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GERIATRIC CO-MANAGEMENT ON CARDIAC CARE UNITS

PROGRAM DEVELOPMENT, IMPLEMENTATION AND EVALUATION

Bastiaan VAN GROOTVEN

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CHAPTER 1

General introduction

INTRODUCTION

Older patients in the hospital

Society ages, and so does its hospital population. While longevity is associated with improved population health, it nonetheless results in an absolute increase of frail individuals suffering multiple chronic health problems. (1) As a result, more older patients with complex problems will require complex care. (2) Patients aged 75 years and older already represent 27% of all hospital admissions and account for 43% of all hospitalisation days in Belgium. (3) Despite being the main users of hospital services, older patients are at high risk for developing iatrogenic complications and adverse events, (4) and functional decline. (5) The incidence numbers reported in the literature vary, but on average, one in three older patients experience new dependencies when performing their activities of daily living (ADL) at discharge from the hospital. (6-8) This hospitalisation-associated functional decline is associated with an increased risk of death, (9-12) nursing home placement, (9, 13-15) sustained disability, (16, 17) and increased costs. (18)

Several factors explain why older patients are more prone to negative health outcomes than younger patients. As people age, physiological reserve and functioning decreases naturally. (19) Individuals become more vulnerable because vision, muscle mass, bone mass, memory, etc. declines. As the loss of function accumulates, older individuals become frail and are predisposed to a higher risk of developing geriatric syndromes. (20) Geriatric syndromes, e.g. dependency in performing activities of daily living, are defined as “multifactorial health conditions that occur when the accumulated effects of impairments in multiple systems render an older person vulnerable to situational challenges”. (20) Specifically, older age, functional impairment (of both upper and lower extremities), cognitive impairment, impaired mobility, sensory deficits, and mood disorders have been identified as the main risk factors in the onset of geriatric syndromes, (5, 20, 21) and predispose older patients to the development of functional decline.

Two conceptual models, i.e. the dysfunctional model and the disability model, (7, 22) explain how the hospital can act as a ‘situational challenge’, and how it contributes to the development of hospitalisation-associated functional decline and dependency in ADL. Patients who are admitted to the hospital enter an alien environment, are forced in a dependent care relationship with a ‘stranger’, spend most of their time in a bed or in a chair, have poor nutritional intake, and may be exposed to harmful medications (i.e. there is dysfunction). These factors precipitate the development of functional

decline and dependency in ADL. A path analysis confirmed that the risk between patient factors and functional decline is mediated by hospital factors. (23)

Geriatric care models for older patients in the hospital

Based on the observations cited above, it is clear that the hospital is a dangerous environment for older patients, (24) and that care should be based on the principle of a comprehensive geriatric assessment (CGA). CGA refers to "a multidimensional interdisciplinary diagnostic process focused on determining a frail older person's medical, psychological and functional capability in order to develop a coordinated and integrated plan for treatment and long term follow-up". (25) Several models of care have been developed to implement CGA in the hospital setting. Dedicated geriatric units are considered the gold standard model for acute geriatric care. Evidence from systematic reviews and meta-analyses demonstrate that these units reduce functional decline, prevent institutionalisation and improve survival. (26) However, they have a limited capacity and 81% of older patients are hospitalised on non-geriatric units. (3) The inpatient geriatric consultation team was therefore developed as a complementary model of care. Geriatric consultation teams are multidisciplinary mobile teams that assess older patients admitted to non-geriatric units and recommend a plan of treatment. (25) However, a meta-analysis detected no significant effect on functional status, length of stay and readmission, and only found a moderate beneficial effect on mortality at six and eight months after hospitalization. (27) As care needs of older patients on non-geriatric units remain unaddressed and current models of care were not found to be effective, exploration of a new model of care is needed.

Geriatric co-management as 'new' care model

Geriatric co-management is emerging as the new favoured model of CGA-based care for non-geriatric units. These programmes are characterised by a shared decision-making and collaboration between non-geriatric and geriatric teams focusing on the prevention and management of geriatric syndromes in older patients. (3) It is not necessarily a new model of care. The first orthogeriatric unit was established in the 1950s. (28, 29) These units are fully dedicated to the management of older patients with a hip fracture, and all patients on the unit are attended by both the geriatrician and surgeon. The geriatrician is responsible for the medical care and the surgeon for the hip fracture care. An alternative form of co-management, although less popular, is to admit older patients on an acute care unit, e.g. an orthopaedic unit, and have a geriatrician attend only a specific subgroup of patients, e.g. all patients aged 85 year of older.

After decades of effectiveness research, co-management is now being recognised as the favoured model of care for the management of frail older surgical patients, (30) and in particular for patients with a hip fracture. (31) However, several gaps remain in the evidence. There are no multicentre randomised controlled trials to support a high grade of evidence of its effectiveness. Evaluations often focus on length of stay and survival, but not on functional status and quality of life. No process evaluations have been performed to help us understand for whom, when and how co-management creates impact. (32) The evidence is largely being generated from co-management programmes for hip fracture patients. (32, 33) Yet many other patient populations are considered frail and could potentially benefit from co-management.

Older patients on cardiac care units are particularly vulnerable for adverse events. Up to 60% of patients with cardiovascular disease suffer from one or more geriatric syndromes. (34) Patients who have a cardiovascular disease and a geriatric syndrome are four times more likely to suffer functional decline, two times more likely to be readmitted to hospital and two times more likely to die. (35, 36) Despite the geriatric needs in these patients, cardiovascular care remains predominantly diagnosis-driven, focusing on the cardiovascular problem. (37) The majority of cardiovascular care guidelines often fail to consider the complex functional, psychosocial, and environmental needs of older patients. As a result, researchers and clinicians have advocated for the integration of cardiac and geriatric care, (37) because the majority of healthcare professionals are not adequately trained to manage the complex needs of older patients on cardiac care units. (38) To date, a standardised collaboration between cardiac and geriatric care has not been evaluated in the acute hospital setting.

This PhD will address several of these gaps by generating the first evidence of co-management in older patients admitted to a cardiac care unit, by measuring functional status as the primary outcome, and by performing a process evaluation. The evaluation will focus on patients who are 75 years or older. Because this is a heterogeneous group, and because not all older patients experience complications, we will focus specifically on patients who have an increased risk for functional decline, or who experience a complication during hospitalisation.

AIM OF THE PHD

The overall aim of the PhD was to develop and evaluate a geriatric co-management programme that was considered acceptable and feasible by stakeholders, and prevents hospitalisation-associated functional decline so that patients experience less dependency in ADL when discharged from the hospital. Six specific objectives were defined.

Objective 1: To determine the effectiveness of in-hospital geriatric co-management by performing a systematic review and meta-analysis.

Objective 2: To develop quality indicators for in-hospital geriatric co-management programmes using a two-round Delphi study.

Objective 3: To develop a risk prediction model for hospitalisation-associated functional decline in patients aged 75 years or older admitted to the cardiac care units of the University Hospitals Leuven.

Objective 4: To develop a geriatric co-management programme using 'purposeful program theory', engaging stakeholders and fitting interventions to the local context.

Objective 5: To evaluate the feasibility, and describe the experiences with the implementation of the geriatric co-management programme in patients aged 75 years or older admitted to the cardiac care units of the University Hospitals Leuven.

Objective 6: To evaluate if a geriatric co-management programme results in a better functional status at hospital discharge in comparison with geriatric consultation, in patients aged 75 years or older admitted to the cardiac care units of the University Hospitals Leuven.

Overview of the PhD methodology

The guidance of the Medical Research Council MRC was used to define a mixed-methods multi-phase project design (see Figure 1), (39) and was embedded in the G-COACH project (Geriatric CO-mAnagement for Cardiology patients in the Hospital). The project focussed specifically on MRC phase 1 'development' (defining an evidence base and programme theory before progressing to the evaluation), phase 2 ' feasibility' (testing whether the programme can be performed as intended in practice) and phase 3 'evaluation' (measuring the impact on patient outcomes and trying to understand how this impact was derived). MRC phase 4 'implementation' was outside the scope of this PhD. However, this classic research process is also associated with a significant time lag before evidence is implemented in practice. (40) We therefore also integrated insights from implementation science in the design and methodology of the studies, in order to facilitate the translation of evidence into practice. (41) This fits within the MRC

guidance, which states that implementation should be considered at every phase of the research process.

MRC phase 1: development

In the first phase, the aim was to develop a programme that was acceptable for the stakeholders by integrating data from empirical studies and expert opinion with a context analysis and by engaging stakeholders in the development process.

The development started with a systematic review and meta-analysis (chapter 2). The aim was to assess the grade of evidence for geriatric co-management and assess its potential for improving patient outcomes. We also aimed to identify specific intervention components that were associated with larger effect sizes.

The next step was to identify structure, process and outcome indicators reported in the co-management literature. This descriptive information was used for an international two-round Delphi study (chapter 3). The aim was to develop a set of indicators that was considered appropriate and feasible to score.

We used data from a prospective cohort study (i.e. the control group from the before-and-after study, see chapter 6) and developed and validated a clinical risk prediction model (chapter 4). The aim was to develop a model that could be used in clinical practice to identify patients at risk for developing hospitalisation-associated functional decline.

A protocol was developed to outline the development, implementation and evaluation of the programme (chapter 5)

The 'purposeful program theory' was used to aggregate information from the three previous studies. The aim was to define a programme theory for geriatric co-management, and to operationalise the programme for implementation on the cardiac care units of the University Hospitals Leuven (chapter 6). Additional data were used from a pilot study to match the programme to the local context of the participating teams and units. Consensus procedures were used to engage the stakeholders in the decision making process.

MRC phase 2: feasibility

In the second phase, the aim was to introduce the programme on the cardiac care units and evaluate the feasibility. The evaluation focussed on how well the interventions were being performed. After an implementation period, a one-group experimental

study was performed to assess the feasibility (chapter 6). The aim was to determine the reach, fidelity, and dose.

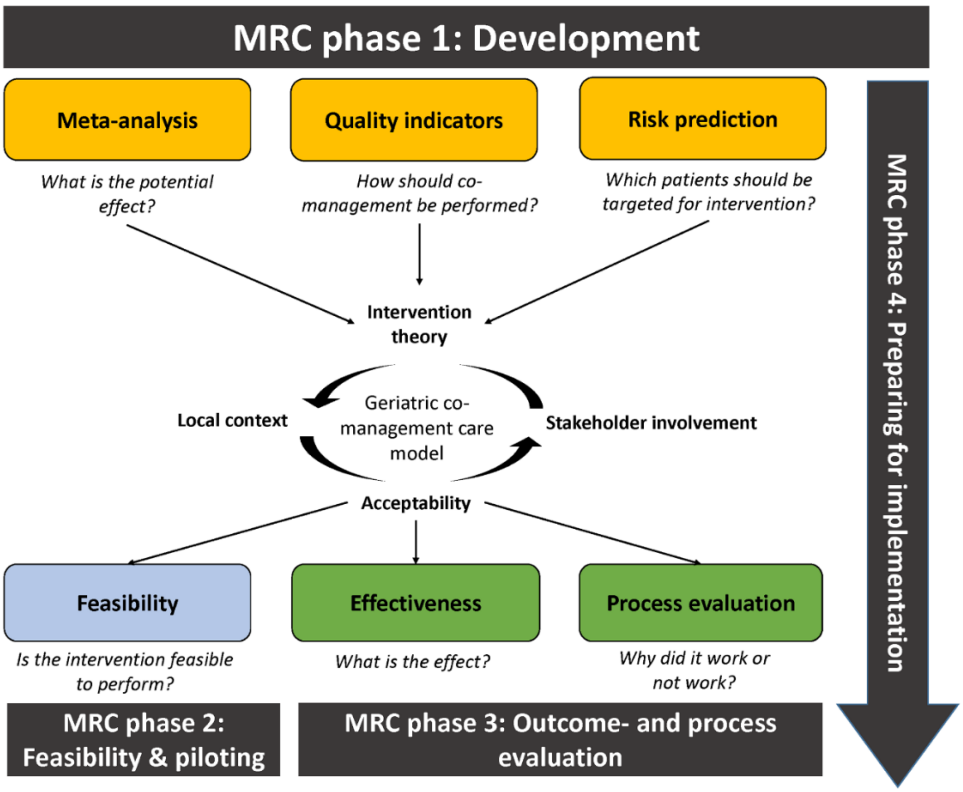
Although outside the scope of the MRC guidance, we also used this study as an opportunity to investigate the barriers and facilitators for the implementation of the programme in practice. This was not considered an implementation study in its own right, but rather a secondary aim to understand the context and collect preliminary data to inform future implementation studies.

MRC phase 3: evaluation

In the third phase, the aim was to evaluate the effectiveness and to understand in whom and how the programme was most effective.

A quasi-experimental before-and-after study was performed to assess the effectiveness (chapter 7). The aim was to determine if patients in the geriatric co-management programme had a better functional status at hospital discharge than patients receiving standard of care with geriatric consultation. A process evaluation was also performed to describe the reach and fidelity to the intervention. Subgroup analyses were performed to explore which patients had a larger effect, and what interventions contributed to a larger effect.

Figure 1. Overview of PhD methodology and studies



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CHAPTER 2

Systematic review and meta-analysis of geriatric co-management programmes

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ABSTRACT

Background: Geriatric consultation teams have failed to impact clinical outcomes prompting geriatric co-management programmes to emerge as a promising strategy to manage frail patients on non-geriatric wards.

Objective: To conduct a systematic review of the effectiveness of in-hospital geriatric co-management.

Data sources: MEDLINE, EMBASE, CINAHL and CENTRAL were searched from inception to 6 May 2016. Reference lists, trial registers and PubMed Central Citations were additionally searched.

Study selection: Randomised controlled trials and quasi-experimental studies of in-hospital patients included in a geriatric co-management study. Two investigators performed the selection process independently.

Data extraction: Standardised data extraction and assessment of risk of bias were performed independently by two investigators.

Results: Twelve studies and 3590 patients were included from 6 randomised and 6 quasi-experimental studies. Geriatric co-management improved functional status and reduced the number of patients with complications in 3 out of 4 studies, but studies had a high risk of bias and outcomes were measured heterogeneously and could not be pooled. Co-management reduced the length of stay (pooled mean difference, -1.88 days [95% CI, -2.44 to -1.33]; 11 studies) and may reduce in-hospital mortality (pooled odds ratio, 0.72 [95% CI, 0.50 to 1.03]; 7 studies). Meta-analysis identified no effect on the number of patients discharged home (5 studies), post-discharge mortality (3 studies) and readmission rate (4 studies).

Conclusions: There was low-quality evidence of a reduced length of stay and a reduced number of patients with complications, and very low-quality evidence of better functional status as a result of geriatric co-management.

INTRODUCTION

Older adults hospitalised on non-geriatric wards are at high risk of developing complications, (1) disability (2) and unplanned readmissions. (3) The need for better in-hospital geriatric care has been voiced: (4) low quality of care has been observed in the management of dementia, delirium, depression and falls. (5, 6)

Geriatric consultation teams have been implemented to recommend a plan of treatment for frail patients hospitalised on non-geriatric wards. (7) However, a meta-analysis observed only a beneficial effect on mortality at 6 and 8 months post-hospital discharge, without an effect on functional status, length of stay and readmission rate. (8) The non-adherence to recommendations and lack of control over patient care likely inhibit the effectiveness of these teams. (9)

Geriatric co-management has been considered an alternative approach, and is defined as a shared responsibility and decision making between at least a treating physician (e.g. surgeon) and a geriatrician who provides complementary medical care in the prevention and management of geriatric-oriented problems. (10) Co-management interventions have previously been evaluated in systematic reviews focusing on ortho-geriatric care. (11-15) However, these reviews were restricted to the orthopaedic population, also included non-co-management interventions, were biased by a limited search strategy or inclusion of retrospective studies or did not explore clinical and methodological heterogeneity.

While there is an increasing interest in the implementation of co-management models, (16) the limitations in the current systematic reviews and the exclusion of non-orthopaedic populations prevent informed decision making. A new and more comprehensive systematic review is therefore warranted. We aimed to determine the effectiveness of in-hospital geriatric co-management on functional status, length of stay, mortality, readmission rate, complications and the number of patients discharged home up to one year follow-up. Secondly, we explored which study and intervention characteristics explain the observed effects.

METHODS

The review protocol was registered in PROSPERO (CRD42015026033). (17)

Search strategy and Data sources

A search string was co-developed with a library information specialist and piloted by one investigator. MEDLINE (Ovid SP), EMBASE (OVID interface), CINAHL (EBSCO health), the Cochrane Central Register of Controlled Trials (CENTRAL) were searched from inception to 6 May 2016 (see supplement). Systematic reviews were searched from inception to 6 May 2016 using the Cochrane Database of Systematic Reviews, PROSPERO, MEDLINE and EMBASE. Additional articles were searched in trial registers, reference lists from primary studies and systematic reviews, and through searching PubMed Central Citations.

Study Selection

Randomised controlled trials and quasi-experimental studies (non-randomised controlled trials with parallel groups, prospective before-and-after studies, interrupted time series) published in English, Dutch, German, French or Spanish were included if they sampled patients aged 65 years or older (or reported a mean age of 75 years or older). See supplement for more details. Studies had to report the effect of an in-hospital geriatric co-management intervention on functional status, length of stay, mortality, readmission rate, complications or the number of patients discharged home up to one year follow-up. Interventions had to report co-management by a geriatrician or describe a shared responsibility or decision making between a treating physician and a geriatrician for patients admitted on a non-geriatric ward. Co-management studies by other physicians (e.g. hospitalists) or health professionals (e.g. nurse practitioners) were excluded. Case reports, letters and abstracts were excluded. Two investigators piloted and performed the selection process independently. Discrepancies were resolved by consensus discussion and by two additional investigators.

Data Extraction and Quality Assessment

Data collection by one investigator was independently verified by a second investigator and included: 1) study characteristics, 2) structure of co-management programmes, 3) process of co-management programmes, 4) intervention components, and 5) outcome data (see supplement). Discrepancies were resolved by consensus discussion. Risk of bias was assessed independently by two of four investigators using the 'Methodological Index for Non-Randomised Studies' (see Table 2. Risk of bias; see supplement). (18) Total scores range between 0 (high risk of bias) and 24 (low risk) based on consensus agreement.

Data synthesis and Analysis

Data were summarized using textual description and tabulation and were entered into RevMan (version 5.3). (19) For continuous outcomes, the median and interquartile range (IQR), standard errors and confidence intervals were converted to mean and standard deviation, (20, 21) and expressed as the mean difference (MD) with a 95% confidence interval (95% CI). Dichotomous outcomes were adjusted for mortality where appropriate, and expressed as an odds ratio (OR) with 95% CI. Outcomes similarly defined by two or more studies on one endpoint at discharge, thirty days, three months, six months or one year follow-up were statistical pooled in a meta-analysis. Continuous outcomes were pooled using the Inverse Variance method and binary outcomes using the Mantel-Haenszel method. All tests were performed using a fixed-effect model and using a random-effect model as sensitivity analysis. Statistical heterogeneity was explored using forest plots and I^2 statistics for all pooled outcomes. Effect differences between studies were explored using study and intervention characteristics and risk of bias in subgroup analyses. A narrative synthesis was performed for outcomes that could not be pooled. (22)

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to define the quality of the body of evidence as high, moderate, low or very low (see supplement). (20)

Funding

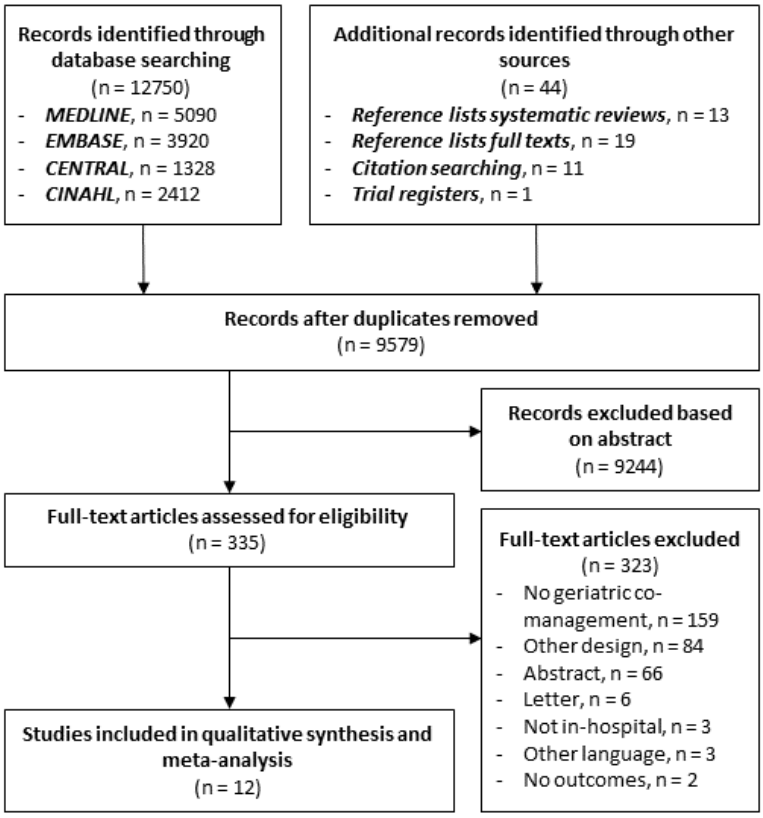
This work was supported by the KU Leuven Research Council (REF 22/15/028). The KU Leuven Research Council had no role in the design, execution, analysis and interpretation of data, or writing of the study.

RESULTS

Study selection

The search strategy identified 12750 hits of which 335 were considered potentially relevant after screening title and abstract (see Figure 1. Flowchart). Twelve studies were included.

Figure 1. Flowchart



Study characteristics

A total of 3590 patients (1626 receiving geriatric co-management) were included from six randomised controlled trials, (23-28) one non-randomised controlled trial (29) and five prospective before-and-after studies. (30-34) All studies were single-center and originated from Europe (n = 8), (23, 25, 28, 30-34) North-America (n = 3) (24, 27, 29) and Australia (n = 1). (26) Seven studies ended before 2000, (23-28, 30) four studies were conducted between 2000 and 2010, (29, 31-33) and one study ended in 2011. (34) Seven studies included hip fracture patients, (23, 26-28, 30, 33, 34) one study elective orthopaedic patients, (32) three studies medical patients, (25, 29, 31) and one study functional or mentally impaired patients. (24) The mean age of patients ranged from 74 to 84 years (median = 82, IQR = 3). See table 1 for study characteristics.

Risk of bias

Risk of bias scores ranged between 11 and 23 (see table 2). No multiple publications were identified. Selective reporting bias could not be evaluated in absence of registered protocols. Publication bias could only be assessed for length of stay in a funnel plot that may indicate asymmetry (see supplement). A summary of the meta-analyses is shown in Table 3.

Effect on functional status

Functional status was assessed in four studies, but could not be pooled due to heterogeneity in outcome measurements (see supplement). (25-28) At hospital discharge, co-managed patients had better functional status in two of three studies as they improved more in activities of daily living (ADL) (25) and level of dependency, (25, 26) but not recovery of baseline ADL and mobility. (28) At three months follow-up, co-managed patients had better functional status in one of two studies as they recovered more in ADL or mobility, (28) but not in level of dependency or ability to transfer. (27) At six and twelve months follow-up, co-managed patients did not differ in recovery of ADL, (28) mobility, (27, 28) transfers (27) and level of dependency. (27) Differences in the observed effects between studies likely result from a difference in risk of bias favouring co-management due to multiple testing, (25) missing data (25, 28) and co-intervention. (25)

Effect on length of stay

Length of stay was assessed in eleven studies (see supplement), (23-32, 34) and was reduced in five intervention groups. (24, 26, 28, 32, 34) The length of stay was increased in one intervention group. (27) However, the authors anticipated this effect as the intervention included a more intensive in-hospital intervention as compared to standard of care. Co-management reduced overall length of stay (MD, -1.88 [95% CI, -2.44 to -1.33]; I^2 = 86%; 3394 patients). This result was robust in a random effects model (MD, -2.62 [95% CI, -4.72 to -0.53]), but the heterogeneity could not be explained. The reduced length of stay corresponds to a low standardised effect size (-0.17 [95% CI, -0.23 to -0.10] for the fixed-effect model and -0.27 [95% CI, -0.48 to -0.05] for the random-effect model). This effect disappeared in studies at low risk of bias (0.03 [95% CI, -0.34 to 0.40]; see supplement).

Table 1. Study characteristics

Study	Country	Design	Study period	Population	Intervention group		Control group	
					N	*Mean age (SD)**	*N*	*Mean age (SD)**
Gilchrist 1988 (23)	UK	RCT	Oct 1984 – Jul 1986	Women with hip fracture ≥ 65 years	97	82	125	80.6
Germain 1995 (24)	Canada, Quebec	RCT	Jul 1986 - Jun 1987	Functional or mentally impaired elderly in-patients	56	81.9	52	80.1
Slaets 1997 (25)	Netherlands	RCT	Oct 1989 - Oct 1990	Medical inpatients ≥ 75 years	140	83.2 (5.1)	97	82.5 (4.9)
Swanson 1998 (26)	Australia, Queensland	RCT	Oct 1994 - Jul 1995	Hip fracture patients ≥ 55 years	38	78.5 (10.1)	33	77.8 (11.1)
Naglie 2002 (27)	Canada, Toronto	RCT	Jun 1993 - Mar 1997	Hip fracture patients ≥70 years	141	83.8 (6.9)	138	84.6 (7.3)
Khan 2002 (30)	UK	Prospective before-and-after study	CG = Jan 1992 - Dec 1994 IG = Jan 1995 - Dec 1996	Elderly patients admitted for fractured femur neck	208	81	537	82
Vidan 2005 (28)	Spain	RCT	1 Feb - 15 Dec 1997	Acute hip fracture surgery patients ≥ 65 years	155	81.1 (7.8)	164	82.6 (7.4)

Study	Country	Design	Study period	Population	Intervention group		Control group	
					N	***Mean age (SD)****	***N***	***Mean age (SD)****
Harari 2007 (32)	UK	Prospective before-and-after study	CG = May - Jul 2003 IG = Aug 2003 - Feb 2004	Elective orthopaedic patients ≥ 65 years	54	74.1 (6.2)	54	75.0 (6.1)
Harari 2007 (31)	UK	Prospective before-and-after study	CG = Aug 2004 IG = Aug 2005	High-risk medical inpatients ≥ 70 years	49	83.0 (8.1)	46	80.7 (6.6)
Marsland 2010 (33)	UK	Prospective before-and-after study	CG = Mar – Jul 2004 IG = Jan – Jun 2006	Hip fracture patients	98	81.8	98	83
Arbaje 2010 (29)	USA, Maryland	nRCT	Jan - Dec 2007	Internal medicine patients ≥ 70 years	366	79.7 (5.7)	351	79.1 (5.6)
Suhm 2014 (34)	Switzerland	Prospective before-and-after study	CG = 1 Jun 2007 - 30 Sep 2008 IG = 1 Apr 2010 - 31 Mar 2011	Hip fracture patients ≥ 65 years	224	84.3 (7.4)	269	83.9 (7.5)

Legend: Abbreviations: SD = Standard Deviation; RCT = Randomised Controlled Trial; nRCT = non-Randomised Controlled Trial; CG = Control Group; IG = Intervention Group;* SD is reported when available or was obtained from the standard error. (20)

Table 2. Risk of bias

Study	Clearly stated aim	Consecutive inclusion	Prospective data collection	Appropriate endpoints	Unbiased assessment	Appropriate follow-up period	Loss to follow-up < 5%	Study sample calculation	Adequate control group	Contemporary groups	Baseline group equivalence	Adequate statistical analyses	Total score
Gilchrist 1988 (23)	2	2	2	1	0	0	0	0	1	2	0	2	12
Germain 1995 (24)	2	2	2	1	0	0	0	0	1	2	1	1	12
Slaets 1997 (25)	1	2	2	1	0	2	0	2	2	2	1	2	17
Swanson 1998 (26)	2	2	2	1	0	2	1	2	1	2	1	1	17
Naglie 2002 (27)	2	2	2	1	2	2	2	2	2	2	2	2	23
Khan 2002 (30)	2	2	2	1	0	1	2	0	2	1	1	0	14
Vidan 2005 (28)	2	2	2	1	2	2	0	2	1	2	2	2	20
Harari POPS 2007 (32)	2	2	2	1	0	1	0	2	2	1	1	2	16

Study	Clearly stated aim	Consecutive inclusion	Prospective data collection	Appropriate endpoints	Unbiased assessment	Appropriate follow-up period	Loss to follow-up < 5%	Study sample calculation	Adequate control group	Contemporary groups	Baseline group equivalence	Adequate statistical analyses	Total score
Harari OPAL 2007 (31)	2	2	2	1	0	0	0	0	2	1	1	2	13
Marsland 2010 (33)	2	1	2	1	0	1	0	0	2	1	0	1	11
Arbaje 2010 (29)	2	1	2	2	2	0	1	1	2	2	2	2	19
Suhm 2014 (34)	1	2	2	1	0	2	1	0	2	1	1	2	15

Legend: Risk of bias was independently assessed using the 'Methodological Index for Non-Randomised Studies' (MINORS). Criteria are scored '0 if not reported', '1 if reported but inadequate', '2 if reported and adequate'. The highest score is 24 indicating low risk of bias.

Effect on mortality

In-hospital mortality was assessed in seven studies (see supplement), (23, 24, 26-28, 30, 34) and was reduced in one intervention group. (28) Co-management reduced in-hospital mortality (OR, 0.72 [95% CI, 0.50 to 1.03]; I2 = 19%; 2237 patients), but this was not statistically significant. Subgroup analysis identified a reduced odds of in-hospital mortality when excluding one large prospective before-and-after study at high risk of bias that did not report co-management roles for non-medical professionals (e.g., physical therapist) (30) as compared to studies who did (OR, 0.50 [95% CI, 0.30 to 0.83]; I^2 = 0%; 1492 patients; 6 studies). (23, 24, 26-28, 34)

Post-discharge mortality was assessed in three studies at thirty days, (32-34) three months, (23, 27, 33) six months, (23, 26, 27) and twelve months follow-up (see supplement). (24, 28, 34) Co-management had no effect on post-discharge mortality at thirty days (OR, 0.94 [95% CI, 0.53 to 1.69]; I^2 = 0%; 796 patients), three months (OR, 0.88 [95% CI, 0.58 to 1.33]; I^2 = 50%; 697 patients), six months (OR, 0.65 [95% CI, 0.42 to 1.01]; I^2 = 0; 572 patients) and twelve months follow-up (OR, 1.07 [95% CI, 0.79 to 1.44); I2 = 77%; 926 patients). Subgroup analysis could explain the observed statistical heterogeneity by excluding two studies at high risk of bias favoring standard of care due to confounding bias, (33, 34) but the effects remained non-significant.

Effect on readmission rate

Readmission rate was assessed in six studies, (24, 25, 28, 31, 32, 34) and was reduced at six months follow-up in one intervention group (OR, 0.49 [95% CI, 0.26 to 0.92]). (25) Three studies were pooled at thirty days follow-up, (31, 32, 34) and two studies at twelve months follow-up (see supplement). (24, 34) Co-management had no overall effect on readmission rate at thirty days follow-up (OR, 1.28 [95% CI, 0.71 to 2.31]; I^2 = 24%; 695 patients), (31, 32, 34) nor at twelve months follow-up (OR, 0.91 [95% CI, 0.64 to 1.29]; I^2 = 0%; 601 patients). (24, 34)

Effect on complications

In-hospital complications were assessed in four studies, but could not be pooled due to heterogeneity in outcome measurements (see supplement). (28, 32-34) Co-managed patients had a lower number of complications (OR, 0.10 [95% CI, 0.05 to 0.20]). (32) Likewise, co-management resulted in a lower number of patients with one or more complications (OR, 0.52 [95% CI, 0.36 to 0.77]), (34) and in a lower number of patients with major complications (OR, 0.46 [95% CI, 0.29 to 0.72]). (28) One study did not report sufficient data to extrapolate an effect. (33) These results suggest a risk

reduction between -14% and -54% which equals a number needed to treat (NNT) between 7 and 2 patients. Differences in the observed effects between studies likely result from a difference between studies in risk of bias favoring co-management.

Effect on patients discharged home

The number of patients discharged home was assessed in five studies. (23, 24, 27, 29, 33) More patients were discharged home as a result of geriatric co-management in two individual studies (see supplement). (24, 27) Co-management had no overall effect on the number of patients discharged home (OR, 1.07 [95% CI, 0.86 to 1.34]; I^2 = 67%; 1370 patients; 5 studies). Subgroup analysis identified more patients being discharged home when discharge planning was an intervention component (OR, 3.00 [95% CI, 1.48 to 6.06]; I^2 = 0; 235 patients; 2 studies). (24, 27) As a result, 16.2% more patients were discharged home which equals a NNT of 6 patients.

DISCUSSION

This systematic review determined the effect of in-hospital geriatric co-management and included 12 studies and 3590 patients. We observed very low-quality evidence for better functional status and low-quality evidence for reducing length of stay and preventing complications as a result of geriatric co-management (see Table 3 and supplement). The effect on length of stay ranged between -7.2 to 3.4 days but subgroup analyses could not explain this dispersion. However, based on the direction of the effect, we infer that co-management will likely reduce length of stay. The effect size was small for functional status and moderate for preventing complications. In-hospital mortality was reduced but this was not statistically significant. No effects were observed for post-discharge mortality, readmission rate and number of patients discharged home.

We explored which study and intervention characteristics explained the effects. This mostly related to risk of bias overestimating treatment effects on functional status, complications and length of stay. The effect on length of stay disappeared when only studies at low risk of bias were included. In-hospital mortality was reduced in RCT's but this may also reflect sampling error by the subgroup analysis. In-hospital mortality was reduced when co-managing patients in a multi-professional team (also including non-physicians). More patients were discharged home when discharge planning was defined as an explicit intervention component.

Subgroup analyses detected no substantial differences in effect between orthopaedic and medical patients. However, the effect in medical patients could only be assessed for the outcomes length of stay, patients discharged home and 30 day readmission rate. Nonetheless, geriatric syndromes are prevalent in older medical patients (36) and these patients experience poor functional outcomes. (37) Care based on the principle of comprehensive geriatric assessment (CGA) could therefore be promising for these patients.

