-59).

Following the Caplan's definition, two **modalities of home hospitalisation** in older adults could be identified from our review task:

- A. Hospital admission substitutive modality:** for patients in need of hospitalisation that can be directly assumed by the home hospitalisation scheme, without admission in the ward.
- B. Supporting hospital discharge modality:** for patients in need of a brief period of conventional hospitalisation who can rapidly benefit from home hospitalisation after an initial clinical stabilisation in the ward.

Characteristics of hospital-at-home models could be summarised in **Table 2**

Table 2. Hospital-home modalities based on strategy of schemes

Table 2a. Hospital admission substitutive modality

- The main objective is acute hospitalisation avoidance in medical crises.
- Referrals come the mainly from Emergency Departments.
- It is focused on acute processes in patients with chronic disease.
- Intervention is limited in time (days).
- Health care is centred on acute care (low component of rehabilitation).
- Several medical specialties are involved depending on patient profile (internists/ pneumologists, geriatricians or surgeons).

Table 2b. Supporting hospital discharge modality

- The main objective is to facilitate early hospital wards discharge.
- Referrals are made from medical wards (including Stroke Units) and surgical wards (including Orthogeriatric Units).
- It is focused in patients with complex conditions (as acute disability) after hospitalisation.
- Intervention is extended over time (up to 6 weeks).
- Health care has a comprehensive approach for the 'whole' health crises (health care and rehabilitation, until community reinsertion).
- Several medical specialties are involved according to patient profile (geriatricians, neurologists or rehabilitation teams with GPs support).

Main findings of our reviewing process can be summarised in:

- There are several models of hospital-at-home care, with favourable clinical outcomes.
- These resources play a complementary role to conventional hospitalisation resources in the management of health crises of older patients.
- These services can be used in selected health crises with good prognostic and enough social support.
- The majority of RCTs who were tailored to older adults, designed interdisciplinary complex interventions (with health professionals and therapists, and staff from other disciplines, depending on the scheme).
- These schemes were oriented to provide intense home care to complex health crises.
- Interventions were often extended to the post-acute phase (mostly up to 4-6 weeks) to achieve clinical and functional goals.

- We could support the development of Comprehensive Geriatric Assessment (CGA)-based hospital-at-home care, provided by multidisciplinary teams led by geriatricians, as an opportunity to develop alternatives to conventional hospitalisation interventions tailored to high risk older patients.
- Their implementation could lead to several integrated care opportunities in our health system (see **Table 3**).

Table 3. Integrated care opportunities by implementing a CGA-based hospital-at-home model in the community

- 1 Alternative to *acute hospitalisation* in selected patients, to provide acute care in good prognostic health crises.
- 2 Alternative to *subacute hospitalisation*, to provide post-acute care in patients in need of geriatric rehabilitation due to low-moderate functional loss associated to the health crisis.
- 3 Management of *health crises in care homes*, by providing admission avoidance or early supported discharge care strategies, depending on needs, in good prognostic health crises.
- 4 *Link between Primary Care services and hospital services*, by playing an active role in the community, in keeping patients at home, maximising functional status, avoiding unnecessary hospital admission and avoiding institutionalisation.

CGA: Comprehensive Geriatric Assessment

For more details on characteristics and outcomes of the schemes analysed in the reviewing process, see **Appendixes 1-3**.

2.2. Hospital-at-home in the Catalan Health System: gaps and opportunities

In our country, hospital-at-home resources were founded in the 80s and 90s in several territories. There is not a homogeneously implemented model of care, and it is not specially designed for the care of older patients. These units have been focusing their efforts on supporting medical and surgical wards by providing acute treatment mainly in younger patients, where parenteral antibiotic treatment at home is one of main services provided (60-64).

From our scoping review, we found five RCT evaluating hospital-at-home interventions in Spain (three of them were designed in Catalonia) including patients aged 65 and older. Three interventions were developed for the treatment of acute exacerbations of COPD (27, 40, 58), one was designed to evaluate treatment of heart failure acute crises (26) and another paper was centred on acute care of patients with pneumonia (23).

Main characteristics of these trials were:

- The design was centred on acute treatment provision.
- Length of intervention (days) was defined based on the resolution of the trigger medical condition.
- They selected patients with comorbidity, suffering a prevalent chronic condition that was usually followed by specialists (as pneumologists or cardiologists) at outpatient level.
- The targeting process included robust older patients.
- Candidates were referred from the Emergency Department and, in some cases, from medical wards.
- Home care work was based on health staff (specialised nurses with outpatient support of hospital physicians).

From this evidence, we could conclude that for samples of robust older patients with comorbidity, suffering low complexity health crises, these schemes can obtain favourable outcomes.

Based on our review of national evidenced schemes, and combining it with international evidenced schemes, previously reviewed, we can identify some **gaps and room for improvement**, to extend the hospital-at-home targeting process to older patients with complex chronic conditions in our care system (**Table 4**).

Table 4. Gaps identified for the consolidation of hospital-at-home schemes to older patients in the Catalan Health System

- 1 Older patients with multimorbidity (suffering several coexisting chronic illnesses and conditions) including baseline geriatric conditions (such as frailty, chronic disability or cognitive impairment) need to be considered as HaH candidates (not being excluded).
- 2 Several social aspects of care (as social support or institutionalisation in care home) need to be considered (care home residents should be included as HaH candidates).
- 3 Medical and surgical processes leading to acute disability need to be included (as orthopaedics or stroke), as a paradigm of complex health crises in need of individualised complex interventions.
- 4 A comprehensive approach should include several aspects evaluated by The Comprehensive Geriatric Assessment clinical technology, such as functional status, cognitive status, nutritional aspects, consequences of health crises for patients and carers, and community reinsertion.
- 5 The intervention should be extended to the whole resolution of health crises (medical resolution of acute crises), and to the restitution of baseline functional status (facilitating community reinsertion, if possible).

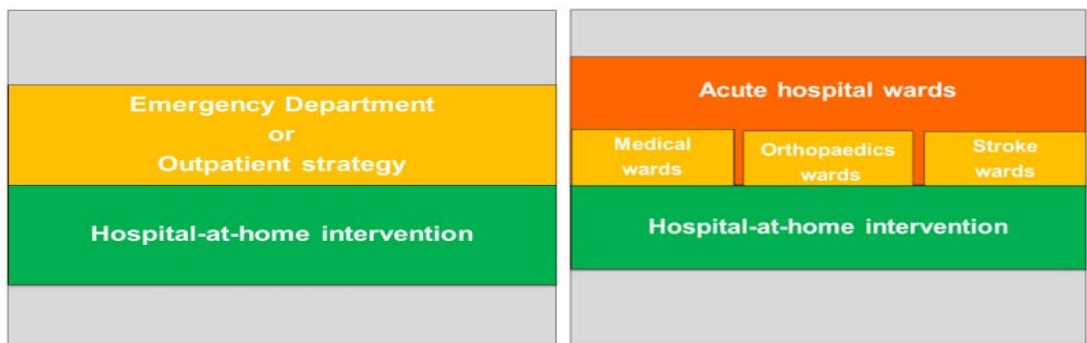
3

AIM AND METHODS

3.1. Objective and hypothesis of the PhD research

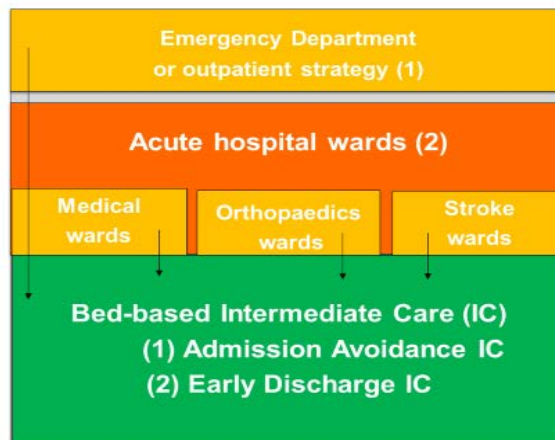
The general objective of this PhD project was to develop and validate an evidence-based HaH scheme specialised in geriatrics, and tailored to older patients with complex conditions, such as frailty, chronic disability and multimorbidity, to provide care for the health crises in the community as an alternative to conventional hospitalisation. This scheme combines Early Supported Discharge (ESD) and Admission Avoidance (AA) strategies in selected trajectories of care, as shown in **Figure 1**.

Figure 1. Comparison of home-based vs. hospital-based trajectories



VS.

Admission Avoidance (1) and Early Supported Discharge bed-based trajectories (2)



The main hypothesis was that in Catalan older adults with acute disabling health crises, due to medical or surgical processes, the development of a **Comprehensive Geriatric Assessment based and multidisciplinary hospital-at-home complex intervention**, with tailored clinical trajectories, could reach *similar clinical results*, compared to conventional hospital-based care (acute wards and bed-based intermediate care wards).

Moreover, we hypothesized that the new hospital-at-home integrated care model, with the adaptation of clinical protocols from geriatric hospital wards to the home environment, by using an integrated care approach, could be *more efficient* than conventional hospital-based trajectory, by shortening length of hospital stay and length of intervention, and aiming to keep patients in the community without an increase of hospital readmissions at the end of the intervention.

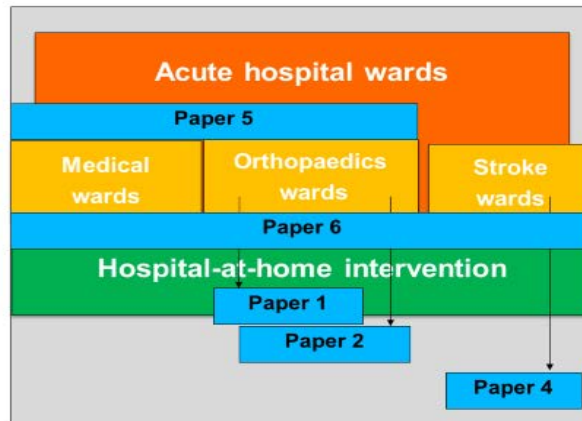
3.2. Methods of the PhD research

Due to the complexity of developing and evaluating RCT-based complex interventions in *real life older patients with complex chronic conditions*, we decided to evaluate the effectiveness of the clinical intervention developed in this doctoral thesis based on **observational studies**. For that, we used a cohort of patients attended following the new model of care from 2009 to 2016 in the institution Badalona Serveis Assistencials, in the territory of influence of **Hospital Municipal de Badalona** and **El Carme Intermediate Care Hospital**, in an urban area in the North of Barcelona.

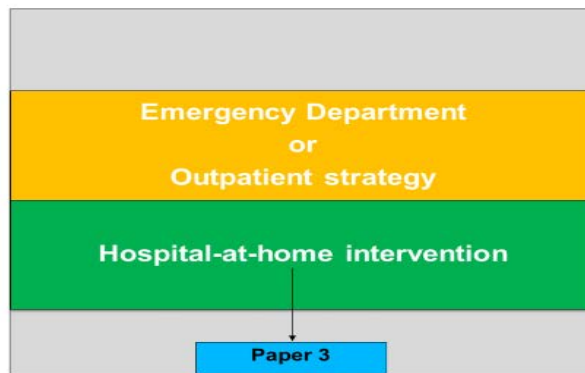
An intense publication activity has been done, for the dissemination of the development, analysis and conclusions of the home-based care model evaluated in this doctoral thesis (see **Figure 2**). A total of *eight papers* have been written to be published in different international indexed journals: two of them were part of the task of **reviewing the evidence** to create the intervention model; two papers analysed the intervention in **orthopaedic processes**; one paper analysed the intervention as **admission avoidance strategy in acute medical crises**; one paper analysed the intervention in **older patients with stroke**; and two evaluated clinical factors for the **effectiveness of the care model** in disabling health processes. To facilitate reading, we organized this thesis following the line of the different papers that we published on this topic, as part of this PhD work. The papers are classified from 1 to 6, according to their chronological order of submission to publication.

Figure 2. Care trajectories analysed and related papers

Early discharge home-based trajectory
 (*vs. hospital-based trajectory in papers 1,2,5; no control group in papers 4 & 6)



Admission avoidance home-based trajectory
 (vs. step-up bed-based intermediate care -paper 3-)



- In the explorative study which included orthopaedic patients (**paper 1**), we compared the home-based scheme with usual care at an intermediate care hospital, based on an unmatched analysis, although adjusted for multiple confounders. To estimate the adjusted difference in rehabilitation outcomes between groups we performed multivariate linear regression with rehabilitation efficiency outcome as the dependent variable and treatment group, together with all potential confounders at baseline, as independent variables.
- Paper 2 and paper 5 were based on a **quasi-experimental intervention design**. The CGA-based hospital-at-home programme was compared with a **propensity score (PS) matched** cohort of contemporary patients attended by usual inpatient hospital care (acute care plus intermediate care hospitalisation, if needed).

- In the orthopaedic costs study (**paper 2**), PS were calculated using a logistic regression model with the treatment group as the dependent variable, and all baseline characteristics (age, gender, Charlson Index, baseline Barthel Index, Barthel Index at admission, number of geriatric syndromes, prevalence of delirium at admission, cognitive impairment, and main clinical diagnosis) as independent variables.
- In the Admission Avoidance strategy in medical crises study (**paper 3**), we compared the home-based scheme with usual care at intermediate care hospital unit, based on an unmatched analysis, and again, adjusting for multiple confounders. We calculated the sample size to include a proportion of 2 controls per case. We performed a multivariate analysis using linear and binary logistic regression models to determine the explanatory variables associated with the outcomes and related to the intervention unit. Adjustment variables were: age, diagnostic group, cognitive impairment, baseline Barthel Index, place of residence and length of stay in the emergency department.
- In the study examining Early Supported Discharge strategy in stroke patients (**paper 4**), to explore the feasibility of the home based-program on stroke patients, we analysed data about all the stroke patients fulfilling ESD-stroke criteria (based on *trialists* recommendations) attended by the hospital-at-home scheme, without any control group.
- In the paper focusing on the clinical management of disabling health crises (**paper 5**), Propensity Score, reflecting the likelihood of receiving treatment at home was derived from a nonparsimonious multiple logistic regression that included all predictor variables that might be related to treatment at home or potential confounders for endpoints. These variables were demographics (age, gender) and characteristics such as diagnostic group, Early Supported Discharge/Admission Avoidance strategy, length of acute stay, baseline Barthel Index, Barthel Index at admission to each unit, Charlson Index, cognitive impairment, delirium, mood disorder and number of geriatric syndromes.
- In the analysis of factors related to effectiveness of the home-based model study (**paper 6**), a logistic regression analysis model was developed to find clinical variables associated to main outcomes of the cohort of HaH care patients attended. Variables significantly associated to outcomes in the univariate analysis were introduced in the multivariate analysis.

As a common element in all the quoted papers, we used a pragmatic approach in the **evaluation of the results**. We performed an evaluation of clinical outcomes (including acute hospital readmission, functional improvement variables (65), discharge to long term care units at the end of the intervention and mortality) to evaluate the effectiveness of the intervention. In the paper exploring the efficiency of the model in orthopaedic patients (paper 2), a sub-analysis of direct costs of the new scheme, compared to conventional hospital-based care, was performed, as shown in **Table 5**.