CGA is characterized by a "multidimensional, interdisciplinary diagnostic process to determine the medical, psychological and functional capabilities of an older person with frailty, followed by the implementation of a coordinated and integrated plan for treatment and follow-up". (7)

Previous meta-analyses have indicated that CGA on geriatric wards resulted in less functional decline at discharge and more patients being alive and living at home after hospitalization, but not when implemented by a geriatric consultation team. (8, 38, 39) Our review indicates that co-management may be superior to consultation as a model for CGA on a non-geriatric ward. Three systematic reviews have previously evaluated the effectiveness of geriatric co-management in orthopedic patients. Two meta-analyses were performed: (13, 14) length of stay was reduced in one analysis, (13) but no effects were observed on mortality, functional status and time to surgery. Both meta-analysis included different studies (compared against each other and against this review) and had low statistical power. One narrative analysis concluded that co-management was associated with the lowest in-hospital mortality rate, length of stay and time to surgery, (11) but it was unclear how the authors reached this conclusion.

There are important differences between reviews in the inclusion and classification of co-management studies. (11-15) This likely reflects a difference in search strategy and clinical differences between co-management programmes and their definitions. The supplement of our manuscript details the intervention characteristics. While most studies included a physical therapist, performed rehabilitation and organised ward rounds, only half included social workers and performed discharge planning, and less than half included a geriatric nurse, participated in multidisciplinary meetings or used evidence-based protocols. These differences highlight an important consideration: the effect of co-management will depend largely on how programmes are organised and implemented and how the programme interacts with its context. (40) For example, in-patient geriatric rehabilitation improves functional status, (41) outpatient geriatric follow-up may improve survival, (42) and our results suggest that including interdisciplinary teams- and proactive discharge planning in co-management interventions may improve in-hospital survival and discharge disposition.

However, further research is needed. First, co-management effects in hip fracture patients have been replicated sufficiently to warrant cluster RCT's and increase the quality of the evidence. Prospective quasi-experimental studies with sufficient case-mix variables to adjust for baseline confounding may be considered to further explore the effects in non-orthopedic populations. Secondly, analyses should focus on (post-discharge) functioning and cognition, and should determine the cost-effectiveness. Thirdly, a better understanding is needed on what constitutes an effective geriatric co-management programme. Several sources of variation in effects should be considered: differences in patient case-mix, structure and processes of co-management and the implementation of programmes. Process evaluations can be used to identify contextual factors, intervention theory and core mechanisms of impact to facilitate implementation. (43)

Methodological considerations

This review included non-randomised controlled studies as individual randomisation can result in contamination bias. Confounding and selection may therefore have biased the co-management effect, but this proved hard to assess due to poor reporting of study methodology. A fixed effect model was used, despite heterogeneity, due to the low number of included studies, the risk of bias in smaller studies and the high likelihood of publication bias. (44) While a random effects model did not change the conclusion, we caution readers about inferring an exact treatment effect. The assessments of mortality, hospital readmission and number of patients discharged home suffered low statistical power and a clinically significant reduction remains possible within the limits of the confidence intervals. Subgroup analyses were used to explain differences in effect estimates between studies, but these results may be biased by both multiple testing and low statistical power, and should be considered hypothesis generating evidence.

Conclusions

There was low-quality evidence of a reduced length of stay and a reduced number of patients with complications, and very low-quality evidence of better functional status as a result of geriatric co-management. These results suggest that geriatric co-management has a potential benefit for managing frail patients admitted to a non-geriatric ward, but there is a high degree of uncertainty related to both the association and magnitude of the effect. Further research should therefore be considered a priority before considering scaling-up geriatric co-management programmes throughout health systems.

Table 3. Pooled effects of geriatric co-management

Outcome	N° studies	N° patients	Fixed-effect model [95% CI]	I^2	Random-effect model [95% CI]	GRADE*
Length of stay	11	3394	MD, -1.88 [-2.44 to -1.33]	86%	MD, -2.62 [-4.72 to -0.53]	Low
In-hospital mortality	7	1492	OR, 0.72 [0.50 to 1.03]	19%	OR, 0.70 [0.44 to 1.10]	Low
Mortality at 30 days follow-up	3	796	OR, 0.94 [0.53 to 1.69]	0%	OR, 0.95 [0.53 to 1.70]	Very low
Mortality at 3 months follow-up	3	697	OR, 0.88 [0.58 to 1.33]	50%	OR, 0.88 [0.48 to 1.61]	Very low
Mortality at 6 months follow-up	3	572	OR, 0.65 [0.42 to 1.01]	0%	OR, 0.65 [0.42 to 1.01]	Very low
Mortality at 12 months follow-up	3	926	OR, 1.07 [0.79 to 1.44]	77%	OR, 0.91 [0.46 to 1.81]	Very low
Readmission rate at 30 days follow-up	3	695	OR, 1.28 [0.71 to 2.31]	24%	OR, 1.24 [0.60 to 2.57]	Very low
Readmission rate at 12 months follow-up	2	601	OR, 0.91 [0.64 to 1.29]	0%	OR, 0.91 [0.64 to 1.29]	Very low
Number of patients discharged home	5	1370	OR, 1.07 [0.86 to 1.34]	67%	OR, 1.24 [0.78 to 1.98]	Very low

Legend: Abbreviations: N° = number; MD = Mean Difference; OR = Odds Ratio; CI = Confidence Interval; d = Cohen's d; RD = Risk Difference; * GRADE = Grading of Recommendations Assessment, Development and Evaluation and defines the quality of the body of evidence. Low GRADE evidence indicates that "further research is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate". (35) Very low GRADE evidence indicates that "our group is uncertain about the estimate" (see supplement). (35)

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CHAPTER 2

Supplementary materials

Supplement Table 1. Search string per database

Number	MEDLINE	EMBASE	CINAHL	CENTRAL
1	exp Aged/	'aged'/exp	(MH "Aged+")	MeSH descriptor: [Aged] explode all trees
2	aged.ab,ti.	aged:ab,ti	TI aged	aged:ti,ab,kw
3	elder*.ab,ti.	elder*:ab,ti	AB aged	elder*:ti,ab,kw
4	older.ab,ti.	older:ab,ti	TI elder*	older:ti,ab,kw
5	senior.ab,ti.	senior:ab,ti	AB elder*	senior:ti,ab,kw
6	frail.ab,ti.	frail:ab,ti	TI older	frail.ab,ti.
7	Geriatrics/	'geriatrics'/exp	AB older	MeSH descriptor: [Geriatrics] explode all trees
8	geriatrics.ab,ti.	geriatrics:ab,ti	TI senior	Geriatric*:ti,ab,kw
9	geriatric.ab,ti.	geriatric:ab,ti	AB senior	ortho geriatr*:ti,ab,kw
10	"ortho geriatr*".ab,ti.	'ortho geriatric':ab,ti	TI frail	orthogeriatr*:ti,ab,kw
11	"orthogeriatr*".ab,ti.	'ortho geriatrics':ab,ti	AB frail	"Referral and Consultation"/
12	"Referral and Consultation"/	'orthogeriatrics':ab,ti	(MH "Geriatrics")	consultation*:ti,ab,kw
13	"consultation*".ab,ti.	'orthogeriatric':ab,ti	TI geriatric*	Patient Care Team/
14	Patient Care Team/	'patient referral'/exp	AB geriatric*	care team*:ti,ab,kw

Number	MEDLINE	EMBASE	CINAHL	CENTRAL
15	"care team*".ab,ti.	'consultation'/de	TI ortho geriatric*	mobile team*:ti,ab,kw
16	"mobile team*".ab,ti.	consultation:ab,ti	AB ortho geriatric*	mobile adj3 care:ti,ab,kw
17	(mobile adj3 care).ab,ti.	'care team':ab,ti	TI ortho- geriatric*	comanagement:ti,ab,kw
18	comanagement.ab,ti.	'mobile team':ab,ti	AB ortho- geriatric*	co-management:ti,ab,kw
19	co management.ab,ti.	comanagement:ab,ti	TI orthogeriatr*	comanaged:ti,ab,kw
20	comanaged.ab,ti.	comanaged:ab,ti	AB orthogeriatr*	co managed:ti,ab,kw
21	co managed.ab,ti.	'co management':ab,ti	(MH "Referral and Consultation")	liaison:ti,ab,kw
22	liaison.ab,ti.	'co managed':ab,ti	TI consultation	Geriatric Assessment/
23	Geriatric Assessment/	liaison:ab,ti	AB consultation	Geriatric Assessment*:ti,ab,kw
24	"Geriatric Assessment*".ab,ti.	'geriatric assessment'/exp	(MH "Multidisciplinary Care Team")	cga:ti,ab,kw
25	cga.ab,ti.	cga:ab,ti	TI care team	comprehensive geriatric assessment:ti,ab,kw
26	"comprehensive geriatric assessment".ab,ti.	'comprehensive geriatric assessment':ab,ti	AB care team	Patient Care Planning/
27	Patient Care Planning/	'patient care planning'/exp	TI mobile team	“care planning”:ti,ab,kw
28	"care planning".ab,ti.	'care planning':ab,ti	AB mobile team	Health Services for the Aged/

Number	MEDLINE	EMBASE	CINAHL	CENTRAL
29	Health Services for the Aged/	'geriatric care'/de	TI comanagement	Hospitalization/
30	Hospitalization/	'elderly care'/de	AB comanagement	patients/
31	patients/	‘geriatric care’:ab,ti	TI co-management	inpatients/
32	inpatients/	'hospital service'/de	AB co-management	hospitalized:ti,ab,kw
33	hospitalized.ab,ti.	'aged hospital patient'/de	TI co management	hospitalised:ti,ab,kw
34	hospitalised.ab,ti.	hospitalized:ab,ti	AB co management	or/1-10
35	or/1–11	hospitalised:ab,ti	TI comanaged	or/11-28
36	or/12–29	or/1–15	AB comanaged	or/293
37	or/30–34	or/16–34	TI co-managed	or/9-10;17-20
38	or/10-11;18 – 21	or/36–38	AB co-managed	34 and 35 and 36
39	35 and 36 and 37	or/10–13;19–22	TI co managed	37 or 38 [§]
40	38 or 39 [*,†]	36 and 37 and 38	AB co managed	
41		39 or 40 [†]	(MH "Nurse Liaison")	
42			TI liaison	
43			AB liaison	
44			(MH "Geriatric Assessment+")	

Number	MEDLINE	EMBASE	CINAHL	CENTRAL
45			TI geriatric assessment	
46			AB geriatric assessment	
47			TI cga	
48			AB cga	
49			TI comprehensive geriatric assessment	
50			AB geriatric comprehensive geriatric assessment	
51			TI care planning	
52			AB care planning	
53			(MH "Health Services for the Aged")	
54			TI geriatric care	
55			AB geriatric care	
56			TI elderly care	
57			AB elderly care	
58			(MH "Hospitalization")	

Number	MEDLINE	EMBASE	CINAHL	CENTRAL
59			(MH "Patients")	
60			(MH "Aged, Hospitalized")	
61			TI hospitalized	
62			AB hospitalized	
63			TI hospitalized	
64			AB hospitalized	
65			or/1–20	
66			or/2 –57	
67			or/58–64	
68			or/15–20;29–40	
69			65 and 66 and 67	
70			68 or 69 ‡	

Legend: Results were * limited to Dutch, English, French, German and Spanish, † excluded case reports, editorials and letters, ‡ limited to academic journals, or § limited to trials.

Supplement Text

Methods: Data sources

Trial registers searched included ClinicalTrials.gov and the International Clinical Trials Registry Platform search Portal.

Methods: Eligibility criteria

The following study designs were considered eligible for inclusion (definitions are based on the CRD's guidance for undertaking reviews in health care; Centre for Review and Dissemination. Systematic reviews. CRD's guidance for undertaking review in health care. University of York. 2008):

1. Randomised controlled trials (RCT) = a "parallel group trial which randomises eligible participants to two or more groups, treats according to assignment, and compares the groups with respect to outcomes of interest".

2. Cluster randomised trials = an RCT "where clusters of people rather than single individuals are randomised to different interventions".

3. Quasi-experimental studies = differs from an RCT in the way participants are allocated to the intervention and control groups. Quasi-experimental studies do not use randomisation when allocating patients to intervention groups. Several quasi-experimental study designs exist:

3.1 Non-randomised controlled trials (nRCT) = "individuals are allocated to a concurrent comparison group, using methods other than randomization." A nRCT has parallel groups.

3.2 Interrupted time series = "multiple observations over time that are interrupted, usually by an intervention or treatment."

3.3 Before-and-after studies = "comparison of outcomes in study participants before and after the introduction of an intervention." The before-after comparison is made with one group without intervention and one group with intervention. Before-and-after studies had to prospective recruit participants and prospective measure outcomes to be deemed eligible for inclusion.

The following study designs were excluded (definitions are based on the CRD's guidance for undertaking reviews in health care):

1. Before-and-after studies with a historic cohort = a before-and-after study that selects participants for the control group from an available database or from electronic patient records. The participants in the control group are not prospectively recruited and assessed.

2. Observational studies: "a study in which natural variation in interventions or exposure among participants (i.e. not allocated by an investigator) is investigated to explore the effects

of the intervention or exposure on health outcomes." Observational studies include cohort studies, case-control studies and case series.

Methods: Data sources

A standardised data collection Word document was piloted by two investigators.

Methods: Quality Assessment

MINORS can be used to assess both randomised and non-randomised studies. Twelve criteria were scored: '0 if not reported', '1 if reported but inadequate', '2 if reported and adequate'. Publication bias was explored with a funnel plot for outcomes measured by ten studies or more. (20) Multiple publication bias was evaluated by comparing bibliographic information and study methodology. Selective reporting bias was evaluated by searching trial registers.

Methods: Structure of co-management programmes

Variables included: hospital unit of intervention, team composition, training (not enough information available), and team size (not enough information available).

Methods: Process of co-management programmes

Variables included: use of protocols, providing staff education, performing ward rounds, organizing multidisciplinary team meetings and contact and communication with unit staff.

Methods: Definitions of intervention characteristics

The acute care for elder components were used to define intervention components performed by the geriatric co-management programmes. This approach has previously been used to define the effectiveness of acute geriatric ward care. (45) Interventions were categorized as:

1) Early rehabilitation is defined as assessing the need for physical therapy and providing physical and occupational therapy to prevent or reverse functional decline.

2) Patient-centered care is defined as assessment and interventions with a focus on cognition and physical capacity

3) Medical care review is defined as the prevention of iatrogenic complications through assessment and delivery of interventions that addresses actual or potential problems identified in the assessment.

4) Planning for discharge

5) Prepared environment refers to physical environment modifications, e.g. clocks, calendars, handrails, raised toilet seats.

Results: Intervention characteristics

Nine geriatric co-management studies also involved physical therapists, (23-29, 31, 32) seven studies social workers, (23, 24, 26-29, 32) five studies geriatric nurses (24, 25, 29, 31, 32), four studies occupational therapists, (23, 26, 27, 32) and two studies internal medicine residents. (27, 34) Nine studies incorporated early rehabilitation, (24-29, 31, 32, 34), eight studies medical care review (n = 8) (24, 25, 27-29, 31-33), and six studies discharge planning (24-27, 31, 32) and patient-centered care (24, 25, 29, 31, 32, 34) in their intervention. No interventions modified the physical environment. Eight studies organized ward rounds, (23, 25-28, 30, 33, 34) five studies multidisciplinary meetings, (23, 25, 26, 28, 30, 34), four studies used protocols for preventing complications (e.g. delirium), (24, 27, 31, 34) and three studies educated staff (27, 29, 32) and organized follow-up meetings with staff. (24, 25, 29) Four studies reported a post-discharge intervention component. (26, 29, 31, 32)

Results: Outcome measures used to assess functional status

Barthel-index: The Barthel index is an evaluation measure of activities of daily living: feeding, moving, personal toilet, getting on and off toilet, bathing self, walking on level surface, ascend and descend stairs, dressing, controlling bowels, controlling bladder. (46) Each item is scored as 'with help' or 'independent', and values are weighted dependent on the time and amount of actual physical assistance required if a patient is unable to perform the activity. Scores range between 0 and 100, with higher scores indicating more independence.

Help-index of the SIVIS dependency scale: The SIVIS dependency scale is a measure of physical functioning. The Help-index assesses to the amount (time per day) of help is needed from another person for activities related to communication, mobility, transfers, washing, dressing, eating and toileting. (28)

The Grading of Recommendations Assessment, Development and Evaluation (GRADE)

The quality of the body of evidence relates to 1) study limitations, 2) imprecision, 3) inconsistency of results, 4) indirectness of evidence and 5) likelihood of publication bias. (35)

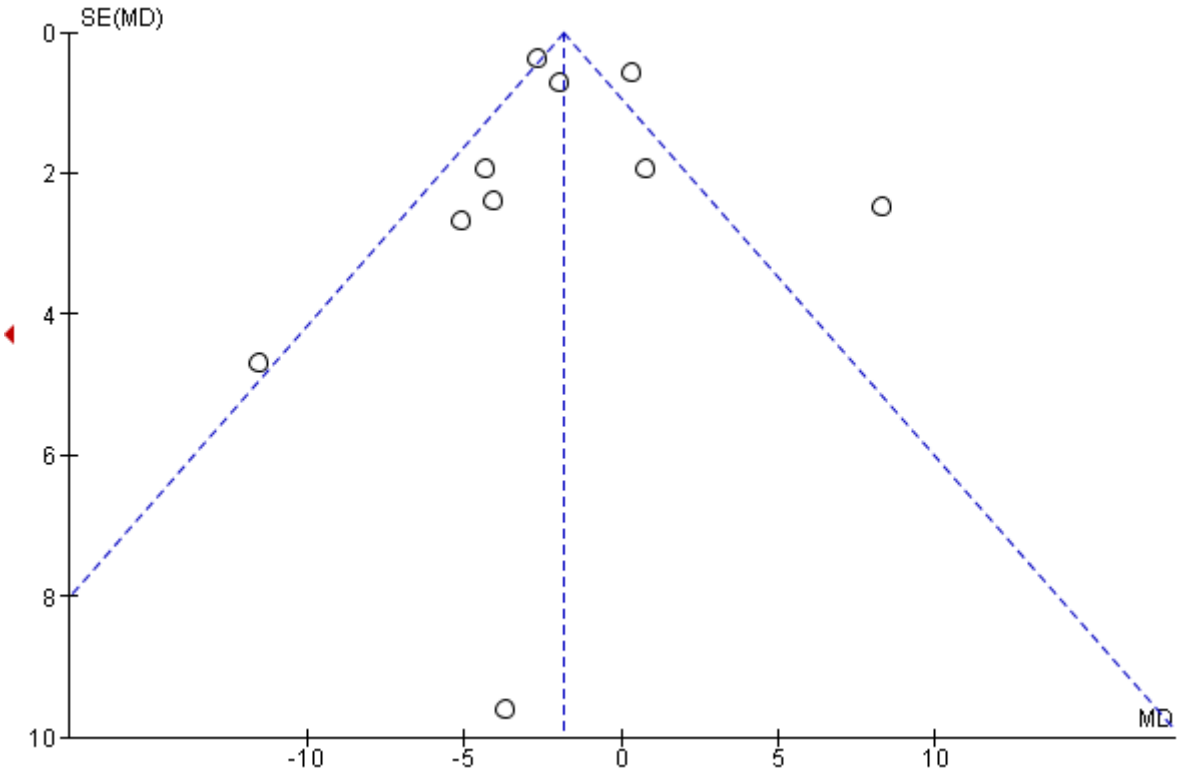
- High-quality evidence indicates that "further research is very unlikely to change our confidence in the estimate of effect".

- Moderate-quality evidence indicates that "further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate".

- Low-quality evidence indicates that "further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate".

- Very low-quality evidence indicates that "any estimate of effect is very uncertain".

Supplement Figure 1. Funnel plot for length of stay



Legend: The funnel plot assesses publication bias. Only one funnel plot was constructed because at least 10 studies are needed for a valid assessment, and only the outcome length of stay was measured in 10 studies or more.

Supplement Table 2a. Effect of geriatric co-management on functional status

Functional status: Improvement or recovery of activities of daily living (ADL)					
Study	***Outcome***	***Endpoint***	***Proportion intervention group (%)***	***Proportion control group (%)***	***Odds ratio [95% CI]***
Slaets 1997 (28)	Improvement in ADL	Hospital discharge	73/119 (61.3)	42/92 (45.7)	1.89 [1.09 to 3.28]
	Improvement in mobility		57/119 (47.9)	40/92 (43.5)	1.19 [0.69 to 2.07]
	Improvement in level of dependency *		71/119 (59.7)	33/92 (35.9)	2.65 [1.51 to 4.64]
Vidan 2005 (31)	Recovery of ADL	Hospital discharge	3/154 (1.9)	1/155 (0.6)	3.05 [0.31 to 29.74]
	Recovery of mobility		3/154 (1.9)	2/155 (1.3)	1.51 [0.25 to 9.22]
	Recovery of ADL and mobility		5/154 (3.2)	3/155 (1.9)	1.70 [0.40 to 7.24]
	Recovery of ADL	3 months follow-up	66/125 (52.8)	52/125 (41.6)	0.74 [0.47 to 1.18]
	Recovery of ADL or Mobility		82/144 (56.9)	59/134 (44.0)	1.68 [1.05 to 2.70]
	Complete recovery in ADL and mobility		22%†	27%†	/†
Naglie 2002 (30)	Decline in transfers	3 months follow-up	57/131 (43.5)	48/126 (38.1)	1.25 [0.76 to 2.061]
	Decline in ambulation		73/131 (55.7)	72/126 (57.1)	0.94 [0.576 to 1.546]

Study	***Outcome***	***Endpoint***	***Proportion intervention group (%)***	***Proportion control group (%)***	***Odds ratio [95% CI]***
Vidan 2005 (31)	Complete recovery in ADL and mobility	6 months follow-up	39%†	33%†	/†
Naglie 2002 (30)	Decline in transfers	6 months follow-up	45/124 (36.3)	44/117 (37.6)	0.95 [0.56 to 1.595]
	Decline in ambulation		59/124 (47.6)	56/117 (47.9)	0.98 [0.596 to 1.640]
Vidan 2005 (31)	Complete recovery in ADL and mobility	12 months follow-up	47%†	39%†	/†

Legend: Abbreviations: ADL = Activities of Daily Living; SD = Standard Deviation; CI = Confidence Interval; * Measured by the HELP-index of the SIVIS dependency scale; † Proportions could not be obtained from the available data

Supplement Table 2b. Effect of geriatric co-management on functional status

Functional status: Difference in Barthel score						
Study	***Endpoint***	***Intervention group***		***Control group***		***Mean difference [95% CI]***
		No. of patients	***Mean (SD)***	***No. of patients***	***Mean (SD)***	
Swanson 1998 (29)	Hospital discharge	38	92.8 (8.8)	33	85.6 (12.5)	7.20 [2.10 - 12.30]
Naglie 2002 (30)	3 months follow-up	131	62 (/)§	126	62.4 (/)§	/‡
	6 months follow-up	124	65 (/)§	117	65.7 (/)§	/‡

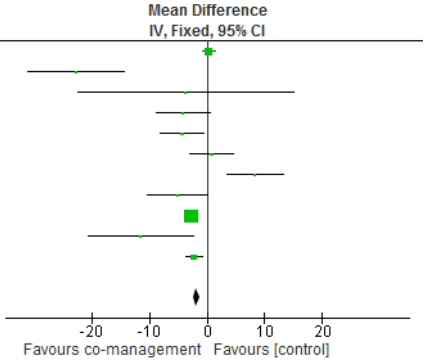
Legend: Abbreviations: SD = Standard Deviation; CI = Confidence Interval; ‡ Odds ratio or Mean difference could not be estimated; § study did not report standard deviation

Supplement Figure 2. Effect of geriatric co-management on length of stay

Fixed effects model

Study or Subgroup	Geriatric co-management Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Arbaje 2010	5.9	7.7	366	5.6	7.5	351	24.7%	0.30 [-0.81, 1.41]
Germain 1995	42.8	20.8	56	65.5	23.5	52	0.4%	-22.70 [-31.09, -14.31]
Gilchrist 1988	44	56.1	97	47.7	86.1	125	0.1%	-3.70 [-22.47, 15.07]
Harari OPAL 2007	10.4	11.1	49	14.5	12.2	46	1.4%	-4.10 [-8.80, 0.60]
Harari POPS 2007	11.5	5.2	54	15.8	13.2	54	2.1%	-4.30 [-8.08, -0.52]
Khan 2002	26.9	22.6	208	26.1	26	537	2.1%	0.80 [-2.98, 4.58]
Naglie 2002	29.2	22.6	141	20.9	18.8	138	1.3%	8.30 [3.43, 13.17]
Slaets 1997	19.7	14.2	140	24.8	23.6	97	1.1%	-5.10 [-10.35, 0.15]
Suhm 2014	8.6	3.9	224	11.3	4.8	269	51.7%	-2.70 [-3.47, -1.93]
Swanson 1998	21	11.3	38	32.5	24.8	33	0.4%	-11.50 [-20.69, -2.31]
Vidan 2005	16	4.5	155	18.3	8.2	164	14.7%	-2.30 [-3.74, -0.86]
Total (95% CI)			**1528**			**1866**	**100.0%**	**-1.88 [-2.44, -1.33]**

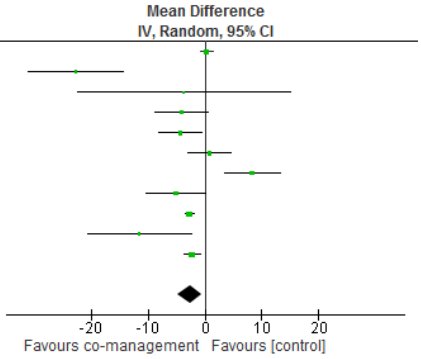
Heterogeneity: Chi² = 69.89, df = 10 (P < 0.00001); I² = 86%
Test for overall effect: Z = 6.69 (P < 0.00001)



Random effects model

Study or Subgroup	Geriatric co-management Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Arbaje 2010	5.9	7.7	366	5.6	7.5	351	14.9%	0.30 [-0.81, 1.41]
Germain 1995	42.8	20.8	56	65.5	23.5	52	4.5%	-22.70 [-31.09, -14.31]
Gilchrist 1988	44	56.1	97	47.7	86.1	125	1.2%	-3.70 [-22.47, 15.07]
Harari OPAL 2007	10.4	11.1	49	14.5	12.2	46	8.7%	-4.10 [-8.80, 0.60]
Harari POPS 2007	11.5	5.2	54	15.8	13.2	54	10.3%	-4.30 [-8.08, -0.52]
Khan 2002	26.9	22.6	208	26.1	26	537	10.4%	0.80 [-2.98, 4.58]
Naglie 2002	29.2	22.6	141	20.9	18.8	138	8.5%	8.30 [3.43, 13.17]
Slaets 1997	19.7	14.2	140	24.8	23.6	97	7.9%	-5.10 [-10.35, 0.15]
Suhm 2014	8.6	3.9	224	11.3	4.8	269	15.3%	-2.70 [-3.47, -1.93]
Swanson 1998	21	11.3	38	32.5	24.8	33	3.9%	-11.50 [-20.69, -2.31]
Vidan 2005	16	4.5	155	18.3	8.2	164	14.5%	-2.30 [-3.74, -0.86]
Total (95% CI)			**1528**			**1866**	**100.0%**	**-2.62 [-4.72, -0.53]**

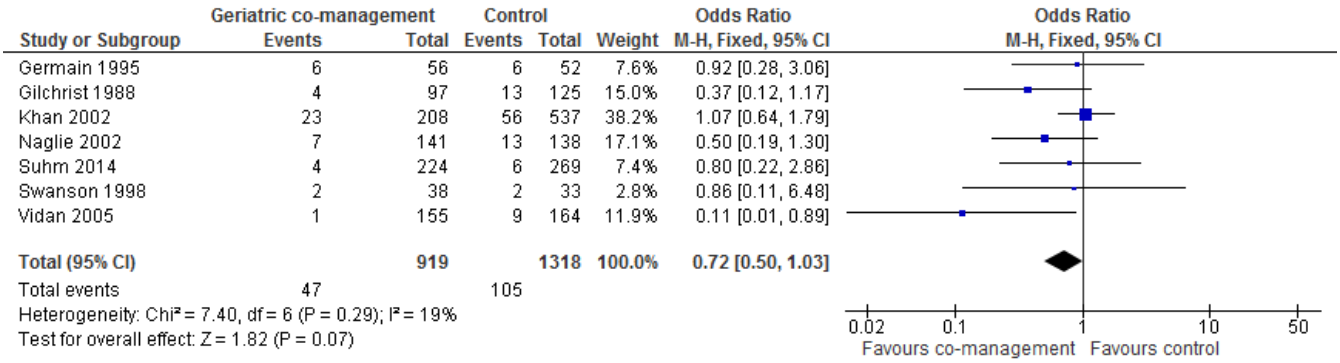
Heterogeneity: Tau² = 7.33; Chi² = 69.89, df = 10 (P < 0.00001); I² = 86%
Test for overall effect: Z = 2.45 (P = 0.01)



Legend: the forest plot details the meta-analyses on the outcome length of stay. The plot details both the individual effects and the summary effect. Heterogeneity was explored visually and using I2 as shown in the forest plot.

Supplement Figure 3. Effect of geriatric co-management on in-hospital mortality

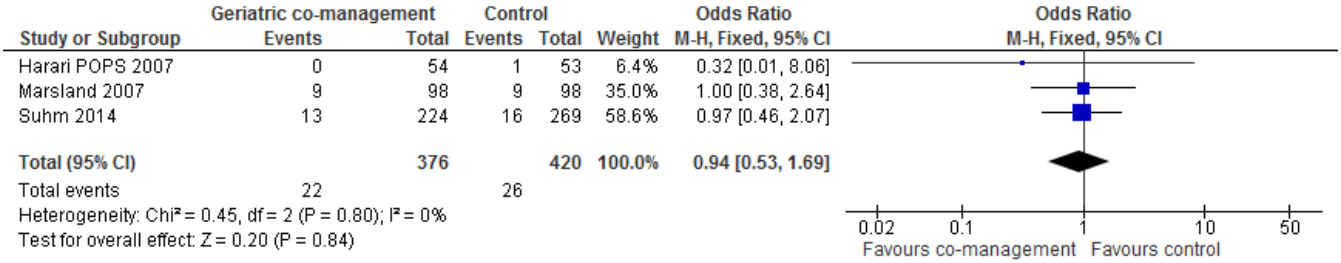
In-hospital mortality



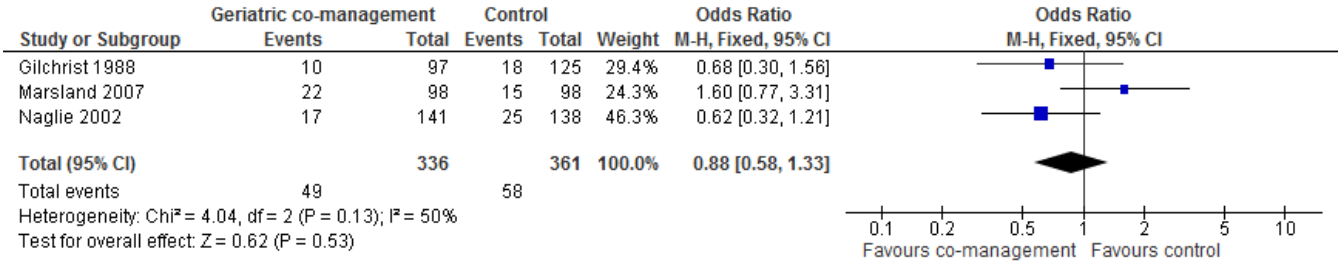
Legend: the forest plot details the meta-analysis on the outcome in-hospital mortality. The plot details both the individual effects and the summary effect. Heterogeneity was explored visually and using I2 as shown in the forest plot.

Supplement Figure 4. Effect of geriatric co-management on post-discharge mortality

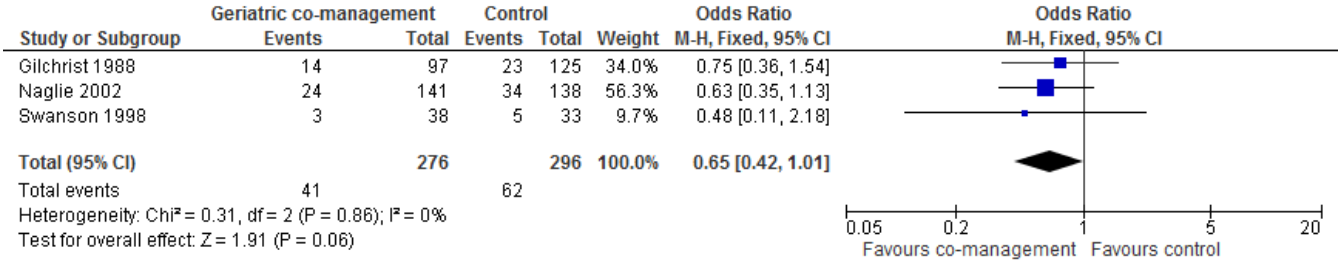
Mortality at thirty days follow-up



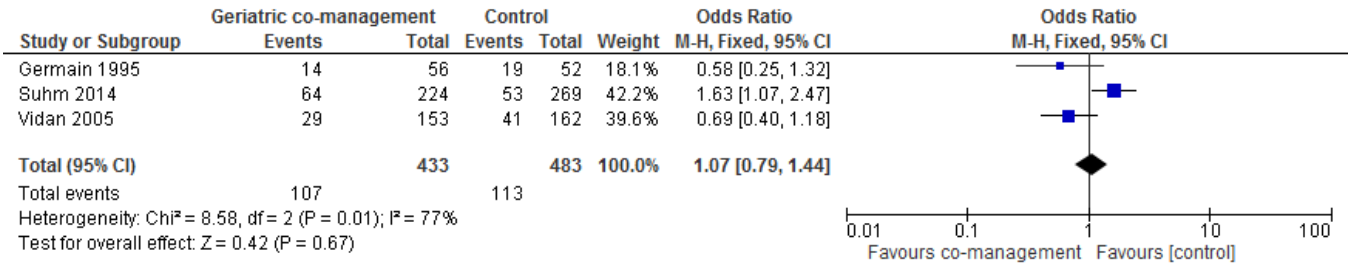
Mortality at three months follow-up



Mortality at six months follow-up



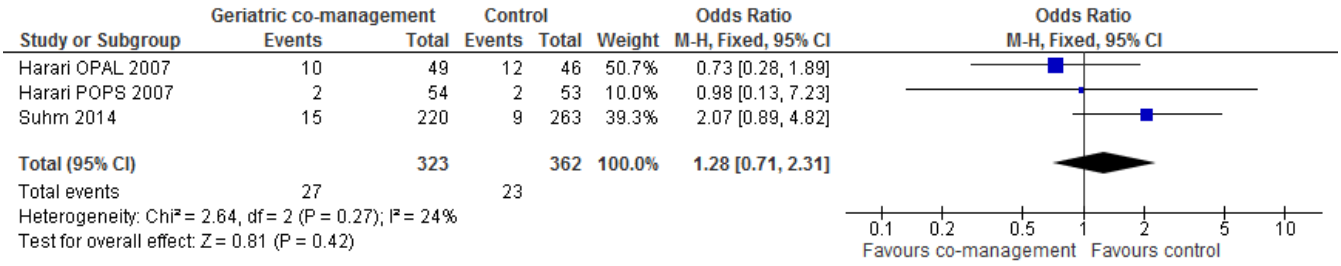
Mortality at twelve months follow-up



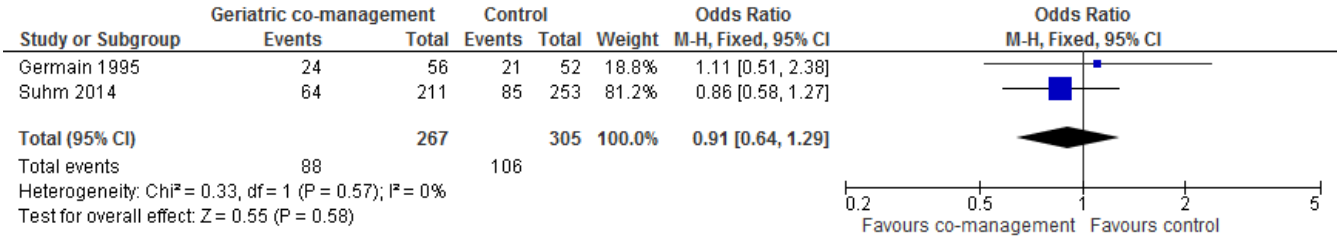
Legend: the forest plot details the meta-analyses on the outcome post-discharge mortality. The plot details both the individual effects and the summary effect. Heterogeneity was explored visually and using I2 as shown in the forest plot.

Supplement Figure 5. Effect of geriatric co-management on readmission rate

Readmission at thirty days follow-up



Readmission rate at twelve months follow-up



Legend: the forest plot details the meta-analyses on the outcome readmission rate. The plot details both the individual effects and the summary effect. Heterogeneity was explored visually and using I2 as shown in the forest plot.

Supplement Table 3a. Effect of geriatric co-management on complications

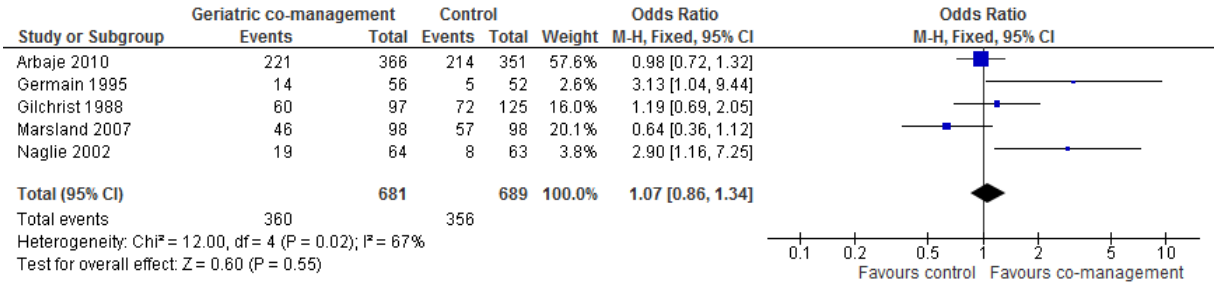
Number of patients with complications				
Study	***Outcome***	***Proportion intervention group (%)***	***Proportion control group (%)***	***Odds ratio [95% CI]***
Harari 2007 (35)	Difference in proportion of total number of complications	21/91 (23.1)	70/91 (76.9)	0.09 [0.05 to 0.18]
Suhm 2014 (37)	Number of patients with one or more complications	131/244 (58.5)	196/269 (72.9)	0.52 [0.36 to 0.77]
Vidan 2005 (31)	Number of patients with major medical complications	70/154 (45.5)	100/155 (64.5)	0.46 [0.29 to 0.72]

Supplement Table 3b. Effect of geriatric co-management on complications

Mean frequency of postoperative complications					
Study	***Intervention group***		***Control group***		***Mean difference (95% CI)***
	No. of patients	***Mean (SD)***	***No. of patients***	***Mean (SD)***	
Marsland 2010 (36)	98	0.75 (no SD)	98	0.49 (no SD)	/*

Legend: * Mean difference could not be estimated

Supplement Figure 6. Effect of geriatric co-management on number of patients discharged home



Legend: the forest plot details the meta-analysis on the outcome number of patients discharged home. The plot details both the individual effects and the summary effect. Heterogeneity was explored visually and using I2 as shown in the forest plot.

Supplement Table 4. Grading of recommendations, Assessment, Development and Evaluations for each outcome

Outcome	Type of evidence	Study limitations	Precision	Inconsistency of results	Indirectness of evidence	Likelihood of publication bias *	GRADE
Functional status	+ 4	- 3	0	- 1	0	?	Very low
Length of stay	+ 4	- 1	+ 1	- 1	0	- 1	Low
In-hospital mortality	+ 4	- 2	0	0	0	?	Low
Post-discharge mortality	+ 4	- 3	0	0	0	?	Very low
Readmission rate	+ 2	- 2	0	0	0	?	Very low
Complications	+ 4	- 2	0	0	0	?	Low
Number of patients discharged home	+ 4	- 1	0	- 1	0	?	Low

Legend: * Publication bias was only assessed for outcomes measured by 10 studies or more; The level of evidence was rated for each outcome using the Grading of Recommendations, Assessment, Development and Evaluations. Information is aggregated at the outcome level as GRADING did not differ substantially on the different endpoints. Type of evidence is scored as + 4 for RCT's and as + 2 for observational evidence. Study limitation are scored as 0 if no methodological problems, - 1 if one methodological problem, - 2 if two methodological problems, and – 3 if three or more methodological problems. Precision is scored as 0 if effect size (OR, RR) < 2 or not significant, as + 1 if effect size > 2, and as + 2 if effect size > 5. Inconsistency of results is rated as + 1 if there is evidence of a dose response across or within studies, as 0 if most studies show similar results, and as – 1 if there is disagreement between studies. Indirectness of evidence is scored as 0 if population and outcomes are generalizable, as – 1 if problem with one element, and as – 2 if problem with two or more elements. Likelihood of publication bias could only be assessed for length of stay and scored as – 1 for evidence of publication bias. GRADE scores are rated as high (at least four points overall), as moderate (three points), as low (two points) and as very low (one point or less). Low GRADE evidence indicates that "further research is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate". Very low GRADE evidence indicates that "our group is uncertain about the estimate". (46)

Supplement Table 5. Subgroup analyses to determine differences in effect size

Outcome	Effect size	Internal medicine	Hip fracture	Randomization	Low risk of bias	Rehabilitation	Discharge planning	Patient centered care	Medical care review
Length of stay	Standardised mean difference	-0.15 [-0.42 to 0.11], n = 3	-0.21 [-0.50 to 0.07], n = 7	-0.29 [-0.65 to 0.07], n = 6	0.03 [-0.34 to 0.40], n = 3	-0.33 [-0.60 to -0.07], n = 9	-0.36 [-0.78 to 0.06], n = 6	-0.42 [-0.74 to -0.11], n = 6	-0.26 [-0.54 to 0.03], n = 7
In-hospital mortality	Odds ratio	n/a	0.64 [0.37 to 1.10], n = 6	0.50 [0.28 to 0.89], n = 5	0.31 [0.08 to 1.27], n = 2	0.59 [0.33 to 1.07], n = 5	0.66 [0.33 to 1.32], n = 3	0.86 [0.36 to 2.06], n = 2	0.49 [0.19 to 1.24], n = 3
30 day mortality	Odds ratio	n/a	0.95 [0.53 to 1.70], n = 3	n/a	n/a	0.92 [0.44 to 1.92] , n = 2	0.32 [0.01 to 8.06] , n = 1	0.92 [0.44 to 1.92] , n = 2	0.91 [0.36 to 2.30] , n = 2
3 month mortality	Odds ratio	n/a	0.88 [0.48 to 1.61] , n = 3	0.64 [0.38 to 1.08] , n = 2	0.62 [0.32 to 1.21] , n = 1	0.62 [0.32 to 1.21] , n = 1	0.62 [0.32 to 1.21] , n = 1	n/a	0.99 [0.39 to 2.50] , n = 2
6 month mortality	Odds ratio	n/a	0.65 [0.42 to 1.01] , n = 3	0.65 [0.42 to 1.01] , n = 3	0.63 [0.35 to 1.13] , n = 1	0.61 [0.35 to 1.05] , n = 2	0.61 [0.35 to 1.05] , n = 2	n/a	0.63 [0.35 to 1.13] , n = 1

Outcome	Effect size	Internal medicine	Hip fracture	Randomization	Low risk of bias	Rehabilitation	Discharge planning	Patient centered care	Medical care review
12 month mortality	Odds ratio	n/a	1.18 [0.58 to 1.63] , n = 2	0.66 [0.42 to 1.03] , n = 2	0.69 [0.40 to 1.18] , n = 1	0.91 [0.46 to 1.81] , n = 3	0.58 [0.25 to 1.32] , n = 1	1.04 [0.38 to 2.83] , n = 2	0.66 [0.42 to 1.03] , n = 2
Patients discharged home	Odds ratio	0.98 [0.72 to 1.32] , n = 1	1.07 [0.76 to 1.53] , n = 3	1.97 [0.99 to 3.91] , n = 3	1.54 [0.54 to 4.42] , n = 2	1.86 [0.76 to 4.52] , n = 3	2.99 [1.48 to 6.06] , n = 2	1.54 [0.50 to 4.71] , n = 2	1.33 [0.70 to 2.50] , n = 4
30 day readmission rate	Odds ratio	0.73 [0.28 to 1.89] , n = 1	1.84 [0.85 to 4.02] , n = 2	n/a	n/a	1.24 [0.60 to 2.57] , n = 3	0.77 [0.32 to 1.82] , n = 2	1.24 [0.60 to 2.57] , n = 3	0.77 [0.32 to 1.82] , n = 2
1 year readmission rate	Odds ratio	n/a	0.86 [0.58 to 1.27] , n = 1	1.11 [0.51 to 2.38] , n = 1	n/a	0.91 [0.64 to 1.29] , n = 2	1.11 [0.51 to 2.38] , n = 1	0.91 [0.64 to 1.29] , n = 2	1.11 [0.51 to 2.38] , n = 1

Legend: Subgroup analyses were used to explore differences in effect size based on study and intervention characteristics. The results represent the effect size in that specific subgroup. Statistical tests between groups were not performed as these results are considered exploratory. All results are reported with 95% Confidence Intervals; n/a indicates that no observations were available in that specific subgroup. N refers to the number of studies.

CHAPTER 3

Quality indicators for geriatric co-management programmes

Van Grootven, B., McNicoll, L., Mendelson, D., Friedman, S., Fagard, K., Milisen, K., Flamaing, J., Deschodt, M., G-COACH consortium. (2018) Quality indicators for in-hospital geriatric co-management programmes: a systematic literature review and international Delphi study. BMJ Open, 8 (3), 1-11.

ABSTRACT

Objective: To find consensus on appropriate and feasible structure, process and outcome indicators for the evaluation of in-hospital geriatric co-management programmes.

Design: An international two-round Delphi study based on a systematic literature review (searching databases, reference lists, prospective citations and trial registers).

Setting: Western Europe and United States.

Participants: Thirty-three people with at least two years of clinical experience in geriatric co-management were recruited. Twenty-eight experts (sixteen from the USA and twelve from Europe) participated in both Delphi rounds (85% response rate).

Measures: Participants rated the indicators on a nine point scale for their A) appropriateness and B) feasibility to use the indicator for the evaluation of geriatric co-management programmes. Indicators were considered appropriate and feasible based on a median score of seven or higher. Consensus was based on the level of agreement using the RAND/UCLA appropriateness method.

Results: In the first round containing 37 indicators there was consensus on fourteen indicators. In the second round containing 44 indicators there was consensus on 31 indicators (structure = eight, process = seven, outcome = sixteen). Experts indicated that co-management should start within 24 hours of hospital admission using defined criteria for selecting appropriate patients. Programmes should focus on the prevention and management of geriatric syndromes and complications. Key areas for comprehensive geriatric assessment included cognition/delirium, functionality/mobility, falls, pain, medication, and pressure ulcers. Key outcomes for evaluating the program included length of stay, time to surgery and the incidence of complications.

Conclusion: The indicators can be used to assess the performance of geriatric co-management programmes and identify areas for improvement. Furthermore, the indicators can be used to monitor the implementation and effect of these programmes.

INTRODUCTION

Geriatric co-management programmes are emerging as a potential strategy to manage frail patients on non-geriatrics wards. These programmes are characterized by a shared decision making and collaboration between non-geriatrics and geriatrics teams focusing on the prevention and management of geriatric-oriented problems and syndromes. (1) A promising aspect of this model is that geriatrics teams are directly involved in and have direct control over relevant medical issues, which is associated with improved effectiveness of the comprehensive geriatric assessment approach. (2, 3) Comprehensive geriatric assessment, a central component in geriatric co-management, is defined as a "multidimensional, interdisciplinary diagnostic process to determine the medical, psychological and functional capabilities of an older person with frailty, followed by the implementation of a coordinated and integrated plan for treatment and follow-up". (4)

A recent systematic review identified a potential effect on better functional status, prevention of complications and reduced length of stay as a result of geriatric co-management, but the quality of evidence was low. (5) Most notably, the high risk of bias in primary studies and low effect sizes across outcomes limited strong conclusions. Furthermore, the majority of studies were limited to effect evaluations in orthogeriatric populations, while process evaluations and qualitative data are needed to inform how co-management works and how it should be implemented.

Despite the low level of evidence, co-management programmes are increasingly being implemented (6) due to their high face validity and the limited impact of in-hospital geriatric consultation teams. (1, 7) However, some knowledge gaps remain. First, there is no evidence-based understanding of core interventions that should be implemented for all co-management programmes to have their desired effect.(8) Second, there is no framework including both effect and process outcomes for evaluating co-management programmes. (9)

Indicators can inform how to organise in-hospital geriatric co-management programmes, detail the interventions that have to be implemented and define which components of the programme and its implementation that have to be evaluated. (10) Structure indicators refer to "health system characteristics that affect the system's ability to meet the health care needs of individual patients or a community". Process indicators refer to "what the provider did for the patient and how well it was done". Outcome indicators refer to "states of health or events that follow care and that may be affected by health care". (10)

In the absence of systematic evidence on how to organise and evaluate geriatric co-management programmes, expert opinion can be a first step to address this evidence gap. (11) We therefore aimed to find consensus on structure, process and outcome indicators that are appropriate and feasible to use for the implementation and evaluation of geriatric co-management programmes.

METHODS

A two-round Delphi study based on a systematic literature review was performed including international experts on geriatric co-management. A Delphi study involves several survey rounds in which experts are asked to answer a questionnaire anonymously. Results can include both quantitative data (e.g. rating indicators on a numeric scale) and qualitative data (e.g. comments explaining the rating or suggestions for new indicators) and these results are reported back to the participants. This iterative process aims to find group consensus in which participants can change their rating based on the feedback of previous survey rounds. (11)

The first Delphi round was performed from December 2015 to January 2016; the second round from February to March 2016.

Systematic literature review

The study methodology and search strategy has been detailed elsewhere and is available in a review protocol in the PROSPERO database (CRD42015026033). (12) We searched databases (MEDLINE, EMBASE, CINAHL and CENTRAL), reference lists, trial registers and Pubmed Central Citations from inception until October 2015. Evaluation studies were included if they reported at least one structure, process or outcome of an in-hospital geriatric co-management programme. Two investigators performed the selection process independently using Endnote and data was tabulated using standardized forms. Discrepancies were resolved using consensus discussion. Data was structured using the Donabedian model of the three dimensions of care: structure, process and outcomes (see introduction for definitions). (13)

Selection of participants

Participants were required to have a minimum of two years of clinical experience with co-management for geriatric in-hospital patients in Europe or North America. Recruitment strategies included using our own network, sending e-mail invitations through national geriatrics societies, contacting authors that have published or presented on geriatric co-management, and contacting members of special interest groups on geriatric co-management. Potential participants were contacted via e-mail, asked to complete their demographic (name, age, gender, country, state) and professional (affiliation, professional education) information, and to report their experience with co-management. The final participants were purposively selected with an aim to achieve a balanced sample based on profession, experience, gender, age, and region. All participants were offered the opportunity to receive a voluntary reimbursement for their participation.

Developing the Delphi questionnaire

A preliminary set of indicators was drafted based on the systematic literature review. First, a long list of quality indicators was drafted, structured according to their typology (i.e. pertaining to the structure, process or outcome of co-management programmes) and duplicates were removed. Two investigators experienced in geriatric research (BVG, MD) independently scored these indicators as 'relevant', 'relevant after rephrasing' or 'not relevant' for inclusion in the Delphi questionnaire. A consensus meeting decided which indicators were included and how indicators were rephrased. A questionnaire was drafted in English and piloted by four independent experts (KF, KM, JF, MD) in geriatric research and medicine (who did not participate in the Delphi rounds) to evaluate the face and content validity. A consensus meeting between investigators (BVG, KM, JF, MD) decided the final inclusion of indicators in the Delphi questionnaire.

Finding consensus among participants (Delphi rounds)

Participants were contacted via an e-mail explaining the aim and procedure of the Delphi study. In round one, participants were asked to rate the indicators on a nine point scale for their A) appropriateness and B) feasibility to use the indicator for the evaluation of geriatric co-management programmes. If implemented, appropriate indicators are likely to provide a net benefit to patients and improve patient outcomes. (14) Feasibility refers to the measurement of the indicator in clinical practice (and not the feasibility of implementing the indicator). Participants could suggest additional indicators based on their experience and knowledge. These suggested indicators were reviewed by the researchers for their relevance and included in the second round questionnaire based on a group consensus. In round two, participants were presented with quantitative and qualitative feedback on the rating of the indicators using summary statistics at the group level and anonymous qualitative quotes by individual participants. Participants were again asked to rate the appropriateness and feasibility of the indicators for which there was no consensus after round one and the new indicators suggested by the participants. For both rounds, reminders were sent to participants.

Analysis

Descriptive statistics were used to report the structure, processes and outcomes identified in the literature and participants' characteristics and their rating of the indicators. Indicators were considered appropriate and feasible based on a median score of seven or higher. Consensus was based on the level of agreement using the RAND/UCLA appropriateness method. (15) In short, agreement is observed if the interpercentile range is smaller than the interpercentile range adjusted for asymmetry. We explored descriptive differences in the level of agreement between experts from the United States and Europe. Data was analysed using SPSS version 20 (SPSS, Chicago, IL, USA).

Ethics

All participants consented to participate in the study via e-mail. Approval by a local ethics committee was not required as a Delphi study with healthcare professionals is not considered an experiment (Belgian law dated 7th May 2004 related to experiments on human people).

RESULTS

Systematic literature review

A total of 12794 titles and abstracts were independently screened by two authors. A total of 335 full text articles were independently assessed for eligibility by two authors. A final 44 manuscripts were included for data extraction. Studies were excluded because they did not report the evaluation of an in-hospital co-management programme (n = 248), were an abstract (n = 66), letter to the editor (n = 6) or published in another language (n = 3).

A total of 39 programmes were identified in 44 publications (see Figure 1). (16-59) The majority of programmes included hip fracture or orthopaedic patients (87%), (16-19, 21-29, 31-37, 39-49, 52-59) (see Supplementary Table 1) including patients aged 65 years or older (74%) (16-20, 23-27, 31-36, 38, 39, 42, 43, 47-51, 53, 55-59) (see table 1).

Only a minority of programmes used care pathways (38%), (16, 17, 19, 20, 22, 23, 25, 26, 29, 32, 37-40, 42, 43, 45, 48, 53) protocols (33%), (22-26, 29, 30, 33, 34, 37-40, 48, 49, 53) standard order sets (21%), (19, 25, 26, 29, 37, 40, 42, 48, 49, 53) or educational sessions (15%) (20, 29, 36, 39, 40, 48, 59) to support their implementation. The majority of programmes integrated medical review (71%), (16-21, 23-27, 29, 30, 32, 35-42, 44-46, 48-53, 56) discharge planning (69%), (18, 20, 23, 24, 27-31, 33-40, 42, 45, 47-54, 56, 59) and rehabilitation (77%) (16-21, 23, 24, 27-32, 35-40, 42, 45, 47-56, 59) as intervention components (see table 2). Daily follow-up was provided in 58% of the programmes, (16, 17, 23, 25, 26, 29, 32-34, 36, 37, 40, 42, 46, 48-51, 53, 56) and 44% participated in multidisciplinary team meetings. (18-21, 23-26, 31, 36, 37, 41, 50-52, 54, 56, 59)

The five most reported outcomes were length of stay, survival, discharge disposition and post-discharge residential status, time to surgery and complications.

Figure 1. Flowchart

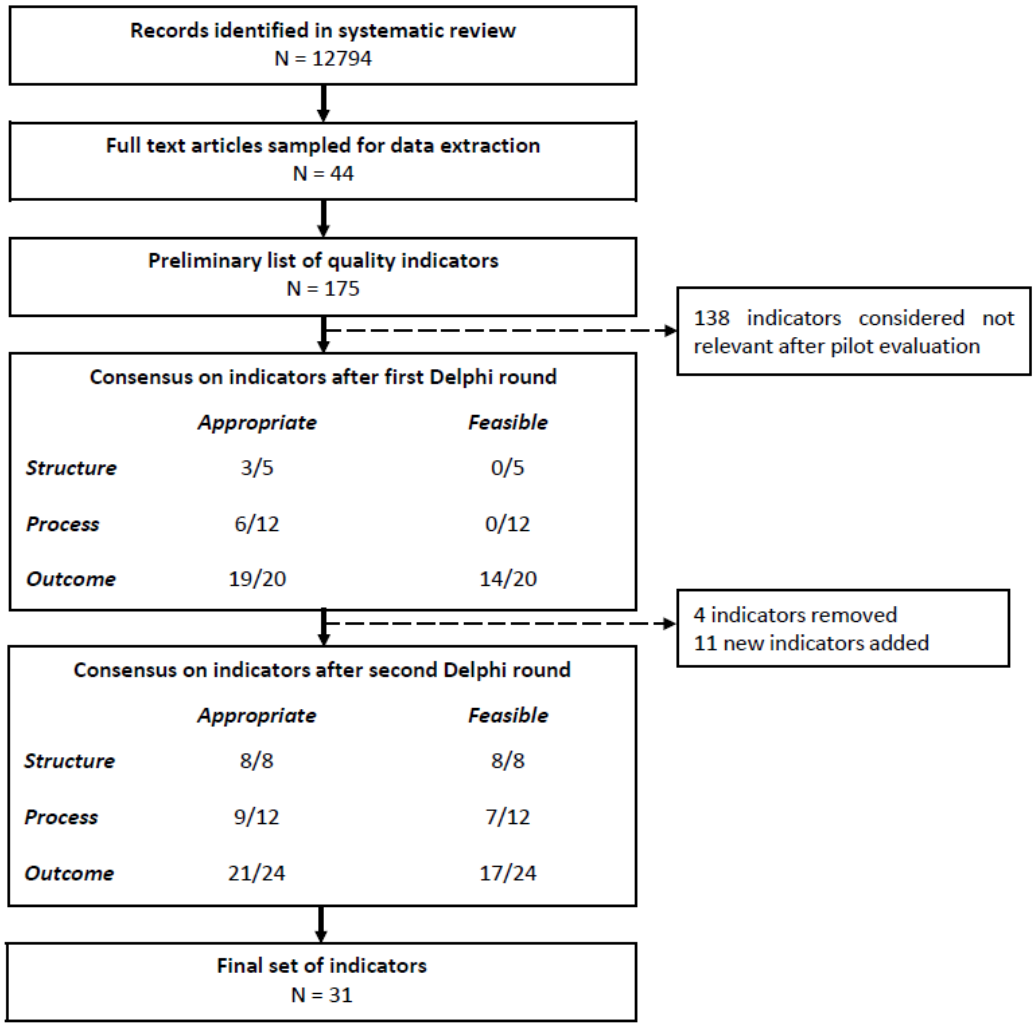


Table 1. Structures identified in co-management programmes

Structure of co-management programmes	Reported by programmes
Patient population of interest	
- Surgical	34/39 (87%)
- Medical	4/39 (10%)
- Hospital wide	1/39 (3%)
Team composition	
- Geriatrician	38/39 (97%)
- Geriatric nurse	8/39 (21%)
- Physical therapist	25/39 (64%)
- Occupational therapist	14/39 (36%)
- Social worker	19/39 (49%)
Patient selection for co-management	
- Age based characteristics [1]	
1. Age < 65 years [2]	10/39 (26%)
2. Age ≥ 65 years	18/39 (46%)
3. Age ≥ 70 years	5/39 (13%)
4. Age ≥ 75 years	3/39 (8%)
- Geriatric based characteristics	
1. Functional or cognitive impairment	2/39 (5%)
2. Multimorbidity, polypharmacy	1/39 (3%)
- Screening tool	2/39 (5%)
Program defined in a care pathway	15/39 (38%)
Evidence-based protocols available	13/39 (33%)
Standard geriatric order sets available	8/39 (21%)
Organization of educational sessions	6/39 (15%)

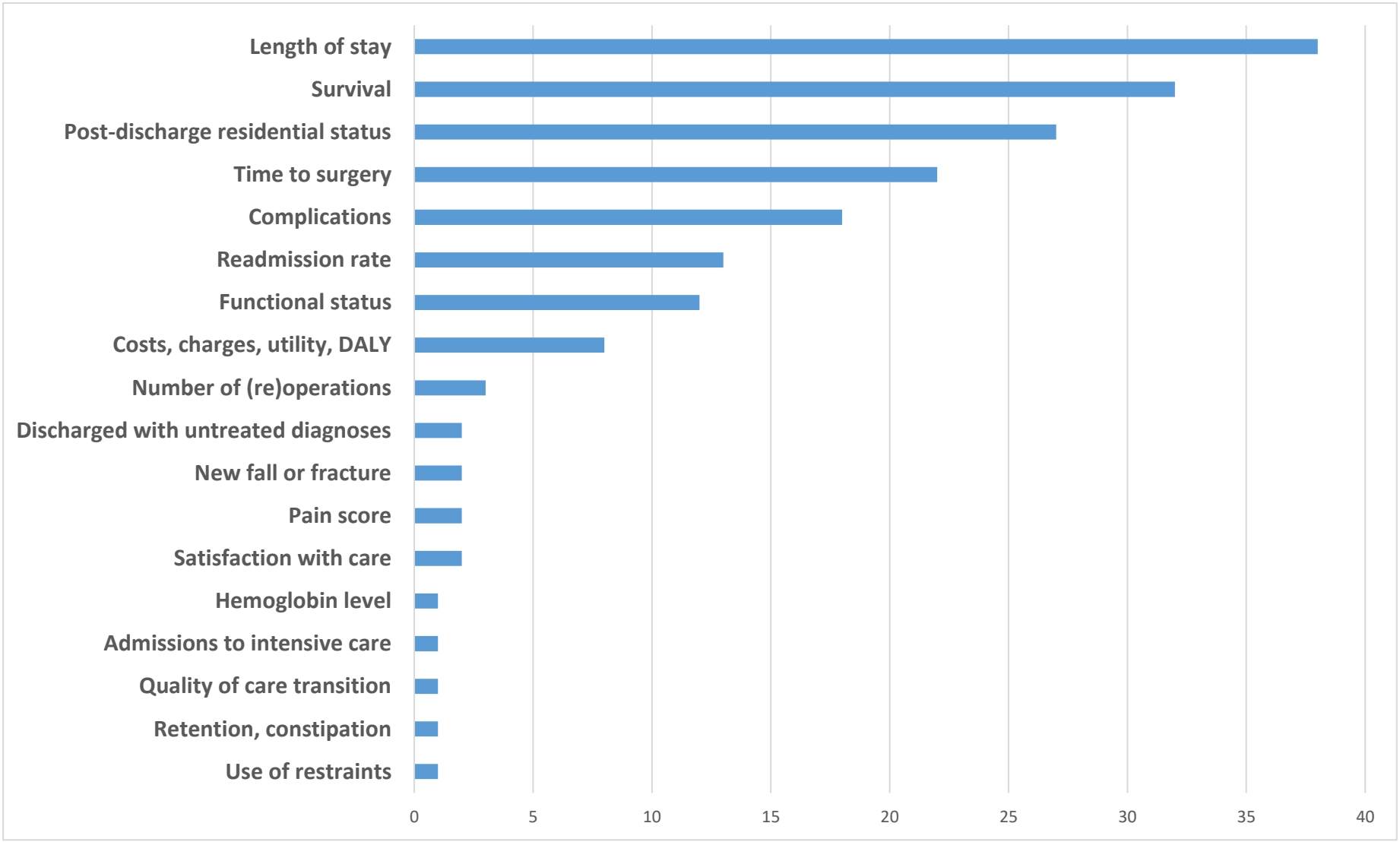
Legend: 1 Data was missing for 3 studies; 2 The category Age < 65 years refers to studies recruiting patients aged 26 years or older (n = 1), 50 years or older (n = 3), 55 years or older (n = 1), 60 years or older (n = 5).

Table 2. Processes identified in co-management programmes

Processes of co-management programmes	Reported by programmes
In-hospital follow-up	26/39 (67%) [1]
- Daily	15/26 (58%)
- Thrice weekly	3/26 (12%)
- Twice weekly	3/26 (12%)
- Weekly or on request	4/26 (15%)
Participation in team meetings [2]	17/39 (44%)
- Daily	2/17 (12%)
- Thrice weekly	1/17 (6%)
- Twice weekly	2/17 (12%)
- Weekly	12/17 (71%)
Medical review/assessment [3]	28/39 (72%)
- Cognition	11/28 (39%)
- Functional status	13/28 (46%)
- Falls	9/28 (32%)
- Medication	4/28 (14%)
- Nutritional status	5/28 (18%)
- Complications	13/28 (46%)
Rehabilitation [4]	30/39 (77%)
Discharge planning	27/39 (69%)
Transitional care [5]	1/39 (3%)
Post-discharge follow-up	16/39 (41%)
- Referral to community services or outpatient clinics	9/16 (56%)
- Home visit	5/16 (31%)
- Telephone contact	2/16 (13%)

Legend: 1 There is 1 missing data: study reported 'rounds with staff' but did not indicate the frequency; 2 Team meetings were defined as case conferences or multidisciplinary meeting in which the geriatrician or geriatrics team interacts with the primary treating physician or other ward staff (e.g. registered nurses, physical therapists) to discuss patients included in the co-management programme; 3 Medical review was defined as "the prevention of iatrogenic complications through assessment and delivery of interventions that addresses actual or potential problems identified in the assessment".(60); 4 Rehabilitation was defined as "assessing the need for physical therapy and providing physical and occupational therapy to prevent or reverse functional decline".(60); 5 Transitional care was defined as "a set of actions designed to ensure the coordination and continuity of health care as patients transfer between different locations or different levels of care in the same location".(61)

Figure 2. Outcomes reported in systematic review



Delphi study

A total of 63 individuals expressed their interest to participate. Based on a purposive selection of participants, 33 experts were selected, sixteen from the United States and seventeen from Europe. The majority of participants were medical doctors specialized in geriatric medicine having both clinical and academic experience in co-management (see table 3). Only four nurses and one manager could be included. Participants had a median of five years of experience with geriatric co-management, ranging between two and twenty years.

The first round contained 37 indicators. There was consensus on fourteen indicators, partial consensus on fourteen indicators and no consensus on five indicators based on a 90.9% response rate (n = 30 experts). Based on the qualitative responses, four indicators were removed and eleven new indicators were added to the questionnaire (see supplemental tables 2 and 3). These new indicators were suggested by the Delphi participants. The second round contained 44 indicators and was sent to the 30 responders of round one. A final consensus on 31 indicators was observed based on an overall response rate of 84.8% (n = 28 experts) (see figure 2).

Structure indicators

All eight structure indicators were considered appropriate and feasible (see table 4). Geriatric co-management programmes should include at least a geriatrician, treating physician of the ward, registered nurse or nurse practitioner with geriatric expertise, nursing staff of the ward, physical therapist, occupational therapist and social worker. At least one geriatrics team member should be available on a daily basis. The roles and responsibilities of all professionals participating in the program should be defined in a care pathway, and their work should be supported by geriatrics order sets and evidence-based protocols for the prevention and management of geriatric syndromes. A screening tool or criteria should be available for including patients into the program. A geriatrics education program should be available for all new healthcare professionals at induction, and could be repeated yearly for all professionals participating in the co-management program. Lastly, team meetings should be organised for reviewing the performance of the programme and formulating strategic improvement plans. Experts from Europe did consider that using geriatric order sets was appropriate but there was no consensus within this subgroup.