Table 5. Measurements of outcomes of the HaH-ICP

A. Effectiveness of the intervention

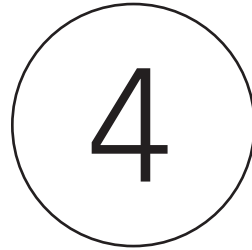
- Health crisis resolution: referral to Primary Care at the end of the intervention.
- Functional gain: Barthel Index score at discharge - Barthel Index score at admission
- Functional crisis resolution: Relative Functional Gain (RFG = functional gain/functional loss, measured by changes in Barthel Index) ≥ 0.35 .
- Favourable crisis resolution (health + functional) = Discharge to Primary Care at the end of the intervention, with RFG ≥ 0.35 .
- Mortality during process (mortality at 30 days of discharge was also measured in the Admission Avoidance medical crises management study).

B. Resources use

- Length of acute hospital stay, in days (length of Emergency Department stay was also measured in the Admission Avoidance medical crises management study).
- Length of intervention, in days.
- Readmission at discharge (Readmission at 30 days of discharge was also measured in the Admission Avoidance medical crises management study).

C. Costs of the intervention

The total direct cost of care per patient was calculated by multiplying the resources used by the unit cost of each resource (home-based vs. bed-based) in the orthopaedic trajectory, based on stay and on the involvement of staff.



DEVELOPMENT OF THE COMPLEX INTERVENTION

4.1. Development of the Hospital-at-Home Integrated Care Programme (HaH-ICP)

In 2009, a new home care unit was developed by the Department of Geriatric Medicine and Palliative Care of Badalona Serveis Assistencials (BSA). BSA acts as an integrated care social and health care institution, providing public integrated care services in Badalona, Catalonia's third-largest city (240,000 inhabitants). The initial objective of the creation of this unit was to assume medical care and follow-up, post-acute health care, and rehabilitation interventions for medical, orthogeriatric, and stroke patients selected in the acute care hospital, as an alternative to referring them to conventional hospital-based geriatrics services. The new team, created by the **Department of Geriatric Medicine and Palliative Care of BSA** in collaboration with the rehabilitation community services institution **Corporació Fisiogestió**, was requested to establish a comprehensive health care programme to provide acute and post-acute care in older patients' homes. It was the unit in which we could develop the complex intervention analysed in this thesis. In this way, a new **Hospital-at-Home Integrated Care Programme** (66), was created.

A community care team, comprising geriatricians and geriatric nurses, from the department of geriatrics, and community therapists, from community rehabilitation services, with support of social workers, from the integrated care institution, developed the new programme. Care protocols were tailored and validated to the older patients from geriatrics wards to the community, for the management of prevalent complex health conditions (67-70). Main protocols adapted to the community were:

- Management of acute care in complex health crises.
- Delirium detection and management.
- Management of patients with dementia and their behavioural symptoms.
- Prevention and management of deconditioning and functional decline.
- Nutritional risk assessment and care.
- Management of pressure ulcers.

The protocol for the activation and organisation of this clinical intervention (71), was based on reviewed evidence (see **Appendix 4**).

Main **key points of the programme** are summarised in **Table 6** (71):

Table 6. Key points of the HaH-ICP

- Complex intervention specialised in geriatric medicine as alternative to bed-based geriatrics care.
- For patients referred from hospital wards, Emergency Department, or the community (including care homes).
- Interdisciplinary word tailored to older patients with chronic complex conditions, such as frailty or multimorbidity.
- Comprehensive Geriatric Assessment as the centre of individualised care plans, adapted to every individual health crisis.
- Care plan centred on stabilisation of health crises and community reinsertion.
- Patient centred plan that include values and expectatives of patients and carers.
- Length of intervention adapted to resolution of health crises and functional improvement, with community reinsertion.
- After clinical and functional resolution, the discharge protocol includes transferring information on care to the Primary Care team, for the continuum of care.

HaH-ICP: Hospital-at-Home Integrated Care Programme

Main premises for the development of the new scheme can be summarised as:

- 1 **Correct targeting** of candidates at the hospital or at the community: a comprehensive assessment must include health criteria (good prognostic of health crises, without needing any additional complex diagnostic/imaging testing or management/follow-up by specialised units of the acute hospital) and social criteria (identification of an effective primary caregiver with enough physical and cognitive capacity to assure health care at home and willing to accept responsibility for the home-based care), and a patient agreement consenting to be attended at home.
- 2 **Rapid referral**, as soon as targeting criteria assessed and case accepted (access to home-services during first 12-24h of acceptation).
- 3 **Responsibility of care**: it was assumed by the hospital-at-home team. Health care capacity and diagnostic procedures equivalent to hospital-level care must be assured. In case of deterioration of clinical status or no response to treatment, patients were referred to acute hospital, based on shared protocols of the department.
- 4 **Multidimensional assessment**: performed by a multidisciplinary team for each individual case, to develop an individualised care plan for each health crises.
- 5 **Interdisciplinary teamwork**: the programme included shared therapeutic plans established at weekly meetings attended by the entire team to review individualised therapeutic goals and plans.
- 6 **Communication with Primary care teams**: when goals of the admission were achieved, patients were discharged from the unit, to the GPs and other Primary Care professional's for follow-up after the crisis resolution.

Main strategies of care of the home-based intervention are shown in **Table 7**.

Table 7. The main strategies and clinical processes attended by the HaH-ICP

Early Supported Discharge from acute wards

- Stroke.
- Fragility fractures (hip fracture, pelvic fracture or vertebral fracture).
- Surgical procedures (orthopaedic surgery of osteoarthritis and others).
- Medical processes, as decompensation of chronic conditions in frail/multimorbid patients, in need of short admission to acute medical wards for clinical stabilisation followed by post-acute care.

Admission Avoidance

- Medical processes, as decompensation of chronic conditions in frail/multimorbid patients, attended at Emergency Department or directly referred from the community (including care homes), after being assessed using an outpatient strategy.
- Non-surgical orthopaedics processes (such as pelvic fractures or acutely disabling traumatological), or clinical crises related to chronic arthropathies (as pain, falls etc.) attended at the Emergency Department.

HaH-ICP: Hospital-at-Home Integrated Care Programme

4.2. The paradigm of Early Supported Discharge in stroke patients

Considering stroke as a paradigmatic disabling health crises condition, we used data from an initial scoping review, analysing the model of care designed to facilitate discharge from stroke units/medical wards after the diagnostic and treatment of acute stroke, as a *key paradigm of complex intervention* from the hospital to the community. This model was called **Early Supported Discharge** (ESD) for stroke patients, by the pioneer trialists at the end of 90s of last century (72-75).

In the past two decades, many randomised clinical trials have aimed at investigating the effects of early discharging stroke survivors from hospital to home maintaining an equivalent intensity of the rehabilitation care. The original goal of ESD interventions was to accelerate discharge from hospital with the provision of both rehabilitation and health support to the community setting. Several authors have hypothesised potential advantages of ESD compared with conventional hospital-based rehabilitation care: avoiding complications of hospitalisation, improving patients and carer's morale, focusing on more realistic rehabilitation goals with discharge planning, providing rehabilitation in a more relevant environment, encouraging more focus on self-directed

recovery, and providing higher levels of health education and therapy input over the whole patient journey among others.

In the review article published in **International Journal of Stroke** (21), we aimed at analysing and discussing current evidence from trials and essential concepts derived from consensus of experts about the effects, generalisability, and applicability of ESD hospital-at-home schemes for the management of stroke cases in the community. With this article, and using the case of stroke patients, we critically reviewed methodological aspects of the available studies, and organisational aspects of multi-disciplinary specialised schemes developed from hospital to the community. From this review process, we identified key aspects for the creation of the HaH-ICP.

For more details on *inclusion and exclusion criteria* of the ESD in stroke patients schemes analysed in the reviewing process, see **Appendix 3**.



MAIN RESULTS

5.1. Analysis in orthopaedics processes (papers 1 and 2)

We initially explored the **clinical effectiveness** of the CGA-based hospital-at-home complex intervention in older patients with orthopaedic processes (**paper 1**). Secondly, we explored the **cost-effectiveness** of the CGA-based hospital-at-home complex intervention in older patients with these processes (**paper 2**).

Paper 1 (Clinical effectiveness of HaH-ICP in orthopaedic processes)

Incident disability and risk of negative events, as institutionalisation or death, are prevalent in older patients with orthopaedics processes, as hip fracture, pelvic fracture, vertebral fracture or osteoarthritis surgery. These processes has negative effects on quality of life and on the ability of older persons to remain independent in the community, at short-term and long-term follow up. Several authors developed ESD schemes to move specialised hospital-based teams into the community, for the management of acutely disabling traumatic conditions, to minimise clinical complications and to manage complex condition, facilitating early community reintegration and avoiding early hospital readmission (76).

With an initial observational explorative study, entitled *Hospital-at-home integrated care programme for older patients with orthopaedic conditions: Early community reintegration maximising physical function* and published in *Maturitas* (77), we aimed to **explore the usefulness** of the HaH-ICP developed at our Hospital-at-Home Unit (HHU) in older patients with orthogeriatric processes (as intervention group) and to compare its clinical outcomes with those of contemporary patients attended by usual bed-based orthogeriatric care provided at the Geriatric Rehabilitation Unit (GRU) of the same department (as control group). We included 270 patients consecutively admitted to the acute hospital through a 2 years period due to hip fractures and other orthopaedic processes (61 were referred to HHU and 201 were referred to GRU).

As in a pilot intervention paper, we described the multidisciplinary complex intervention, focusing on the collaboration between disciplines and on intensity of care (number of home visits of the staff members). An approach to inter professional work intensity of the home-care team was done based on the number of home visits in the intervention group for the process of care can be found in **Table 8**. We reported a mean of 39 home visits. These were performed during a period of 43 days.

Table 8. Number of home visits by disciplines involved in the hospital-at-home intervention in hip fracture patients

Physicians	(5)
Nurses	(15)
Physiotherapists	(14)
Occupational therapists	(5)
Total number of home visits (mean)	(39)
Length of intervention (days)	(43)

Finally, we compared clinical outcomes of the home-based trajectory (early discharge to hospital-at-home care from orthopaedics wards) versus usual bed-based trajectory of care (referral to geriatric rehabilitation unit from orthopaedics wards). Main characteristics of the samples (age, gender, geriatric syndromes, including cognitive impairment and delirium) and functional status (based on Barthel Index score) and results for several orthopaedics processes of the study were summarised in **Table 9** and **Table 10**. Main diagnostic subgroups in HHU (vs GRU) were: hip fracture 62.3% (vs.67.2%); vertebral/pelvic/other fractures 37.7% (vs. 32.8%).

Table 9. Comparative of baseline characteristics between HHU intervention group and GRU control group for hip fracture and other orthopaedic processes

	Hip fracture			Other orthopaedic processes		
	HHU n=43	GRU n=135	p value	HHU n=26	GRU n=66	p value
Age	84 (80-88)	85 (80-89)	0.63	82 (79-84)	81.5 (77-85)	0.75
Number of geriatric syndromes	5 (4-6)	5 (3-6)	0.06	5 (4-6)	4 (3-6)	0.04
Cognitive impairment	14 (32.6)	37 (27.4)	0.51	5 (19.2)	13 (19.7)	0.96
Delirium	4 (9.3)	11 (8.2)	0.76	11 (42.3)	2 (3)	<0.01
Preadmission Barthel score	88 (63-100)	95 (78-100)	0.05	91 (73-100)	95 (85-100)	0.18
Barthel score at admission	41 (15-57)	45 (30-57)	0.33	35.5 (29-54)	40 (23-58)	0.89
Functional decline	40 (32-48)	43 (35-55)	0.13	42.5 (26-58)	46 (30-65)	0.25

HHU: hospital-at-home unit; GRU: geriatric rehabilitation unit

All numbers represent mean (IQR: interquartile range), except N (%) in cognitive impairment and delirium.

Kruskal-Wallis rank test in quantitative variables; Fisher's exact test in qualitative variables

In hip fracture, as the main prevalent process analysed, we found no statistical differences between groups in baseline characteristics. Both groups were very old patients, with low level of baseline disability previously to the acute admission, and with complex geriatric conditions at admission to the unit, including cognitive impairment (1 of 3 cases) or delirium (nearly 10% of cases).

Table 10. Comparative of patient outcomes at discharge between HHU intervention group and GRU control group, for hip fracture and other orthopaedic processes

	Hip fracture			Other orthopedic conditions		
	HHU n=43	GRU n=135	p value	HHU n=26	GRU n=66	p value
Barthel score at discharge	80 (45-95)	81 (55-95)	0.98	82 (51-94)	86 (57-100)	0.37
Functional gain	35 (22-44)	31 (18-43)	0.29	31.5 (14-46)	33 (22-54)	0.32
Length of intervention (days)	43 (32-56)	57 (44-81)	<0.01	63 (49-77)	58 (44-76)	0.59
Discharge destination						
Home	36 (83.7)	115 (85.2)	0.816	23(88.5)	58 (87.9)	0.938
Acute unit	4 (9.3)	7 (5.2)	0.329	1 (3.8)	2 (3)	0.843
Long term or death	3 (7)	13 (9.6)	0.596	2 (7.7)	6 (9.1)	0.830

HHU: Hospital-at-Home Unit; GRU: Geriatric Rehabilitation Unit.

All numbers represent median (IQR: interquartile range), except (%) in discharge destination Kruskal-Wallis rank test in quantitative variables; Fisher's exact test in qualitative variables.

We found that the hospital-at-home group obtained good functional results (median of functional gain, measured as Barthel score at discharge - Barthel score at admission, of more than 30 points), that they were comparable to usual hospital-based care, with a low rate of negative results (such as readmission, mortality or institutionalisation) of less of 20% of cases.

Moreover, in the hip fracture trajectory, as the main prevalent process analysed, we observed better results in rehabilitation efficiency, due to the consecution of similar functional gain with shorter length of intervention (mean reduction of 14 days).

Paper 1 conclusion

- The HaHICP could be tailored to older patients after acute trauma and/or orthopaedic surgery due to a fracture. We could adapt hospital-based protocols from orthogeriatric wards to the community, to obtain an intense home-based intervention (mean of 39 visits in 43 days).
- Clinical results reached for the new home-based trajectory, were similar than results obtained by usual hospital-based care (not increasing readmission or mortality rates). The new home-based trajectory shortened length of intervention in hip fracture patients.

Paper 2 (Cost-effectiveness of HaH-ICP in orthopaedic processes)

This quasi-experimental study, entitled *Hospital-at Home Integrated Care Program for Older patients with Orthopedic Processes: An Efficient Alternative to Usual Hospital-Based Care*, published in **Journal of the American Directors Association** (78), aimed to evaluate direct costs of the HaH-ICP in orthopaedics processes, not only in hip fractures and other fracture cases (included in the paper 1 sample) but also adding patients receiving osteoarthritis surgery. We compared the HaH-ICP trajectory (early discharge from orthopaedics ward to the Hospital-at-Home Unit -HHU-) vs. the hospital-based trajectory (referral from orthopaedics ward to bed-based Geriatric Rehabilitation Unit -GRU-). Cost and functional recovery were calculated for a subsample of matched patients (one GRU case for each HHU case) according to propensity score (see **Methods** section).