Table 3. Characteristics of participants in Delphi study

Characteristics	Total Sample	United States	Europe
Response rate, n (%)			
- Round 1	30/33 (91)	16/16 (100)	14/17 (82)
- Round 2	28/33 (85)	16/16 (100)	12/17 (71)
Age, median years (range)	43 (32 – 62)	40.5 (32 – 51)	46.5 (34 – 62)
Female gender, n (%)	16/30 (53)	9/16 (56)	7/14 (50)
Professional education, n (%)			
- Medicine	25/30 (83)	15/16 (94)	10/14 (71)
1. Geriatric medicine	23/30 (77)	13/16 (81)	10/14 (71)
2. Medical doctor	1/30 (3)	1/16 (6)	0
3. Orthopaedic surgeon	1/30 (3)	1/16 (6)	0
- Nursing	4/30(13)	0	4/14 (29)
- Management	1/30 (3)	1/16 (6)	0
Academic position, n (%)			
- Professor	6/30 (20)	3/16 (19)	3/14 (21)
- Research associate	1/30 (3)	0	1/14 (7)
- Postdoctoral fellow	2/30 (7)	0	2/14 (14)
- Doctoral student	1/30 (3)	0	1/14 (7)
- Clinical instructor	13/30 (43)	12/16 (75)	1/14 (7)
- No academic position	7/30 (23)	1/16 (6)	6/14 (43)
Co-management background, n (%)			
- Clinical	29/30 (97)	16/16 (100)	13/14 (93)
- Academic	22/30 (73)	12/16 (75)	10/14 (71)
Median years of experience with co-management (range)	5 (2 – 20)	4.5 (2 – 15)	8.5 (2 – 20)

Participants were from the following countries: United Kingdom (n = 5), Netherlands (n = 1), Italy (n = 2), Spain (n = 1), Sweden (n = 2), Belgium (n = 1), Germany (n = 1), Denmark (n = 1), and states: New York (n = 4), North Carolina (n = 1), Massachusetts (n = 3), Florida (n = 1), Ohio (n = 2), New Jersey (n = 1), Virginia (n = 1), Arkansas (n = 1), Rhode Island (n = 2)

Table 4. Structure indicators for geriatric co-management programmes

Indicators	Median Score (IQR)	
All structure indicators were appropriate and feasible [1]	***Appr***	***Feas***
A *geriatrician, treating physician of the ward, registered nurse or nurse practitioner with geriatric expertise, nursing staff of the ward, physical therapist, occupational therapist and social worker/discharge or case manager* is a core member of the geriatric co-management programme.	7.8 (1.5) [2]	8 (2)
A member of the geriatric team is available on a daily basis for patients included in the geriatric co-management programme.	8 (1)	8 (1.8)
Team meetings for reviewing the performance on indicators associated with the geriatric co-management programme are organised at least once yearly with the aim of evaluating the current performance and formulating strategic improvement plans.	8 (1)	8 (1)
An educational programme or sessions are organised or facilitated at induction of every new staff member, and at least once a year for all current hospital staff participating in a geriatric co-management programme, focusing on the identification and management of geriatric syndromes.	8 (2)	8 (2)
A validated screening tool or objective criteria to select patients for the geriatric co-management programme is available to all hospital staff.	8.5 (1)	8 (2.8)
A multidisciplinary care pathway is available detailing the roles and responsibilities of all hospital staff participating in the geriatric co-management programme.	9 (1)	8 (1.8)
Evidence-based protocols for the prevention and/or management of *cognitive impairment, delirium, depression, hospital-acquired infections, pressure ulcers, incontinence, urinary retention, constipation, pain, palliative care, polypharmacy, malnutrition, falls, osteoporosis, sleep deprivation, functional impairment/mobility and frailty* are available to hospital staff participating in the geriatric co-management programme.	8.3 (1.6) [2]	8 (1)
Standard geriatric order sets (e.g. labs, technical investigations) are available to hospital staff participating in the geriatric co-management programme.	9 (3)	8 (1)

Legend: Abbreviations: Appr = Appropriateness; Feas = Feasibility; IQR = Interquartile Range; 1 Appropriateness and feasibility was determined by a disagreement index: see appendix for all indicators that were considered not appropriate or feasible; 2 scores have been averaged for all response options (see text in italic for the different response options): see appendix for the raw scores;

Process indicators

Seven out of twelve process indicators were considered appropriate and feasible (see Table 5). Two indicators were also appropriate but not feasible. Geriatric co-management programmes should start preoperatively or within 24 hours of hospital admission, followed by a geriatric assessment also within 24 hours of hospital admission. A member of the geriatrics team should perform daily patient rounds to see patients in the program if indicated, and interdisciplinary meetings with the co-management staff should be organised at least twice a week. Patients should have their care preferences documented in an advance care plan and should have a discharge plan documented in their patient record. On hospital discharge, a summary of the hospital care and post-discharge instruction should be sent to the primary care practitioner and/or care facility.

Experts from the United States agreed that verbally communicating the findings of the geriatric assessment, recommendations and care plan to other professionals in the co-management program is both appropriate and feasible. Experts from Europe considered this appropriate, but not feasible.

Outcome indicators

Sixteen out of 24 outcome indicators were considered appropriate and feasible (see table 6). Five indicators were also appropriate but not feasible. The highest scoring outcome indicators were length of stay, time from admission to surgery, patient satisfaction with hospital care, institutionalisation and the incidence of delirium and wound infections.

Experts from Europe did consider that length of stay was appropriate, and monitoring physical restraints was feasible, but the level of agreement was insufficient to indicate consensus.

Supplementary Table 4 details the results for all indicators, including those considered not appropriate or feasible or indicators without consensus.

Table 5. Process indicators for geriatric co-management programmes

Indicators	**Median Score (IQR)**	
Process Indicators considered appropriate and feasible with agreement [1]	***Appr***	***Feas***
For patients included in the geriatric co-management programme, co-management starts preoperatively or within 24 hours of hospital admission.	9 (1)	8 (2)
Daily patient rounds are performed by a member of the geriatric team participating in the geriatric co-management programme.	8 (1)	8 (1)
Collaborative interdisciplinary meetings with the primary treating hospital staff participating in the geriatric co-management programme and a member of the geriatric team are organised to discuss patients included in the geriatric co-management programme at least twice a week.	7 (1)	8 (2)
Percentage of patients included in the geriatric co-management programme who had a screening or assessment focusing on *delirium, dementia, functional status, fall risk, social aspects and environment, comorbidity, pressure ulcer risk, pain, nutritional status, incontinence, urinary tract infection, bowel movement, hearing, vision, sleeping disorder, medication use, frailty and advanced care plans* using a validated tool within 24 hours of hospital admission.	8.5 (1.6) [2]	8 (1.8)
Percentage of patients included in the geriatric co-management programme who had their care preferences documented in an advance care plan or advanced directive.	9 (1)	8 (1.8)
Percentage of patients included in the geriatric co-management programme who have a discharge plan documented in their patient record.	9 (0.3)	8 (1)
Percentage of patients included in the geriatric co-management programme who have a summary of their hospital care and post-discharge instructions send to their primary care practitioner and/or care facility.	9 (0)	8 (2)

Legend: Abbreviations: Appr = Appropriateness; Feas = Feasibility; IQR = Interquartile Range; [1] Appropriateness and feasibility was determined by a disagreement index: see appendix for all indicators that were considered not appropriate or feasible; [2] scores have been averaged for all response options (see text in italic for the different response options): see appendix for the raw scores;

Table 6. Outcome indicators for geriatric co-management programmes

Indicators	**Median Score (IQR)**	
Indicators considered appropriate and feasible with agreement [1, 2]	***Appr***	***Feas***
Mean length of stay in the hospital.	9 (1.3)	9 (1)
Mean time spent in the emergency department. [3]	7 (3)	8 (2)
Mean time from hospital admission to surgery. [4]	9 (1.5)	9 (1.3)
Readmission rate within *30 days and three months* of hospital discharge.	8 (2) [5]	8 (2)
Patient satisfaction with hospital care.	9 (1)	7 (3)
Caregiver satisfaction with hospital care provided for patients included in the geriatric co-management programme.	8.5 (2)	7 (3)
Percentage of patients who were physically restrained during their hospital stay.	9 (2)	8 (3)
In-hospital mortality rate.	9 (2)	9 (0.3)
Percentage of patients admitted to a nursing home on hospital discharge.	9 (1)	9 (1)
Percentage of patients who declined in functional status between hospital admission and hospital discharge.	8 (2)	7 (3)
Percentage of patients who developed delirium.	9 (1)	8 (2)
Percentage of patients who developed a urinary tract infection.	9 (2)	9 (2)
Percentage of patients who developed a wound infection.	9 (1.3)	9 (1.3)
Percentage of patients who developed a pneumonia.	9 (2)	8 (2)
Percentage of patients who developed a sepsis.	9 (2.3)	9 (2)
Percentage of patients who developed a pressure ulcer.	9 (2)	8 (2)

Legend: Abbreviations: Appr = Appropriateness; Feas = Feasibility; IQR = Interquartile Range; [1] Appropriateness and feasibility was determined by a disagreement index: see appendix for all scores; [2] The denominator relates to patients admitted in the co-management program; [3] the denominator only includes patients admitted through the emergency department; [4] the denominator only includes patient included in a surgical co-management program ; [5] scores have been averaged for all response options (see text in italic for the different response options): see appendix for the raw scores

DISCUSSION

This study aimed to find consensus on structure, process and outcome indicators that are appropriate and feasible to use for the implementation and evaluation of geriatric co-management programmes using a two-round Delphi study and systematic literature review. We included 33 participants from Europe and North America and observed consensus on 31 indicators that are considered both appropriate and feasible.

Experts indicated the importance of providing proactive care to frail patients by geriatric care professionals within 24 hours of hospital admission. A central focus of these programmes is the comprehensive geriatric assessment aiming to identify, prevent or manage geriatric syndromes and complications. There was a strong consensus that co-management should focus on areas related to delirium, functional status, falls, pressure ulcers, medication use, comorbidity, nutrition, pain, advance care planning and discharge planning and its communication.

The ability of comprehensive geriatric assessment to improve outcomes has been associated with the ability to implement the treatment plan by the multidisciplinary team. (3) There was a strong consensus that co-management programmes should be multidisciplinary and include a geriatrician, treating physician of the non-geriatric ward, a nurse with geriatrics expertise, physical therapist and social worker. There seems a value for daily co-management, yet experts argued that the frequency should be based on the severity of a specific patient case. Nonetheless, this reflects one of the hallmarks of co-management: shared decision making with daily communication. (62)

A standard set of outcome parameters for the evaluation of orthogeriatric co-management programmes was previously developed based on a review of orthogeriatric co-management evaluation studies,(63) and a consensus development conference. (64) Likewise to our results, length of stay, time to surgery, incidence of complications, institutionalisation, readmission rate and mortality were considered important outcomes. However, our Delphi results disagreed with the panelist of the consensus development conference on post-discharge follow-up of outcomes, which were generally not considered feasible by our experts. Furthermore, the appropriateness of post-discharge follow-up declined the longer the endpoint after hospitalization was defined. This indicates that in-hospital co-management may not be expected to have long-term effects without appropriate follow-up interventions after hospital discharge. Despite long-term follow-up being a key component of comprehensive geriatric assessment, (4) this likely reflects a challenge of implementing transitional care in routine practice as there are often no formal relationships between

care settings, no financial incentives, inadequate resources and communication, and a lack of time. (65)

Indeed, many effective interventions in healthcare fail to be implemented in practice. (8) Or alternatively, many routine practices are not (as) effective as defined. (66) The results from this Delphi study can be used to address this challenge. First, the indicators can be used to measure the current performance of geriatric co-management programmes and identify areas for improvement. (67) Second, the indicators can be used to start a new geriatric co-management program. The structure and process indicators can be considered good geriatric care for frail patients. However, their implementation should be tailored to the local context of the health system, hospital and co-management programme. Third, the indicators can be used to monitor both the effect and the implementation of the programme. (68) We therefore advise to monitor both process and outcome indicators when evaluating geriatric co-management programmes. This should be a continuous process and should be followed by strategic improvement plans and re-evaluations.

Methodological considerations

Some considerations should be noted. Firstly, the abstraction of data in the systematic literature review was dependent of the quality of reporting in the primary studies. A recent meta-analysis on geriatric co-management programmes observed a high risk of bias and poor reporting of study methodology in published manuscripts. (5) This may result in underreporting or missing information about particular structures and processes. For example, detailed information about the implementation strategy or process data on the actual delivery of interventions were missing. Secondly, the results are based largely on the views of medical doctors as we could only recruit four nurses and one manager. The selection of participants was based on those experts who responded to an e-mail invitation. We did not specifically select medical doctors trained in geriatric medicine. For our strategies, we used author lists from publications and abstracts and special interest groups focusing on geriatric co-management. However, it is very likely that geriatricians are more interested in geriatric co-management and therefore more likely to respond to an invitation. The indicators may therefore not fully reflect the interdisciplinary nature of co-management or the economics of implementing geriatrics care models (e.g. no economic indicators have been defined). No patients were included because of the technical nature of the indicators and the focus on system characteristics. Nonetheless, Patients' views on the acceptability of implementing indicators should be considered. If not acceptable, the indicators will unlikely result in improved outcomes. Thirdly, because the majority of

evidence on geriatric co-management originates from North America and Europe, the results of this study may only be valid for these regions. Furthermore, it should be noted that despite the differences between countries in organising their health systems, there were only minimal differences in appropriateness between regions. Validation of the indicators in other countries is recommended. Fourthly, the observed consensus is based on a specific sample of 33 motivated experts, and it is unclear if the same results would have been produced with a different sample of experts. However, a systematic review concluded that RAND/UCLA method has moderate to very good reliability and good construct and predictive validity. (69) Fifthly, we did not define any threshold standards that should be met when evaluating the indicators, and for many indicators these thresholds are not available. Finally, these indicators are based on expert opinion in the absence of clinical trial data. The strength of the evidence should therefore be considered very low and requires further testing for validity and reliability. (14)

Conclusion

This Delphi study identified 31 indicators for the evaluation of geriatrics co-management programmes. Patient selection, early inclusion, and interdisciplinary care with geriatric expertise based on a comprehensive geriatric assessment are considered key elements of co-management programmes. The indicators can be used to assess the performance of co-management programmes, identify areas for improvement and monitor the implementation and effect of these programmes. Future research should focus on the development of post-discharge outcomes who are feasible to measure, multicentre studies, cluster randomization and process evaluation to support the scaling up of effective co-management programmes.

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CHAPTER 3

Supplementary materials

Supplementary Table 1. Study characteristics systematic literature review

Study	Country	Design	Population
Adunsky 2003, 2011; Ginsberg 2013 (16, 17, 32)	Israel	Retrospective cohort study	Hip fracture patients aged 65 years or older
Antonelli Incalzi 1993 (19)	Italy	Before-and-after study with historic cohort	Patients aged 70 years or more admitted to the orthopaedic ward
Arbaje 2010 (20)	USA, Maryland	Non randomised controlled trial	Adults 70 years or older admitted on an internal medicine unit
Bhattacharyya 2013 (21)	UK	Retrospective before-and-after study	Hip fracture patients
Biber 2013 (22)	Germany	Before-and-after study with historic cohort	Hip fracture patients aged 60 years and older
Bielza Galindo 2013 (23)	Spain	Before-and-after study with historic cohort	Hip fracture patients aged 75 years or older
Cogan 2010 (24)	Ireland	Retrospective before-and-after study	Hip fracture patients
Elliot 1996 (27)	New Zealand	Retrospective cohort study	Hip fracture patients aged 65 years or older
Farnworth 1994 (28)	Australia, New South Wales	Retrospective before-and-after study	Hip fracture patients
Folbert 2011, 2012 (25, 26)	Netherlands	Before-and-after study with historic cohort	Hip fracture patients aged 65 years or older
Gilchrist 1988 (31)	UK	Randomised controlled trial	Women with hip fracture aged 65 years or older

Study	Country	Design	Population
Fisher 2006 (45)	Australia, New South Wales	Before-and-after study with historic cohort	Patients aged 60 years or older with a primary diagnosis of nonpathological hip fracture
Friedman 2009; Kates 2011 (29, 40)	USA, New York	Retrospective cohort study	Patients aged 60 years or older admitted for surgical repair of proximal femur fracture
Germain 1995 (30)	Canada, Quebec	Randomised controlled trial	Functional or mental impaired elderly in-patients
Gregersen 2012 (35)	Denmark	Retrospective before-and-after study	Hip fracture patients aged 65 years or older
Grund 2015 (36)	Germany	Before-and-after study with historic cohort	Patients with a fracture aged 75 years or older
Gupta 2014 (37)	UK	Before-and-after study with historic cohort	Hip fracture patients aged 50 years or older
Harari 2007 (39)	UK	Prospective before-and-after study	High-risk medical inpatients aged 70 years or older
Harari 2007 (38)	UK	Prospective before-and-after study	Elective orthopaedic patients aged 65 years or older
Leung 2011 (44)	China	Retrospective before-and-after study	Hip fracture patients aged 60 years or older
Khan 2002 (41)	UK	Prospective before-and-after study	Elderly patients admitted for fractured femur neck
Khasraghi 2005 (42)	USA, Baltimore	Retrospective before-and-after study	Elderly hip fracture patients
Kristensen 2015 (43)	Denmark	Retrospective cohort study	Hip fracture patients aged 65 years or older
Marsland 2010 (46)	UK	Prospective before-and-after study	Hip fracture patients

Study	Country	Design	Population
Mazzola 2010 (47)	Italy	Prospective cohort study	Hip fracture patients aged 70 years and older
Miura 2009 (48)	USA, Oregon	Before-and-after study with historic cohort	Hip fracture patients aged 55 years or older
Gonzalez-Montalvo 2010, 2011 (33, 34)	Spain	Prospective cohort study	Patients with osteoporotic hip fracture aged 65 years or older
Naglie 2002 (49)	CA, Toronto	RCT	Hip fracture patients aged 70 years or older
Ortiz 2008 (18)	Spain	Before-and-after study with historic cohort	Hip fracture patients aged 65 years or older
Sennour 2009 (50)	USA, Indiana	Retrospective cohort study	Older patients at risk for functional decline
Slaets 1997 (51)	Netherlands	RCT	Medical inpatients aged 75 years or older
Street 1994 (52)	Australia	Before-and-after study with historic cohort	Hip fracture patients aged 50 or older
Suhm 2014 (53)	Switzerland	Prospective before-and-after study	Hip fracture patients aged 65 years or older
Swanson 1998 (54)	Australia, Queensland	Randomised controlled trial	Hip fracture patients aged 55 years or older
Tha 2009 (55)	Australia	Retrospective cohort study	Hip fracture patients aged 65 years or older
Vidan 2005 (56)	Spain	Randomised controlled trial	Patients aged 65 years or older admitted for acute hip fracture surgery
Wagner 2012 (57)	Chile	Before-and-after study with historic cohort	Hip fracture patients aged 65 years or older
Zeltzer 2014 (58)	Australia, New South Wales	Multicentre Retrospective cohort study	Hip fracture patients aged 65 or older
Zuckerman 1991 (59)	USA, New York	Retrospective before-and-after study	Hip fracture patients aged 65 years or older

Supplementary table 2. Indicators removed after round 1

Indicators removed after round 1	Reason
1. Percentage of hospital staff participating in the geriatric co-management programme who received education by a member of the geriatric team on the identification and management of geriatric syndromes	Participants suggested to replace this with a new indicator
2. For surgical patients, co-management starts preoperatively	Participants suggested to replace this with a new indicator
3. For medical patients, co-management starts within 24 hours of hospital admission	Participants suggested to replace this with a new indicator
4. The geriatrician and treating physician meet to discuss patients included in the geriatric co-management programme.	Participants noted that the indicator contains duplicate information with another indicator

Supplementary table 3: Indicators added after round 1

New indicators added after round 1	Reason
1. A member of the geriatrics team is available on a daily basis for patients included in the geriatric co-management programme.	Suggestion by participant
2. Team meetings for reviewing the performance on indicators associated with the geriatric co-management programme are organised at least once yearly with the aim of evaluating the current performance and formulating strategic improvement plans.	Suggestion by participant
3. An educational program or sessions are organized or facilitated at induction of every new staff member, and at least once a year for all current hospital staff participating in a geriatric co-management programme, focusing on the identification and management of geriatric syndromes.	Suggestion by participant
4. Percentage of patients eligible for geriatric co-management who were assessed or screened for their eligibility to be included in the geriatric co-management program.	Suggestion by participant
5. Percentage of patients included in the geriatric co-management programme who received post-discharge follow-up from a member of the geriatric team.	Suggestion by participant
6. If a co-managed patient is discharged to a facility, a member of the geriatric co-management team calls the facility with post-discharge instructions.	Suggestion by participant
7. Satisfaction with the co-management service, rated by the treating physician of the ward participating in the geriatric co-management programme.	Suggestion by participant
8. Satisfaction with the co-management service, rated by the nursing staff of the ward participating in the geriatric co-management programme.	Suggestion by participant
9. Perceived level of support by hospital staff participating in the geriatric co-management programme in caring for geriatric patients rated on a numeric scale (0 to 10).	Suggestion by participant
10. Evidence-based protocols for the prevention and/or management of *sleep deprivation, functional impairment, frailty* are available to hospital staff participating in the geriatric co-management programme. (three new response options were added)	Suggestion by participant
11. Percentage of patients included in the geriatric co-management programme who had a screening or assessment focusing on depression, dysphagia, frailty using a validated tool within 24 hours of hospital admission.	Suggestion by participant

Supplementary Table 4. Median scores and agreement index for all indicators

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Structure indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
A(n) *… (see response options below)* is a core member of the geriatric co-management programme.		8 (2)		-0.6
Geriatrician	9 (0)		0	
Treating physician of the ward	8 (1.3)		-0.3	
Physician assistant	4.2 (3.3)		1.9	
Geriatric nurse practitioner	6.2 (3)		-1.8	
Registered Nurse with geriatric expertise	7 (2)		-0.9	
Registered nurse OR nurse practitioner with geriatric expertise	8 (1)		-0.4	
Nursing staff of the ward	7 (2)		-0.9	
Physical therapist	8 (1)		-0.3	
Occupational therapist	7 (2)		-0.9	
Social worker or discharge of case manager	8 (1)		-0.3	
Dietician	6,5 (2)		10	
Speech therapist	6.5 (3.3)		30	
Pharmacist	7 (2)		-3.1	

Indicator	Median (IQR)		Agreement Index [a]	
Structure indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
A member of the geriatrics team is available on a daily basis for patients included in the geriatric co-management programme.	8 (1)	8 (2)	-0.3	-0.3
Team meetings for reviewing the performance on indicators associated with the geriatric co-management programme are organized at least once yearly with the aim of evaluating the current performance and formulating strategic improvement plans.	8 (1)	8 (1)	-0.3	-0.3
An educational programme or sessions are organised or facilitated at induction of every new staff member, and at least once a year for all current hospital staff participating in a geriatric co-management programme, focusing on the identification and management of geriatric syndromes.	8 (2)	8 (2)	-0.3	-0.3
A validated screening tool or objective criteria to select patients for the geriatric co-management programme is available to all hospital staff.	8.5 (1)	8 (2.8)	-0.3	-0.9
A multidisciplinary care pathway is available detailing the roles and responsibilities of all hospital staff participating in the geriatric co-management programme.	9 (1)	8 (1.8)	-0.3	-0.3

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Structure indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Evidence-based protocols for the prevention and/or management of … *(see response options below)* are available to hospital staff participating in the geriatric co-management programme.		8 (1)		-0.1
Cognitive impairment	9 (1)		-0.3	
Delirium	9 (0)		0	
Depression	7 (2.3)		-0.9	
Hospital-acquired infections	8 (2)		-0.3	
Pressure ulcers	9 (1)		-0.3	
Incontinence	8 (2)		-0.9	
Urinary retention	8 (2)		-0.8	
Constipation	8.5 (1)		-0.3	
Pain	9 (1)		-0.3	
Palliative care	8 (2)		-0.8	
Polypharmacy	9 (2)		-0.3	
Malnutrition	8 (2)		-0.9	
Falls	9 (1)		0	

Indicator	Median (IQR)		Agreement Index [a]	
Structure indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Evidence-based protocols for the prevention and/or management of … *(see response options below)* are available to hospital staff participating in the geriatric co-management programme. (continued)				
Osteoporosis	8 (2)		-0.9	
Sleep deprivation	7 (1.8)		-0.9	
Functional impairment/mobility	9 (1)		-0.3	
Frailty	8 (2.8)		-0.9	
Standard geriatric order sets (e.g. labs, technical investigations) are available to hospital staff participating in the geriatric co-management programme.	9 (3)	8 (1)	-0.9	-0.3
Process indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
For patients included in the geriatric co-management programme, co-management starts preoperatively or within 24 hours of hospital admission.	9 (1)	8 (2)	-0.3	-0.3
Mean time spent in the emergency department, of patients included in the geriatric co-management programme.	8 (1)	8 (1)	-0.3	-0.3
A member of the geriatric team meets daily with the nurses on the wards participating in the geriatric co-management programme.	9 (1)	7 (2)	0	-3.1

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Process indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Collaborative interdisciplinary meetings with the primary treating hospital staff participating in the geriatric co-management programme and a member of the geriatric team are organised to discuss patients included in the geriatric co-management programme at least twice a week.	7 (1)	8 (2)	-0.7	-0.8
A member of the geriatric team communicates the findings of the geriatric assessment, recommendations and care plans of patients included in the geriatric co-management programme verbally with the primary treating hospital staff.	9 (1)	7 (4.8)	-0.3	-7.4
Percentage of patients eligible for geriatric co-management who were assessed or screened for their eligibility to be included in the geriatric co-management programme.	7 (2)	7 (3)	-3.1	-3.1
Percentage of patients included in the geriatric co-management programme who had their care preferences documented in an advance care plan or advanced directive.	9 (1)	8 (1.8)	-0.3	-0.3

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Process indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Percentage of patients included in the geriatric co-management programme who had a screening or assessment focusing on … *(see response options below)* using a validated tool within 24 hours of hospital admission.		8 (1.8)		-0.9
Delirium	9 (1)		-0.3	
Dementia	8.5 (2)		-0.3	
Depression	6 (3)		-3.1	
Functional status	9 (0)		0	
Fall risk	9 (1.3)		-0.3	
Social aspects and environment	9 (2)		-0.8	
Comorbidity	9 (2)		-0.3	
Pressure ulcer risk	8.5 (2)		-0.3	
Pain	9 (1)		0	
Nutritional status	9 (1.3)		-0.3	
Incontinence	8 (2)		-0.3	
Urinary retention	8 (2)		-0.9	
Bowel movement	8 (1.3)		-0.3	

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Process indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Percentage of patients included in the geriatric co-management programme who had a screening or assessment focusing on … *(see response options below)* using a validated tool within 24 hours of hospital admission. (continued)				
Hearing	8 (2)		-0.9	
Vision	8 (2)		-0.9	
Sleeping disorder	7 (2.5)		-0.9	
Medication use	9 (1)		0	
Dysphagia	7 (3.8)		-2.1	
Frailty	8 (1.8)		-0.7	
(health related) quality of life	6 (4)		30	
Advanced directive/care plan	8,5 (1)		-0.3	
Percentage of patients included in the geriatric co-management programme who have a discharge plan documented in their patient record.	9 (0.3)	8 (1)	0	-0.3
Percentage of patients included in the geriatric co-management programme who have a summary of their hospital care and post-discharge instructions send to their primary care practitioner and/or care facility.	9 (0)	8 (2)	0	-0.8

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Process indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Percentage of patients included in the geriatric co-management programme who received post-discharge follow-up from a member of the geriatric team … *(see response options below)*.	7 (1)	7 (1)	-2.6	-2.6
Within 3 days of hospital discharge	6.5 (6)		-46.1	
Within 5 days of hospital discharge	6.5 (5)		5.4	
Within 7 days of hospital discharge	7 (3.8)		-9.7	
Within 14 days of hospital discharge	7 (3)		-26.6	
If a co-managed patient is discharged to a facility, a member of the geriatric co-management team calls the facility with post-discharge instructions.	7 (3)	6 (3.8)	-4.8	2.1
Outcome indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Mean length of stay in the hospital, of patients included in the geriatric co-management programme.	9 (1.3)	9 (1)	-0.3	-0.3
Daily patient rounds are performed by a member of the geriatric team participating in the geriatric co-management programme.	7 (3)	8 (2)	-0.9	-0.3
Mean time from hospital admission to surgery, of surgical patients included in the geriatric co-management programme.	9 (1.5)	9 (1.3)	-0.3	-0.3

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Outcome indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Readmission rate of patients included in the geriatric co-management programme within *… (see response options below)*.		8 (2)		-0.9
Within 30 days of hospital discharge	9 (1)		-0.3	
Within 3 months of hospital discharge	7 (3)		-0.9	
Within 6 months of hospital discharge	5 (3)		1.9	
Within 1 year of hospital discharge	5 (6.5)		3.3	
Patient satisfaction with hospital care, of patients included in the geriatric co-management programme.	9 (1)	7 (3)	-0.3	-0.9
Caregiver satisfaction with hospital care provided for patients included in the geriatric co-management programme.	8.5 (2)	7 (3)	-0.3	-0.9
Percentage of patients included in the geriatric co-management programme who were physically restrained during their hospital stay.	9 (2)	8 (3)	-0.9	-0.9
In-hospital mortality rate of patients included in the geriatric co-management programme.	8 (2)	9 (0.3)	-0.3	0

Indicator	Median (IQR)		Agreement Index [a]	
Outcome indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Post-discharge mortality rate of patients included in the geriatric co-management programme *… (see response options below).*		7 (3)		30
Within 30 days of hospital discharge	8,5 (2)		-0.3	
Within 3 months of hospital discharge	7 (3.5)		-1.3	
Within 6 months of hospital discharge	5,5 (3)		-22.6	
Within 1 year of hospital discharge	7 (5)		-6.2	
Percentage of patients included in the geriatric co-management programme admitted to a nursing home on hospital discharge.	9 (1)	9 (1)	-0.3	-0.3
Percentage of patients included in the geriatric co-management programme who declined in functional status between hospital admission and hospital discharge.	8 (2)	7 (3)	-0.8	-0.7
Percentage of patients included in the geriatric co-management programme admitted to a nursing home *post-discharge … (see response options below).*		6 (4.5)		32
Within 30 days of hospital discharge	8 (3)		-0.9	
Within 3 months of hospital discharge	5.5 (2.3)		14.5	
Within 6 months of hospital discharge	5 (3)		0.9	
Within 1 year of hospital discharge	4 (4.5)		1.6	

Indicator	**Median (IQR)**		**Agreement Index [a]**	
Outcome indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Percentage of patients included in the geriatric co-management programme who declined in cognitive functioning between hospital admission and post-discharge … *(see response options below).*		5 (3.5)		1.9
Within 30 days of hospital discharge	8 (2)		-0,.3	
Within 3 months of hospital discharge	7 (3)		30	
Within 6 months of hospital discharge	5 (3)		2.3	
Within 1 year of hospital discharge	5 (4.5)		1.7	
Percentage of patients included in the geriatric co-management programme who declined in cognitive functioning between hospital admission and hospital discharge.	8 (3)	6.5 (2.5)	-0.9	14.5
Percentage of patients included in the geriatric co-management programme who declined in cognitive functioning between hospital admission and post-discharge … *(see response options below).*		5 (3)		0.9
Within 30 days of hospital discharge	7 (3)		-1.0	
Within 3 months of hospital discharge	6 (2.3)		2.4	
Within 6 months of hospital discharge	5 (4)		1.7	
Within 1 year of hospital discharge	5 (4)		1.0	

Indicator	Median (IQR)		Agreement Index [a]	
Outcome indicators	***Appropriateness***	***Feasibility***	***Appropriateness***	***Feasibility***
Percentage of patients included in the geriatric co-management programme who developed/experienced delirium.	9 (1)	8 (2)	-0.3	-0.8
Percentage of patients included in the geriatric co-management programme who developed/experienced an urinary tract infection.	9 (2)	9 (2)	-0.8	-0.8
Percentage of patients included in the geriatric co-management programme who developed/experienced a wound infection.	9 (1.3)	9 (1.3)	-0.3	-0.3
Percentage of patients included in the geriatric co-management programme who developed/experienced a pneumonia	9 (2)	8 (2)	-0.3	-0.9
Percentage of patients included in the geriatric co-management programme who developed/experienced a sepsis	9 (2.3)	9 (2)	-0.3	-0.3
Percentage of patients included in the geriatric co-management programme who developed/experienced a pressure ulcers	9 (2)	8 (2)	-0.3	-0.9
Satisfaction with the co-management service, rated by the treating physician of the ward participating in the geriatric co-management programme.	7 (3)	7 (3)	-3.1	-3.1
Satisfaction with the co-management service, rated by the nursing staff of the ward participating in the geriatric co-management programme.	7.5 (2)	7 (3)	-0.8	-3.1
Perceived level of support by hospital staff participating in the geriatric co-management programme in caring for geriatric patients rated on a numeric scale (0 to 10).	6 (3.5)	6.5 (4.8)	-3.1	8.1

Legend: Abbreviations: IQR = interquartile range; a An agreement index score of < 1 indicates consensus between experts. Note: the higher the interquartile range, the higher the agreement index score, and the lower the level of consensus.

CHAPTER 4

Predicting hospitalisation-associated functional decline

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ABSTRACT

Background: Up to one in three of older patients who are hospitalised develop functional decline, which is associated with sustained disability, institutionalisation and death. This study developed and validated a clinical prediction model that identifies patients who are at risk for functional decline during hospitalisation. The predictive value of the model was compared against three models that were developed for patients admitted to a general medical ward.

Methods: A prospective cohort study was performed on two cardiac care units between September 2016 and June 2017. Patients aged 75 years or older were recruited on admission if they were admitted for non-surgical treatment of an acute cardiovascular disease. Hospitalisation-associated functional decline was defined as any decrease on the Katz Index of Activities of Daily Living between hospital admission and discharge. Predictors were selected based on a review of the literature and a prediction score chart was developed based on a multivariate logistic regression model.