A total of 367 patients consecutively admitted for fractures or arthroplasty surgery in a 2 year-period, were included: 91 were referred to HHU and 276 were referred to the GRU. **Table 11** shows main baseline characteristics between groups. In a similar

matter to results from the previous article (Paper 1), we found both groups were very old patients, with low level of baseline disability and with an orthogeriatric process (hip fracture in 1 of 2 cases) leading to moderate onset of acute disability. Both interventions obtained favourable clinical evolution of the process, with clinical resolution leading to discharge home for Primary Care follow up in 9 of 10 cases attended. Acute readmission was nearly 5% for both groups.

Table 11. Comparative of baseline characteristics between HHU intervention group and GRU control group in orthopaedic processes

	HHU N=91	GRU N=276	p
Female; n (%)	78 (85.7%)	231 (83.7%)	0.647
Age; mean (SD)	82 (7)	81 (9)	0.295
Charlson index	1 (0–2)	1 (0–2)	0.402
Main diagnosis; n (%)			0.619
Hip fracture	44 (48.4%)	134 (48.6%)	
Arthroplasty (hip/knee)	22 (24.2%)	75 (27.1%)	
Pelvic fracture	11 (12.1%)	35 (12.7%)	
Vertebral fracture	7 (7.7%)	19 (6.9%)	
Other fractures multiples	7 (7.7%)	9 (6.3%)	
Situation and clinical outcome			
Baseline Barthel index score	90 (68–100)	95 (85–100)	0.027
Barthel index score at admission	47 (28–67)	51.5 (31–64)	0.475
Barthel index score at discharge	88 (66–95)	90 (67.5–95)	0.634
Acute hospital stay (days) mean (SD)	10.1 (7)	15.3 (12)	<0.001
Discharge destination, n (%)			0.673
Home (Primary Care)	80 (87.9%)	245 (88.8%)	
Acute unit	6 (6.6%)	11 (4%)	
Long-term stay or care home	5 (5.5%)	19 (6.9%)	
Death	0	1 (0.4%)	

Variables are median (IQR: interquartile rang) for quantitative variables, except if noticed.

HHU: Hospital-at-Home Unit; GRU: Geriatric Rehabilitation Unit.

We compared intervention and control groups on three aspects: a). Degree of functional recovery; b). Direct cost of care; and c). Resource savings resulting from a reduction in acute hospital stay.

- A. Degree of functional recovery:** to assess limitations in activities of daily living we used the Barthel Index. To measure Relative Functional Gain, we used the Heinemann index calculating the functional gain/loss ratio, where functional gain was the difference between Barthel Index at end-treatment and at admission, and functional loss was the difference between Barthel Index at admission and at pre-admission.
- B. Direct cost:** the total cost of care per patient was calculated by multiplying the resources used by the unit cost of each resource (see **Table 12**). The cost of acute hospitalisation in the orthopaedics ward was estimated by calculating the cost of the stay in the acute hospital from the rates applied by the Catalan Department of Health for acute hospitalization (€680 per day for the first 5 days, and €485 euros per day thereafter). The unit costs applied to GRU were calculated from the hours per day allocated to the professionals involved. In the HHU, healthcare staff costs (geriatricians and nurses) were calculated from the hours per day allocated to the professionals involved, and from the number and type of home visits (initial assessment visits and follow-up visits) by rehabilitation physicians and therapists (physiotherapists and occupational therapists) per patient; the HHU cost also includes professionals' travelling time. Costs of pharmacy, transportation, catering, and caregivers were not included.
- C. Hospital stay:** the acute hospital stay (in days) before referral to the HHU or GRU was recorded.

Table 12. Unit cost calculated for HHU intervention group and GRU control group

Unit cost	Cost per patient (euro/unit)	
	HHU ²	GRU ³
Stay at acute hospital¹ (euros per day)		
Up to 5 days	680	680
More than 5 days	485	485
Cost per day, except HHU rehabilitation staff (per visit)		
Rehabilitation physician	33*	9.04
Physiotherapist	20*	3.54
Occupational therapist	20*	1.06
Nursing staff	12.9	21.74
Geriatrician	10.6	9.04
Orderlies	-	2.45
Nurse assistant	-	29.84

¹Source: public rates from the Department of Health of Catalonia

² Accounting source: Badalona Serveis Assistencials geriatric services and home rehabilitation service provider *Corporación Fisiogestión*

³Accounting source: Badalona Serveis Assistencials geriatric services.

*Rehabilitation staff for HHU

HHU: Hospital-at-Home Unit; GRU: Geriatric Rehabilitation Unit

Direct costs were lower in the intervention group for the reduction in the stay -mean (SD: Standard Deviation)- at Traumatology-Orthopaedics acute hospital ward [10.1 (7) days vs. 15.3 (12) days in GRU, $p < 0.001$] and for the shortening of rehabilitation phase, -mean (SD)- [49.4 (22.6) vs. 61.1 (35) days in GRU, $p = 0.001$], related to clinical effectiveness of the intervention group (see **Table 13**).

Table 13. Direct costs of HHU intervention group and GRU control group in orthopaedic processes

	HHU ¹ Cost per patient, Mean (SD)	GRU ² Cost per patient, Mean (SD)	p
A. Traumatology- Orthopaedics	€5,517 (3486)	€8,010 (5791);	<0.001
B. Rehabilitation	€1,603 (596)	€4,139 (2357)	<0.001
Physicians (geriatrics+rehabilitation)	€590 (240)	€552 (314)	0.027
Nurses	€638 (291)	€1329 (757)	<0.001
Nurses' aides	-	€1824 (1038)	
Orderlies	-	€150 (85)	
Physiotherapists and occupational therapists	€375 (102)	€284 (162)	<0.001
C. Total cost of care (A + B)	€7,120 (3381)	€12,149 (6322)	<0.001

SD: standard deviation.

¹ Accounting source: Badalona *Serveis Assistencials* geriatric services and home rehabilitation service provider Corporación Fisiogestión.

² Accounting source: Badalona *Serveis Assistencials* geriatric services.
Payment for process as per CatSalut rates.

HHU: Hospital-at-Home Unit; GRU: Geriatric Rehabilitation Unit

The multivariate linear regression analysis found the overall cost per patient was lower in HHU than in GRU: by €5,029 in the unadjusted analysis and by €5,062 after adjusting for baseline characteristics. The reduction was by €4,781 in the matched sample (**Table 14**).

Table 14. Direct costs of the HHU intervention and the GRU control in orthopaedic processes.

	Unadjusted mean difference (95% CI)	Adjusted mean (95% CI) difference using multivariate linear regression *	Adjusted mean (95%CI) difference in the propensity score analysis **
Total cost (€)	-5,029 (-6,394- -3,666)	-5,062 (-6,446 - -3,678)	-4,781 (-6,073- -3,489)
Functional gain/loss ratio (Heinemann index)	0.18 (-0.02 – 0.38)	0.14 (-0.05 – 0.33)	0.05 (-0.26 – 0.36)

*Adjustment variables: Charlson index, age, gender, preadmission Barthel score, and number of geriatric syndromes; **Variables for calculating propensity score: age, gender, Charlson index score, baseline Barthel index score, Barthel index score at admission, number of geriatric syndromes, prevalence of delirium at admission, cognitive impairment, and main clinical diagnosis.

HHU: Hospital-at-Home Unit; GRU: Geriatric Rehabilitation Unit

Paper 2 conclusion

- The HaH-ICP, when tailored to older patients after acute trauma and/or orthopaedic surgery, was as effective as standard inpatient care and significantly lowered costs for our local health system (due to reduction of the acute hospital stay and to shortening of rehabilitation phase).

5.2. Analysis in acute medical crises (paper 3)

We designed a small work to do an explorative analysis centred on the capacity of the HaH-ICP to provide alternative care in older patients with chronic conditions and in need of acute care due to a medical health crisis.

Paper 3 (Clinical effectiveness of HaH-ICP in medical crises)

Old age, the presence of cognitive impairment or delirium and the prevalence of geriatric conditions, could lead to readmission and institutionalisation, in medical health crises if they are not attended by using a Comprehensive Geriatric Assessment (CGA)-based approach, specially in ACEU (79). Several hospital-in-the-home groups evidenced the role of moving hospital-based care to the community for the management of medical health crises in selected patients, mainly in independent older adults with comorbidity, referred mainly from Emergency Departments. These groups found home admission as effective, not only from a clinical resolution view but also from a perspective of positive results on community reinsertion, with minimisation of both, readmission and institutionalisation (80). After more than two decades of previous studies (see **Appendices 1 and 2**) that evidenced hospital-at-home care as efficient alternative to substitute hospital wards care for acute medical crises in older adults with comorbidity, novel approaches are needed to implement CGA-based schemes to the most vulnerable older adults (81).

With this quasi-experimental study, entitled *Effectiveness of a Hospital-at-home Integrated Care Program as Alternative Resource for Medical Crises Care in Older Adults with Complex Chronic Conditions*, and **accepted in the Journal of the American Directors Association** (82), we aimed to explore the HaH-ICP in *real world older patients with complex medical health crises*, due to acute geriatric conditions related to frailty and multimorbidity, and at elevated risk of readmission. We compared clinical outcomes of a sample of older patients consecutively attended at the Hospital-at-Home Unit (HUH) versus a contemporary sample of older patients attended at the Intermediate Care Geriatric Unit (ICGU) during a winter season. We included older patients with chronic conditions who presented an acute medical crisis, assessed at Emergency Department (ED) or at Day Hospital, and considered as of good prognosis by the physician that activate the referral, without needing any additional complex diagnostic/imaging testing or management by other specialized units of the acute hospital.

We calculated sample size considering a proportion of 30% of death and admissions to acute hospital at follow-up, and 20% of risk reduction in a proportion of 2 controls per case (power of 90%; alpha 5%; beta 10%) (83). A total of 171 patients were included:

57 attended by the HHU and 114 at the ICGU. At admission, main data included: main diagnostic (respiratory infection, acute heart failure, urinary tract infection and other), referral from Emergency Department (ED)/outpatient, living at home/care home, length of stay in ED (for patients referred from ED) and main clinical characteristics of the patients (age, gender, baseline Barthel Index and Barthel Index at admission, morbidity measured by Adjusted Morbidity Groups (84), and prevalence of cognitive impairment and delirium). At discharge, Relative Functional Gain was calculated, and destination and length of stay in the unit were recorded. Main outcomes evaluated were: a. Health crisis resolution: discharge to Primary Care at discharge; b. Readmission to acute care unit at 30 days of discharge; c. Death at 30 days of discharge. We performed a multivariate analysis using linear and binary logistic regression to determine the explanatory variables associated with outcomes, and related to intervention unit. Adjustment variables were: age, diagnostic group, cognitive impairment, baseline Barthel Index, place of residence and length of stay in the emergency department.

Main baseline characteristics of both groups were summarised in **Table 15**. There is a sample of very old patients with complex health crises (1 of 2 cases had functional impairment and more than 15% of patients suffered delirium at admission). More than a half of patients had elevated risk of readmission (punctuation of 4 in AMG score).

Table 15. Baseline characteristics of the HHU intervention group and ICGU control group, in admission avoidance of medical crises

	HHU n = 57	ICGU n = 114	p value
Age (y), mean (SD)	84.3 (7.6)	86.9 (6.3)	0.02
Sex (Female); n (%)	28 (49.1)	73 (64)	0.07
Main diagnosis n (%)			0.03
Respiratory infection	24 (42.1)	66 (57.9)	
Heart failure	16 (28.1)	14 (12.3)	
UTI	11 (19.3)	28 (24.6)	
Other	6 (10.5)	6 (5.3)	
Referring unit; n (%)			<0.01
ED	32 (56.1)	111 (97.4)	
Day hospital	25 (43.9)	3 (2.6)	
Place of residence; n (%)			<0.01
Own home	48 (84.2)	65 (57)	
Nursing home	9 (15.8)	49 (43)	
Length of ED stay* (h); mean (SD)	12.6 (6.4)	22 (13.9)	0.02
Adjusted Morbidity Group score of 4, n (%)	34 (59.6)	85 (74.6)	0.12
Functional loss due to acute illness, n (%)	32 (56.1)	60 (52.6)	0.75
Cognitive impairment, n (%)	22 (38.6)	64 (56.1)	0.04
Delirium, n (%)	10 (17.5)	19 (16.7)	1.00

HHU: Hospital-at-Home Unit; ICGU: Intermediate Care Geriatric Unit; SD: Standard Deviation; UTI: Urinary Tract Infection; ED: Emergency Department; *For patients referred from ED

HHU and ICGU obtained comparable results, with health crises resolution in 9 of 10 cases referred, and lower rate of readmission or death at discharge, as shown in **Table 16**. For patients referred from ED, a shorter length of ED stay was found for the HHU group (12.6 vs. 22 hours, $p = 0.02$).

Table 16. Comparison of outcome measures between patients attended by the HHU and those attended by the ICGU

	HHU n = 57	ICGU n = 114	p value	OR (95 IC)*	p value*
Recovered from acute health crisis, n (%)	52 (91.2)	101 (88.6)	0.79	1.64 (0.27-9.83)	0.58
Died during stay, n (%)	1 (1.8)	5 (4.4)	0.67	2.03 (0.04-93.5)	0.71
Readmitted to an acute hospital within 30 days, n (%)	6 (10.5)	22 (19.3)	0.19	0.83 (0.23-2.95)	0.77
Died within 30 days of discharge, n (%)	5 (8.6)	11 (9.6)	1.00	0.51 (0.05-4.45)	0.53

	Unadjusted results			Adjusted results*		
	HHU n = 57	ICGU n = 114	p value	HHU	ICGU	p value
Length of stay, mean (SD), days	9.6 (3.9)	8.3 (2.9)	0.01	9.7 (3.9)	8.2 (2.9)	< 0.01
Relative functional gain, mean (SD)	0.77 (0.39)	0.49 (0.32)	0.01	0.75 (0.34)	0.51 (0.67)	0.01

HHU: Hospital-at-Home Unit; ICGU: Intermediate Care Geriatric Unit; SD: Standard Deviation; *Adjustment variables: age, diagnostic group, cognitive impairment, baseline Barthel Index, referral unit, place of residence and length of stay in the Emergency Department

The multivariate analysis showed that differences between schemes were non-significant, after adjusting for age, diagnostic group, cognitive impairment and baseline BI. This analysis showed significant differences on Length of Stay in the unit, between HHU and ICGU (9.7 days vs. 8.2 days, $p < .001$). RFG mean was higher for the HHU group (75% vs. 51%, $p=0.01$).

Paper 3 conclusions

- The HaH-ICP obtained similar favourable results on clinical resolution in 9 of 10 cases (with 30-day mortality of less than 10%), when it was compared with an implemented inpatient geriatric care program, in selected medical health crises of very old patients, and at risk of readmission due to multimorbidity or conditions related to frailty.
- Moreover, the home program was found related with better functional outcomes at discharge of the unit, and with, a non-significant but clinically relevant, reduction in readmission rate at short term follow-up (30 days) (10.5% vs 19.3%).

5.3. Analysis in frail older stroke patients (paper 4)

After a stroke, evidence supports the implementation of ESD schemes for the continuity of care from stroke units to the community in general populations of stroke patients. This model had been evidenced mainly in Northern Europe, but more research is needed to adapt schemes to other health systems, as the Catalan Health System. Moreover, some gaps have been identified from this evidence (21), with several unanswered questions identified, such as: a. What was the role of these resources in the oldest populations, that are more vulnerable due to geriatric conditions as frailty, cognitive impairment or delirium? or b. Is ESD adequate for candidates living in nursing homes?

The aim of this study entitled *Implementing Early Supported Discharge schemes to frail older survivors of a stroke: a pilot experience from Catalonia*, in process of publication (85), was to describe the feasibility of developing a new ESD programme tailored to very old stroke patients, at risk of negative results due to geriatric conditions. We would like to assess main usefulness of the HaH-ICP tailored to *real life* older stroke patients, focusing on functional and community reinsertion outcomes, as an exploratory experience for our local health system.

We analysed data from a small sample of consecutive stroke patients attended by adapting the HaH-ICP to the stroke care trajectory (n=32). We included patients aged ≥ 65 years with geriatric/frailty conditions (e.g. previous low level of disability, cognitive impairment or falls); suffering a stroke leading to sudden onset of disability and suitable to be early discharged and attended by a ESD scheme based on recommendations from a trialists' consensus (73); and having a 24 h caregiver with enough

physical and cognitive capacity to assure health care at home. In addition, patient/family caregiver consent was required. Having a diagnosis of cognitive impairment and living in a nursing home were not exclusion criteria. Main characteristics of the whole sample can be found in **Table 17**. Main outcomes of the sample according to baseline mRS, can be found in **Table 18**.

Table 17. Characteristics of the study Early Supported Discharge sample of older stroke patients (all mRS categories), attended by adapting the HaH-ICP

	n=32
Age	88.5 (81-91.5)
Women	22 (68.9)
Charlson Index	2 (2-3)
Number of geriatric syndromes	4 (3-5)
Hemorrhagic stroke	4 (12.5)
Main diagnosis	
Atherothrombotic	4 (12.5)
Cardioembolic	6 (18.9)
Lacunar	4 (12.5)
Indeterminate	11 (34.4)
Unusual	7 (21.9)
OCSP classification	
LACS	7 (21.9)
PACS	19 (59.4)
POCS	6 (18.8)
Baseline Barthel Index score	88 (62-100)
NIHSS at admission	5.5 (4-12.5)
Barthel Index score at admission	48.5 (34-65.5)
Functional loss	31.5 (16-47)
Functional gain	18 (7-27.5)
Relative Functional Gain	0.76 (0.33-1)
Barthel Index score at discharge	68.5 (46-88.5)
Discharge destination	
Community	28 (87.5)
Acute hospital	2 (6.25)
Long term care unit	2 (6.25)
Acute ward length of stay	9 (6-12)
Home unit length of stay	46.5 (38.5-59.5)

Variables are % or median (IQR: interquartile range).

OCSP: Oxfordshire Community Stroke Project; LACS: lacunar syndrome; PACS: partial anterior circulation; POCS: posterior circulation. NIHSS: National Institute of Health Stroke Scale.

HaH-ICP: Hospital-at-Home Integrated Care Programme; mRS: modified Rankin Scale

Table 18. Characteristics of stroke patients attended by adapting the HaH-ICP according to baseline mRS

	mRS 0-1 n=14	mRS 2 n=6	mRS 3-4 n=12	p value
Age	81.5 (79.5-87)	86 (81-92)	90.5 (89-96)	0.002
Women	7 (58.3)	4 (66.7)	11 (78.6)	0.536
Charlson Index	2.5 (1-3.5)	2.5 (2-3)	2 (2-2)	0.753
Number geriatric syndromes	3.5 (2.5-4.5)	5 (5-6)	3.5 (2-5)	0.101
Hemorrhagic stroke	2 (16.7)	0	2 (14.3)	0.580
Main diagnosis				0.952
Atherothrombotic	2 (16.7)	1 (16.7)	1 (7.1)	
Cardioembolic	2 (16.7)	1 (16.7)	3 (21.4)	
Lacunar	2 (16.7)	0	2 (14.3)	
Indeterminate	4 (33.3)	3 (50)	4 (28.6)	
Unusual	2 (16.7)	1 (16.7)	4 (28.6)	
OCSP classification				0.528
LACS	2 (16.7)	1 (16.7)	4 (28.6)	
PACS	6 (50)	4 (66.7)	9 (64.3)	
POCS	4 (33.3)	1 (16.7)	1 (7.1)	
NIHSS at admission	4.5 (3-13)	3 (1-4)	3 (2-4)	<0.001
Baseline Barthel Index score	100 (100-100)	91 (84-100)	59.5 (47-63)	0.661
Barthel Index score at admission	61 (48-76)	44.5 (43-65)	37 (20-54)	0.005
Barthel Index score at discharge	88.5 (78.5-100)	65 (57-75)	60.5 (40-69)	0.018
Functional loss	36.5 (24-49.5)	41.5 (29-57)	25.5 (10-33)	0.071
Functional gain	22 (11-33.5)	15 (10-25)	10 (5-27)	0.697
Relative Functional Gain	0.77 (0.56-1)	0.41 (0.34-0.44)	1 (0.23-1.33)	0.007
Discharge destination				0.359
Community	10 (83.3)	6 (100)	12 (85.6)	
Acute hospital	1 (8.3)	0	1 (7.1)	
Long term care unit	1 (8.3)	0	1 (7.1)	
Acute ward length of stay	7 (6-9.5)	8.5 (7-12)	10.5 (6-12)	0.566
Home unit length of stay	39 (23-46.5)	45.5 (38-48)	59.5 (47-62)	0.009

Variables are % or median (IQR: interquartile range).

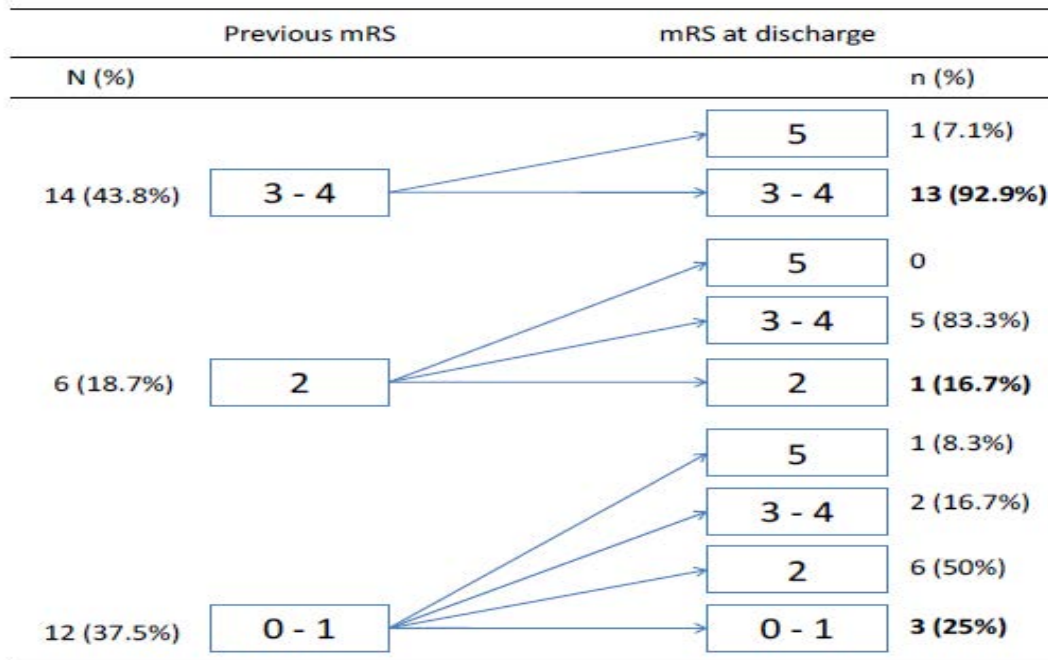
OCSP: Oxfordshire Community Stroke Project; LACS: lacunar syndrome; PACS: partial anterior circulation syndrome; POCS: posterior circulation syndrome; NIHSS: National Institute of Health Stroke Scale; mRS: modified Rankin Scale.

We included a sample of very old patients, with low/moderate level of limitation in functionality at baseline, suffering moderate severity (median NIHSS 5.5) ischaemic stroke (in 87.5% of cases), and leading to a moderate grade of acute disability.

Despite the mean of geriatric conditions presented at admission to the unit suggest this was a frail population, at risk of negative evolution, we found favourable clinical evolution in 87.5% of cases (readmission or admission to long term care unit was lower than 15%), with a median length of intervention of 7.5 weeks.

Figure 3 shows the evolution of functional status, according to previous functional status (based on modified Rankin Score).

Figure 3. Modified Rankin Scale (mRS) status reached at the end of the HaH-ICP intervention according to categories of previous mRS



HaH-ICP: Hospital-at-Home Integrated Care Programme; mRS: modified Rankin Scale

The HaH-ICP seems especially effective in patients presenting a baseline complex geriatric profile (modified Rankin score of 3 or 4). In these cases, 75% of patients were discharge from acute hospital wards between 6 and 12 days of admission. With median a length of intervention of 59.5 days, 9 of 10 patients reach previous status based on modified Rankin score status category. In these complex patients, the rehabilitation intervention seems especially adapted, with median Relative Functional Gain of 1.

Paper 4 conclusions

- The HaH-ICP could be adapted to very old frail patients suffering moderate severity stroke, with clinical resolution of health crises in 9 of 10 cases (re-admission was lower than 10%).
- Despite the complex profile of patients with baseline disability, the scheme could facilitate acute hospital ward discharge and provide efficient rehabilitation care leading to community reinsertion (discharge to institution was lower than 10%).

5.4. Evaluation of effectiveness in disabling processes (papers 5 and 6)

To assess the clinical effectiveness of HaH-ICP in disabling health crises, we designed a quasi-experimental study including older patients suffering medical and orthopaedics processes and comparing their outcomes with outcomes of a contemporary group of older patients suffering the same processes and attended by bed-based care (**paper 5**). In the evaluation of clinical factors for the effectiveness of the home-based study, we added stroke patients to the medical and orthopaedics cohort of hospital-at-home patients, to find variables related to clinical evolution of the intervention (**paper 6**).

Paper 5 (Effectiveness of HaH-ICP in disabling health crises)

Older adults with medical or surgical health crises need complex interventions (86) due to the high prevalence of frailty, baseline disability or multimorbidity, which increase the risk of bad outcomes. In these patients, a hospital admission could be associated with adverse events, such as acute onset of disability or delirium. These factors might limit their ability to resume life at home after the acute discharge, determining the need of post-acute care to improve this transition. These patients are not only exposed to higher risk of clinical adverse outcomes but also to longer hospital stays. For these reasons, innovative early discharge strategies have been validated in the last decades

to improve clinical outcomes for several prevalent conditions, such as heart failure, COPD, infectious diseases, hip fracture and stroke, among others (36, 39).

The aim of this study, entitled *Hospital-at-home Integrated Care Programme for Older Patients with Disabling Health Crisis: Comparison with Bed-based Intermediate Care*, and published in **Age and Ageing** (87), was to analyse the results, in terms of effectiveness and efficiency, of the HaH-ICP, extended from acute phase to post-acute phase tailored to older patients with health crises leading to acute disability, as alternative care to usual inpatient care in our territory. Outcomes of patients attended by the HHU were compared with outcomes of a propensity score matched cohort of contemporary patients attended by usual inpatient hospital care (acute care plus intermediate care hospitalisation, at Bed-Based Unit -BBU-), for the management of medical and orthopaedics processes. We analysed health crisis resolution, functional resolution, and the combined outcomes of favourable crisis resolution (health + functional) as main outcomes (see **Methods** section).

We included a total of 849 subjects (244 in the HHU and 605 in the BBU). The sample included all the orthopaedics patients from paper 1 and 2, and we added a group of medical patients, in need of geriatric rehabilitation after clinical stabilisation. Mean age was 83.2, 72% females, 73.4% referred from acute wards (ESD strategy), acute condition medical was medical in 43% vs. orthopaedics in 57%. Mean age was 83.2, 72% females, 73.4% referred from acute wards (ESD strategy), acute condition medical was medical in 43% vs. orthopaedics 57%. Baseline characteristics of the sample (age, gender, functional status, Charlson Comorbidity Index score, geriatric syndromes presence as cognitive impairment, delirium, functional loss or mood disorder), by groups are shown in **Table 19**.

Table 19. Characteristics of the HHU intervention group and BBU control group, in disabling health crises

	HHU n = 244	BBU n = 605	p value
Age (yr.)	83.8 (82.9-84.6)	83 (82.4-83.6)	0.160
Gender (Female)	167 (68.4)	444 (73.4)	0.152
Medical condition	152 (62.3)	213 (35.2)	<0.001
ESD/AA strategy	56.6/43.4	80.2/19.8	<0.001
Length of acute stay (d)	6.1 (5.3-6.9)	11.2 (10.5-11.9)	<0.001
Baseline Barthel Index score	75.2 (72.4-77.9)	83.9 (82.2-85.6)	<0.001
Barthel Index at admission score	41.5 (38.4-44.6)	42.6 (40.7-44.5)	0.527
Charlson Index	2 (1-3)	2 (1-3)	0.467
Number of geriatric syndromes	5 (4 - 6)	4 (3 - 6)	<0.001
Cognitive impairment	101 (41.4)	157 (26)	<0.001
Delirium	41 (16.8)	81 (13.4)	0.197
Mood disorder	48 (19.7)	119 (19.7)	1.000
Functional loss	33.7 (31.5-35.9)	41.1 (39.5-42.7)	<0.001

Variables are n (%) or median (IQR: interquartile range).
 HHU= Hospital-at-home unit; BBU = Bed-based unit; CI= confidence interval; IQR= Interquartile range; ESD = Early Supported Discharge; AA =Admission Avoidance.

We found a sample of older patients with complex health crises (high prevalence of geriatric syndromes), and moderate functional loss due to acute process (medical or orthopaedical). Baseline functional status pre-event was worst for the HHU group (due to higher prevalence of cognitive impairment and other geriatric syndromes), and functional loss due to the health crisis was higher in the BBU.

For ESD strategy, length of acute stay was significantly shorter in HHU group.

Table 20 shows main clinical results for the groups in the resolution of disabling health crises.

Table 20. The main outcomes in the HHU intervention group and the BBU control group, in disabling health crises

	HHU n = 244	BBU n = 605	p value
Length of intervention (days)	46.6 (43.9-9.2)	55.5 (52.9-57.2)	0.000
Barthel Index score at discharge	67.9 (64.3-71.6)	69.7(67.1-72.2)	0.036
Functional gain	26.4 (23.9-28.9)	26.8 (24.8-28.9)	0.312
Health crisis resolution	192 (78.7)	479 (79.2)	0.926
Functional resolution	193 (79.1)	455 (75.2)	0.247
Favourable crisis resolution	180 (73.8)	421 (69.6)	0.243
Rehabilitation efficiency	0.60 (0.53-0.66)	0.52 (0.46-0.58)	0.292
Discharge destination			0.027
Community	192 (78.7)	479 (79.2)	
Acute care unit	26 (10.7)	37 (6.1)	
Long term care setting	22 (9)	61 (10.1)	
Death	4 (1.6)	28 (4.6)	

Variables are n (%) or median (IQR: interquartile range), except Length of intervention and Rehabilitation efficiency: mean (95% Confidence Interval).
 HHU= Hospital-at-home unit; BBU = Bed-based unit; CI= confidence interval; IQR= Interquartile range; FHCRC= favourable health crisis resolution; FFR= favourable functional resolution

Both groups obtained satisfactory results of health crisis resolution in 8/10 cases, with low percentage of readmission or death (unadjusted results).