Results: A total of 189 patients were recruited and 33% developed functional decline during hospitalisation. A score chart was developed with five predictors that were measured on hospital admission: mobility impairment = 9 points, cognitive impairment = 7 points, loss of appetite = 6 points, depressive symptoms = 5 points, use of physical restraints or having an indwelling urinary catheter = 5 points. The score chart of the developed model demonstrated good calibration and discriminated adequately (C-index = 0.75, 95% CI (0.68 – 0.83) and better between patients with and without functional decline (chi^2 = 12.8, p = 0.005) than the three previously developed models (range of C-index = 0.65 – 0.68).

Conclusion: Functional decline is a prevalent complication and can be adequately predicted on hospital admission. A score chart can be used in clinical practice to identify patients who could benefit from preventive interventions. Independent external validation is needed.

INTRODUCTION

Up to one out of three older patients who are admitted to the hospital experience a new disability in their basic activities of daily living. (1) This hospitalisation-associated functional decline in bathing, dressing, walking, toileting, continence or eating is associated with prolonged hospitalisation, hospital readmission, nursing home admissions and decreased survival. (1-3)

While some functional decline is caused by an acute illness, it is more often the result of an interaction between a patients' vulnerability and hospitalisation factors. (1) Frail patients are more vulnerable to develop functional decline because of the immobility, forced dependency in self-care and polypharmacy associated with hospitalisation. The presence of geriatric syndromes, e.g., mobility or cognitive impairment, are important pre-illness determinants for the development of functional decline. (1, 4-11) Older patients admitted for acute cardiovascular disease are particularly vulnerable for functional decline because up to 60% of this group suffers from one or more geriatric syndromes on hospital admission. (3)

Despite the high incidence of functional decline and the high prevalence of geriatric syndromes, acute cardiovascular care remains largely a diagnosis driven discipline, and often neglects the patients' functional needs. (12) Clinical prediction models identify patients who are likely to experience functional decline and who may benefit from preventive rehabilitative interventions and follow-up. A review of the literature identified three clinical models that were developed in patients who were 70 years or older and who were admitted to a general medical ward. (1, 9-11) All three models assess the presence of geriatric syndromes and medical comorbidities on hospital admission using a scoring chart. These models discriminated poorly to adequately between patients with and without functional decline (Area Under the Curve of 0.65 to 0.78). (9-11) The clinical usefulness of these models was not evaluated. To date, no clinical prediction model is available for patients who are admitted to a cardiac care unit with acute cardiovascular disease.

We therefore developed and validated a clinical model for the prediction of hospitalisation-associated functional decline in patients aged 75 years or older and who were admitted to a cardiac care unit with acute cardiovascular disease. The aim was to construct a risk score that is easily measured by healthcare professionals with no additional cost or resources than those available during routine care. As a secondary aim, we compared the performance of the developed model against the available models that were previously developed for patients admitted to a general medical ward.

METHODS

A prospective cohort study was performed on two cardiac care units of the University Hospitals Leuven, Belgium, between September 2016 and June 2017. Patients aged 75 years or older were recruited on admission if they were admitted for non-surgical treatment of acute cardiovascular disease, had an expected length of stay of three days or longer, consented to participate and were able to complete the assessment. Patients who were admitted from another hospital or from the intensive care unit were excluded. The Medical Ethics Committee of the Leuven University Hospitals approved this study and written informed consent was obtained for all patients who consented to participate. The study adhered to the Declaration of Helsinki.

All data were assessed by three researchers using standardised assessment forms. Assessments on admission were performed within 72 hours: 88% within 24 hours and 99% within 48 hours. Researchers were trained by performing paired bedside assessments and having case discussions until a 100% inter-rater agreement was observed. A meeting was organised every three months to confirm agreement.

Baseline characteristics

Sample characteristics included age, gender, living situation (home, retirement home or nursing home) and medical diagnosis (heart failure, valvular heart disease, ischemic heart disease, arrhythmia or other).

Outcome

Hospitalisation-associated functional decline was defined as the development of new or worse dependency in Activities of Daily Living (ADL) according to the Katz index when patients were discharged home. The Katz index was measured on admission to the unit and on the day that the patient was discharged home. Patients were asked whether they needed assistance for bathing, dressing, walking, continence, toileting, or feeding. (13) Assistance was scored on a three-point scale: independent, partially dependent, completely dependent. A change of one point on the scale was considered clinically relevant. Nurses and informal caregivers were asked to confirm the ADL status in patients with cognitive impairment.

Development and validation of a prediction model

Predictors were a priori selected based on their association with functional decline in previous studies, (1, 4-11) and their clinical utility (i.e., easy to assess with no additional costs or resources than those available during routine care). The model complexity was a priori restricted to five predictors based on the assumption that we would observe a minimal of 50 events (assuming a conservative incidence of 27% based on the review of McCusker et al. (7)). This allows for a more precise estimate of the coefficients for the risk score and prevents against overfitting of the model.

The predictors were assessed within the first 72 hours of hospital admission. Mobility impairment was defined as the use of a walking aid before hospital admission as reported by the patient. Cognitive impairment was defined as a Mini-Cog score < 3 out of 5 points. The Mini-Cog assesses performance on two cognitive tasks, i.e., three-item word recall and clock drawing test. A higher score indicates a better cognitive performance. (14) The presence of depressive symptoms was defined as a score > 3 on the 10-item version of the geriatric Depression Scale. Patients were asked whether they experienced any of the 10 symptoms in the past week. Sum scores vary between 0 and 10 with higher scores indicating more depressive symptoms. (15) Loss of appetite was defined as self-reported loss of appetite in the past 3 months and was used as a proxy for risk for malnutrition. Use of restraints was defined as the use of physical restraints (e.g., vests, limb ties or chairs with restraints) or an indwelling urinary catheter between admission to the unit and assessment of the predictors. (16) Bed rails were not considered a restraint.

A multivariate logistic regression model was built using a full model approach. Unadjusted and adjusted Odds Ratios (OR) and regression coefficients were calculated with 95% Confidence Intervals (CI). Coefficients were shrinked to compensate for potential over-fitting of the model. A uniform shrinkage factor was calculated based on the Chi^2 and the degrees of freedom (df) of the model *((model Chi^2 – df)/model Chi^2).* (17) Multicollinearity was evaluated using the Variance Inflation Factor and Tolerance values. A score chart for the prediction model was developed by multiplying the shrinked coefficients with 10 and rounding the score. (18)

Discrimination was assessed using the C-index. We performed an internal validation of the model using nonparametric bootstrapping samples (n = 1000). This procedure estimates the optimism of developing and validating the prediction model in the same sample of patients, and provides a bias-corrected measure for model discrimination.

Comparison with existing prediction models

Three clinical prediction models for hospitalisation-associated functional decline were previously developed in patients admitted to a general medical ward (see Table 1 and 2 in the supplementary material). Each model was scored within the first 72 hours of hospital admission (see Table 3 in the supplementary material for definitions of all predictors). The model by Inouye et al. defines the presence of a decubitus ulcer, cognitive impairment, functional impairment and low social activity level as predictors. (9) The model by Mehta et al. defines age, premorbid dependency on instrumental activities of daily living and basic ADL, inability to run a short distance, inability to walk stairs, metastatic cancer or stroke, cognitive impairment and albumin level as predictors. (10) The model by Sager et al. defines age, cognitive impairment and premorbid dependency on instrumental ADL as predictors. (11)

The discrimination of the models was compared using the chi^2 test for equality for two or more Receiver Operating Characteristic areas. Calibration was assessed using the Hosmer-Lemeshow Goodness of Fit test and by constructing calibration plots. The clinical usefulness was assessed using classification statistics (sensitivity, specificity, predicted values). For all models, the cut-off value, that identifies if a patient is considered at risk, was based on the Youden index to allow for equal comparison between the models. (19) The Youden index corresponds to the cut-off value with the optimal combination of sensitivity and specificity.

Missing data

There were 53 cases (28%) with missing data for the Mehta et al. model because of missing albumin levels, which were not routinely assessed on hospital admission. There was no significant relationship between missing data and hospitalisation-associated functional decline (OR 1.8, 95% CI (0.9 – 3.5)). We therefore assumed that data were missing completely at random. (20) Multiple imputation (M = 5) with all predictors, the outcome and auxiliary variables was performed to allow comparison between models with an equal number of subjects. A parametric multiple linear regression model was used as the data were normally distributed. A sensitivity analysis with a complete case analysis was performed to evaluate the influence of data imputation.

Post-hoc analysis

After the model was developed and validated, we used a nested model approach to investigate if adding the predictor 'age' improved the discrimination. We also performed a chi-squared test to compare the C-index estimates per age group (75 to 80, 81 to 84, or > 84).

RESULTS

Sample characteristics

A total of 930 patients were screened for inclusion, 244 patients were eligible and 189 patients consented to participate. The mean age was 84 years and the largest group of patients (37%) had acute decompensated heart failure (see Table 1). Half of the patients had a mobility impairment and 40% reported a loss of appetite before hospital admission, one in three patients had a cognitive impairment and one in four patients reported depressive symptoms or was restrained. In total, 33% of patients developed functional decline during hospitalisation.

Performance and validation of the prediction model

All predictors increased the odds for functional decline but only mobility impairment, cognitive impairment and loss of appetite were statistically significant (see Table 2). The full model with five predictors discriminated adequately between patients with and without functional decline (C-index = 0.76, 95% CI (0.68 to 0.83)) and was well calibrated (p = 0.326; i.e., patients considered to have a low risk had a low probability for functional decline and patients with a high risk had a high probability for functional decline). After internal validation, the discrimination remained adequate (C-index = 0.73, 95% CI (0.65 – 0.80)). A score chart was developed by estimating points for each predictor based on their regression coefficients (see Table 2). The discrimination remained adequate (C-index = 0.75, 95% CI (0.68 – 0.83) with good calibration (p = 0.499). In the nested model, age was not a significant predictor for functional decline (OR = 1.00, 95% CI (0.93 – 1.08), and it did not improve the 'fit of the model' (p = 0.958). The discrimination remained the same (C-index = 0.75, 95% CI (0.68 – 0.82)). The discrimination was statistically not different between age groups (p = 0.395).

Table 1. Sample characteristics (n = 189)

Sample characteristics	Sample
Age, mean (SD)	84 (5)
Male gender, n (%)	100 (53)
Medical diagnosis, n (%)	
- Heart failure	70 (37)
- Valvular heart disease	8 (4)
- Ischemic heart disease	30 (16)
- Arrhythmia	46 (24)
- Other	35 (19)
Living situation, n (%)	
- At home	170 (90)
- Retirement home	6 (3)
- Nursing home	13 (7)
Katz index of ADL, mean (SD)	
- On admission	8.6 (2.7)
- On discharge	8.8 (2.7)
Functional decline, n (%)	63 (33)
Length of stay (days), mean (SD)	9 (6)
Predictors for functional decline, n (%)	
- Mobility impairment: use of ambulatory device	106 (56)
- Cognitive impairment: Mini-Cog score < 3/5	62 (33)
- Depressive symptoms: GDS score > 3/10	47 (25)
- Loss of appetite in past 3 months	75 (40)
- Use of physical restraints or indwelling urinary catheter	46 (24)

Legend: Abbreviations: SD = Standard Deviations; ADL = Activities of Daily Living; GDS = Geriatric Depression Scale;

Table 2. Developing of a prediction score for hospitalisation-associated functional decline

Predictors	**Estimation of main effects**		**Prediction model [a]**		
	Unadjusted OR (95% CI)	***Adjusted OR (95% CI)***	***Coefficients (95% CI)***	***Shrinked coefficients [b]***	***Score chart [c]***
Mobility impairment	3.75 (1.91 – 7.39)	2.81 (1.37 – 5.77)	1.03 (0.31 – 1.75)	0.88 (0.26 – 1.49)	9
Cognitive impairment	2.97 (1.57 – 5.62)	2.32 (1.16 – 4.62)	0.84 (0.15 – 1.53)	0.71 (0.13 – 1.30)	7
Loss of appetite	2.69 (1.44 – 5.01)	2.14 (1.08 – 4.22)	0.76 (0.08 – 1.44)	0.64 (0.07 – 1.22)	6
Depressive symptoms	2.17 (1.10 – 4.27)	1.70 (0.80 – 3.59)	0.53 (-0.22 – 1.28)	0.45 (-0.19 – 1.09)	5
Use of restraints	2.58 (1.30 – 5.10)	1.76 (0.84 – 3.70)	0.57 (-0.18 – 1.31)	0.49 (-0.15 – 1.11)	5

Legend: Abbeviations: OR = Odds Ratio; CI = Confidence Interval;a Model evaluation: Discrimination: C-index = 0.76, 95% CI (0.68 – 0.83); Discrimination after internal validation: C-index = 0.73, 95% CI (0.65 – 0.80); Calibration: Hosmer-Lemeshow goodness of fit Chi2 = 8.07, p = 0.362; Assumptions: mean VIF = 1.09, VIF < 10 and tolerance > 0.1 was observed for all variables; b Coefficients were shrinked using a uniform shrinkage factor ((34.32 – 5)/ 34.32) = 0.85; c Score chart was developed by multiplying the shrinked coefficients with 10 and rounding the score;

Table 3. Evaluation of clinical models for predicting hospitalisation-associated functional decline

Model evaluation	Prediction models			
	Developed model	***Inouye et al. 1993***	***Mehta, et al. 2011 [b]***	***Sager et al. 1996***
OR (95% CI)	1.12 (1.08 – 1.17)	2.44 (1.56 – 3.81)	1.26 (1.12 – 1.41)	1.62 (1.24 – 2.12)
Discrimination [a]	0.75 (0.68 – 0.83)	0.67 (0.59 – 0.74)	0.68 (0.61 – 0.76)	0.65 (0.57 – 0.73)
Calibration	Chi^2 = 6.35, p = 0.499 [c]	Chi^2 = 0.11, p = 0.948 [d]	Chi^2 = 11.80, p = 0.0667 [e]	Chi^2 = 11.80, p = 0.0667 [f]
Clinical usefulness	Cutoff value = 13 Sensitivity = 71% Specificity = 70% PPV = 54% NPV = 83% Correctly classified = 70%	Cutoff value = 1 Sensitivity = 46.0% Specificity = 80.2% PPV = 54% NPV = 75% Correctly classified = 69%	Cutoff value = 4 Sensitivity = 65% Specificity = 60% PPV = 45% NPV = 78% Correctly classified = 62%	Cutoff value = 4 Sensitivity = 60% Specificity = 61% PPV = 44% NPV = 76% Correctly classified = 61%

Legend: Abbreviations: PPV = Positive Predictive value; NPV = Negative Predictive Value; CI = Confidence Interval; IADL = Instrumental Activities of Daily Living; ADL = Activities of Daily Living; a Discrimination was assessed using the C-index, and models were compared using the chi2 test for equality for two or more Receiver Operating Characteristic areas: chi2 = 12.8, p = 0.005; b Sensitivity analysis for Mehta et al. 2011 using a complete case analysis instead of multiple imputation: OR = 1.18 (1.03 – 1.36); Discrimination: 0.63, 95% CI (0.54 – 0.73); Calibration: chi2 = 4.27, p = 0.640; Calibration was assessed using the Hosmer – Lemeshow goodness of fit test. The goodness of fit could only be assessed in quantiles of c 9 groups, d 4 groups, e 8 groups and f 5 groups because of ties in the data;

Comparison of prediction models

All models increased the odds for developing functional decline during hospitalisation (see Table 3). The previously developed models discriminated poorly (range C-index of models = 0.65 – 0.68) between patients with and without functional decline. After internal validation, the discrimination of the new model remained better than that of the previous models when comparing the C-Index (chi^2 = 12.8, p = 0.005). Based on the calibration plots (see Figure S1 in the supplementary material), the calibration was adequate for the new model and the model of Inouye et al., and was poor for the models of Mehta et al. and Sager et al. The clinical usefulness was comparable for all models with high negative predictive values ranging from 83% to 76% and low positive predictive values ranging from 54% to 44%. The overall classification was best for the new model (70%) and the model by Inouye et al (69%) compared against the models by Mehta et al. (62%) and Sager et al. (61%).

DISCUSSION

Because no prediction model for hospitalisation-associated functional decline was available for older cardiac patients, this study developed a new prediction model and compared it against three models that were previously developed for patients who were admitted to a general medical ward.

The majority of patients in our cohort had at least one geriatric syndrome on hospital admission (see Table 1) and one in three patients developed functional decline during hospitalisation. The newly developed model uses mobility and cognitive impairment, depressive symptoms, the loss of appetite and the use of physical restraints or indwelling urinary catheters as predictors for functional decline. In the four prediction models, mobility or functional and cognitive impairment were consistent predictors for hospitalization-associated functional decline. Mobility impairment was the strongest predictor. All models confirm a dose response relationship: the more predictors that were present, the higher the risk score, and the higher the probability for functional decline (see Table 4 in the supplementary material). This dose response relationship between the presence of geriatric syndromes and the development of functional dependency in community dwelling older adults, (21) and for the onset of delirium in hospitalized older adults was previously observed. (22)

After internal validation, the new model discriminated better than the previous models but the calibration plots indicate that the risk for functional decline was consistently underestimated in all models. This may indicate that an important predictor may be

missing. For example, medical comorbidities and illness severity have also demonstrated an association with functional decline. (23) These variables were not considered in the model because they require diagnostic interviewing and testing and may be too complex for clinical practice. Furthermore, we only considered a static prediction on hospital admission but the probability for functional decline changes during hospitalisation. For example, the onset of delirium has been associated with functional decline. (24) Dynamic predictions can adjust the probability for functional decline using repeated assessments, but this was not investigated.

Predicting functional decline on hospital admission can offer several advantages. First, resources can be used more efficiently and effectively because high-risk patients have a higher absolute benefit from interventions to prevent functional decline than low-risk patients do. Second, it facilitates a proactive approach and shifts the focus to the prevention of functional decline and its negative consequences for the older patient. A meta-analysis of randomized controlled trials studying the effects inpatient rehabilitation observed improved functional status in geriatric patients. (25) Programs were more effective when a comprehensive geriatric assessment (CGA), defined as a "multidimensional, interdisciplinary diagnostic process to determine the medical, psychological and functional capabilities of an older person with frailty, followed by the implementation of a coordinated and integrated plan for treatment and follow-up" was used to tailor the rehabilitation to the patients' needs. (26) The four prediction models all assess basic aspects of a CGA and can in this way be used to select patients in need for follow-up. To the best of our knowledge, a CGA-based program has not yet been evaluated in older patients on a cardiac care unit.

All current models result in substantial number of false positive predictions. For the purpose of this paper, the Youden index was used to illustrate the clinical usefulness. However, the Youden index assumes that false positive and false negative predictions are equally good or bad. For the use in practice, the 'at-risk cut-off score' should be decided on the individual context. When there are sufficient resources for the follow-up of at risk patients, a lower cut-off score can be used at the expense of more false positive predictions. A follow-up assessment can further select patients that could benefit from rehabilitation. When resources are scarce, a higher cut-off score will minimise false positive predictions. Clinicians interested in using a prediction model can find the probabilities, sensitivity and specificity for functional decline for each cut-off score of each model in Table 4 in the supplementary materials.

The prospective data collection using standardised assessments by trained researchers and a comprehensive evaluation of the four models contributed to the strengths of this study. However, some considerations should be noted. First, an independent data set

was not available to validate the newly developed model. As a result, the performance of the developed model may be too optimistic. This may have biased the comparison of the discrimination between the models in favor of the developed model. However, several measures were used to minimise this bias: 1) predictors were selected based on a review of the literature and not based on p-values. A stepwise selection of predictors using p-values overestimates the regression coefficients and model performance; (27) 2) the number of predictors were a priori restricted to five and coefficients were shrunk to minimise over-fitting of the model; and 3) bootstrapping methods were used to adjust the discrimination for bias. Second, there is considerable heterogeneity in how predictor variables are defined and assessed in practice. Using a different instrument may decrease (or increase) the performance of a prediction model. We tried to decrease the dependency of predictions for a specific scale by dichotomising predictors using validated cut-off values. For example, the presence of cognitive and functional impairment are key predictors in the different models even when different instruments are used. However, dichotomising the predictors may also have resulted in less accurate estimates of predictor scores leading to a less accurate discrimination and calibration. Third, selection of predictors is a balance between methodological and clinical considerations and therefore to a certain extent subjective. Nonetheless, the developed model demonstrates adequate discrimination, which confirms that we selected appropriate predictors.

Future research should focus on an independent external validation of the developed model, expanding the model with predictors that can be easily assessed in clinical practice and interventions that effectively prevent functional decline in older patients admitted to a cardiac care unit with acute cardiovascular disease. Interesting areas for exploration are the use of dynamic predictions and the comparison of the prediction model with a frailty assessment. The use of electronic health records to identify frailty profiles may be particularly promising to identify patients at risk for functional decline. [28] However, validation in the acute care setting is currently lacking.

Conclusion

Geriatric syndromes are prevalent on hospital admission in patients who are hospitalised on a cardiac care unit with cardiovascular disease and can adequately predict hospitalisation-associated functional decline. Cognitive and mobility impairment are key predictors for decline. A prediction model appears to have clinical value for selecting patients who could benefit from rehabilitation, but false positive predictions should be considered. Independent external validation is needed.

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CHAPTER 4

Supplementary materials

Table 1. Characteristics of studies identified in the literature

Study characteristics	Clinical prediction models identified in the literature		
	Inouye et al. 1993	***Mehta, et al. 2011***	***Sager et al. 1996***
Study design	Two prospective cohort studies: development and validation	Prospective cohort study and secondary analysis of randomised controlled trial	Secondary analysis from prospective cohort study and clinical trial
Setting	Teaching hospital, Connecticut (USA)	Two teaching hospitals, Ohio (USA)	Six hospitals: medical centres and university hospitals in California, Ohio, Wisconsin, Illinois, Connecticut (USA)
Study dates	Development: Nov 1989 to June 1990 Validation: July 1990 to July 1991	1993 to 1998	Development: 1990 to 1992 Validation: 1989 to 1990
Sample size	Development: 188 Validation: 142	Development: 885 Validation: 753	Development: 597 Validation: 783
Participants	Patients aged 70 years or older and admitted to medical service - Age development cohort: 78.4 (5.8) - Age validation cohort: 78.1 (6.0)	Functionally independent patients aged 70 years or older and admitted to medical services - Age development cohort: 78 (6) - Age validation cohort: 79 (7)	Noninstitutionalised patients aged 70 years or older and admitted to medical services and who survived three months after discharge - Age development cohort: 79 (6.2) - Age validation cohort: 80 (6.1)

Study characteristics	**Clinical prediction models identified in the literature**		
	Inouye et al. 1993	***Mehta, et al. 2011***	***Sager et al. 1996***
Outcome	Nurses recorded new decline occurring in the hospital and persisting until discharge in five Activities of Daily Living (feeding, bathing, grooming, dressing, toileting)	Self-reported new dependency in one or more Activities of Daily Living of the Katz Index at hospital discharge (bathing, dressing, transferring, toileting, eating)	Self-reported new dependency in one or more Activities of Daily Living at hospital discharge (bathing, dressing, transferring, walking, toileting, eating)
Blinding	Assessors blinded to research question	Not reported	Not reported
Selection of predictors	1) A-priori clinical relevance 2) Relative Risk ≥ 1.5 3) Statistical significance at $p < 0.05$	1) Studies or risk factors 2) Conceptual models of disablement	Not reported
Missing data	5 cases with missing data Complete case analysis	For most variables, missing < 2% Multiple imputation	135 (23%) cases in development cohort 185 (33%) cases in validation cohort Complete case analysis
Statistical analysis	Proportional Hazard model: forward stepwise procedure: $p < 0.1$ enter, $p > 0.15$ remove	Logistic regression: best subset regression procedure creating range of models with 1 to 20 predictors. Final selection based on clinical relevance	Logistic regression: selection based on $p < 0.05$
Score chart	One point per predictor	Points for each predictor assigned by dividing regression coefficient with lowest coefficient in model and rounding to nearest integer	Scoring system based on parameter estimates of regression model and their relative contribution to loss of ADL function

Table 2. Performance of studies identified in the literature

Model performance	Clinical prediction models		
	Inouye et al. 1993	***Mehta, et al. 2011***	***Sager et al. 1996***
Score chart	Decubitus ulcer = 1 Cognitive impairment = 1 Functional impairment = 1 Low social activity level = 1	Age 80 – 89 = 1 Age > 89 = 2 Dependent on > 2 IADLs = 2 Unable to run short distance = 1 Unable to walk stairs or uphill = 2 2 – 3 ADL dependencies = 1 4 – 5 ADL dependencies = 3 Metastatic cancer/stroke = 2 Severe cognitive impairment = 1 Albumin < 3.0 g/dL = 2	Age - Age 75 – 84 = 1 - Age > 84 = 2 Cognitive impairment = 1 IADL score 0 – 5 = 2
Discrimination	Not reported	Development = 0.78 Validation = 0.78	Development = not reported Validation = 0.65
Calibration	Not reported	Development p = 0.4 Validation p = 0.54	Not reported
Clinical usefulness	Not reported	Not reported	Not reported

Legend: Abbreviations: IADL = Instrumental Activities of Daily Living; ADL = Activities of Daily Living; Discrimination was assessed using the C-index or Area Under the Curve; Calibration was assessed using the Hosmer – Lemeshow goodness of fit test;

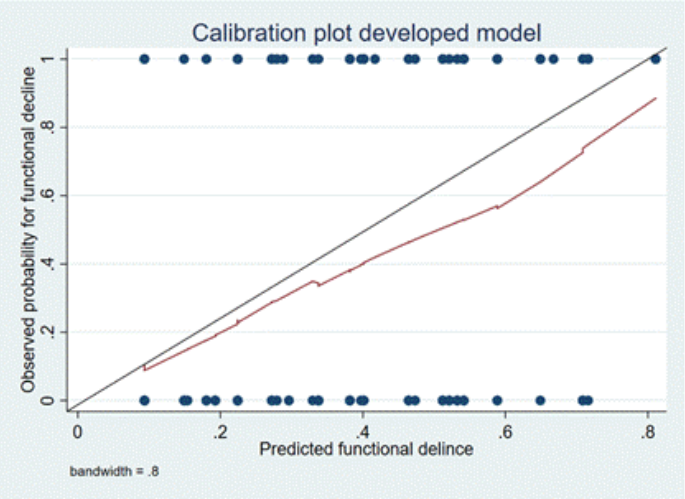
Table 3. Assessment of predictors in the cohort study of models that were identified in the systematic review

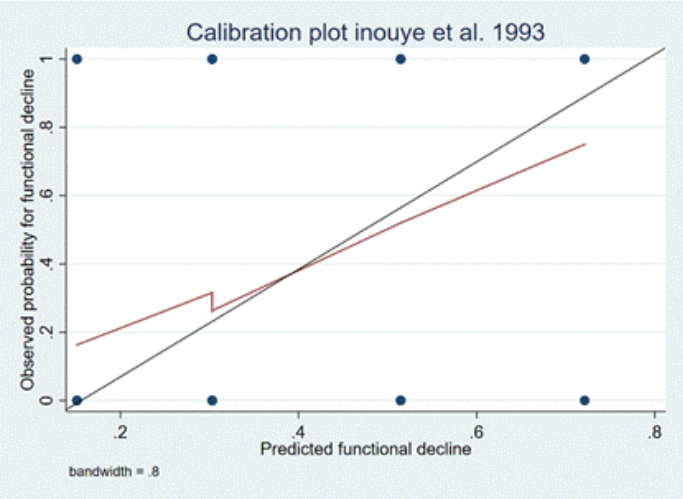
Predictors	Study	Definition of assessment in original paper	Definition of assessment in current validation study
Decubitus ulcer	Inouye et al 1993	Standardised skin check for breakdown at 11 pressure points	Nurses recorded presence of decubitus ulcer in electronic patient record
Cognitive impairment	Inouye et al 1993	Mini-Mental State Examination < 20	Mini-Cog < 3
	Mehta et al. 2011	Five or more errors on the Short Portable Mental Status Questionnaire	
Functional impairment	Inouye et al 1993	Self-reported (in)dependency with at least one of seven ADLs two weeks before admission: feeding, bathing, grooming, dressing, toileting, transferring, walking	Self-reported (in)dependency with at least one of seven ADLs two weeks before admission: feeding, bathing, grooming, dressing, toileting, transferring, walking
	Mehta et al. 2011	Self-reported (in)dependency with 1) two or three and 2) four or five of five ADLs on hospital admission: bathing, dressing, transferring, toileting, eating	Self-reported (in)dependency with 1) two or three and 2) four or five of five ADLs on hospital admission: bathing, dressing, transferring, toileting, eating
	Mehta et al. 2011	Self-reported (in)dependency in three or more of seven IADLs two weeks prior to hospital admission: telephone, transportation, shopping, preparing meals, doing housework, taking medicines, handling money	Self-reported (in)dependency in three or more of seven IADLs two weeks prior to hospital admission: telephone, transportation, shopping, preparing meals, doing housework, taking medicines, handling money

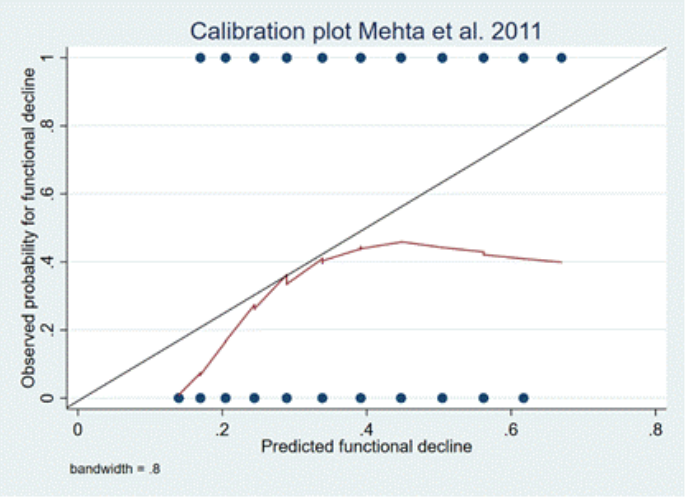
Predictors	Study	Definition of assessment in original paper	Definition of assessment in current validation study
Mobility impairment	Mehta et al. 2011	Self-reported ability to walk uphill or stairs	Self-reported ability to walk stairs
	Mehta et al. 2011	Unable to run a short distance	Self-reported ability to walk outside the house
Low social activity level	Inouye et al 1993	Participation in three or fewer of 11 representative social activities in a typical month, including religious and group activities (e.g. senior center, community group), outings (e.g. movies, plays, restaurants, sporting events), hobbies, sports, bingo or games and paid or volunteer work	Patient self-reported social isolation
Age	Mehta et al. 2011	Patients aged 80 – 89 Patients aged > 89	Patients aged 80 – 89 Patients aged > 89
Metastatic cancer or stroke	Mehta et al. 2011	Clinical diagnosis	Clinical diagnosis in medical record
Albumin < 3g/dL	Mehta et al. 2011	Laboratory analysis	Laboratory analysis in medical record

Legend: Abbreviations: IADL = Instrumental Activities of Daily Living; ADL = Activities of Daily Living

Figure 1. Calibration plots for predicting hospitalisation-associated functional decline







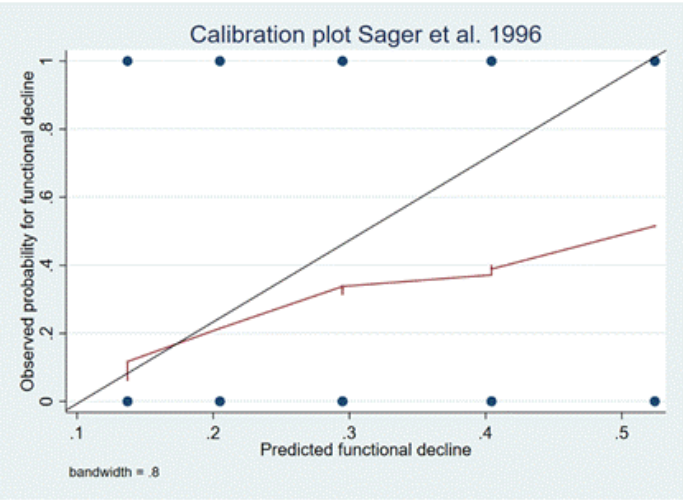


Table 4. Probability for hospitalisation-associated for observed cut-off values of prediction models

Cutoff score	Developed model			Inouye et al. 1993			Mehta, et al. 2011			Sager et al. 1996		
	Prob	***Sens***	***Spec***	***Prob***	***Sens***	***Spec***	***Prob***	***Sens***	***Spec***	***Prob***	***Sens***	***Spec***
0	0.09	1.0	0.0	0.0	1.0	0.0	0.14	1.0	0.08			
1	-	-	-	0.15	1.0	0.0	0.17	0.97	0.25	0.14	0.97	0.24
2	-	-	-	0.51	0.46	0.80	0.20	0.94	0.36	0.20	0.87	0.29
3	-	-	-	0.72	0.04	0.99	0.24	0.84	0.50	0.29	0.60	0.61
4	-	-	-	-	-	-	0.29	0.65	0.60	0.40	0.27	0.87
5	0.15	0.92	0.33	-	-	-	0.34	0.54	0.69	0.52	0.0	1.0
6	0.18	0.90	0.37	-	-	-	0.39	0.41	0.75	-	-	-
7	0.19	0.90	0.43	-	-	-	0.45	0.22	0.85	-	-	-
8	-	-	-	-	-	-	0.50	0.11	0.91	-	-	-
9	0.22	0.83	0.56	-	-	-	0.56	0.06	0.96	-	-	-
10	-	-	-	-	-	-	0.62	0.02	1.0	-	-	-
11	0.27	0.78	0.60	-	-	-	0.67	0.0	1.0	-	-	-
12	0.30	0.75	0.62	-	-	-	-	-	-	-	-	-
13	0.34	0.71	0.70	-	-	-	-	-	-	-	-	-
14	0.34	0.71	0.67	-	-	-	-	-	-	-	-	-

Cutoff score	Developed model			Inouye et al. 1993			Mehta et al. 2011			Sager et al. 1996		
	Prob	***Sens***	***Spec***	***Prob***	***Sens***	***Spec***	***Prob***	***Sens***	***Spec***	***Prob***	***Sens***	***Spec***
15	0.38	0.60	0.77	-	-	-	-	-	-	-	-	-
16	0.40	0.51	0.79	-	-	-	-	-	-	-	-	-
17	0.42	0.49	0.79	-	-	-	-	-	-	-	-	-
18	0.46	0.46	0.82	-	-	-	-	-	-	-	-	-
19	0.46	0.48	0.80	-	-	-	-	-	-	-	-	-
20	0.52	0.40	0.88	-	-	-	-	-	-	-	-	-
21	0.54	0.29	0.94	-	-	-	-	-	-	-	-	-
22	0.59	0.21	0.96	-	-	-	-	-	-	-	-	-
25	0.65	0.16	0.97	-	-	-	-	-	-	-	-	-
26	0.67	0.14	0.97	-	-	-	-	-	-	-	-	-
27	0.71	0.10	0.99	-	-	-	-	-	-	-	-	-
32	0.81	0.0	1.0	-	-	-	-	-	-	-	-	-

Legend: Abbreviations: Prob = Probability; Sens = Sensitivity; Spec = Specificity; Score without observations were deleted from the table.