However, when results were adjusted by PS model, HHU was associated with favourable crisis resolution (health and functional) [OR = 1.54 (1.06–2.22)], and with shorter intervention stay (mean difference: –5.72 days (–9.75 to –1.69)).

Paper 5 conclusions

- The HaH-ICP had at least the same health crisis resolution capacity, but reducing days of hospitalisation, compared to a usual hospital-based trajectory contemporary cohort.
- Moreover, these results were obtained with a shorter length of intervention, and with better functional outcomes and rehabilitation efficiency at discharge for the home group.

Paper 6 (Clinical factors for the effectiveness of the home-based model)

Vulnerability to hospitalisation of older patients with frailty and multimorbidity, urges the need to develop alternatives to conventional hospital-based trajectory of care. Innovative integrated care strategies in the community could led to efficient outcomes for health crises management and community reinsertion.

The aim of the final work, entitled *Hospital-at-Home Integrated Care Programme as an Efficient Care Model for Disabling Acute Crises in Older Patients: Identification of Good Prognostic Factors*, in process of publication (88), was the identification of prognostic factors of this intervention, as a key point for improving the targeting process of candidates.

We analysed the cohort of 484 older patients attended due to disabling health crises (medical, orthopaedics or stroke) during five years by the HaH-ICP, by using the same clinical outcomes reported in previous studies: health crisis resolution, functional resolution, and their combined variable favourable crisis resolution -health resolution plus functional resolution-. A logistic regression analysis was performed including clinical variables from Comprehensive Geriatric Assessment at admission (age, gender, baseline and at admission Barthel Index score, baseline and at admission Lawton Index score, Mini Mental State Examination score at admission, Charlson Comorbidity Index score, number of geriatric syndromes, origin of the referral and main carer) to detect factors related to favourable outcomes (see **Methods** section). Characteristics of the sample, by diagnostic profiles (based on diagnostic groups: Medical, Orthopaedics and Stroke) are shown in **Table 21**.

Table 21. Baseline characteristics and patient's profiles at admission for the HaH-ICP

	Medical (n = 283)	Orthopaedic (n = 152)	Stroke (n = 49)
Age	85.4 (6.1)	82.4 (6.9)	85.1 (7.9)
Gender female	62.9	82.9	61.2
Baseline Lawton Index score	1.7 (2.2)	2.6 (2.5)	1.4 (2.2)
Baseline Barthel Index score	71.3 (22.6)	80.1 (21.3)	72.7 (23.4)
Barthel Index score at admission	38.1 (25.3)	45.4 (24.9)	38.1 (24.7)
MMSE score at admission	19.4 (6.6)	20.5 (8.7)	15.5 (8.2)
Number of geriatric syndromes	5.1 (1.4)	4.7 (1.6)	4.9 (1.5)
Charlson Index score	2.1 (1.3)	1.5 (1.3)	2.6 (1.3)
Referred from			
Hospital wards	46.6	69.7	57.1
ED/Community	53.4	30.3	42.9
Main carer			
Family member	72.4	58.6	75.5
Private carer	14.8	11.2	14.3
Nursing home	12.7	30.3	10.2

Variables are % or mean (Standard Deviation). MMSE: Mini Mental State Examination; ED: Emergency Department

- Several differences were found between groups: Orthopaedics patients were mainly younger women, with better baseline and at admission functional status, and with higher percentage of cases living in care home. On the other hand, the medical subgroup had a higher percentage of referrals from ED or the community.

Table 22 and **Table 23** show the univariate and multivariate analysis of factors related with good prognosis of the home intervention.

Table 22. Factors related with resolution of health crises attended by the HaH-ICP (univariate analysis)

	Health crisis resolution			Functional resolution			Favourable crisis resolution		
	Yes	No	p value	Yes	No	p value	Yes	No	p value
Age*	84.2 (6.5)	85.2 (7.2)	0.046	83.9 (6.5)	86.1 (7.0)	0.001	84.0 (6.5)	85.5 (7.1)	0.008
Gender			0.816			0.644			0.913
Male	117 (78)	33 (22)		112 (74.7)	38 (25.3)		107 (71.3)	43 (28.7)	
Female	257 (76.9)	77 (23.1)	257 (76.9)	77 (23.1)	249 (71.9)	94 (28.1)			
Main clinical process			0.001			0.010			0.005
Medical	203 (71.7)	80 (28.3)		204 (72.1)	79 (27.9)		190 (67.1)	93 (32.9)	
Orthopaedic	133 (87.5)	19 (12.5)		129 (84.9)	23 (15.1)		124 (81.6)	28 (18.4)	
Stroke	38 (77.6)	11 (22.4)	36 (73.5)	13 (26.5)	33 (67.3)	16 (32.7)			
Baseline LI score			0.061			0.015			0.016
<5	303 (75.6)	98 (24.4)		297 (74.1)	104 (25.9)		278 (69.3)	123 (30.7)	
≥5	71 (85.5)	12 (14.5)	72 (86.7)	11 (13.3)	69 (83.1)	14 (16.9)			
Baseline BI score			0.004			0.103			0.011
≤40	28 (59.6)	19 (40.4)		31 (66)	16 (34)		26 (55.3)	21 (44.7)	
>40	346 (79.2)	91 (20.8)	338 (77.3)	99 (22.7)	321 (73.5)	116 (26.5)			
BI score at admission			<0.001			<0.001			<0.001
≤40	163 (68.8)	74 (31.2)		158 (66.7)	79 (33.3)		143 (60.3)	94 (39.7)	
>40	211 (85.4)	36 (14.6)	211 (85.4)	36 (14.6)	204 (82.6)	43 (17.4)			
MMSE at admission			0.003			<0.001			<0.001
≤14	72 (69.9)	31 (30.1)		66 (64.1)	37 (35.9)		62 (60.2)	41 (39.8)	
15-20	103 (71.5)	41 (28.5)		103 (71.5)	41 (28.5)		93 (64.6)	51 (35.4)	
≥21	199 (84)	38 (16)	200 (84.4)	37 (15.6)	192 (81)	45 (19)			
Ngeriatric syndromes*	4.8 (1.6)	5.3 (1.3)	0.007	4.8 (1.6)	5.4 (1.4)	0.001	4.8 (1.6)	5.3 (1.3)	0.001
Charlson Index score*	1.9 (1.4)	2.3 (1.3)	<0.001	1.9 (1.3)	2.3 (1.4)	0.012	1.9 (1.3)	2.3 (1.4)	<0.001
Strategy			0.588			0.915			0.839
Early Discharge	203 (76.3)	63 (23.7)		202 (75.9)	64 (24.1)		192 (72.2)	74 (28.7)	
Admission Avoidance	171 (78.4)	47 (21.6)	167 (76.6)	51 (23.4)	155 (71.1)	63 (28.3)			
Main caregiver			0.474			0.192			0.148
Family member	261 (78.9)	70 (21.1)		260 (78.5)	71 (21.5)		246 (74.3)	85 (25.7)	
Private carer	48 (72.7)	18 (27.3)		46 (69.7)	20 (30.3)		42 (63.6)	24 (36.4)	
Nursing home	65 (74.7)	22 (25.3)	63 (72.4)	24 (27.6)	59 (67.8)	28 (32.2)			

Variables are N (%), except * mean (Standard Deviation). N: number, LI: Lawton Index; BI: Barthel Index; MMSE: Mini Mental State Examination score

Table 23. Factors related with resolution of health crises attended by the HaH-ICP (multivariate analysis)

Variable	OR (95% CI)	p value
Health crisis resolution		
Orthopaedic clinical process	2.44 (1.40 – 4.26)	<0.001
ADLs score at admission		0.063
Barthel Index ≤40	ref.	
Barthel Index >40	1.70 (0.97 – 3.98)	
Absence of pressure ulcers at admission	2.26 (1.34 – 3.84)	0.002
Functional resolution		
Orthopaedic clinical process	1.97 (1.16 - 3.36)	0.012
ADLs score at admission		
Barthel Index ≤40	ref.	
Barthel Index >40	1.87 (1.08 – 3.25)	0.026
Absence of pressure ulcers at admission	2.80 (1.67 – 4.71)	<0.001
Favourable crisis resolution		
Orthopaedic clinical process	2.00 (1.22 – 3.29)	0.006
ADLs score at admission		
Barthel Index ≤40	ref.	
Barthel Index >40	2.03 (1.20 – 3.42)	0.008
Absence of pressure ulcers at admission	2.80 (1.68 – 4.65)	<0.001
.....		
OR: Odds Ratio; IC: Confidence Interval; ADLs: Activities of Daily Living		

HaH-ICP: Hospital-at-Home Integrated Care Programme

Variables found related to Health Crisis Resolution were: suffering an orthopaedic process, and not having the geriatric syndrome of pressure ulcers.

Variables found related to Functional Resolution were: suffering an orthopaedic process, Barthel Index score higher than 40 points at admission, and not having the geriatric syndrome of pressure ulcers.

Variables found related to Favourable Crisis Resolution were: suffering an orthopaedic process, Barthel Index score higher than 40 points at admission, and not having the geriatric syndrome of pressure ulcers.

Paper 6 conclusions

- Slight differences were found between several profiles of patients attended by the HaH-ICP obtained (medical, orthopaedics and stroke), based on results. Favourable health crisis resolution was found higher in orthopaedics patients.
- Suffering an orthopaedic process, Barthel Index score higher than 40 points at admission, and not having the geriatric syndrome of pressure ulcers, were found factors related with favourable crisis resolution.
- Other clinical factors as main carer, living in nursing home, or suffering cognitive impairment or delirium, were not found related with unfavourable resolution of health crises attended by the HaHICP.



DISCUSSION

This Doctoral Thesis, starting from the review of the available evidence on hospital-at-home for older adults as a person-centred care alternative to conventional hospitalisation in health crises (89), aimed to contribute to design and evaluate an innovative integrated care scheme for disabling health crises in need of hospital care, tailored to vulnerable older patients with chronic conditions in the Catalan Health System.

6.1. Summary of results

The evaluation of results on several medical and surgical processes, supports the role of this clinical intervention in several trajectories and strategies of care of health crises affecting older patients with complex chronic conditions. Overall, the HaH-ICP obtained comparable clinical results to the hospital-based trajectory in different processes. A reduction in length of hospitalisation was evidenced. A cost-effectiveness benefit was evidenced in the analysis of orthopaedics patients.

Main results of the analysis of the complex intervention for different clinical processes

In **orthopaedics processes**, the HaH-ICP could be tailored to older patients after acute trauma and/or orthopaedic surgery, by adapting hospital-based protocols from orthogeriatric wards to the community and obtaining an intense home-based intervention. Clinical results reached by the new home-based trajectory, were similar than results obtained by usual hospital-based care (not increasing readmission or mortality rates). By using an adjusted analysis between interventions, it seemed the new care trajectory could have an impact on facilitating early community reinsertion in hip fracture patients.

When we compared both schemes, based on a PS matching method, in orthopaedic fractures and osteoarthritis surgery, we found the HaH-ICP as effective as standard inpatient care, but it significantly led to lower direct costs for the health system. This cost-effectiveness benefit was in part related to reductions in acute hospital stay and to the shortening of the rehabilitation phase (due to early community reinsertion).

In selected **medical crises**, the direct admission to the HaH-ICP unit, was related to favourable clinical resolution in 90% of cases (with 30-day mortality of less than 9% and 30-day readmission of less than 11%). Health crisis resolution was equivalent to usual bed-based intermediate care, when it was compared, by using and adjusted analysis, with an implemented inpatient geriatric care program, despite old age of the patients, and despite high prevalence of patients being at risk of readmission due to multimorbidity and conditions related to frailty.

Moreover, the home trajectory was found related with better functional outcomes at discharge of the unit, and with a non-significant but clinically relevant reduction in readmission rate at short term follow-up, when compared to inpatient care. More research is needed to support these preliminary results on the feasibility of HaH-ICP in the Admission Avoidance strategy tailored to complex medical crises.

In selected **stroke patients**, the HaH-ICP could be adapted to very old frail patients suffering a moderate severity stroke, with clinical resolution of health crises in 90% of cases. Despite the complex profile of patients with baseline disability, the scheme could facilitate acute hospital ward discharge and provide efficient rehabilitation care leading to community reinsertion (discharge institution at discharge was lower than 10%). More research is needed to support these preliminary results on the feasibility of HaH-ICP in frail stroke patients.

Main results of the analysis of the complex intervention focusing in disabling health crises

When we analysed the results by comparing the HaH-ICP trajectory with a PS matched sample in the conventional trajectory (acute care plus bed-based intermediate care) in disabling health crises, we evidenced that the HaH-ICP trajectory had at least the same health crisis resolution capacity, with a reduction in days of hospitalisation. Moreover, these results were obtained with a shorter length of intervention, and with better functional outcomes and rehabilitation efficiency at discharge, in the home-based trajectory.

Finally, when we evaluated **clinical factors** related to positive outcomes of the HaH-ICP, we found slight differences between several profiles of patients attended (medical, orthopaedics and stroke). Percentage of favourable health crisis resolution was found higher in orthopaedics patients, in part due to a baseline profile with slightly lower complexity.

Suffering an orthopaedic process, scoring Barthel Index higher than 40 points at admission, and not having the geriatric syndrome of pressure ulcers, were found factors related to favourable crisis resolution. Other clinical factors as the kind of main carer, living in nursing home, or suffering cognitive impairment or delirium, were not found related to unfavourable resolution of health crises attended by the HaH-ICP.

6.2. Comparison with previous evidence

In the following paragraphs several considerations related to this doctoral research will be discussed.

A. Designing a new home-based intermediate care resource

Different Cochrane reviews and other systematic reviews (90-92) have evaluated home-based schemes in the care of complex health crises and for the management of functional loss. Most of the schemes had favourable clinical outcomes, but there is not a homogeneous home-based intermediate care model that could be considered as *gold standard*. Variations in schemes are related to the context and evolution of each single local system where it was implemented. In some regions, home-based Intermediate Care is fragmented between hospital-at-home teams, designed to provide acute treatment (93), and reablement schemes, that act as community rehabilitation services (92). Most HaH interventions were designed to respond to the short-term phase of medical health crisis (94-97). It seems that the rehabilitation phase was not included in some of the described interventions. In some cases, reablement services are activated after the acute treatment, with a delay between referral and activation, in a trajectory that leads to fragmentation, and to a higher risk of complications and readmission. In most papers, the role of standardised CGA in the intervention is not clear. Other schemes focused on early discharge and rehabilitation, for paradigmatic disabling conditions such as stroke, but these schemes do not have the capacity to provide acute care at home if needed. In some cases, these resources are linked to a hospital but in other cases they are linked to community teams and primary care.

In order to provide a possible response to fragmentation, the development of our model was centred on a unique home-based team that provided acute care and rehabilitation. The model was built on the idea of adapting care models and protocols of geriatric wards to the community, and of promoting continuity of care for the 'whole' crisis, earlier from acute phase to community reinsertion, by improving functional outcomes and minimising complications (98,99). The admission to the service was planned to be done during first 12 hours after referral (by performing a home visit or a phone visit) without any gap or delay. With this home-care model, the intervention was performed in two stages during a unique process of care: the first stage was centred on acute treatment provision; the second stage was centred on rehabilitation of functional loss related to the health crises, and on community reinsertion.

B. Development of a CGA-based complex intervention centred on person needs

As previously noticed, the hospital-at-home model not only focused on early discharge or admission avoidance strategies for acute treatment and clinical stabilisation, but also extends the CGA-based intervention to patient's home, tailoring the intervention until completing resolution (from both health and functional perspectives) of the crises. It was an opportunity to deliver patient-centred care plans, based on patient values and considering social-familiar aspects of each individual case, that ends with the reinsertion of the patient to the community, with a very flexible approach which might be adapted to the need of patients' care within a territory.

Several groups, from Australia (22, 36), Italy (28-31) and the UK (39), have published in the last two decades, data from the evaluation process of similar geriatrician-led models of hospital-in-the-home care, based on RCT for selected clinical processes. The Sydney group (36) found early home discharge after acute hospitalisation associated with a lower risk of delirium, and greater patient satisfaction. In the admission avoidance (22) strategy, the same group found home-based admission after assessment in Emergency Department associated with better clinical outcomes, such as lower incidence of confusion, urinary complications (incontinence or retention) and bowel complications (incontinence or constipation), with no significant difference in number of adverse events and deaths (up to 28 days after discharge), and with higher patient and carer satisfaction. This scheme was composed by the same disciplines as ours: nurses, physicians, physiotherapists and occupational therapists. In the early discharge modality of the scheme, they reported a length of intervention of less than 3 weeks (shorter than the results reported in paper 5, in part due to the heterogeneity of our sample). In the admission avoidance modality of the scheme in medical crises, its length of intervention was 10 days (equivalent to the results reported in paper 3).

The Torino group found favourable clinical results at follow up (compared to inpatient care) of a similar scheme on the admission avoidance modality for several medical crises of older patients discharged from the Emergency Department, including decompensation of heart failure (31) or COPD (29), medical processes in patients with advanced dementia (30), or in stroke cases (28). In heart failure patients, 6 months after treatment, they found no differences in mortality (15%), but the mean time to first additional admission was significantly longer (difference of 15 days) for the home treated group. Only the home treated patients experienced improvements in depression, nutritional status, and quality-of-life scores. Equivalent results were obtained at 6 months follow-up in COPD patients: cumulative mortality was low (up to 20%), with significant reduction in readmission rate for the home group. Only these patients experienced improvements in depression and quality-of-life scores. In selected medical cases of patients with severe dementia, no differences on mortality were found, but

positive outcomes in dementia care were evidenced (lower anti-psychotic drugs use, and a significant reduction in the stress of caregivers about discharge was noticed). In this case, they concluded that the continuous support allowed to control the family caregiver's stress. At home, it was possible to have a better control of behavioural symptoms by the home hospitalisation unit; in their own environment patients and caregivers do not have to change their routine, and care can be adapted to symptoms. Finally, in older patients with first acute uncomplicated events, referred after assessment and stabilisation in the ED, they found no significant differences observed in mortality rates or residual neurological deficits and functional impairment. With a length of treatment of six weeks, home-treated patients had less need of further rehabilitation after discharge and a lower rate of admission to long-term facilities. Moreover, home-treated patients had fewer depressive symptoms than patients treated in the hospital trajectory. Medical complications were minimal, although not significantly different from the bed based.

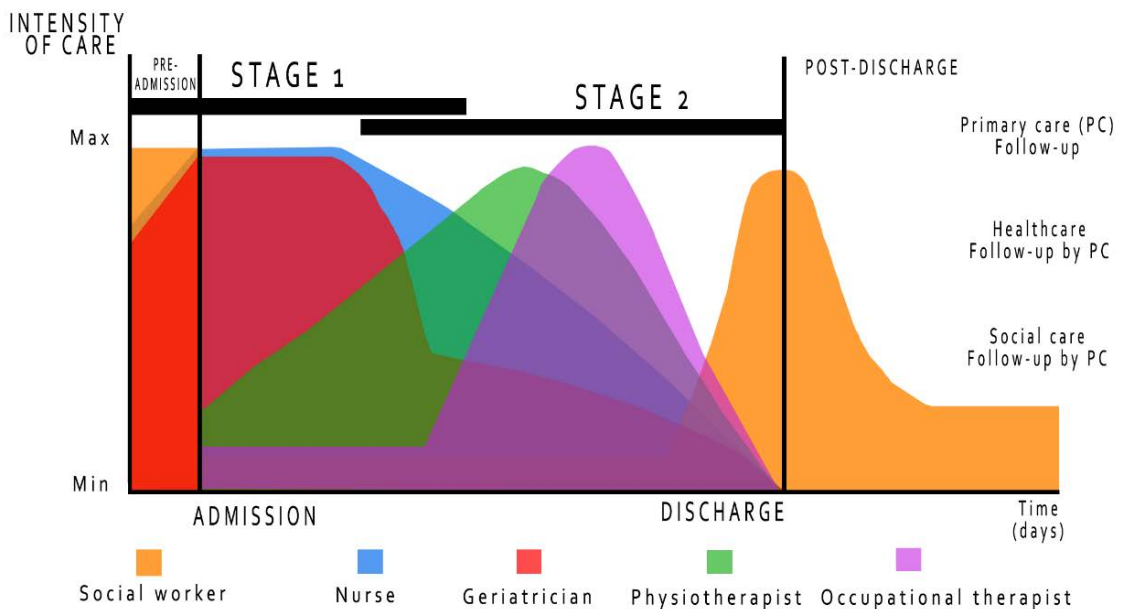
All this robust evidence was based on an extended multidisciplinary team that included geriatricians, nurses, dietitians, physiotherapists, speech therapists, occupational therapists, psychologists, and social workers, and it is specifically dedicated to the care at home. As in our work on medical crises from the ED, in the COPD trial, they found longer mean length of stay than those cared for in the hospital trajectory (15.5 vs 11 days). It seems very reasonable to prolong home intervention, if it is associated with better long-term outcomes at follow of as lower readmission rate, lower cognitive symptoms, better functional outcomes or higher quality of life perception.

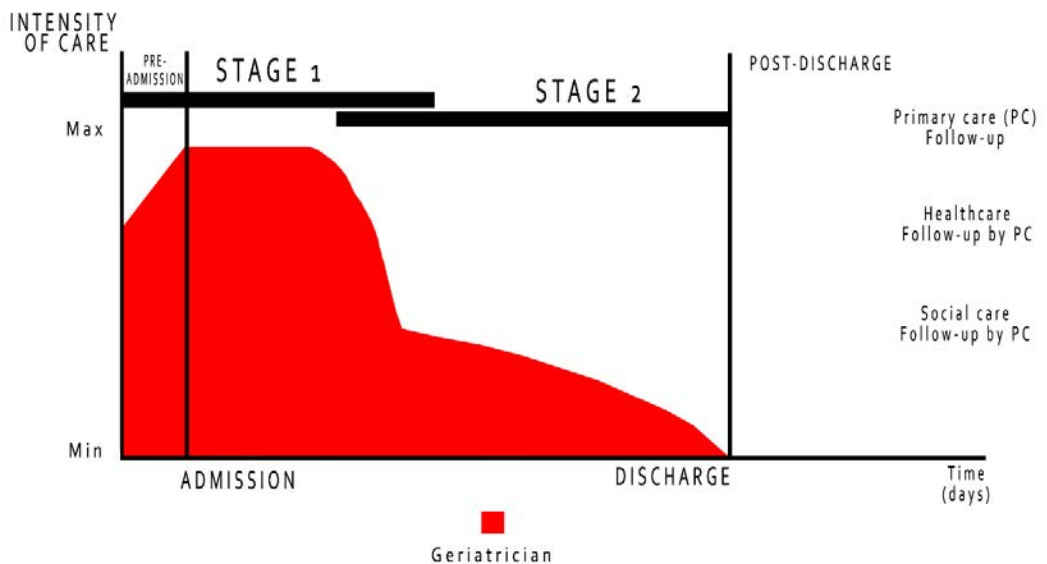
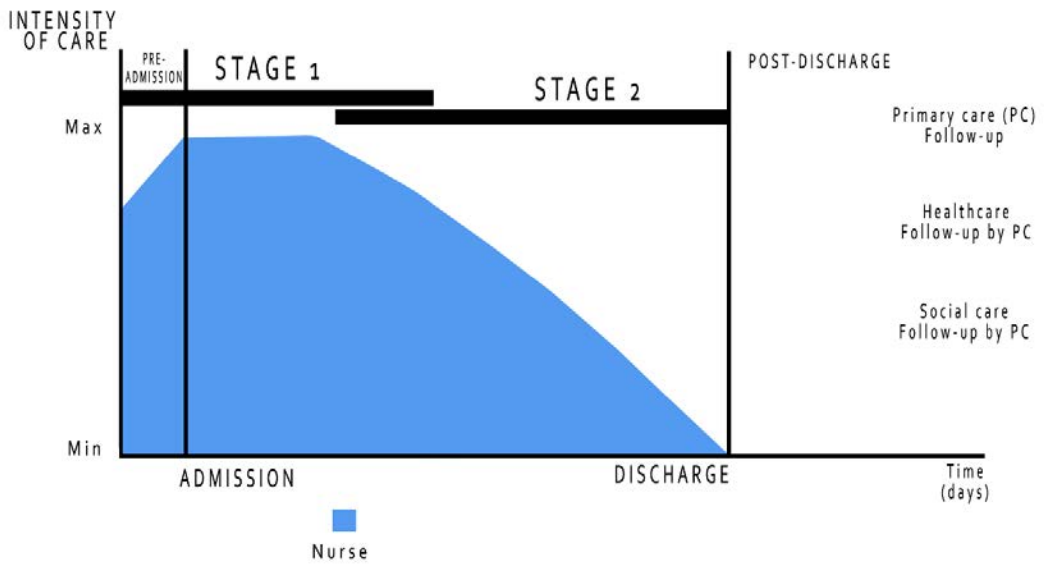
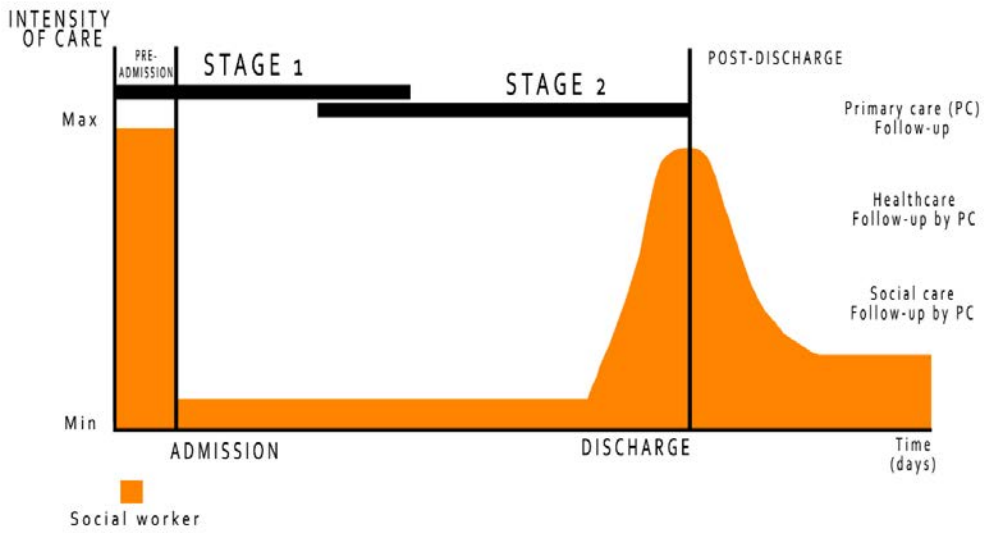
The Nottingham group (39), found that patients attended by its home-based early discharge and rehabilitation service, after disabling acute crises (50% of cases were fracture or neurological), spent fewer days in hospital at 3 months, with better functional scores and better results in general health questionnaire. Patients improved their health in terms of activity limitation and psychological well-being in the short term. Furthermore, their carers had better psychological well-being. Benefits in terms of reduced activity limitation and better mood were evident one year later. These health gains were achieved by home-based intensive rehabilitation and support, providing a mean of 22 visits over a maximum of 4 weeks (equivalent to the mean of 39 home visits performed during a period of 6 weeks by our team). In Nottingham, the team was staffed by two occupational therapists, two physiotherapists, three nurses, a community care officer (liaising with social services), seven rehabilitation assistants, and secretarial support. Medical care was given by the hospital team while in hospital and by the general practitioner when at home.