CHAPTER 5

Protocol for an effectiveness-implementation evaluation study of the geriatric co-management programme

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ABSTRACT

Introduction: Although the majority of older patients admitted to a cardiology unit present with at least one geriatric syndrome, guidelines on managing heart disease often do not consider the complex needs of frail older patients. Geriatric co-management has demonstrated potential to improve functional status, and reduce complications and length of stay, but evidence on the effectiveness in cardiology patients is lacking. This study aims to determine if geriatric co-management is superior to usual care in preventing functional decline, complications, mortality, readmission rates, reducing length of stay and improving quality of life in older patients admitted for acute heart disease or for Transcatheter Aortic Valve Implantation, and to identify determinants of success for geriatric co-management in this population.

Methods and analysis: This prospective quasi-experimental before-and-after study will be performed on two cardiology units of the University Hospitals Leuven in Belgium in patients aged ≥75 years. In the pre-cohort (n = 227), usual care will be documented. A multitude of implementation strategies will be applied to allow for successful implementation of the model. Patients in the after-cohort (n = 227) will undergo a comprehensive geriatric assessment within 24 hours of admission to stratify them into one of three groups based on their baseline risk for developing functional decline: low-risk patients receive proactive consultation, high-risk patients will be co-managed by the geriatric nurse to prevent complications, and patients with acute geriatric problems will receive an additional medication review and co-management by the geriatrician.

Ethics and dissemination: The study protocol was approved by the Medical Ethics Committee UZ Leuven/ KU Leuven (S58296). Written voluntary (proxy-)informed consent will be obtained from all participants at the start of the study. Dissemination of results will be through articles in scientific and professional journals both in English and Dutch and by conference presentations.

1. INTRODUCTION

Longevity is the result of improved population health, but at the same time leads to an absolute increase of people suffering from multiple chronic health problems and disability. (1) The complex care for these patients is hampered by the high prevalence of frailty, cognitive impairment and functional dependency, which has been associated with functional decline, increased mortality, hospital readmission, and need for new social support. (2-4) Concurringly, the majority of healthcare staff is not adequately trained to manage the complex geriatric needs of these older patients. (5) Inappropriate medication use, delirium, cognitive impairment, and depression are often not recognized in older patients, emphasizing the need for better geriatric care. (6-10)

Cardiovascular disease is the leading cause of death and hospitalisation in the Western world. (11) Notably, the majority of older patients admitted to a cardiology unit present with at least one geriatric syndrome. (2) Current evidence-based guidelines on the management of heart disease often do not consider the complex needs of frail older patients, and may even incur harm. (12) This has prompted researchers and clinicians to advocate for a closer collaboration between cardiology and geriatric medicine as the “management of cardiac issues is fundamentally linked to the frailties and multi-morbidities associated with advanced age”. (12, 13)

Comprehensive geriatric assessment (CGA) has previously been identified as the gold standard for managing geriatric patients, but has not yet been evaluated in older cardiology patients. (14) CGA refers to a “multidimensional, interdisciplinary diagnostic process to determine the medical, psychological and functional capabilities of an older person with frailty, followed by implementation of a coordinated and integrated plan for treatment and follow-up”. (15) A model of care that embeds the principles of CGA is the geriatric consultation team model. Geriatric consultation teams are multidisciplinary mobile teams that assess older patients admitted to non-geriatric units and recommend a plan of treatment. However, a meta-analysis detected no significant effect on functional status, length of stay and readmission and only found a moderate beneficial effect on mortality at six and eight months after hospitalization. (16) Subsequently, geriatric co-management programmes have emerged as a new model of CGA-based care for non-geriatric units.

Geriatric co-management is defined as a shared responsibility and decision making between at least a primary treating physician (e.g., cardiologist) and a geriatrician or geriatric team who provides complementary medical care in the prevention and management of geriatric problems. (17) A recent meta-analysis observed a better

functional status, a decrease in complications and a reduced length of stay in favour of co-managed patients. (18) These results confirm the potential value of geriatric co-management, but also indicate a need to further evaluate the concept due to the low-quality of evidence. Furthermore, only four studies with inconsistent results assessed functional status as outcome and the majority of studies were performed in orthopaedic patients. (18) There is currently no evidence on the effectiveness of geriatric co-management in older cardiology patients.

This protocol is part of the G-COACH project, which aims to develop and evaluate an in-hospital cardio-geriatric co-management model using a mixed-methods multi-phase methodology. The aim of this paper is to present a detailed overview of the methodology of the G-COACH feasibility and effectiveness study, based on the SPIRIT statement. (19)

2. METHODS

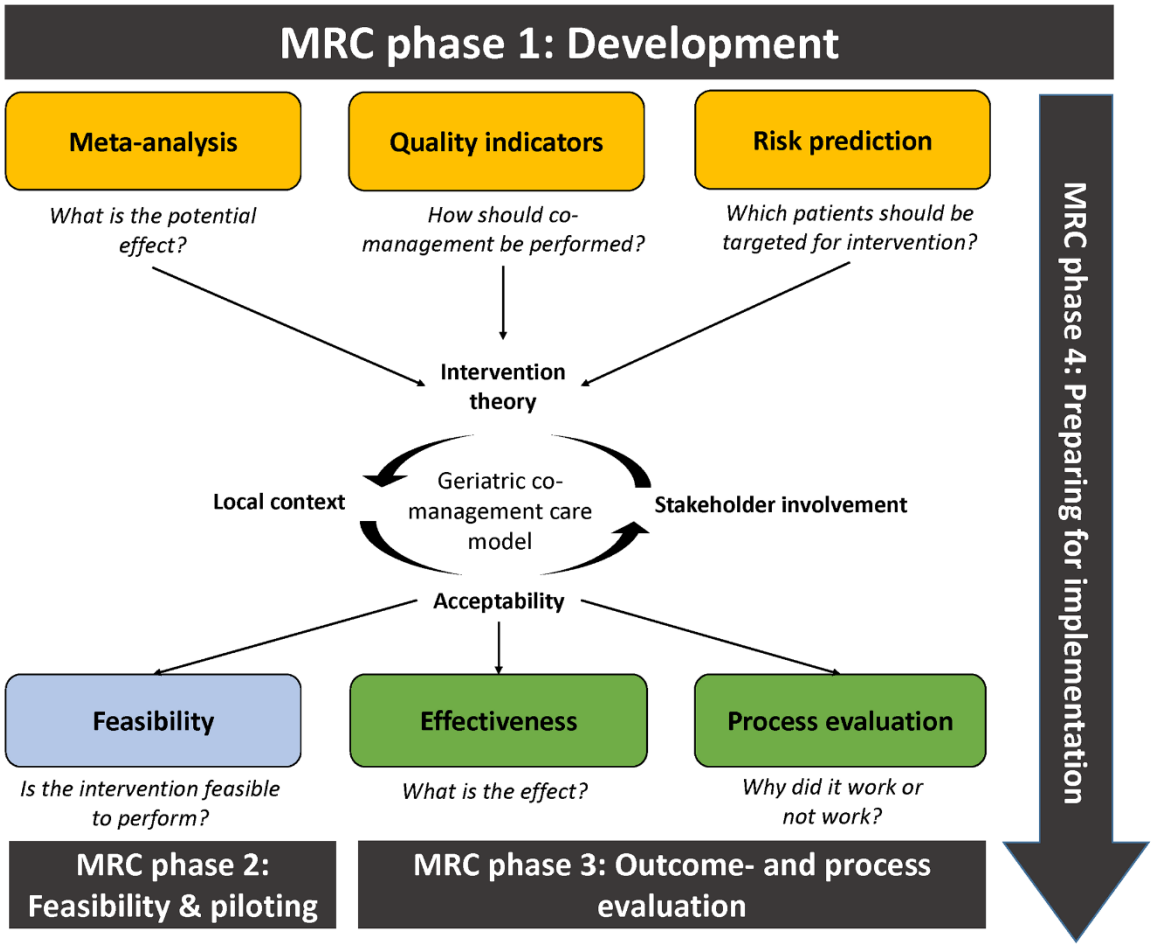
2.1 Methodological framework

The G-COACH project is based upon the Medical Research Council (MRC) framework for the development and evaluation of complex interventions (see Figure 1). (20) As part of the development phase of the MRC framework and in preparation of the feasibility and evaluation studies, we first developed an intervention theory for geriatric co-management that details how the G-COACH intervention will affect the desired change in outcomes. This theory was developed by integrating evidence from 1) a systematic review and meta-analysis on the effectiveness of geriatric co-management programmes, (18) 2) an international Delphi study that aimed to find consensus on appropriate and feasible structure, process and outcome indicators for the evaluation of in-hospital geriatric co-management programmes (21) and 3) an exploratory prospective cohort study in hospitalized patients with cardiac conditions to determine the incidence of in-hospital functional decline, the associated risk factors, and the link with care processes. (22) Additionally, we developed a clinical prediction model that identifies patients who are at risk for developing functional decline during hospitalisation. This risk prediction model was built based on data from the pre-cohort of this intervention study, and will be used to identify patients in need for geriatric co-management, i.e. patients with an increased risk for functional decline (submitted manuscript). To the best of our knowledge, no such model is available for older patients admitted to an acute cardiac care unit. The model will be validated in a cohort

of 189 patients aged 75 year or older who are admitted to an acute cardiac care unit. Nonparametric bootstrapping will be used for internal validation.

The G-COACH feasibility and effectiveness study described in this paper concerns phase 2 and phase 3 of the MRC framework. However, to substantially increase the likelihood that the evaluated geriatric co-management programme moves from trial to real world, we use a hybrid 1 effectiveness-implementation design. (23) This means that in parallel with evaluating the effectiveness of the geriatric co-management model, we will gather information to inform future implementation strategies for scaling up and scaling out the geriatric co-management model. Hence, while trying to get an in-depth understanding of which intervention components are effective and which are not, we aim to provide a comprehensive overview of barriers and facilitators for large-scale implementation of the care model following its evaluation. The latter will be done by considering contextual factors that may influence the success of the implementation and the variation in outcomes from the very beginning of the project and by actively involving stakeholders in each project phase. (23)

Figure 1. G-COACH methodological framework



2.2 Study aims

The overall aim of the feasibility study is to 1) assess reach, fidelity and dose of the intervention; 2) investigate the perceived acceptability of the intervention by healthcare professionals and patients participating in the intervention and 3) determine facilitators and barriers for the implementation of the intervention.

The overall aim of the effectiveness study is twofold. The *outcome* evaluation will determine if geriatric co-management is superior in preventing in-hospital functional decline (primary outcome) and complications, reducing length of stay, decreasing mortality and readmission rates and improving quality of life in older patients admitted for acute heart disease or for Transcatheter Aortic Valve Implantation (TAVI) compared to usual care. The *process* evaluation will determine the quality of the implementation by investigating how well the fidelity and dose is maintained during the study period and how the geriatric co-management programme is adapted over time due to interaction with the local context. (24)

2.3 Design and setting

This single-center, prospective, quasi-experimental before-and-after study will be performed on two cardiology units of the University Hospitals Leuven in Belgium. The University Hospitals Leuven is one of the seven university and tertiary hospitals in Belgium, and has 1995 beds. The two general cardiology units consist of 44 hospitalisation beds. Between recruiting patients in the before and after-cohort, the geriatric co-management intervention will be implemented and piloted to assess its feasibility.

2.4 Study population

Dutch-speaking patients aged 75 years or over are included if they are admitted through the emergency department or cardiology outpatient services for non-surgical treatment of acute heart disease or TAVI, have an expected length of stay of ≥ 3 days and give (proxy) informed consent. Patients are excluded if they are admitted from another hospital or hospital unit (no baseline data for functional status), if they stay in the intensive care unit for three days or longer (health care professionals on these wards are not involved in the development of the geriatric co-management intervention and/or impossibility to execute core components of the intervention, e.g. mobility protocols) or if they receive palliative treatment on hospital admission.

2.5 Interventions

2.5.1 Usual care

The control group receives usual care on the cardiology units. Team members include a cardiology or internal medicine resident supervised by a consultant cardiologist, ward nurses, a physiotherapist, a social worker and a dietician, who meet weekly at a multidisciplinary team meeting. A geriatric support team, consisting of seven geriatric nurses (3.8 FTE including one master-trained nurse), a master-trained head nurse (1 FTE), four occupational therapists (2 FTE) and two geriatricians (0.2 FTE), is available for consultation services upon request of all non-geriatric wards in the study hospital, including the cardiology wards. If consulted, the geriatric support team performs a CGA and gives written and oral recommendations about detected geriatric problems. (25)

2.5.2 Geriatric co-management intervention

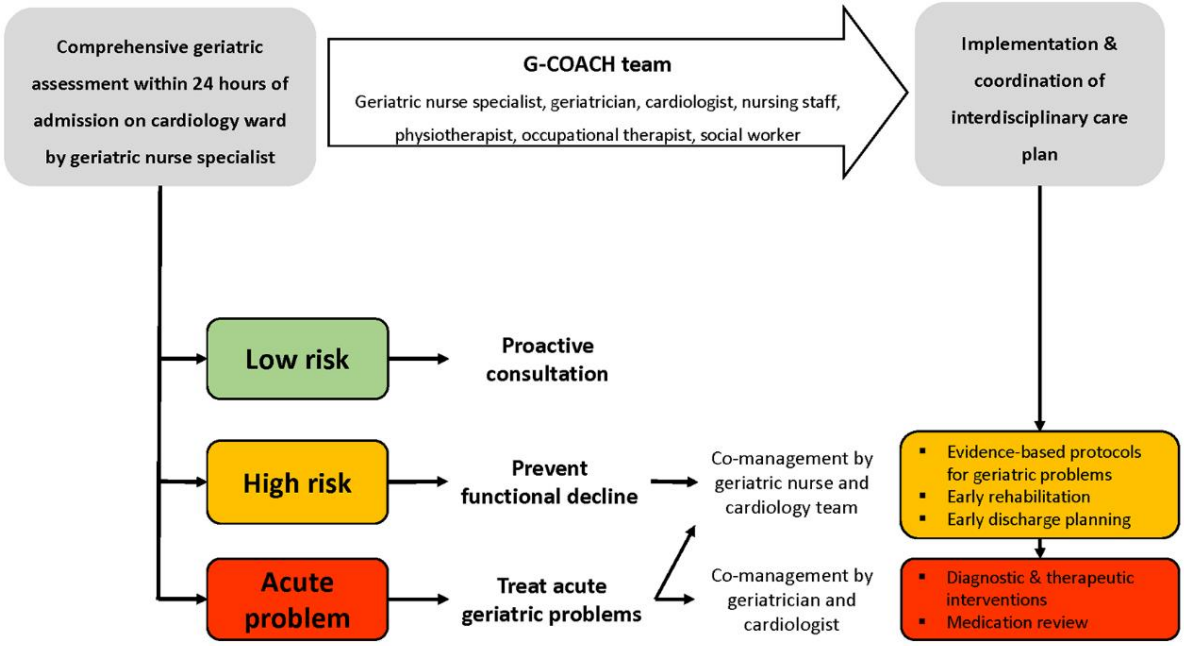
Every weekday a geriatric nurse is responsible for the geriatric co-management patients and conducts a CGA within 24 hours of admission in eligible patients newly admitted to the cardiology unit (See Figure 2). Subsequently, patients are stratified into one of three groups based on their baseline risk for developing functional decline. This risk prediction considers cognitive impairment (Mini-cog score), mobility impairment (use of ambulatory aid), nutritional risk status (Mini Nutritional Assessment score), depressive symptoms (Geriatric Depression Scale score) and the presence of physical restraint use or an indwelling urinary catheter (data not yet published).

Low risk patients are patients who are at low risk for developing functional decline during hospitalisation. The geriatric nurse provides a proactive consultation without systematic follow-up.

High risk patients are at risk for developing functional decline and other geriatric complications during hospitalisation. The geriatric nurse will work collaboratively with the cardiology team to prevent complications. Interventions include care coordination and bedside education by the geriatric nurse, early rehabilitation by a physical therapist, early discharge planning by a social worker, and availability of evidence-based protocols for the prevention and/or management of functional decline, falls, delirium, cognitive impairment, agitation, malnutrition, urinary incontinence, urinary retention, urinary tract infection, obstipation, pressure sores and pain. All intervention components selected from the protocols are tailored to the specific needs of an individual patient as detected with the CGA on admission. The geriatric nurse provides daily follow-up and coordinates the implementation of the protocols.

Patients with acute geriatric problems have developed one of the following geriatric syndromes: agitation, delirium, urinary retention, urinary incontinence or malnutrition (MNA < 8/14) and are subsequently considered to be at high risk of developing functional decline. These patients receive the same care as the high risk patients. Additionally, the geriatrician will perform a medication review based on clinical expertise and will co-manage the delirium, urinary retention, urinary incontinence and/or malnourishment with the cardiologist.

Figure 2. G-COACH programme



2.6 Implementation strategies

Changing the organisation and daily activities of a geriatric support team that has been working as a consultation team since 2005 is challenging. Both the geriatric support team and the healthcare professionals of the cardiology units need to take up a new role with new responsibilities and competencies. Since the aim is to change behaviour in both the geriatric support team and the cardiology teams, we use the Intervention Mapping taxonomy of behaviour change methods to ensure that our applied implementation strategies were targeting determinants that predict behaviour and were able to actually change that determinant. (26) Table 1 gives a detailed overview of the targeted determinants and practical strategies to change behaviour in the geriatric support and cardiology team.

Table 1. Implementation strategies and related behaviour change methods

Process	Determinant and Aim	Strategy	Taxonomy of behaviour change (26)
Orientation	Knowledge: Stakeholders are aware of the co-management programme	Listing all relevant stakeholders in the organisation	Participation
		Stakeholder meetings in initiation phase to propose programme with head of departments of geriatrics, cardiology, nursing, physiotherapy, nutritional therapy, social work and with head nurses of cardiology and geriatric support team, care programme managers and ICT	Consciousness raising Discussion Participation Systems change
		Use of G-COACH acronym in all communication	Chunking Repeated exposure
	Attitude: Stakeholders are interested and seek involvement in the co-management programme	Inclusion of stakeholders in consensus-development meetings for developing programme, focusing on definition, scope and goals of programme, intervention components and expected benefits	Motivational interviewing Participation
Insight	Knowledge: Stakeholders understand the goals, concepts and intervention components of the co-management programme	Educational presentations focusing on describing the care processes and outcomes of the current standard of care and new intervention components that are expected to improve processes and outcomes. Presentation included case discussion of geriatric needs and how the programme is expected to improve outcomes	Active learning Advance organizers Consciousness raising Discussion Persuasive communication

		Inclusion of stakeholders in consensus-development meetings for developing intervention protocols	Participation
		Intervention manual is available online and in hardcopy to stakeholders	Facilitation
		Publication of poster on participating units detailing the programme components and interventions	Cultural similarity Repeated exposure
	Knowledge: Stakeholders understand the geriatric needs of patients admitted to their unit and know the prevalence of geriatric syndromes on hospital admission and the incidence of geriatric complications during hospitalisation	Situational analysis to document geriatric care needs and the current standard of care by project team	Consciousness raising Organisational diagnosis and feedback
		Fact sheets are disseminated and short educational sessions are repeated in the feasibility and evaluation phase with the purpose of disseminating knowledge about geriatric needs to stakeholders based on the situational analysis	Consciousness raising Providing cues Repeated exposure
		Adaptations to the electronic patient file: risk stratification level and type of follow up visible for all eligible patients	Facilitation Providing cues Technical assistance
Acceptance	Positive attitude: Healthcare professionals are motivated to work with each other and collaborate as one interdisciplinary team	Contracting: an expert in group dynamics and leadership organises two sessions between stakeholders	Elaboration Nudging Shifting perspective
	Self-confidence: Stakeholders feel confident that participating	Inclusion of stakeholders in consensus-development meetings for developing programme, focusing on	Nudging Participation

	in the co-management programme is feasible and that any problems arising will be solved	definition, scope and goals of programme, intervention components and expected benefits	Systems change
		The intervention is tailored to match the local context by engaging stakeholders to ensure feasibility of the programme	Elaboration Systems change Tailoring
	Attitude: Stakeholders are convinced that the co-management programme is useful and effective to improve care outcomes for geriatric patients on their units	Programme support by head of department and head nurses	Participation
		Fact sheets and short educational sessions are repeated in the feasibility and evaluation phase with focus on impact and positive feedback on achieved goals	Active learning Advance organizers Consciousness raising Repeated exposure
	Attitude: Stakeholders have decided to change their standard of care and try-out the geriatric co-management programme	Official start of programme announced by head of department	Early commitment Persuasive communication
Systems change	Skills and organization of new care structures and processes: Stakeholders can try the co-management programme on a small scale and gain experience and skills necessary for the programme	Phased implementation with evaluation of feasibility allowing the programme to adjust if necessary	Active learning Direct experience Feedback Guided practice Individualisation Tailoring
		Audit and feedback on implementation based on feasibility study	Discussion Feedback

			Participatory problem solving
	Skills, habits: Stakeholders have integrated the co-management programme in their daily care and routines	Working group: audit and feedback with key stakeholders from every discipline to discuss the adaptations that are needed to the programme based on audit and future needs	Feedback Participation Participatory problem solving Tailoring
	Qualified staff, self-confidence: Stakeholders are adequately staffed and skilled to try out the co-management programme	Coaching of geriatric nurses and geriatricians responsible for implementing the programme	Active learning Direct experience Feedback Guided practice Individualisation
Maintenance	Skills, habits: Stakeholders have integrated the co-management programme in their daily care and routines	Working group: audit and feedback with key stakeholders from every discipline to discuss the adaptations that are needed to the programme based on audit and future needs	Feedback Participation Participatory problem solving Tailoring
	Leadership, financial resources, opinion of leaders and key figures: University Hospitals Leuven has formally recognized ownership of the co-management programme	Dissemination of programme results to UZ Leuven staff and management	Agenda setting Feedback

Note: the determinants were based on guidance of Grol R, Wensing M, Eccles M, Davis D (2013). Improving patient care: the implementation of change in heath care, second ediction. John Wiley & Sons, ltd.

The study coordinator (BVG) and research assistant (AJ) take up the role of external facilitators to allow for successful implementation of the G-COACH intervention. One month before the pilot implementation, they organised information sessions for all stakeholders: nurses, physicians, physiotherapists, occupational therapists, social workers, nutritional therapists and management from both the cardiology and geriatric department. Participants were informed on the current standard of care and the prevalence of geriatric problems. A sense of urgency of why change is needed was created. They were further informed on what will change, how it will change and what the intended benefits will be. Instructional materials, such as an electronic project manual including all intervention protocols, intervention pocket cards and posters, were distributed and training sessions were organised for the geriatric support team to explain and practice the intervention protocols. Finally, a meeting was organised with the external facilitators and geriatric support team to discuss how the team perceives the G-COACH intervention, their specific role, and to determine their needs for support towards the external facilitators. This meeting was led by a highly experienced external moderator of the Department of Leadership Development of the University Hospitals Leuven.

At the start of the implementation, an e-mail was sent by the medical head of the departments detailing both the study and instructional materials. The head nurses of the participating units supervised the start of the intervention. A working group was formed consisting of the head nurses of the cardiology units and the geriatric support team, two champion nurses of the cardiology ward, a geriatric expert nurse, cardiologist, geriatrician, physiotherapist, social worker and study coordinator. The purpose of this group that meets monthly, is to discuss the implementation of the intervention, e.g.: Are all intervention components implemented?; What are the reasons for non-implementation?; What are barriers for implementation; and Are adaptations to the intervention needed?. Based on a consensus decision, the working group will propose changes to the intervention or formulate additional implementation strategies.

During the implementation phase, process data will be systematically collected from the electronic patient record and summarized by the study coordinator and research assistant to inform the working group. The study coordinator will organize short informational sessions throughout the study period to inform all stakeholders on the progression and success of the intervention. Weekly updates about the project are sent by mail to the geriatric support team and regular individual feedback sessions with the members of the geriatric support team are organised to emphasize which parts of the implementation of the intervention went well or were challenging.

2.7 Patient and public involvement

Patients and public were not involved in the development of the research questions and outcome measures, the design, recruitment of conduct of the study. Feedback of patients regarding the acceptability of the intervention is actively explored in the feasibility phase of the study using structured patient interviews.

2.8 Feasibility evaluation

The feasibility of the intervention will be assessed in a single intervention group before proceeding to the inclusion of patients in the after-cohort. The reach, fidelity (see table 2) and dose (see table 3) will be evaluated by trained researchers using a multi-methods approach.

The *reach* determines the number of eligible patients that were recruited in the intervention. Successful recruitment is defined as 1) having received CGA and 2) being stratified into a risk group. The number of patients recruited in the intervention will be compared against the number of eligible patients using the electronic patient record. The *fidelity* determines how well the intervention is implemented as defined by the protocol and considers both the implementation of specific intervention components, and the correct timing of the implementation. The *dose* determines how much of the intervention is implemented as defined by the protocol and considers both the duration and frequency of specific intervention components. The fidelity and dose will be observed on a daily basis using patient interviews and the electronic patient record.

The experiences of participating healthcare professionals will be captured using focus group discussions or individual interviews. A total of four to five focus groups, including physicians, nurses from the cardiology department and the geriatric support team, physical and occupational therapists and social workers, will be organised. Healthcare professionals not able to participate in the focus groups will be interviewed individually. The experiences of participating patients will be captured using structured patient interviews. The sampled experiences of healthcare professionals and patients will be used to determine the *acceptability* and to *assess for barriers and facilitators* of both the intervention and implementation strategy.

Table 2. Fidelity indicators

Fidelity indicators	Adherence	Timing	Source
The intervention group assignment of a patient is documented in GER contact	Yes No	Within 24 hours of admission to c CAR	Electronic patient record
The intervention group assignment of a patient is documented in CAR contact	Yes No	Within 24 hours of admission to CAR	Electronic patient record
The intervention group assignment of a patient is documented in the patient file	Yes No	Within 24 hours of admission to CAR	Electronic patient record
The number of geriatric risks that are documented in the GER contact compared with the number of geriatric risks that are present	Proportion	Within 24 hours of admission to CAR	Electronic patient record
The number of geriatric complications that are documented in the GER contact compared to the number of geriatric complications that are present	Proportion	Within 24 hours of admission to CAR	Electronic patient record
A follow-up note summarizing the identified risks/complications and interventions is documented in the CAR contact	Yes No	Within 24 hours of admission to CAR	Electronic patient record
If a patient is at risk for functional decline or has experienced acute functional decline, the patient receives physiotherapy *	Yes No	Within 48 hours of admission to CAR	Electronic patient record
If a patient is at risk for functional decline or has experienced acute functional decline, the patient completes an individual exercise programme *	Yes No	Within 48 hours of admission to CAR	Electronic patient record

Fidelity indicators	Adherence	Timing	Source
If a patient is at risk for functional decline or has experienced acute functional decline, the patient receives physiotherapy	Yes No	Within 24 hours of detection	Electronic patient record
If a patient is at risk for delirium or has developed delirium, the patient completes an individual exercise programme	Yes No	Within 24 hours of detection	Electronic patient record
If a patients is at risk for malnutrition or is malnourished, the patient receives a nutritional intervention by a dietician *	Yes No	Within 48 hours of admission to CAR	Electronic patient record
If a patient is in need for discharge planning, the patient is seen by a social worker	Yes No	Within 48 hours of admission to CAR	Electronic patient record
If a patient developed acute functional decline at hospital admission, the patients receives ADL-training by an occupational therapist.	Yes No	Within 48 hours of admission to CAR	Electronic patient record
If a patient is demonstrating agitation, the patient is co-managed by a geriatrician *	Yes No	Within 48 hours of onset of symptoms	Electronic patient record
If a patient is demonstrating agitation, the precipitating factors for the agitation are document in de patients' record	Yes No	Within 48 hours of onset of symptoms	Electronic patient record
If a patient is delirious, the patient is co-managed by a geriatrician *	Yes No	Within 48 hours of onset of symptoms	Electronic patient record
If a patient is delirious, the precipitating factors for the delirium are document in de patients' record	Yes No	Within 48 hours of onset of symptoms	Electronic patient record

Fidelity indicators	Adherence	Timing	Source
If a patient has a swallowing disorder and is placed on a 'nothing by mouth' order, the patient receives parenteral or intravenous nutritional support	Yes No	Within 2 days	Electronic patient record
If a patient has not passed stool for 3 days, the patient is prescribed oral laxatives *	Yes No	Before day 4 without stool	Electronic patient record
If a patient has not passed stool for 5 days, the patient receives an enema *	Yes No	Before day 6 without stool	Electronic patient record
If a patient reports acute urinary incontinence, the patient is co-managed by a geriatrician *	Yes No	Within 48 hours of onset of symptoms	Electronic patient record
If a patient reports acute urinary incontinence, the precipitating factors for the incontinence are documented in the patients' record	Yes No	Within 48 hours of onset of symptoms	Electronic patient record
If a patient reports acute urinary retention, the patient is co-managed by a geriatrician *	Yes No	Within 48 hours of onset of symptoms	Electronic patient record
If a post-void residual volume of ≥ 300ml is observed in a patient, the residual volume is removed using intermittent catheterization	Yes No	Before end of shift after detection of symptoms	Electronic patient record
If a post-void residual volume of ≥ 300ml is observed in a patient, the post-void residual volume is monitored using a bladder scan in the next shift	Yes No	n/a	Electronic patient record

Fidelity indicators	Adherence	Timing	Source
If there is no indication for an indwelling catheter, the patient is free of an indwelling catheter *	Yes No	n/a	Electronic patient record
If a patient reports a pain score of 4 or higher (out of 10), pain medication is given unless refused by the patient	Yes No	Within 1 hour of onset of symptoms	Electronic patient record
If a patient reports a pain score of 4 or higher (out of 10), the pain is re-evaluated	Yes No	Within 1 hour of onset of symptoms	Electronic patient record
If a patient has delirium, agitation, acute urinary retention or incontinence, malnutrition, a medication review is performed by a geriatrician	Yes No	Before hospital discharge	Electronic patient record
If a patient has a Mini-Cog score < 3 on hospital admission, a Mini-Mental Status Examination is performed by an occupational therapist	Yes No	Before hospital discharge	Electronic patient record
If a patient is at risk for functional decline, the patient is co-managed by a geriatric nurse *	Yes No	Within 48 hours of admission to CAR	Electronic patient record
If a patient has delirium, agitation or acute urinary retention or incontinence, the patient is co-managed by a geriatric nurse *	Yes No	Within 48 hours of onset of symptoms	Electronic patient record

Legend: * Indicator that will used to determine the maintenance of the intervention; CAR = cardiology; GER= geriatrics;

Table 3. Dose indicators

Dose indicators	Adherence	Duration	Source
The number of days an at risk patient is seen by a geriatric nurse compared to the number of days a patient is at risk per protocol *	Proportion	Hospitalisation period	Electronic patient record
The number of days a patient with geriatric complications is seen by a geriatric nurse compared against the number of days a patient has geriatric complications per protocol	Proportion	Hospitalisation period	Electronic patient record
If a patient has delirium, agitation or acute urinary incontinence or retention, the patient is seen three times a week by a geriatrician	Yes No	Duration of complication	Electronic patient record
If a patient is at risk for functional decline, the patient completes an individual exercise programme *	No Yes, daily Yes, not daily	Hospitalisation period	Patient interview, self-report
If a patient is in need of an ambulatory device, the ambulatory device is available	No Yes, always Yes, not always	Hospitalisation period	Patient interview, self-report
If a patient is at risk for delirium, the Delirium Observation Scale is documented in the morning and evening shift *	Yes No	Three consecutive days after detection of risk	Electronic patient record

Dose indicators	Adherence	Duration	Source
If a patient is delirious, the Delirium Observation Scale is documented during the morning and evening shift *	Yes No	Duration of delirium	Electronic patient record
If a patient is at risk for malnutrition or is malnourished, the daily nutritional intake is documented	Yes No	Hospitalisation period	Electronic patient record
If a post-void residual volume between 200 – 300ml is observed in a patient, the post-void residual volume is monitored every shift until volume < 100ml	Yes No	Until < 100ml	Electronic patient record

Legend: * Indicator that will used to determine the maintenance of the intervention.