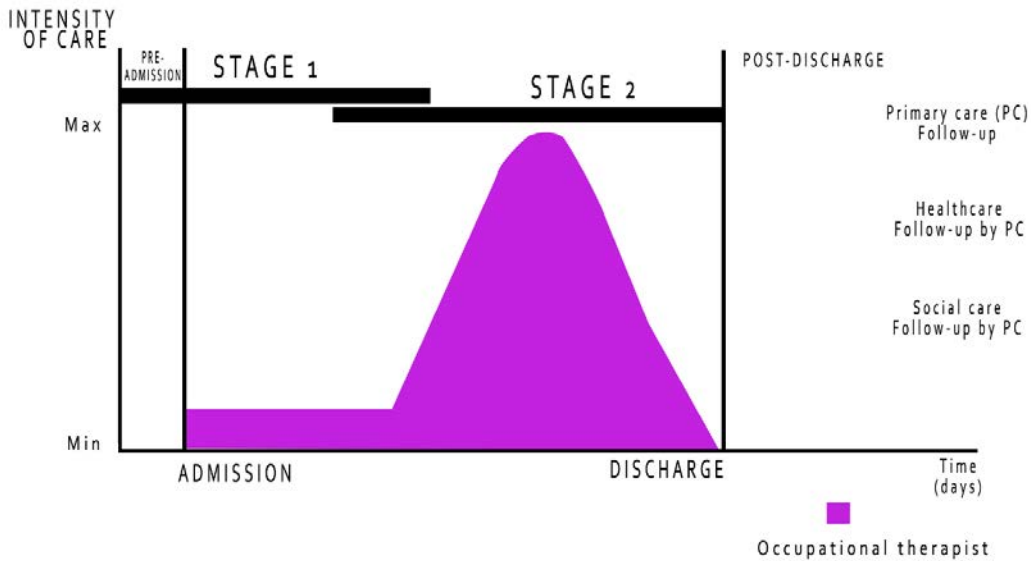
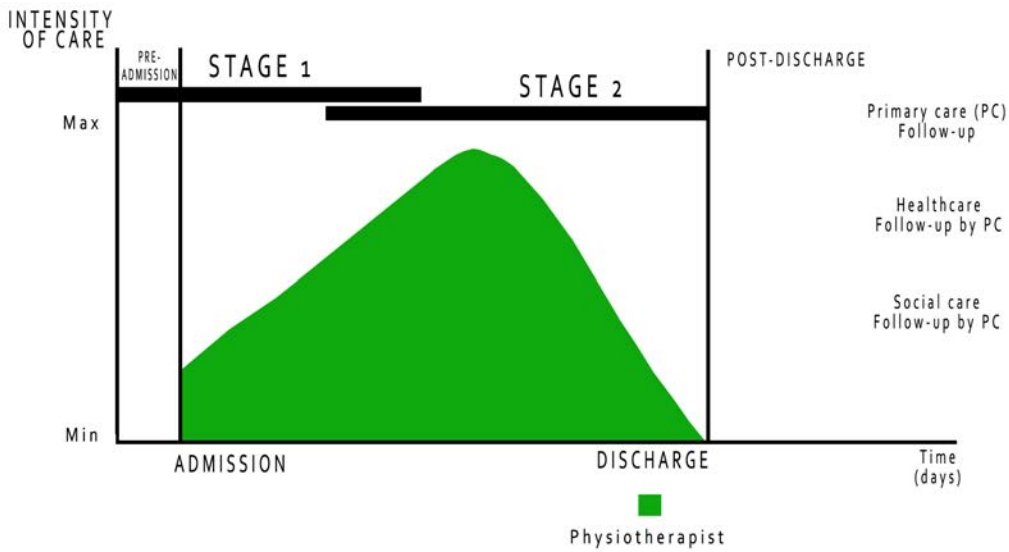
Robustness of our model, compared to previously evidenced schemes, was that CGA was performed using the protocols of care of the department of geriatrics from hos-

pital wards, triggered for a substantial number of medical and surgical processes, adapted to the community, and prolonged to the rehabilitation stage, with the help of rehabilitation staff and of social workers, and with full-time availability of geriatrician during the entire process of care. This scheme enables the participation of all staff from several disciplines, from the first day to the last day of admission. From an integrate care perspective, involving social workers, from the pre-admission stage to the post-discharge stage, could be an effective way to facilitate the integration of social and health care during the health crises management, that would facilitate community reinsertion. **Figure 3** shows that the intensity of care of several disciplines of the staff could be adapted to each stage of the process. Notice, two main stages of the process identified: **Stage 1** (to complete acute treatment and medical stabilisation of the crisis); **Stage 2** (for mobility improvement, functional resolution and community reinsertion).

Figure 4. Role of interdisciplinary care by interaction of several disciplines involved in the HaH-ICP







HaH-ICP: Hospital-at-Home Integrated Care Programme

Social worker role was concentrated in the pre-admission stage (selection of caregivers) and at the end of the community reinsertion stage (with post-discharge follow-up).

Nursing role was continuous during the full process, from a peak of activity in the first stage until the end of stage 2 (health education to patients and carers).

Geriatrician role had a peak in stage 1 of the intervention (stabilisation of the health crises) with a continuous support in geriatric conditions care in stage 2.

Physiotherapist role started with low intensity in stage 1 and it was progressively increasing until a peak at the beginning of stage 2 (mobility improvement for functional resolution).

Occupational therapist role started with low intensity in stage 1 and it was progressively increasing until a peak at the end in stage 2 (functional resolution and community reinsertion).

Our team had the possibility to provide intensive health care (100) from specialised hospital staff (up to 2–3 health visits per day if necessary, depending on patient's needs). At home, complex conditions (as severe functional loss leading to immobility, delirium or behavioural symptoms) could be managed by specialist nurses and therapists from the multidisciplinary team. The care process could be tailored to each patient, adapting individualised sessions/home visits to patients' profiles (previous level of disability, multimorbidity, cognitive status, etc.). The intervention could be modified depending on the health status of the patients during the functional trajectory of recovery (e.g. evolution of delirium or fluctuations of cognitive status). It was considered relevant because of the elevated risk of negative results based on baseline characteristics of these patients (frailty, baseline disability and presence of multiple chronic conditions). In this sense, the active role of geriatricians as full-time specialist physicians is key to participate in the CGA-based process of care.

C. Clinical usefulness of the intervention compared with hospital-based usual care

Positive results on outcomes related to the intervention were in the line of previous RCT-based research (20).

Related to health crises resolution, most home-based schemes from the literature have evidenced comparable capacity to reach clinical objectives at the end of the intervention to conventional hospitalisation. In the Early Supported Discharge modality, positive results were mainly found in stroke and medical crises (91), with a reduction in length of hospitalisation (equivalent to results of our work in disabling health processes), with lower the risk of living in institutional setting, and improvement on patient satisfaction. In the Admission Avoidance modality, these resources may have an impact on time to readmission for people with COPD (96) and heart failure (97) at long term follow-up (we found a non-significant reduction in readmissions at 30-days in medical crises care).

Related to cost-effectiveness, all three previously mentioned schemes (from Australia, Italy and the UK), evidenced economic benefits for these home-based schemes, com-

pared to conventional hospitalisation. In disabling health crises, the Sydney group found home-based care related to lower cost and more efficient hospital bed use. The cost was lower for the acute plus rehabilitation phases (7,680 pounds versus 10,598 pounds) and for the rehabilitation phase alone (2,523 pounds versus 6,100 pounds). In medical crises, the Torino group found, on a cost per patient per daily basis, that home hospitalisation costs were 50% lower than costs in the hospital trajectory (\$101.4+/-61.3 vs \$151.7+/-96.4). In the Nottingham trial, analyses were conducted from the perspective of service providers (health and social services) over a period of 12 months. The mean untransformed total cost for the home-based scheme was 8,361 pound sterling compared to 10,088 pound sterling for usual care, a saving of 1,727 pound sterling. Cost-effectiveness acceptability curves showed a high probability that the home-based intervention was cost effective across a range of monetary values for a QALY.

When we designed this research, it was not clear that home-based schemes could reduce total days of care (hospital plus hospital-at-home) in disabling health crises. A recent update of a Cochrane review (91), supported our results obtained by developing a CGA-based protocol at home with a full-time geriatrician integrated in the multidisciplinary team. In our scheme, the health staff came from the same hospital department as the conventional hospital-based trajectory, and they had the same capability for managing multiple morbidities, persistent acute conditions after hospital discharge (e.g. delirium) and provide acute treatment (e.g. low-risk infections, heart failure and other acute illnesses with a good prognosis), without readmission to an acute unit in most cases. It was key, to reduce days of hospitalisation, without increasing readmission or negative events.

6.3. Strengths and limitations

The main strength of this research is the pragmatic approach on developing and evaluating a 'real world' intervention, not limited to an experimental setting but currently part of available system's option. We included older patients with baseline chronic conditions and suffering complex health crises leading to acute disability. Compared to previous evidence, we decided not excluding patients for having cognitive impairment or living in a care home. In this sense, the availability of complete clinical data, based on CGA at admission to both units, let us to the analysis of clinical factors related to outcomes. Based on our results, excluding HaH candidates for the presence or not of cognitive impairment or for being institutionalised seems not adequate.

The non-randomisation might be considered a limitation. Some authors suggest that approaches other than RCT are useful to evaluate complex clinical interventions in

some innovative complex schemes (e.g. implementing ESD programmes in the clinical practice for the treatment of stroke or other acutely disabling conditions). In this sense, the PS method validates the hypothesis of comparable samples according to the collected variables in analyses of papers 2 and 5. The limitation of PS is that the balance of observed covariates does not guarantee balance of unobserved covariates (as the impact of illness acuity or social support). We assume that omitting an unknown confounder from the PS model could produce some biases. Another relevant aspect of non-randomisation could be the presence of a 24h caregiver as an inclusion criterion of the experimental intervention. From a clinical perspective, the criterion of availability of a 24 h caregiver at the beginning of the clinical process does not seem a key factor. For the inpatient sample, we hypothesised that a health crisis resolution should be based on the clinical intervention, not in social support at home. The lack of data on pre-admission social status could be another limitation of the study.



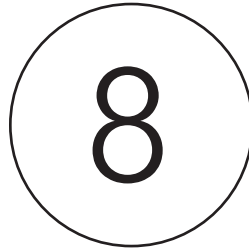
CONCLUSIONS

In conclusion, in this Doctoral Thesis we developed a multidisciplinary home-based programme, piloted and evaluated by a geriatrician-led hospital-at-home team in a local integrated care scenario in Catalonia, for complex health crises management in the community.

- We could adapt CGA-based complex interventions from inpatient to a HHU in several disabling processes (orthopaedics, medical and stroke cases). The new home based trajectory was as save and efficent than the usual hospital trajectory.
- This complex intervention reach similar clinical outcomes than conventional care. It could reduce length of conventional hospitalisation without relevant increases in length of hospital-at-home stay and without increasing readmission or obtaining negative clinical results (compared to the control groups), for several orthopaedic and medical processes.

From our local 'real life' pragmatic approach, we support there is a role for new integrated care strategies to provide acute and post acute care in the community.

Although our results need to be confirmed in larger multicentre studies, they suggest that the availability of "intense care" community services in our national health system, might enable patients to be attended at own home when suffering a complex health crisis, in selected cases.



8

**CONSIDERATIONS
FOR FUTURE
IMPLEMENTATION AND
FUTURE RESEARCH LINES**

Our work suggests that an intense home care scheme (100) could be a key element for the management of disabling health crises in an integrated care scenario if we consider several premises (with future research lines):

Candidate patients selection

It is essential to select cases for hospital in the home care based on both health and clinical criteria. One of the premises for case selection in our hospital-at-home intervention was the identification of a 24h effective primary caregiver that was willing to accept responsibility for the home-based programme. In other previously evidenced schemes, this premise was not necessary. In the case of disabling health crises in high risk patients, the interaction between health status and functional status leading to elevated complexity of care, urges the introduction of the social evaluation point in the selection process. More research is needed in this sense.

Length of intervention

Compared to other schemes in the literature, for the early discharge modality, length of intervention of our scheme could be considered longer than expected. From our perspective, and following ESD approaches in stroke patients, this intervention was a good opportunity not only to reduce days of hospitalisation, but also to work on functional restitution, and facilitating community reinsertion. In this sense, we consider that in the implementation of this scheme, length of intervention should be tailored to every single process and hospitalisation trajectory, and to every individual case, depending on health and social needs of each crisis.

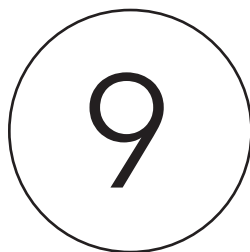
Continuity of care at follow-up

This research showed a multidisciplinary model of care for health crises management in older patients at risk of negative outcomes. In our work we did not follow patients at long term. Our intervention was not followed by an intense home care follow-up period by Primary Care teams. We have not enough data on the impact of this intervention in patients and carers after the discharge of our programme. In future works, we consider it would be necessary to coordinate the hospital-at-home intervention with the post-discharge follow up intervention, to build a complete integrated care strategy for vulnerable older patients.

Role of home hospitalisation for the system

Hospital-at-home units should not be considered in an isolated way in the future system. We know the implementation of these kind of interventions could be integrated in the future health system as an effective resource of the system. A study in Jerusalem (101), found high the impact of home hospitalisation units in the health system. The observed hospital utilisation in the year following home hospitalisation unit closure cost 6.2 million US dollars in excess of predicted expenditure; closure of the home hospitalisation resulted in the saving of 1.3 million US dollars. The ratio of direct increased costs to savings was 5:1 thus confirming the hypothesis that home hospitalisation service closure would result in increased hospital utilization rates among the local older population.

Future research directions might include larger randomised studies, multicentre designs, and other evaluation of economic or cost-effectiveness aspects of the different modalities/schemes of this type of interventions.



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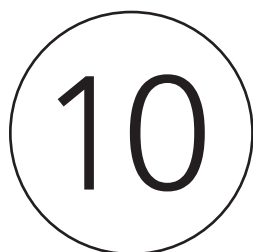
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APPENDIXES

Appendix 1. Hospital at home schemes modalities, based on care strategies, main diagnostic of the health crisis and age of the sample, from RCTs reviewed (20)

Appendix 1A. Admission Avoidance schemes

Author and year (country)	Modality (based on strategy)	The main diagnostic	Age (years; mean except when modified)
Caplan 1999 (Australia)	Admission Avoidance	Medical processes	73 (median)
Carratalà 2005 (Catalonia)	Admission Avoidance	Pneumonia	67
Davies 2000 (United Kingdom)	Admission Avoidance	Chronic Obstructive Pulmonary Disease	70
Kalra 2000 (United Kingdom)	Admission Avoidance	Stroke	78
Mendoza 2009 (Spain)	Admission Avoidance	Heart Failure	78
Puig-Junoy 2007 (Catalonia)	Admission Avoidance	Chronic Obstructive Pulmonary Disease	71
Ricauda 2004 (Italy)	Admission Avoidance	Stroke	82 (median)
Ricauda 2008 (Italy)	Admission Avoidance	Chronic Obstructive Pulmonary Disease	80
Tibaldi 2004 (Italy)	Admission Avoidance	Dementia	83
Tibaldi 2009 (Italy)	Admission Avoidance	Heart Failure	82
Wilson 1999 (United Kingdom)	Admission Avoidance	Medical processes	84

RCTs: Randomised Controlled Trials.

Appendix 1B. Early Supported Discharge schemes

Author and year (country)	Modality (based on strategy)	The main diagnostic	Age (years; mean except when modified)
Anderson 2000 (New Zealand)	Early Discharge	Stroke	72
Askim 2004 (Norway)	Early Discharge	Stroke	77
Bautz-Holter 2002 (Norway)	Early Discharge	Stroke	79
Caplan 2006 (Australia)	Early Discharge	Disabling processes	84
Cotton 2000 (United Kingdom)	Early Discharge	Chronic Obstructive Pulmonary Disease	66
Crotty 2002 (Australia)	Early Discharge	Hip Fracture	82
Cunliffe 2004 (United Kingdom)	Early Discharge	Disabling processes	80 (median)
Diaz Lobato 2005 (Spain)	Early Discharge	Chronic Obstructive Pulmonary Disease	66
Donald 1995 (United Kingdom)	Early Discharge	Several processes	82
Donnelly 2004 (United Kingdom)	Early Discharge	Stroke	75
Indredavik 2000 (Norway)	Early Discharge	Stroke	77
Mayo 2000 (Canada)	Early Discharge	Stroke	70
Martin 1994 (United Kingdom)	Early Discharge	Several processes	81.5
Nikolaus 1999 (Germany)	Early Discharge	Several processes	81.5
Ojoo 2002 (United Kingdom)	Early Discharge	Chronic Obstructive Pulmonary Disease	70

Palmer Hill 2000 (United Kingdom)	Early Discharge	Knee surgery	-
Patel 2008 (Sweden)	Early Discharge	Heart Failure	77
Richards 1998 (United Kingdom)	Early Discharge	Several processes	79
Rodgers 1997 (United Kingdom)	Early Discharge	Stroke	70
Rudd 1997 (United Kingdom)	Early Discharge	Stroke	70
Siggeirsdottir 2005 (Iceland)	Early Discharge	Hip surgery	69
Skwarska 2000 (United Kingdom)	Early Discharge	Chronic Obstructive Pulmonary Disease	68
Widen-Homqvist 1998 (Sweden)	Early Discharge	Stroke	71
Ziden 2008 (Sweden)	Early Discharge	Hip Fracture	82

Appendix 1C. Early Supported Discharge and Admission Avoidance schemes

Author and year (country)	Model (based on strategy)	The main diagnostic	Age (years; mean except when modified)
Harris 2005 (New Zealand)	Early Discharge and Admission Avoidance	Several processes	80
Hernandez 2003 (Catalonia)	Early Discharge and Admission Avoidance	Chronic Obstructive Pulmonary Disease	71
Shepperd 1998 (United Kingdom)	Early Discharge and Admission Avoidance	Several processes	HS 71 KS 68 Medical 77 COPD 71

HS: Hip surgery, KS: Knee surgery, COPD: Chronic Obstructive Pulmonary Disease.

Appendix 2. Description of each complex intervention and outcomes from RCTs reviewed (20)

Appendix 2A. Admission Avoidance schemes

Author and year of publication	MDT staff members	Length of stay in the unit (days)	The main variables included (in bold when favourable differences for HaH care)
Caplan 1999	N/M/PT/OT	10	Clinical variables , readmission, mortality, satisfaction and costs
Carratalà 2005	N/M	10	Clinical variables, readmission, mortality, quality of life and satisfaction
Davies 2000	N/SW/M	14	Readmission, pulmonary function and mortality
Kalra 2000	M/N/PT/ OT/ SALT/ SW	Up to 90	Mortality, institutionalisation and function
Mendoza 2009	N/M	11	Clinical variables, readmission, mortality, function, quality of life, resources use and costs
Puig-Junoy 2007	N/M	Up to 56	Clinical variables, readmission and costs
Ricauda 2004	M/N/PT	38	Survival, function, clinical variables and institutionalization
Ricauda 2008	M/N/PT/ SW/A	15	Resource use, clinical variables , readmission, mortality, quality of life and costs
Tibaldi 2004	M/N/PT/D/ SW/A	-	Mortality, clinical variables (behavioural disturbance, antipsychotics use) and carer burden
Tibaldi 2009	M/N/PT/ SW/A	22	Clinical variables, quality of life , readmission, mortality and costs
Wilson 1999	N/PT/ OT/A/M	8	Mortality, readmission, quality of life, satisfaction , function and clinical variables

MDT: Multidisciplinary team; HaH: Hospital-at-home; M: Medical staff; N: Nurse; PT: Physiotherapy; OT: Occupational Therapy; SALT: Speech and Language Therapy; M: physician; SW: Social Worker; A: Assistant; D: Dietitian.

Appendix 2B. Early Supported Discharge schemes

Author and year of publication	MDT staff members	Length stay unit (days)	The main variables included (in bold when favourable differences for HaH care)
Anderson 2000	M/PT/OT/ SW/SALT/N	35	General health, resource use , carer burden , satisfaction and costs
Askim 2004	N/PT/OT/M	Up to 30	Function, quality of life , carer burden and mortality
Bautz-Holter 2002	M/N/OT/PT/ SALT/SW	Up to 30	Function, general health , mortality , institutionalisation and satisfaction
Caplan 2006	N/PT/OT/M	16	Clinical variables (delirium incidence) , resource use , costs and satisfaction
Cotton 2000	N/M	24	Resource use (hospital days) and mortality
Crotty 2002	PT/OT/SALT/ SW/A/M	21	Function , quality of life, clinical variables , carer burden, satisfaction and resource use
Cunliffe 2004	OT/PT/N/A/M	Up to 30	Function , quality of life, satisfaction, general health and resource use
Diaz Lobato 2005	M/N	5	Clinical variables, resource use and mortality
Donald M 1995	N/PT/OT/A/M	Up to 28	Readmission, resource use , mortality and function
Donnelly 2004	PT/OT/SALT/A	Up to 90	Function, resource use, satisfaction and costs
Indredavik 2000	N/PT/OT/M	Up to 30	Function , institutionalisation and mortality
Mayo 2000	PT/OT/N/ SALT	Up to 30	Physical health , function , clinical variables, reinsertion, costs and resource use
Martin 1994	N/A/M	Up to 42	Resource use , home stay , function and mental status
Nikolaus 1999	N/PT/OT/ SW/M	8	Mortality, function, resource use , institutionalisation and costs
Ojoo 2002	N/M	7	Satisfaction and care preferences

Palmer Hill 2000	N/A/PT	-	Clinical variables and satisfaction
Patel 2008	N/M	7	Clinical variables, readmission, quality of life and costs
Richards 1998	N/PT/OT/A	17	Quality of life, function, resource use , mortality and costs
Rodgers 1997	PT/OT/SALT/ A/SW/N/M	56	Home stay, resource use , mortality, function, general health and carer burden
Rudd 1997	PT/OT/SALT/ A/M	Up to 90	Function, clinical variables, carer burden, satisfaction and resource use
Siggeirsdottir 2005	PT/OT/N	Up to 14	Resource use , quality of life , clinical variables and function
Skwarska 2000	N/M	7	Clinical variables, resource use , satisfaction and costs
Widen- Homqvist 1998	PT/OT/ SALT/M/SW	Up to 120	Function, resource use , clinical variables, satisfaction and quality of life
Ziden 2008	PT/OT/A/ N/M/SW/D	Up to 21	Clinical variables and function

MDT: Multidisciplinary team; HaH: Hospital-at-home; M: Medical staff; N: nurse; PT: Physiotherapy; OT: Occupational Therapy; SALT: Speech-Language Therapy; M: Physician; SW: Social Worker; A: Assistant;

Appendix 2C. Early Supported Discharge and Admission Avoidance schemes

Author and year (country)	MDT staff members	Length of stay in the unit (days)	The main variables included (in bold when favourable differences for HaH care)
Harris 2005 (New Zealand)	M/N/OT/PT/SW/A	9	Function, quality of life, clinical variables, resource use, satisfaction, carer burden, costs
Hernandez 2003 (Catalonia)	N/M	Up to 56	Mortality, resource use, quality of life, empowering, satisfaction and costs
Shepperd 1998 (United Kingdom)	N/PT/OT SALT/M	HS 7; KS 6 Medical 9 COPD 5.5	General health, function, clinical variables, quality of life , resource use, mortality, carer burden, care preferences and costs

MDT: Multidisciplinary team; HaH: Hospital-at-home; M: Medical staff; N: nurse; PT: Physiotherapy; OT: Occupational Therapy; SALT: Speech-Language Therapy; M: Physician; SW: Social Worker; A: Assistant; HS: Hip surgery, KS: Knee surgery, COPD: Chronic Obstructive Pulmonary Disease.

Appendix 3. The main inclusion and exclusion criteria and level of disability/severity of Early Supported Discharge schemes in stroke patient's RCTs reviewed

Place and year of publication	The main inclusion criteria	The main exclusion criteria	Level of initial disability/stroke severity
London 1997	If alone: independent transfer; If carer: transfer with assistance	<i>Setting:</i> living too far away for the team to visit	BI at randomization: 15-19/20 (47%)
Newcastle 1997	Medically stable; BI 5-19/20 at 72h post stroke	<i>Setting:</i> living in residential/nursing home care Previous conditions: severely handicapped prior to stroke <i>Actual conditions:</i> other condition likely to preclude rehabilitation	Median BI 7days post stroke 15/20
Stockholm 1998	Independence in feeding and continence; MMSE score of >23; impaired motor capacity and/or dysphasia	<i>Actual conditions:</i> discharged before 5 days of hospitalization; progressive stroke; subdural hematoma; subarachnoid haemorrhage; clinical sign of massive perceptual deficit; renal, heart or respiratory failure; nonstroke epilepsy; alcoholism; psychiatric disease; other condition likely to shorten length of life dramatically	Independence in Katz ADL Index one week after stroke (41%)
Akershus 1998	60 years or older with SSS score 12-52; conscious on admission; who could cooperate in the rehabilitation program	<i>Setting:</i> admission from nursing home <i>Actual conditions:</i> malignant disease in terminal stages; comatose or somnolent on admission	Median BI at day 5: 70/100

RCTs: Randomised Controlled Trials.

<p>Adelaide 2000</p>	<p>Medically stable and suitable to be discharged for ESD; sufficient physical and cognitive function for “active” participation; home environment suitable; community team available; GP to provide necessary medical care; caregiver (if identified) gave consent for participation</p>	<p>NM</p>	<p>Median BI at randomization: 85/100</p>
<p>Montreal 2000</p>	<p>Persistent motor deficits after stroke; caregiver willing and able to provide live-in care over a 4 week period after discharge from hospital</p>	<p><i>Actual conditions:</i> by 28 days after stroke still requiring care assistance of more than 1 person to walk; cognitive impairment (>5 errors in SPMSQ); important coexisting conditions affecting the ability to function independently</p>	<p>Moderate stroke severity measured by CNS (85%)</p>
<p>Trondheim 2000</p>	<p>SSS score 2-57; living at home before stroke (urban area); included within 72h after admission to SU within 7 days after the onset of symptoms</p>	<p>NM</p>	<p>Median BI after randomization: 65/100</p>
<p>Oslo 2002</p>	<p>Onset less than 6 days prior to hospitalization and admission to SU; home dwelling; medical stable; BI score 72h after stroke 5-19/20</p>	<p><i>Previous conditions:</i> severely disabled prior to the stroke <i>Actual conditions:</i> Medical condition to preclude rehabilitation; subarachnoid haemorrhage; unable to consent (mental or communication)</p>	<p>Median BI score at day 7: 16.5/20</p>
<p>Bangkok 2002</p>	<p>48h of symptom onset; diagnosis of ischemic stroke by brain CT scan</p>	<p><i>Actual conditions:</i> consciousness; NIHSS more than 20; large infarct by clinical and CT scan; cardiogenic embolism; significant carotid stenosis; moderate aphasia, unable to communicate</p>	<p>Median NIHSS at admission: 5</p>

Belfast 2004	Stroke during 4 weeks preceding admission potential to benefit from further rehabilitation	<i>Setting:</i> Resident of nursing or residential home <i>Previous conditions:</i> pre-existing physical or mental disability judged to make further rehabilitation inappropriate	Median BI at baseline assessment: 15/20
Trondheim 2004	SSS score 2-57; living at home before stroke (rural area); included within 72h after admission to SU and within 7 days after the onset of symptoms; able and willing to provide informed consent	NM	Median BI at baseline 55/100 Median SSS 46.0

ADL: Activities of daily living; BI: Barthel index; CNS: Canadian Neurological Scale; GP: General practitioner; MMSE: Folstein Mini Mental State Examination; NIHSS: National Institute of Health Stroke Scale; NM: Not mentioned; SPMSQ: Short Portable Mental Status Questionnaire; SSS: Scandinavian Stroke Scale; SU: Stroke Unit.

Appendix 4. Protocol for the activation and running of the complex intervention (71)

The protocol of activation of the service included an initial assessment of the candidates by two staff members of the institution; a health professional (physician or nurse, assessing health criteria) and a social care professional (a social worker, assessing social criteria).

For every candidate, health and social criteria must be assessed for the team of professional activating the protocol at the hospital or at home (including the confirmation of patient and carer's consent). This assessment must be sent to the hospital-at-home team by an electronic referral letter.

After the acceptance of the referral, patient and carers should be informed on the availability of the hospital-at-home admission, and this initial process should end with an arrangement of the initial home visit from the hospital-at-home staff team during the first 12-24h of acceptance.

Appendix 4.1 Criteria for the activation of the complex intervention

***Health criteria (assessed by a physician and nurse)**

1. Older patient with chronic conditions (frailty, disability or multimorbidity) suffering an acute health crisis, leading to reversible functional loss.
2. The maintaining enough clinical stability to assure home care follow-up.
3. Health complexity not requiring 24h follow up by a nurse in a hospital ward.

***Social criteria (assessed by a social worker)**

4. Identification of a 24h effective primary caregiver that was willing to accept responsibility for the home-based programme.
5. Patient agreement to be hospitalised at home.

4.2. Description of the multidisciplinary team intervention and staff roles

1. Home visits

Home visits were programmed from monday to sunday (from 8am to 8pm).

Two nursing ward rounds were defined from monday to friday (from 8am to 3pm and from 2pm to 9pm). Physicians programmed home visits from 8am to 5 pm.

Nursing ward round at the weekend was from 8am to 8pm

On-call physician support by phone was available at the weekends.

2. Availability by phone

Patients had 24h/day phone contact available.

After 9pm, an on-call physician was available by phone, with the capacity of activate community urgent services if necessary.

3. Scheduling of home visits

***For Admission Avoidance strategy**

Within 12h of the referral, all patients received an initial assessment and treatment home visit by a nurse specialist in geriatrics of the team.

All patients received an initial visit from a geriatrician within 24h of referral.

***For Early Discharge strategy**

Within 12h of the referral, all patients received an initial virtual visit (phone call) by a nurse specialist in geriatrics of the team.

Within 24h of the referral, all patients received a home visit by a nurse specialist in geriatrics and by a geriatrician of the team.

4. Interdisciplinary work

A weekly multidisciplinary meeting was the centre of the work of the team (physicians, nurses, physiotherapists, occupational therapists and social workers).

The main functions of the multidisciplinary meeting were:

- To develop shared individualised therapeutic care plans for every case attended by the team.
- To tailor a home-based intervention, with the implementation at home of a list of interventions to be provided for every discipline of the staff involved.
- To monitor the evolution of health crises problems related to health crises identified by the team.

A discharge plan was activated, and registered on a discharge letter, informing of the intervention and on the follow-up needs, for the continuum of care of the integrated care team that assume the case after the hospital-at-home unit discharge.

Nursing role

The main tasks of nurses specialised on geriatrics were:

- Provide and assure medical treatment (oral, subcutaneous, intramuscular or intravenous).
- Blood tests, ECG and microbiological tests (ulcers, urine or sputum).
- Assessment of patient's needs (Virginia Henderson nursing needs theory).
- Use of several risk assessment tools: pressure ulcers (EMINA tool), falls (Downton tool), malnutrition (Mini-Nutritional Assessment tool) and dysphagia (MECV-V tool).
- Provide health education to patients and carers on several problems identified during the health crisis

Physician role

The main tasks of the geriatricians were:

- Provide medical assessment and follow up, to complete health crisis resolution.
- Assessment of polypharmacy.
- Assessment of cognitive status (by using Folstein Mini Mental State Examination).
- Assessment of mood (by using 15-item Yesavage Geriatric Depression scale).

Role of therapists (physiotherapists and occupational therapists)

- Rehabilitation assessment and treatment considered the need to apply techniques to reduce joint stiffness, strengthen muscles, reduce oedema and pain, re-educate transfers, and basic activities of daily living, recover the ability to walk (improving balance and coordination), improve pulmonary capacity and improve tolerance to daily activity.
- Moreover, the patient's need for technical assistance to improve everyday activities and to deal with the physical environment was assessed and managed.



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