2.9 Effectiveness evaluation

2.9.1 Baseline variables

The baseline evaluation of control and intervention patients serves to assess baseline equivalence between patients in the before-and-after cohort for the outcome evaluation. (See Table 4) *Demographic data* will be collected on age, gender, living situation and use of healthcare services using patient interview or review of the electronic record. *Medical variables* include the medical diagnoses, number and type of medications and comorbidities. (27) The following variables related to *functional status* will be measured: (in)dependence on activities of daily living (ADL), (28, 29) instrumental ADL, (30) community mobility, (31) physical performance, (32), handgrip strength, (33) fall history, (34) and physical frailty. (35) Regarding *mental status*, presence of cognitive impairment, (36) depression, (37) anxiety, (38) and delirium (39) will be measured. Finally, *nutritional status* will be assessed using the Mini Nutritional Assessment – Short form (MNA-SF). (40)

2.9.2 Outcome variables

Functional decline is the primary outcome of interest measured by comparing the Katz ADL score on hospital admission, hospital discharge, and at 1, 3 and 6 months follow-up. (24,25) An increase of 1 point on the Katz Index will be considered clinically relevant to define functional decline. Secondary outcomes are community mobility assessed at 1, 3 and 6 months follow-up measured with Life-Space Assessment and physical performance at hospital discharge measured with the Short Physical Performance Battery. (31, 32)

Incident in-hospital geriatric syndromes include delirium, cognitive decline, falls, and obstipation. Delirium will be operationalized using the 3D-CAM after a trained researcher assessed cognitive functioning using the CAM questionnaire on day 1 (day of admission), 3, 5, 7 and 9 (or daily in delirious patients). (46, 47) Patients are considered delirious based on the sensitive CAM algorithm criteria. The duration of delirium will be determined as the number of days from the first positive CAM score until the day before a negative CAM score was obtained. (36) In-hospital cognitive decline will be determined by a decline on the Mini-Cog score between hospital admission and discharge. (44) Symptomatic infections will be assessed by reviewing the patient record for antibiotic treatment for a clinical infection (e.g. lower respiratory tract infection, urinary tract infection, skin and soft tissue infection, infection of unknown origin, and sepsis without primary focus).

Obstipation defined as 'not having passed stool in five days or more', will be assessed by reviewing the patient record for nurses recorded observations (which are assessed every shift). In-hospital falls and fall related injuries will be monitored using the patient record, while post-discharge falls and fall related injuries will be monitored at 1, 3 and 6 months follow-up by telephone.

Length of hospital stay will be measured in days and hours for admission on the cardiology unit and non-cardiology unit. Unplanned readmission rate will be assessed at 1, 3 and 6 month follow-up by telephone and by checking the electronic patient file. To be considered unplanned, patients should be admitted through the emergency department or outpatient clinic. Mortality will be assessed in-hospital using the electronic patient record, and at 1, 3 and 6 months follow-up by telephone. Institutionalisation, defined as a new admission to a long-term care facility compared to baseline, will be assessed at discharge and on 1, 3 and 6 months follow-up by telephone. Quality of life will be assessed using the EQ-5D-5L on hospital admission, hospital discharge and at 1, 3 and 6 months follow-up. (48, 49)

2.10 Process evaluation

A process evaluation will be embedded in the after-cohort of the evaluation study to determine how the process of care was changed as a result of the implementation of the intervention and how the intervention was maintained and adapted over time and how this related to the interaction between context factors and the implementation of the intervention. The change in process of care will be observed using the electronic patient record and include the use, time to start and frequency of geriatric support services, physical therapy, discharge planning and nutritional advice, the use and duration of physical restraints and indwelling catheters, the detection of geriatric syndromes, medication reconciliation and referral to outpatient services. The maintenance of the intervention relates to how well the reach, fidelity and dose of the intervention is maintained over time, which will be monitored using the electronic patient record (see selection of indicators in tables 2 and 3). Adaptations to the intervention will be monitored by the study coordinator during the monthly working group meetings with stakeholders. Focus groups and interviews will be organised to sample the experiences of all healthcare professionals participating in the intervention. The experiences will focus on how contextual factors influenced the maintenance and adaptations of the intervention and how this relates to the sustainability of the intervention.

Table 4. Overview of baseline variables and care processes measured

Variable	Instrument	Description	Score	Type of assessment	Admission	In-hospital	Discharge	1/3/6 month follow-up
			BASELINE VARIABLES					
Demographic data	n/a	Age, gender, living situation (home alone or together, assisted living, nursing home), use of healthcare resources	n/a	Interview	X			
Medical status								
Medical diagnoses	n/a	n/a	n/a	Record	X			
Comorbidity	Cumulative Illness Rating Scale (27)	Assessment of 14 body systems scored based on severity	Score 0 – 56 Overall severity index Range 0 – 4 = total score divided by number of body systems evaluated	Record	X			
Medication	n/a	Polypharmacy ≥ 5 medications		Record	X		X	
Functional status								
Activities of Daily Living (ADL)	Katz Index (28)	Bathing, dressing, toileting, transferring, continence, feeding	Score 6 – 18	Interview	X		X	X
	Barthel Index (29)	Bowels, bladder, grooming, toilet use, feeding, transfer, mobility, dressing, stairs, bathing	Score 0 – 100	Interview	X		X	X
Instrumental ADL	Lawton and Brody Scale (30)	Telephone use, shopping, food preparation, housekeeping, laundry, mode of transportation, medication use, finances		Interview	X			
Community mobility	Life-Space Assessment (31)	Self-reported mobility in last 4 weeks based on mobility in specific life-space levels, frequency of movement and use of assistance	Score 0 – 120	Interview	X			X
Physical performance	Short Physical Performance Battery (32)	Gait speed, standing balance, chair stand test	Score 0 – 12	Test	X		X	

Grip strength	Hydraulic hand dynamometer (Jamar JA Preston Corporation; Jackson, MI) (33)	At the dominant side with the elbow at 90° of flexion, and the forearm and wrist in a neutral position.	Highest value out of 3 tests	Test	X		X	
Fall history	Fall history in the past 6 and 12 months (34)	Fall = "an unexpected event in which the patient comes to rest on the ground, floor or lower level" (41)	Yes / No	Interview	X		X	X
Physical frailty	Adjusted Fried criteria (35)	1) self-reported unintentional weight loss of ≥ 4.5 kg in the last year; grip strength in the lowest 20% adjusted for gender and BMI; 2) self-reported poor endurance and energy (question from GDS: "Do you feel full of energy?"); 3) reduced walking speed (≥ 6 sec. to cover 5m); 4) low physical activity (< 30min./day of self-reported physical activity of moderate intensity) (42, 43)	Frail = score ≥ 3	Test/ Interview	X		X	
Mental status								
Cognition	Mini-Cog (44)	three-item word memory and clock drawing	Score 0 – 5 Impairment = score < 4	Interview	X		X	
Depressive symptoms	10-item Geriatric Depression Scale (45)		Score 0 – 10 Risk for depression = score ≥ 4	Interview	X			
Anxiety symptoms	Hospital Anxiety and Depression Scale (38)	7-item subscale for anxiety	Score 0 – 21 Anxiety = score ≥ 8	Interview	X			
Delirium	3D Confusion Assessment Method (39)		Delirium = (acute onset OR fluctuating course) AND inattention AND (disorganised thinking OR altered level of consciousness)	Interview	X	X	X	
Nutritional status	Mini Nutritional Assessment (40)	6 screening questions	Score 0 – 14 Malnutrition = score 0 – 7 Risk of malnutrition = score 8 - 11	Interview	X			

CARE PROCESSES					
Rehabilitation	n/a	Number of patients receiving rehabilitation Number of days until start of rehabilitation Number of interventions and contacts by a physiotherapist	Record	X	
Discharge planning	n/a	Number of patients receiving discharge planning Number of days until start of discharge planning Number of social interventions and contacts by a social worker	Record	X	
Dietary advice	n/a	Number of patients receiving dietary advice, the number of days until start of dietary advice, and the number of dietary interventions and contacts by a dietician.	Record	X	
Geriatric consultation	n/a	Number of patients receiving consultation by a member of the geriatric team Number of days until start of the geriatric consultation Number of interventions and contacts by the geriatric consultation team	Record	X	
Physical restraints	n/a	Number of patients being restrained Duration of the use of restraints Type of restraints used	Record	X	
Indwelling catheters	n/a	Number of patients with an indwelling catheter Duration of catheterization Reason for catheterization	Record	X	
Medication reconciliation	n/a	Number of patients discharged with a change in medications, and type of change. Change will be assessed for 1) number of drugs and drug intakes at admission and discharge, 2) potentially inappropriate medications at admission and discharge, and 3) vitamin D at admission and discharge	Record	X	
Detection of impairments and complications	n/a	Related to dementia/cognitive impairment, delirium (risk), depression (risk), anxiety (risk), fall risk, incontinence, malnutrition (risk) and frailty. This will be compared with standardized observations/assessments made by the research team to infer underdiagnoses.	Record	X	
Referral to outpatient care at hospital discharge	n/a	Number of patients referred to the falls clinic, the memory clinic, primary home care, and primary nursing care	Record		X

Legend: n/a = not applicable; * underscored number indicates the best possible score for all instruments

2.11 Sample size

2.11.1 Feasibility evaluation

A total of 30 consecutive patients receiving the intervention will be recruited for the feasibility study. Approximately 30 healthcare professionals will be recruited for the focus groups and interviews. The total sample will be based on the willingness to participate and data saturation.

2.11.2 Effectiveness evaluation

A sample size has been calculated for in-hospital functional decline, the primary outcome of the evaluation study. We assumed a minimal important difference of 1 mean point on the Katz ADL and a standard deviation of 3 points on the Katz ADL with equal groups, based on observations in a pilot study. (22) This equals a standardized effect size of 0.33 (Cohen's d) and indicates a low to moderate effect size. Therefore, a total of 159 patients are needed per group (alfa = 0.05, power = 0.8, two sided test), accounting for 10% missing data. However, we hypothesized that not all patients will benefit from the intervention as several studies have identified larger effects sizes in patients with premorbid impairments but sufficient capacity to participate in in-hospital interventions. (50-54) Based on these studies, we expect that 30% of the patients will be at low risk, 50% at high risk, and that 20% will have an acute problem. This means that 227 patients need to be assessed to be able to evaluate the geriatric co-management intervention in 159 patients in the high risk (n = 114) or acute problem group (n = 45).

2.11.3 Process evaluation

The process evaluation is embedded in the sample of patients recruited for the effectiveness evaluation. A comprehensive sample of all healthcare professionals with at least four weeks of exposure to the intervention will be recruited, with the total sample depending on the willingness to participate and data saturation.

2.12 Data collection procedure

2.12.1 Feasibility evaluation

Researchers will recruit patients on hospital admission after written (proxy-)informed consent has been obtained and will monitor the feasibility indicators using the electronic patient record daily and by bedside assessment every other day. Patients are interviewed upon hospital discharge by a researcher using a structured patient questionnaire. At the end of the feasibility phase, focus group discussions will be

organised. One researcher will coordinate the group discussions and a second researcher will take notes. Healthcare professionals not able to participate in group discussions will be interviewed individually. An interview guide will be composed based on a literature search for existing barriers and facilitators and the role of contextual factors. All discussions will be tape recorded and written out verbatim. The audio recordings will be deleted and only the verbatim text will be saved.

2.12.2 Effectiveness evaluation

In the before and after cohorts, patients are recruited on hospital admission by the researchers, who screen the patient records for eligibility criteria and obtain written (proxy-) informed consent in a face-to-face interview. A research assistant will monitor the incidence of complications using patient assessment and by monitoring the patient record throughout hospitalisation, and will assess the outcomes on hospital discharge using patient interview. Patients will receive a letter by post with instructions and an assessment questionnaire for follow-up assessment at 1, 3 and 6 months post discharge. Researchers will contact the patient by telephone to complete the assessment. Due to the nature of the intervention and study design, health professionals and patients cannot be blinded. Blinding of outcome assessors is not considered feasible due to limited resources.

2.12.3 Process evaluation

The data collection procedure for the process evaluation is equal to the one of the feasibility evaluation, but only a selection of fidelity and dose indicators will be measured for all patients in the after cohort.

2.13 Data management and monitoring

Standardized data collection forms will be drafted and piloted by all researchers. Databases will be drafted in Excel and SPSS and all researchers will have access to a codebook. The study coordinator will assess the integrity of all completed informed consents and will monitor the assessment documents for missing data. Written assessments will be recorded in an Excel and SPSS database on a password protected computer, and will be analysed for missing data, wild codes and extreme values. All data will be coded and analysed anonymously. A formal data monitoring committee is not considered necessary as the study duration is relatively short and the risks for patients are considered minimal. Interim analyses and stopping rules have not been defined. Researchers will be trained to monitor for and record adverse events during

assessments and tests, which will always be performed in proximity of a licensed health professional.

2.14 Statistical methods, qualitative analysis and data integration

Variables will be explored using visual and descriptive statistics and analysed for missing data. Categorical data will be expressed as number of cases and percentages. Continuous data will be expressed as means with standard deviations. All primary analyses will be conducted on the patients who were at high risk for functional decline or patients experiencing an acute problem. For evaluating the primary outcome, we will first explore the baseline equivalence between the control and intervention group. If equivalent, we will test the absolute difference in ADL scores on hospital discharge between the two groups. If not equivalent, we will test the mean decline in ADL between hospital admission and discharge in both group. The analysis of covariance (ANCOVA) model will be used to adjust for confounders. For secondary outcomes, logistic regression will be used for dichotomous outcomes, survival analyses for time to event variables and ANCOVA for mean differences between groups. We will explore several moderating variables. We hypothesize that the effect of the intervention will be dependent on 1) the baseline risk of patients for developing functional decline, 2) the fidelity and dose of the implementation and intervention, and 3) the presence of heart failure. Results will not be corrected for multiple testing. Statistical inference will be based on 95% confidence intervals.

Focus group discussions and individual interviews will be analyzed using a thematic analysis to understand how experiences influenced the implementation and feasibility of the intervention. Two researchers will independently code the data using Word-documents. Transcripts and results will not be returned to participants for feedback. The following strategies will be used to support the methodological quality: peer review, triangulation, audit trial, methodological and reflective notes and thick description.

Integration of quantitative and qualitative data will be done through embedding.(55) Data collection and analysis will be recurrently linked at multiple points: in the development phase to clarify outcome measures, in the evaluation phase to understand contextual factors that influence the study findings, and in the post-evaluation phase to explain outliers or develop hypotheses about necessary changes for large-scale implementation. Quantitative and qualitative data will be integrated in a narrative way using a contiguous approach, meaning that findings will be presented in a single report in different sections. In case qualitative and quantitative findings are inconsistent, contradict or conflict, we will reanalyze the existing databases to resolve

differences, seek explanations from theory, or further analyse discordance in follow-up studies. (55)

2.15 Ethics and dissemination

The study protocol was approved by the Medical Ethics Committee of UZ/KU Leuven (S58296). Written voluntary (proxy-) informed consent will be obtained from all participants at the start of the study. Upon each assessment, the research assistant will obtain oral informed consent for the assessment. Patients will be considered the owners of their data, and data will be removed or changed upon the request of the patient. No financial compensation is rewarded for participation, and patients are not charged any costs as a result of any action in this study. Dissemination of the results will be through articles in scientific and professional journals both in English and Dutch and by conference presentations. A G-COACH publication policy has been developed and was approved on the first consortium meeting.

3. DISCUSSION

This paper presents the study design and methods of the G-COACH intervention study, which is to our knowledge the first study evaluating the feasibility and effectiveness of a geriatric co-management intervention in older cardiology patients. In view of the rapidly increasing number of hospitalized older patients and the continuous efforts to further improve quality of care for these frail and complex patients, this study is timely and needed.

We hypothesize that our framework of geriatric co-management will be beneficial in this population, because of the applied methodological framework. First, a theoretical geriatric co-management model was developed by integrating evidence from a meta-analysis, quality indicators, and a prospective cohort study. (18, 21, 22) Such a theoretical model not only details how the intervention will impact the desired outcomes, but also increases the a priori probability for a clinically meaningful effect. (56) Second, important stakeholders will be involved in translating the theoretical care model in an operational geriatric co-management programme. (57) Therefore, not only physicians, nurses and allied healthcare workers, but also nursing, medical and administrative management, are involved in the development, feasibility and evaluation phase of the project. This will allow us to implement and evaluate a care programme that fits the local context of the hospital and the participating units, hence, a programme that is deemed beneficial, acceptable and feasible by all stakeholders

involved. Third, we will formally test the feasibility of a geriatric co-management programme. By first testing the feasibility, the intervention can be adjusted and optimised before investing in a large-scale evaluation. (20, 58) This approach contrasts with the majority of studies in which feasibility problems are detected in evaluation studies leading to inconclusive results. Finally, because information is currently missing on what components make geriatric co-management effective in order to replicate the observed effects in daily practice, we will evaluate geriatric co-management using a mixed-methods design. By incorporating quantitative and qualitative information in both the outcome and process evaluation, we can move beyond effect outcomes and understand how intervention components interact with context and system factors to derive an effect on patient outcomes. (55) This will help us understand why geriatric co-management worked or - in case the intervention would not be successful - why it did not work. The study will therefore in any case add to the evidence-base regarding the development, evaluation and implementation of geriatric co-management programmes.

Despite the absence of strong evidence regarding the impact of geriatric co-management in a recent meta-analysis, (18) we have deliberately chosen to use a hybrid 1 effectiveness-implementation design. This is one of the three hybrid designs described by Curran et al. who mapped different implementation research designs. (23) By systematically addressing the healthcare needs, preferences and values at different levels (i.e. patient, provider, system, and policy level) and by engaging relevant stakeholders, implementation research effectively brings evidence-based models into practice in a context-sensitive way leading to sustainable change. While large-scale implementation is outside the scope of the G-COACH project we will actively explore components that will facilitate future implementation of the care model if it proves to be successful by: 1) defining core intervention components that are essential for all co-management programmes and defining peripheral components that can be adapted to the local context; 2) describing how context factors influenced the processes of geriatric co-management; 3) describing how participants experienced geriatric co-management and how this influenced adopting the programme locally; 4) evaluating how well geriatric co-management was implemented on the participating units. (59) Addressing these knowledge gaps is essential before considering scaling up and scaling out the geriatric co-management model of care.

In conclusion, the G-COACH intervention study will be the first to evaluate the impact of cardio-geriatric co-management and has the potential to change the current clinical practice of frail older hospitalized patients.

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CHAPTER 6

Development, implementation and feasibility of the geriatric co-management programme

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ABSTRACT

Background: Geriatric co-management programmes are advocated to manage frail patients in the hospital. However, to date, no formal programme theory and implementation strategy have been defined for this model of care. We therefore aimed to develop and implement a geriatric co-management programme for older patients admitted to the hospital and to evaluate the feasibility on two cardiac care units. The specific objectives of the feasibility study were to determine the reach, fidelity, dose and implementation determinants of the programme and to describe the experiences of the participants.

Methods: A mixed-method multi-phase design was used. A geriatric co-management programme was developed using the 'purposeful program theory' methodology. Implementation strategies were developed based on the 'process of change model'. Key strategies included context analysis, stakeholder engagement, educational presentations, informational materials, leadership support, training, and audit and feedback. The feasibility was evaluated in a one-group experimental study on two cardiac care units of the University Hospitals Leuven. The reach, fidelity and dose were investigated using registrations in the electronic patient record and by interviewing patients. The experiences of patients were recorded during structured interviews. Implementation determinants were captured using a survey with 46 healthcare professionals and semi-structured interviews or focus groups with 27 healthcare professionals.

Results: The programme reached 91% in a sample of 151 patients with a mean age of 84 years. There was a high fidelity for the major components of the programme: documentation of geriatric risks (98%), co-management by specialist geriatrics nurse (95%), early rehabilitation (80%), and early discharge planning (74%), except for co-management by the geriatrician (32%). Both patients and healthcare professionals rated G-COACH as acceptable (95% and 94%) and feasible (96% and 74%) to perform. The main determinants for affecting the implementation success were staffing, competing roles and tasks of the geriatrics nurse and leadership support.

Conclusions: A multi-phased, stakeholder-centred approach for implementation resulted in the successful initiation of a geriatric co-management programme that was perceived acceptable and feasible. Fidelity was strongly influenced by context factors. Further investigation of the sustainability of the programme is needed.

INTRODUCTION

Frail older patients often experience complications and develop disabilities in their activities of daily living (ADL) during hospitalisation. (1) This results in sustained disability, a lower quality of life and higher costs for society. (2, 3) These observations have voiced the need for a holistic and interdisciplinary approach, i.e., comprehensive geriatric assessment (CGA), when caring for frail older patients in the hospital. CGA refers to "a multidimensional interdisciplinary diagnostic process focused on determining a frail older person's medical, psychological and functional capability in order to develop a coordinated and integrated plan for treatment and long term follow-up". (4)

Co-management programmes are care models that are characterised by shared decision-making and collaboration between a geriatric and non-geriatric teams. The care model aims to implement CGA-based care on hospital units that have a large proportion of frail patients. Although the programme is often coordinated by a geriatrician, some programmes have an interdisciplinary geriatric team to prevent and manage geriatric complications. The geriatric team provides complementary care and support healthcare professionals in the holistic management of frail patients. Both a meta-analysis and recent evidence update concluded that geriatric co-management has clinically beneficial effects on functional status, complications, length of stay and potentially on in-hospital mortality. (5, 6) Most of the evidence comes from orthogeriatric units or geriatric fracture centres. These units integrate orthopaedic and geriatric care and focus on preoperative optimisation, and management of medical, functional and social needs of older patients with a hip fracture. (7) However, frail older patients outside the hip fracture setting, e.g. on internal medicine wards, are equally at risk for complications and could benefit from co-management. (8, 9)

The current 'evidence base' has two important limitations. First, the evidence is limited to hip fracture patients. (5) Second, outside the geriatric fracture centres, there are no standards available that define the programme components that contribute to successful geriatric co-management. (10, 11) The implementation of this promising programme is therefore limited by the lack of a formal programme theory.

Our aim was therefore to develop a programme theory for geriatric co-management of older patients admitted to a non-geriatric unit, operationalise the programme, and evaluate the feasibility of the implementation on two cardiac care units of the University Hospitals Leuven. The specific objectives of the feasibility evaluation were to determine the reach, fidelity, dose and implementation determinants of the programme and to describe the experiences of the participants.

METHODS

A mixed-method multi-phase design was used to develop, implement, and evaluate the feasibility of the G-COACH programme. A protocol paper describing the full methodology of the feasibility study was previously published. (12) The Medical Ethics Committee of the University Hospitals Leuven approved this study (s59543).

Context

The G-COACH programme was developed for two cardiac care units with 16 and 26 beds, respectively, and the inpatient geriatric consultation team of the University Hospitals Leuven in Belgium. The University Hospitals Leuven is a 1995 bed teaching hospital. Each cardiac care unit has a multidisciplinary team with a medical supervisor, two medical residents, registered nurses, healthcare assistants, a logistic assistant, a physical therapist, a social worker and a dietician. The inpatient geriatric consultation team has two geriatricians, seven nurses and four occupational therapists that provide geriatric consultation on requests. The geriatrics department aimed to redesign their geriatric consultation service into a geriatric co-management service by changing their team structures and processes. This paper reports the development and implementation of this new service.

Phase 1: Development of the G-COACH programme

The aim of phase 1 was to develop a programme theory for geriatric co-management of older patients admitted to a non-geriatrics unit, and to operationalise the programme for implementation on the cardiac care units of the University Hospitals Leuven. We used the 'purposeful program theory' methodology to define six phases for the development of the G-COACH programme (see Table 1). (13) Phases 1 to 3 were used to create a theoretical framework, and phases 4 to 6 were used to operationalise the framework for implementation.

First, we performed a context analysis to understand the care needs and outcomes of older patients admitted to the hospital, standard of care practices and local care routines on the cardiac care units, and to assess the potential for change. Focused literature searches were performed to identify evidence on the prevalence and incidence of geriatric syndromes in older patients admitted to the hospital and conceptual models explaining why older patients experience negative outcomes. A pilot observational study with 63 patients who were admitted to the cardiac care units of the University Hospitals Leuven was performed to assess the quality of care by measuring process and outcome indicators. (14) Participant observations were organised. One nurse researcher worked on the participating units to understand the

care context and current practice patterns, and to help explain the performance observed in the pilot observational study.

Second, we defined the scope of the G-COACH programme with the stakeholders. The aim was to create a shared understanding regarding the goals and main components of the programme. A systematic review and meta-analysis was performed to identify programme descriptions and outcomes of geriatric co-management and to define the main theoretical components of the programme. (5, 10) Focus groups and meetings with the head nurses, nurses, medical residents, physical therapists, occupational therapists, social workers and dieticians were organised to identify their interests and expectations for improving the quality of care on their units. Using informal consensus procedures, the aim was to create a shared vision for improvement that was perceived as relevant, acceptable and feasible, and to define the main structural components of the programme.

Third, we defined an outcomes chain that explains how we expect geriatric co-management to achieve the desired improvements for patients, care professionals and hospital. An international two round Delphi study was performed to identify structure, process and outcome indicators. (10) Additionally, stakeholder meetings with hospital management and staff were organised to identify outcomes that were relevant for their strategic decision-making. We hypothesised cause-and-effect relationships between intermediary or process indicators on the one hand, and final or outcome indicators on the other hand (see figure 1 for an example).

Fourth, we defined a set of outcome indicators that can be used to evaluate the effectiveness of the G-COACH programme. Data from the previously described literature searches, Delphi study and stakeholder meetings were used for this purpose.

Fifth, we operationalised the G-COACH programme by developing a protocol book describing the main components, key processes and responsibilities, and detail the protocols for the management of older patients in the hospital. To decrease the tension for change, the aim was to use the available hospital and team protocols as much as possible. The research team collated all available protocols and compared them against the available evidence-based guidelines. All changes to the protocols were discussed with and approved by the stakeholders.

Sixth, we defined the resources that were necessary to perform the protocols. We monitored the prevalence and incidence of geriatric syndromes that the programme was expected to manage (see Table 2) from hospital admission until discharge. Using these data, we plotted the expected weekly caseload for the programme to determine staffing needs.

Table 1. Development of the G-COACH programme

Development phase	Methodology	Main findings
Context analysis	Focused searches in PubMed Screening reference lists	• Outcomes of hospitalisation: functional decline, delirium, falls, incontinence, unplanned readmission, institutionalisation, death (1, 15-20) • Prognostic factors for negative outcomes: older age, functional impairment, cognitive impairment, impaired mobility, sensory deficits, mood disorders (21, 22) • Conceptual models: dysfunctional model, disability model, predisposing and precipitating risk interaction (1, 23, 24) • Effective care programmes: Acute care for Elders (ACE) units, Hospital Elder Life programme, geriatric co-management programmes (4, 25)
	Prospective cohort study on the cardiac care units of the University Hospitals Leuven (n= 63 patients) (14)	• Half of the patients developed functional impairments • Half of the patients recovered from their new disability • Physical restraints, urinary indwelling catheters without indication, pressure ulcer strategies and a longer length of stay were determinants for negative outcomes • Despite a multidisciplinary structure, significant delays in rehabilitation, discharge planning and nutritional therapy were observed

	Participant observations by a nurse researcher on the cardiac care units and the inpatient geriatric consultation team. Observations: context, environment, structures and processes of care. Pragmatic open interviews: barriers in daily care Impressions from the observations were noted at the end of the shift	• High turnover of medical supervisors and residents resulting in a lack of continuity of medical care • Little to no communication and coordination of care between disciplines and often no specific care goals were defined • Delays in starting rehabilitation and discharge planning because information on the patients' functional and cognitive status, and social situation was missing • Initiation of geriatrics consultation team was often late, with no or minimal interaction between teams and limited follow-up of patients • No integrated care plan addressing the geriatric needs of patients
Defining the scope	A meta-analysis including 12 intervention studies on geriatric co-management (5)	• Less functional decline, complications and a shorter length of stay • Improved discharge disposition with a structured discharge planning protocol • Improved survival when co-management by an interdisciplinary team • Low-GRADE evidence identified potential for better outcomes
	A systematic review including 46 studies described structures, processes and outcomes of geriatric co-management programmes (10)	• Medical review, discharge planning and rehabilitation were key programme components • Daily patient follow-up and weekly interdisciplinary team meetings were reported in most programme descriptions
	Stakeholder meetings and focus group discussions to examine goals and vision of stakeholders Participants: nurse managers, head nurses, nursing teams, physical	Key areas for improvement were: • Detection of geriatric syndromes • Delayed discharge • Length of stay • Detection of rehabilitation needs

	therapists, occupational therapists, dieticians, social workers, medical residents, medical supervisors, IT department and care programme managers.	• Team communication The primary outcome was the functional status of patients admitted to the cardiac care units.
Outcomes chain	Hypothesising cause-and-effect relationships between intermediary or process indicators and final outcome indicators	See programme theory (Figure 1)
Defining an outcome set to measure improvement	Two round international Delphi study with 33 experts (10) to identify appropriate and feasible structure, process and outcome indicators for geriatric co-management programme	Key programme indicators were: • Start co-management within 24 hours of admission • Define selection criteria for the programme (high risk patients) • Protocols for the prevention and management of geriatric syndromes: cognition, delirium, functional status, mobility, falls, pain, medication and pressure ulcers • Key outcomes: length of stay and the incidence of complications
	Stakeholder meetings were organised to identify the main outcomes that were relevant for the hospital.	Key outcomes were: • Length of stay (in particular of outlier patients) • Costs • Care efficiency: using resources for the right patient *See protocol paper for full list of indicators (12)*
Operationalising programme	Programme protocol development based on hospital protocols, NICE	See programme theory (figure 1) and programme description (Table 2)

	guidelines, and programme descriptions from systematic reviews Feedback and consensus meetings with stakeholders	
Defining resources	Stakeholder meetings and observational data	See programme theory (figure 1) and programme description (Table 2)

Phase 2: Implementation

Our implementation plan was based on the 'process of change model' by Grol and Wensing, which defines five phases of change: orientation, insight, acceptance, change and maintenance. (26) The maintenance phase was not investigated because of the short study period. Several actions in the development of G-COACH were also used in the implementation process. The full implementation strategy with theoretical frameworks is detailed in the protocol paper. (12)

For *orientation*, the goal was to create awareness and cultivate interest and involvement in the G-COACH programme. A stakeholder analysis identified all individuals who were interested in participating in the project. The results of the context analysis were shared with the stakeholders to create a sense of urgency for change. This was supported by promoting the new programme through an email by the head of the department and head nurses, and the publication of an information sheet on the participating units. The G-COACH programme was then formally introduced by the researchers on the participating units with support of the head nurses, explaining the goals and the expected timeline of the project.

For *insight*, the goal was that stakeholders understood what their current performance was, what the G-COACH programme was trying to achieve, and what was expected from them. Educational sessions were organised to inform stakeholders on the prevalence and incidence of geriatric syndromes on their unit, the intended change targets, and how the programme would achieve these by explaining the programme components and protocols.

For *acceptance*, the goal was that stakeholders perceived the programme as valuable and believed it was feasible to perform. Local leaders and champions on the units were asked to promote the programme on the unit and arrangements were made for staffing the geriatric co-management team. The developed protocols were made available and training sessions were organised using case discussions.

For *change*, the goal was to introduce the programme on a small scale so that stakeholders could experience the change and perceive it as a benefit and added value. An official launch of the program was communicated by the head of the department. To facilitate the change, electronic reminders and protocols were programmed in the electronic patient record. The implementation focused on learning the programme. We started with only one patient, discussed with the healthcare professionals how they perceived their competence, and gradually increased the caseload. At the start, researchers monitored the performance bedside allowing for direct feedback and discussion. In a later phase, cases were reviewed using the electronic patient file and

individual feedback was given. In the final phase, indicators were monitored using the electronic patient record and feedback was given at the group level to the team of healthcare professionals. Throughout this process, feedback was gathered by the research team and the protocols were further optimised in order to increase acceptability and feasibility. For this purpose, a working group of participating healthcare professionals was allowed to make adjustments to the protocol.

Phase 3: Feasibility

The programme was implemented using a one-group experimental study between November 2017 and May 2018 on two cardiac care units of the University Hospitals Leuven. (12) The feasibility was measured using a mixed-methods approach.

All patients aged 75 years or older were screened within the first three days of admission to the participating units. Patients were eligible to receive the programme if they were admitted for acute cardiovascular disease or Transcatheter Aortic Valve Implantation, had an expected length of stay of three days or longer and were not admitted from another hospital or unit. Written informed consent was obtained by the researchers. Healthcare professionals were recruited for the evaluation if they had four or more weeks of 'full time' experience with the programme. Oral informed consent from the healthcare professionals was obtained by the researchers.

Sample characteristics of patients were collected by researchers on admission to the unit (see Table 3). Demographic data included age, gender and living situation. Baseline clinical characteristics included functional status (Katz ADL index), (27) cognitive status (Mini Cog), (28) depressive symptoms (Geriatric Depression Scale 10-item version), (29) and nutritional status (Mini Nutritional Assessment short form). (30)

The reach of the programme was measured using the electronic patient records. A patient was considered to be 'reached' if a geriatric assessment and an interdisciplinary care plan was documented in the electronic patient record.

The fidelity and dose of the programme was observed using registrations in the electronic patient record and by patient interviews (e.g. whether or not the patient performed an exercise programme). The fidelity refers to how well the programme was implemented according to the protocol. (31) The dose refers to how much of the programme was implemented according to the protocol. (31) Indicators were derived from the programme theory and drafted before the start of the study. A standardised checklist was developed to score the indicators and was piloted with the first patients. The researchers monitored the performance on the indicators on a daily basis.

Patient experiences were captured using structured interviews. The questions were developed by the research team, internally reviewed, and piloted with the first patients Eighteen closed-ended questions informed after the perceived acceptability, usefulness and benefit of the programme. . This paper reports the main nine questions that were relevant for the evaluation. The patients were interviewed on the day of or the day before discharge from the hospital.

Implementation determinants were measured at two levels. First, we observed the extent to which our overall programme implementation was successful using an eleven-item survey developed by our research team. The questions were based on the implementation targets that were developed for the implementation strategy (see Table 6). Each question had five response options: completely agree, agree, neutral, do not agree and completely do not agree. The survey was piloted internally for 'readability' by five nurse and clinician researchers (the intended target population). Second, four focus groups and six individual interviews were organised to capture determinants (barriers and facilitators) for the implementation. The participants included nine cardiac care nurses, six geriatrics nurses, two head nurses, a geriatrician, three physical therapists, and six medical residents. One medical resident and social worker declined to participate. One social worker was on leave of absence and could not participate. An interview guide was drafted and was discussed with an experienced qualitative researcher. The interviews were conducted by one researcher and the focus groups by two researchers. All interviews were tape recorded and written out verbatim.

The sample size was informed by the work of Billingham et al. on the sample sizes of pilot studies. (32) We aimed to recruit 30 patients and 30 healthcare professionals who were exposed to the programme, because we believed this number was sufficient to inform us about the performance of the programme. After the first cohort of 30 patients we performed an interim analysis to identify areas for improvement and gave feedback. This process was repeated two more times. The aggregated data from the three cohorts are reported in this paper.

The analysis of the feasibility indicators were reported as frequencies and proportions. Sample characteristics were reported as frequencies and proportions for categorical data and mean and standard deviations for continuous data. Qualitative data were reported using a narrative and thick description. A thematic analysis was used to identify the determinants, i.e. reading the transcripts, initial coding, collating codes in themes, reviewing the themes and defining the themes. (33) The process was performed by two researchers and the results were discussed with the research team.

RESULTS

The G-COACH programme

The programme was initiated when patients aged 75 years or older were admitted to the cardiac care units after referral from the emergency department or outpatient clinic (see Figure 1). An electronic request for the co-management programme was made by the cardiac care nurse. A geriatrics nurse performed a geriatric assessment at the cardiac care unit. The assessment was used to stratify patients in one of three groups: patients at low risk or high risk for functional decline and patients with acute complications (see Table 2 for information about the risk stratification; see also chapter 4), and determined the care needs for the patient.

Patients at low risk for functional decline received care by the cardiac care team with no further follow-up by the geriatric co-management team. If indicated, the geriatric team could provide a proactive consult to the cardiac team based on the care needs identified in the geriatric assessment.

Patients at high risk for functional decline received daily follow-up by the geriatrics nurse, who developed an individual care plan for the patient with the cardiac care team. Individual care goals were determined with a particular focus on early rehabilitation and discharge planning. The geriatrics nurse was responsible for the coordination of the care plan and supported the cardiac care team with the implementation of protocols for the management of geriatric syndromes. All patients received physical therapy and were motivated to perform an individual exercise programme three times daily without supervision. Patients with cognitive or functional impairments were further assessed by the occupational therapist. If necessary, consultation by a dietician or speech therapist was requested. The patients were discussed with all care professionals in a weekly team meeting at the cardiac care unit.

Patients with acute complications received similar follow-up as patients in the group ‘high risk for functional decline’, with additional follow-up by a geriatrician.

Figure 1. G-COACH programme theory

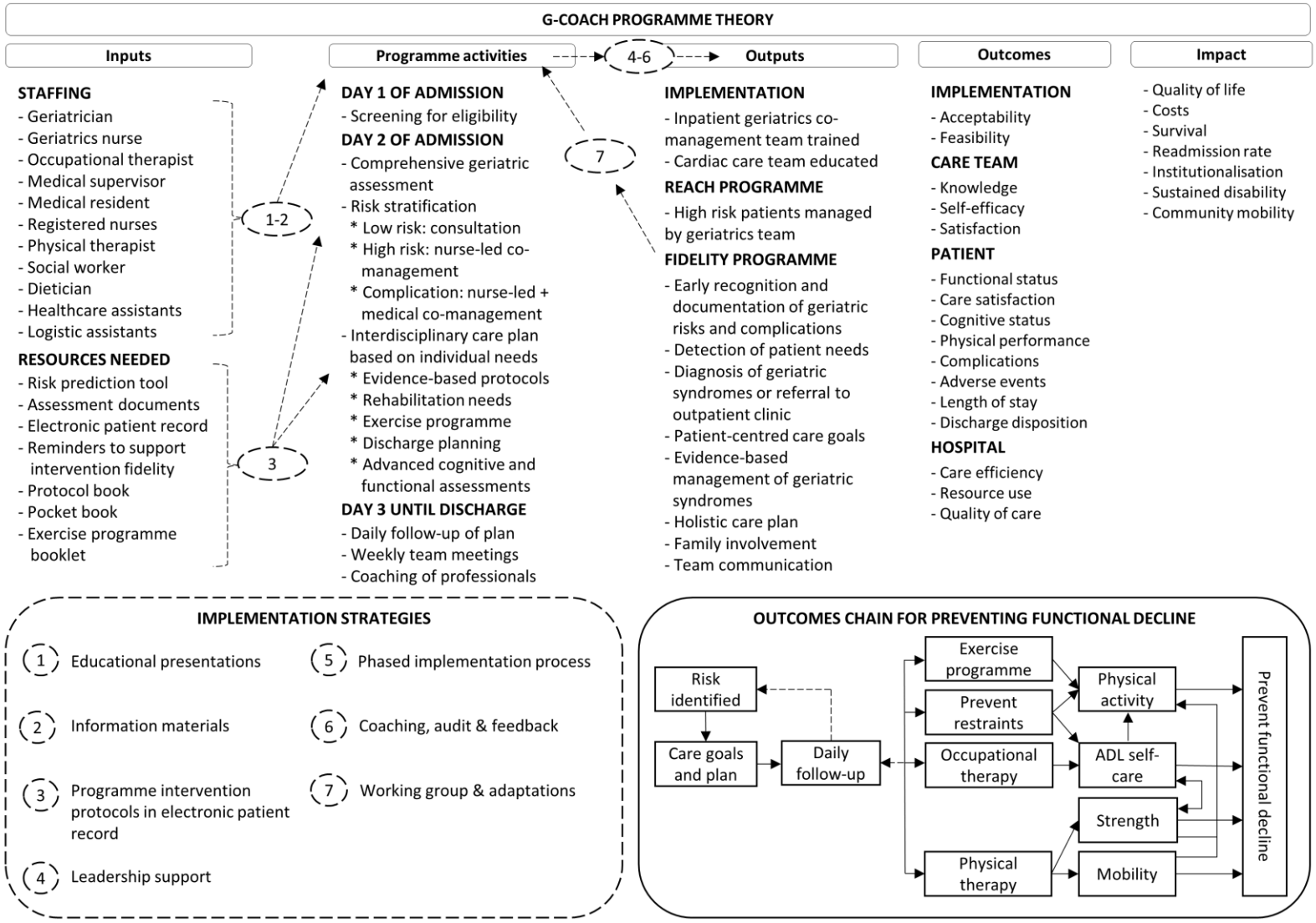


Table 2 Description of G-COACH programme based on TIDieR

Brief name	**G-COACH: Geriatric CO-management for ACute Hospiltalisation**
Why	Older patients admitted to the hospital have a high risk for developing functional decline. This often results in sustained disability and a lower quality of life. The underlying frailty profile of older patients predisposes them to complications. The hospitalisation context is often harmful for older patients, e.g. patients experience bedrest, are in a strange environment, receive harmful medications and are forced in a dependent position. G-COACH addresses this at two levels. First, assess the geriatric risks of patients. Second, organise acute care through an interdisciplinary care plan that is based on individual care needs of the patients.
How	The programme introduced an inpatient geriatric co-management team. Team members from the geriatrics department visited the cardiac care units to coordinate and manage the care for older patients. The introduction of this team on these units was considered the intervention.
Who	The inpatient geriatric co-management team consisted of • Geriatrician (0.1 FTE), a medical doctor with specialist training in internal medicine and geriatric medicine and extensive experience working on Acute Care for Elders units and geriatrics consultation services. • Geriatrics nurse (0.5 FTE), a registered nurse with a bachelor degree and extensive experience working on Acute Care for Elders units and geriatric consultation services. • Occupational therapist (0.3 FTE) with a bachelor degree and extensive experience working on Acute Care for Elders units and geriatrics consultation services.
What	The main components of the programme were: • Geriatric assessment including the living situation, formal and informal care at home, use of aids and assistive devices, patient and family expectations, functional status, fall history, cognitive status, delirium, depression, behavioural problems, nutritional status, substance (ab)use, voiding, pain, sleep, swallowing and use of physical fixation.

- A risk stratification for the outcome functional decline was based on a points score from the geriatric assessment, i.e. mobility impairment = 9 points, cognitive impairment = 7 points, poor appetite = 6 points, depressive symptoms = 5 points, and use of physical fixation or indwelling catheter = 5 points (see chapter 4). However, patients admitted for transcatheter aortic valve implantation were automatically considered as at risk patients because of their underlying frailty profile. A second stratification was made based on the presence of acute complications: delirium, behavioural problems, new incontinence, new urinary retention, and malnutrition. The patients were stratified in one of three groups:
    - Patients at low risk for functional decline (< 10 points): no follow-up by the programme. If indicated, the cardiac care team received a proactive consultation by the geriatric team.
    - Patients at high risk for functional decline (≥ 10 points): The patient received daily follow-up of the geriatrics nurse.
    - Patients with one or more acute geriatric complications: The patient received daily follow-up of the geriatrics nurse and a geriatrician.
- An individualised care plan included
    - Rehabilitation needs: A physical therapist focussed on functional strength and mobility. An occupational therapists performed a full assessment focussing on activities of daily living (ADL) if patients were functionally impaired. Based on this assessment, specific ADL training was discussed with the cardiac care nurse.
    - Individual exercise programme: A physical therapist instructed patients how to perform basic strength and mobility exercises that could be performed without supervision. To support the exercises, patients received a booklet. The patients were motivated by the therapists and nurses to perform the exercises three times a day. A visual reminder was placed in the patients' room.
    - Discharge planning: A social worker organised the discharge planning. An occupational therapist assessed the patients' ability and safety to return home, if this need was indicated by the geriatric assessment.

	○ Implementation of protocols for geriatric syndromes, including functional decline, fall risk, cognitive impairment, behavioural problems, delirium, depressive symptoms, (risk for) malnutrition, (risk for) obstipation, acute urinary incontinence, chronic urinary incontinence, acute urinary retention, (risk for) urinary tract infection, (risk for) pressure ulcers, pain, potentially problematic home situation, medication review. • Daily follow-up on the cardiac care unit was provided by the geriatrics nurse. The follow-up focussed on the implementation of the protocols, coaching of the cardiac care team and reassessing the status of the patients. • Daily team meeting within the inpatient geriatric co-management team were available. The geriatrics nurse had autonomy to coordinate the care for patients at high risk for functional decline, but the geriatrician was available if further discussion was needed. • Weekly team meetings were organised on the cardiac care units, which were attended by the geriatrics nurse. All patients were discussed focussing on the medical treatment, level of nursing care, rehabilitation and discharge planning.
Where	Two cardiac care units of the University Hospitals Leuven, with 16 and 26 beds, respectively. The unit was staffed with a cardiologist, one to two medical residents, 13.2 to 14.2 FTE registered nurses, 0 to 1.6 FTE healthcare assistants, 2.1 to 3.0 FTE to logistic assistants, 0.35 to 0.4 physical therapists, 0.4 to 0.5 FTE social workers and 0.5 FTE dieticians per unit.
When and how much	The programme was running on weekdays during office hours, and started the day the patient was admitted to the cardiac care unit. The aim was to include the patient within 24 hours of admission and to start the care plan within 48 hours of admission. The patient remained included in the programme until the day of hospital discharge.
Tailoring	The protocols were standardised but their implementation was tailored to individual care needs of patients. The inpatient geriatric co-management team was allowed to adjust the protocols based on their clinical expertise. For example, an agreement was made that patients admitted for transcatheter aortic valve implantation did not need daily follow-up by the geriatrics nurse if they demonstrated good postoperative recovery.

Modifications	Several modifications were made during the feasibility evaluation, based on the feedback of the participating healthcare professionals: • Initially, nurses were asked to remind patients to perform the individual exercise programme. Based on their feedback, i.e. they forget to remind patients, a visual reminder was added in the patients' room. • An additional screening document was developed to facilitate the risk stratification by the geriatrics nurse. The screening document was added to the assessment documents. • Initially, the research team screened the patients for the programme, but this responsibility was transferred to the cardiac care nurses. • The nurses reported that the discharge planning process was not optimal and not all social needs were captured, which resulted in delayed discharge. An additional questionnaire was developed to facilitate the assessment of a patients' social situation.
How well	The fidelity is detailed in Table 4

Feasibility indicators

A total of 638 patients were screened for inclusion and 151 patients gave their informed consent (see Figure 2). A total of 52 patients were stratified in the low risk group, 64 in the high risk group, and 35 in the acute complications group. The mean age was 84 years with men and women being equally represented (see Table 3). On average, patients had two ADL impairments (mean Katz score = 8 points), had moderate to poor cognitive status (mean Mini-Cog score = 2.7) and were at risk for malnutrition (mean Mini Nutritional Assessment score = 10.2).

The programme reached 91% of the patients, and in 37% of the patients the threshold of starting the programme within 24 hours was reached (see Table 4). For 67% of the patients, the programme started within 48 hours. The large majority of patients were correctly stratified in the low or high risk for functional decline group, but not in the acute complications group. For 17% of the patients, the wrong stratification resulted in having no care plan and follow-up by the geriatrics team. In patients correctly enrolled in the programme, 98% were co-managed by the geriatrics nurse, 83% received rehabilitation by the physical therapist, 69% received discharge planning by a social worker, and 35% completed the individual exercise programme in accordance with the prescribed procedures. Patients who did not complete the prescribed individual exercise programme either did not receive physical therapy (n = 8), refused to participate (n = 18), received physical therapy but the exercise programme was not instructed (n = 7), or were too close to discharge so that starting the programme was not deemed relevant (n = 3). In patients correctly stratified in the group with acute complications, 86% received follow-up by a geriatrician and 71% had their medication reviewed.

Figure 2. Flowchart of recruitment

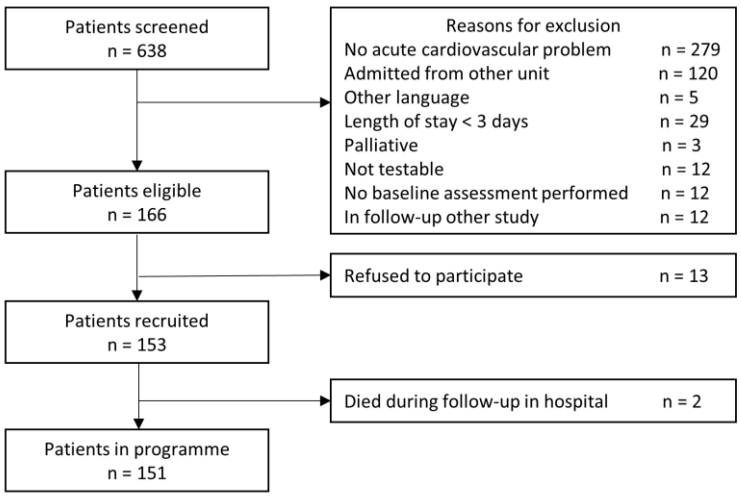


Table 3. Sample characteristics

Characteristics	Sample
Age, mean (SD)	83.8 (4.7)
Male gender, n (%)	76 (50.3)
Living situation, n (%)	
- Home	139 (92.1)
- Service flat	4 (2.6)
- Retirement home	8 (5.3)
Katz ADL index (score 6 – 18), mean (SD)	8.0 (2.6)
Mini Cog (score 0 – 5), mean (SD)	2.7 (1.5)
Geriatric Depression Scale (score 0 – 10), mean (SD)	1.6 (2.1)
Mini Nutritional Assessment (score 0 – 14), mean (SD)	10.2 (2.4)
Stratification to intervention group, n (%)	
- Low risk for functional decline	52 (34.4)
- High risk for functional decline	64 (42.8)
- Acute complication	35 (23.2)

Legend: Abbreviations: ADL = Activities of Daily Living; SD = Standard Deviation; Note: The values underlined in the scales indicate the 'best' score.

Table 4. Feasibility indicators of the G-COACH program

Indicators for management by inpatient geriatric co-management team	**Adherence**
Reach, n (%)	137/151 (91%)
Correct stratification to intervention group, n (%)	
- Low risk for functional decline	40/44 (91%)
- High risk for functional decline	53/60 (88%)
- Acute complication	7/33 (21%)
Patients in programme with follow-up by geriatrics nurse, n (%)	42/43 (98%)[a]
- Median number of days to start co-management (IQR)	2 (2)
- Start within 24 hours of admission, n (%)	16/43 (37%)
- Start within 48 hours of admission, n (%)	29/43 (67%)
- Start within 72 hours of admission, n (%)	38/43 (88%)
- Median proportion of patients with appropriate follow-up (IQR)	0.50 (0.71)
- Patients with documented geriatric risks and complications in electronic patient record, n (%)[b]	43/43 (100%)
- Median proportion of geriatric risks accurately documented in electronic patient record (IQR)	0.80 (0.21)
Patients receiving co-management by geriatrician, n (%)	6/7 (86%)
- Median proportion of patients with appropriate follow-up (IQR)	1 (0.5)
- Median proportion of complications accurately documented in electronic patient record (IQR)	1 (1)
- Patients co-managed by geriatrician receiving medication review, n (%)	5/7 (71%)
- Documentation of precipitating factors for complications in electronic patient record, n (%)	6/7 (86%)
Indicators for management of geriatric risks and complications[c]	**Adherence**
Patients at risk for functional decline receiving physical therapy, n (%)	50/60 (83%)
Patients at risk for functional decline performing an individual exercise program, n (%)	20/58 (35%)[d]

Indicators for management of geriatric risks and complications[c]	Adherence
Patients with functional impairments receiving ADL training by an occupational therapist, n (%)	24/39 (62%)
Patients with mobility impairments have access to an ambulatory device on the unit, n (%)	25/29 (86%)
Patients at risk for malnutrition receiving nutritional therapy, n (%)	43/52 (83%)
Median proportion of accurate documentation of nutritional intake during meals (IQR)	0.73 (0.26)
Patients with potential discharge problems receiving discharge planning, n (%)	27/39 (69%)
Patients with potential cognitive impairment receiving cognitive assessment, n (%)	24/36 (67%)
Median proportion of DOSS observations in patients at risk for delirium (IQR)	0.56 (1)
Median proportion of DOSS observations in patients with delirium (IQR)	0.39 (0.58)
Appropriate use of oral laxative or enema for (risk of) obstipation, n (%)	5/6 (83%)
Patients remaining free from a urinary catheter if no indication is present, n (%)	54/60 (93%)
Median proportion of appropriate use of pain medication (IQR)	1 (0.42)
Median proportion of appropriate re-evaluation of pain within 1 hour (IQR)	1 (0.81)

Legend: Abbreviations: SD = Standard deviation, IQR = Interquartile range, DOSS = Delirium Observation Screening Scale; a Numbers are based on patients who were reached by the programme, correctly stratified and had an active risk status that required follow-up by the inpatient geriatrics co-management team (11 patients did not require follow-up and were not included in the analysis); b Geriatric risks and complications included the presence or risk for functional decline, falls, cognitive decline, delirium, depression, malnutrition, obstipation, incontinence, urinary retention, pressure ulcers, pain, discharge problems, delirium, behavioural problems; c Indicators were scored for patients at risk for functional decline and for patients with complications; d Two missing data

Experiences with the programme

Nineteen five percent of patients included in the G-COACH programme found the care acceptable and 96% indicated that the programme addressed their care needs (see Table 5). However, only 72% of patients understood why they received the programme and 63% felt involved in their care. A vast majority of the patients who completed the exercise program, found the individual exercises acceptable (97%), feasible and safe to perform (96%), an added value to their care (89). About half of the patients (49%) were reminded to perform their exercises. Less than half of the patients (43%) believed that it would improve their functional status.

A total of 48 healthcare professionals completed the survey on implementation determinants. The participants included 35 nurses, three physical therapists, one social worker, two healthcare assistants, four occupational therapists, one dietician and two geriatricians. Almost all healthcare professionals indicated that they knew the programme (98%) and its components (96%), and perceived it as an added value to the care for older patients on the cardiac care units (94%). A total of 94% found the programme acceptable and 74% found it feasible to perform. However, only 49% indicated that the programme was fully integrated in their routine practice.

Implementation determinants

The most important determinant for the implementation of the programme was the staffing of the geriatric co-management team (see Table 6). The participants indicated that the anticipated staffing of a dedicated geriatrics nurse was not available. As a result, the geriatrics team had to combine their co-management role on the cardiac care units and their consultation role on other wards. For example, they had to see three patients in the co-management programme but also two other patients in the consultation programme on a different unit. They felt that they could not complete the programme as intended which negatively impacted the reach and the fidelity of the programme. The competition in roles and tasks created tension and stress, and was an important barrier to fully integrate the programme on the cardiac care units. Adapting the programme to the context and current needs of the teams was an important determinant for dealing with these stressors. However, they also noted concerns that deviations from the key protocols, because of time constraints, would likely decrease the impact of the programme. The head nurses played a key role in motivating their teams in the participation of the programme, and facilitating the communication with the project team.

Table 5. Experiences with the programme

Patients	**Sample, n (%)**
Patients perceive the programme as acceptable	105/111 (95%)
Patients understand why they are included in the programme	80/111 (72%)
Patients perceive the programme as an added value to their care	80/111 (72%)
Patients perceive the geriatric assessment as acceptable	98/111 (88%)
Patients feel involved in the programme	69/110 (63%)
Patients report that all their needs were addressed by the programme	105/109 (96%)
Healthcare professionals	**Sample, n (%)**
Healthcare professionals are aware that the programme exists	47/48 (98%)
Healthcare professionals have theoretical knowledge about geriatric risks of older patients on cardiac care units	38/47 (81%)
Healthcare professionals know the components of the programme	45/47 (96%)
Healthcare professionals have knowledge about the specific G-COACH programme protocols	35/47 (75%)
Healthcare professionals are motivated to change their care and participate in the programme	43/47 (91%)
Healthcare professionals perceive the programme as acceptable	44/47 (94%)
Healthcare professionals perceive the programme as feasible	35/47 (74%)
Healthcare professionals perceive the programme as an added value	44/47 (94%)
Healthcare professionals believe that the programme achieved its aim to prevent hospitalisation-associated functional decline	34/47 (72%)
Healthcare professionals believe that if there are problems with the programme, these will be addressed	41/47 (87%)
Healthcare professionals believe the programme has been integrated in the daily routine	23/47 (49%)

Table 6. Implementation determinants related to the experiences of healthcare professionals

Implementation determinants	Information about the determinant	Selected citations from interviews and focus groups
Belief in usefulness	The belief that the programme would be useful to improve the services of the geriatrics department and lead to better patient outcomes fuelled the implementation.	"The literature demonstrated that co-management had better outcomes than geriatric consultation, and we were looking for ways to improve our liaison services. So we wanted to investigate if this model, that focusses more on an integrated collaboration between teams, has better outcomes."
Project communication	Personal contacts between the project team and the participating healthcare professionals and informal contacts between the participating healthcare professionals were key in creating awareness of the programme, and were preferred over emails and telephone calls. Information sessions created awareness, but not necessarily knowledge on how to perform the programme. This was likely moderated by the complexity of the change: information was sufficient if the change was simple and small but not if the change was complex or large.	"I know that there was an email about the programme but I probably did not read it. Because if you start your rotation you receive a thousand emails and you have to start planning your care." "The supervisors knew the programme and when you start here on the unit information will find you … I think that somebody from the programme approached me and I had heard of it so I just asked for some more information. That was really sufficient." "The programme was presented several times and we received a lot of information but there is always uncertainty how things will go once we bring the theory to practice."

Co-development	A formal needs assessment was necessary for the development of the programme. The assessment had to go beyond quantitative indicators but also include understanding the care culture and routine on the units. The participating healthcare professionals also found it important to understand each other's needs and care routine. The involvement of local leaders and champions was not sufficient. Involvement needed to reach all participants to facilitate a feeling of ownership. It was key that the programme was not designed as a study but that participants felt that they could tailor it to their needs.	"If nurses from our team work on the project it creates a lot of enthusiasm and we feel that we are part of it." "It is important to reach all nurses. There is a difference between a head nurse that is involved, and all other nurses ... they may not be so motivated. The nurses can't have the feeling that they have to do it for a study." "You have to understand practically how they are caring for older patients. We need to work together and experience how things are organised on a daily basis. Then it is easier to see how we can improve care for older patients."
Scaled implementation	A scaled implementation approach, i.e. start small and build the volume of the programme over time, facilitated the learning process and the implementation. It allowed healthcare professionals to try the program and adjust it, which decreased the resistance to change.	"At the beginning, we were afraid of the workload but once we started it went really well. The change was not drastically and it helped to find areas of the program that were not working well."
Learning & skills development	Learning to perform the programme took time and was moderated by several mechanisms: feedback on performance, checklists, protocols and visual reminders. The stakeholders also suggested that case discussions with the entire team would have been helpful. While experimenting with the programme was perceived as useful, complex skills (e.g. coaching) required formal training.	"It is always an adjustment trying something new and it takes time making that transition … You have to experience it and try do to it on your own and learn through the feedback that we received." "The protocols were useful to have. After seeing your patient, you could review what protocols needed to be implemented."

Exposure to the program	A sufficient caseload (exposure/experience) was needed to learn the programme.	"Sometimes it looks as if nurses had not learned from the programme but they may not have had many experience or may not have seen many patients in the programme". "Because of the high staff turnover in medical residents they had not a lot of exposure to the program and were not always well informed."
Feedback & adaptations	Adapting the programme to stakeholder feedback was key to ensuring the feasibility. Regular meetings with the project team and a working group with the participating healthcare professionals facilitated this process. The primary concern was workload and staffing levels. The project team had a central role in collecting the feedback and steering the change. This was both a facilitator and a barrier because it may have inhibited the communication between the different teams. It was also noted that adapting the programme too much may limit the clinical impact as key interventions may be compromised.	"It would have been very difficult to perform the original programme with the available staffing levels. The programme has become more feasible but that may also have changed the effectiveness and the expected level of involvement". "With every step, our feedback was asked and there was a lot of willingness to listen and our feedback was always addressed." "At the working group meetings I could easily discuss the programme with my colleagues and what needed to change … because the program is never really finished."
Leadership	Head nurses had a key role in motivating the healthcare professionals to change their care routine, address fears for change and perform the programme. The leadership style was an important moderator. However, this also meant that when the head nurse was absent, the performance dropped.	"Once a new head nurse was appointed we knew that additional staff would be hired. That gave us reassurance and we believed that the programme would be more feasible." "I believe that it very much depends on the head nurse, and how they lead the team … you can see it when the

		head nurse is not present, then things did not go so well."
Management support	The perceived lack of support by management to facilitate a good working environment was considered a barrier and was probably related to work motivation.	"Our working environment is not really ideal … and we don't have the support of the hospital management. If we raise our concerns, nothing happens."
Resources	Having dedicated resources for the programme was considered important, which included financial resources for dedicated staffing and having a good work infrastructure.	"The staffing levels will really determine if we can make it a success. Now I know that we really need a dedicated nurse every day for the programme." "Initially you start with project funding so you can experiment. But when the project stops and think its valuable you need to be able to continue it."
ICT infrastructure	ICT facilitated the integration of the programme in routine care by becoming more visible. It was perceived that its value was limited by the waiting list by ICT-services.	"If you see the risk score for the patient on your screen, you automatically know that the patient is in the programme and that they are working with the patient." "The Electronic Patient Record has many possibilities but our ICT services need time to programme new modules."
Competing tasks	The programme was influenced by the larger strategy of the department. Projects and tasks outside the programme were a barrier to performing the programme.	"Medical residents are not really that involved, they have a lot of other tasks and the project is not high on their priority list." "The geriatrician was supposed to see the patients on the units and discuss the care with the residents, but they have received a lot of new tasks since the start of the programme so they don't have the time anymore."

DISCUSSION

This study aimed to develop, implement and evaluate the feasibility of a geriatric co-management programme for older patients admitted to the hospital. A mixed methods approach was used and resulted in a programme that was perceived acceptable and feasible to perform on the cardiac care units. This was confirmed by the indicators that demonstrated a good reach and fidelity for most of the programme's core components: geriatric assessment, risk stratification, physical rehabilitation and discharge planning.

Even though the implementation was considered successful, important barriers remained. The staffing levels of the geriatric team, and in particular the geriatricians, prevented sufficient follow-up of acute geriatric complications. Our aim was to use a stakeholder-based development process and adaptive design to fit the programme as best as possible to the context. However, our results infer that structural changes to the context would be needed to improve effective follow-up by the inpatient geriatrics co-management team. (34) For example, the programme was never allotted the defined staffing levels because of competing demands from other projects and tasks in the inner setting. This probably explains why half of the participating healthcare professionals indicated that there was no full integration of the programme into their daily routine.

Furthermore, one of the core components, i.e., the individual exercise programme, was only completed by one third of the patients, mainly because patients were not intrinsically motivated. However, adherence to physical activity is a complex challenge. Patients understand that exercise is important but this does not translate in better adherence to exercise protocols. (35) Several studies have observed a very low level of activity of patients in the hospital, which is associated with functional decline. (36-38) Additional strategies, beyond the reminders that we used, are needed to stimulate the intrinsic motivation and support the self-efficacy of the patients. For example, The SPRINT programme observed that supervision of a health professional was the most important facilitator for patients performing their exercise program on a geriatrics unit. (39)

The developed care model is the first nurse-led geriatric co-management programme for acute hospitalisations. This is different from most co-management programmes that are fully dependent on geriatricians, but who are often not available in clinical practice. (40) The need for healthcare professionals trained in geriatric care and effective care models for older patients will continue to grow with the ageing hospital population. We therefore developed the first formal programme theory, with TIDieR

description to support the replication, for a nurse-led inpatient geriatric co-management care model.

The development of a programme theory was needed because current evidence regarding co-management is limited to outcome evaluations with poor programme descriptions. Besides describing the programme theory in detail, we also described the first standardised implementation strategy for a geriatric co-management programme. The implementation strategy was based on the relevant behaviour change models and theory (which is reported elsewhere). (12, 26, 41) Our qualitative results confirm the importance of multiple constructs of the 'Consolidated Framework for Implementation Research'. Most notably, the availability of resources in the 'inner setting', the adaptability and trialability of the 'intervention characteristics', and the champions in the 'process' were the key determinants for the implementation. (42)

Since the inception of geriatric co-management in the 1950s, the evidence has remained limited to effectiveness data in patients with a hip fracture. However, many other patient populations are frail and could benefit from this model of care. (8) Our results indicate that both patients and healthcare professionals perceive co-management as an added value to conventional care on cardiac care units. Apart from exploring the value of co-management outside hip fracture samples, several actions are needed to move the evidence and availability of the model in clinical practice forward. To date, there have been no multicentre and pragmatic trials to confirm the evidence and quantify the cost-effectiveness. Neither have implementation studies been performed, nor have implementation outcomes been measured. A hybrid effectiveness-implementation design can prove useful to address these gaps in the evidence. (43)

Several considerations should be made when interpreting our results. For the fidelity and dose indicators, we mostly used registrations in the electronic health records. Not all care actions were registered, and registrations could have been made without the interventions being performed. We also did not assess the quality of the interventions. For example, we only observed whether there was physical therapy and not how well the therapy adhered to the protocol for each individual patient. The interviews were performed by two junior researchers with no prior experience in qualitative analysis. However, the interview guides were discussed with an experienced qualitative researcher. We used self-developed questionnaires to describe the experiences of the participants. Validation was omitted because we were not interested in developing a scale. Lastly, the evaluation of the feasibility was limited to a few months and we did not collect data on the sustainability of the implementation.

Conclusion

A multi-phased and stakeholder-centred approach resulted in the successful initiation of a geriatric co-management programme that was perceived acceptable and feasible to perform. Staffing, competing roles and tasks of the geriatrics nurse (i.e., balancing consultation and co-management), and leadership support were key determinants for the implementation. Further research on the sustainability of the implementation is needed. The results of this feasibility study were used for the design of an effectiveness study with the aim of preventing hospitalisation-associated functional decline so that patients are discharged from the hospital with less ADL disability (see chapter 7).

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CHAPTER 7

Effectiveness of the geriatric co-management programme

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ABSTRACT

Importance: Older patients often suffer functional decline and sustained disability during their hospital stays.

Objective: Evaluate whether nurse-led geriatric co-management leads to better functional status at hospital discharge, in comparison with geriatric consultation upon request.

Design: A before-and-after design recruited patients in the control group (2016 – 2017) and the intervention group (2018). The main endpoint was at hospital discharge, with follow-up at six months.

Participants: Patients aged 75 years or older admitted for acute cardiovascular disease or transcatheter aortic valve implantation were consecutively recruited on two cardiac care units of the University Hospitals Leuven, Belgium (n = 454). Patients were eligible for co-management if they were at risk for functional decline or had one or more acute complications (n = 309).

Interventions: Comprehensive geriatric assessment within 24 hours of admission by a geriatrics nurse. Interdisciplinary care plan drafted in collaboration with the cardiac care team. Daily follow-up of patients by geriatrics nurse, focusing on early rehabilitation and discharge planning, completion of exercise program, implementation of protocols for preventing geriatric complications, and coaching the cardiac care team. A geriatrician co-managed patients with acute complications.

Main outcomes and measures: The primary outcome was functional status measured using the Katz Index for independence in Activities of Daily Living (ADL). Secondary outcomes included the incidence of ADL decline and complications, length of stay, hospital costs, unplanned readmissions, survival, and quality of life.

Results: The mean age of patients eligible for co-management (control group: 185; intervention group: 151) was 85 years; 53% were male. Intervention group patients had better functional status at hospital discharge (Katz ADL = 8.9, 95% CI (8.7 to 9.3) versus 9.5, 95% CI (9.2 to 9.9); p = 0.019), and experienced 18% less functional decline during hospitalization (25% versus 43%, 95% CI (-28% to 7%); number needed to treat = 6). The intervention group experienced significantly fewer cases of delirium and obstipation during hospitalization, and significantly fewer nosocomial infections. At the 6-month follow-up, patients had better functional status and quality of life. There were no significant differences regarding length of stay, hospital costs, readmissions, or survival.

Conclusions and relevance: Geriatric co-management on cardiac care units significantly improved patient outcomes at equal cost.

INTRODUCTION

Hospitalized patients often experience physical inactivity, forced dependency, poor nutritional intake, and exposure to harmful medications. (1, 2) This leads to functional decline, which can cause sustained disability, hospital readmissions, and high societal costs. (3-5) Therefore, interdisciplinary care based on a comprehensive geriatric assessment (CGA) is advocated. In many settings, CGA is implemented using bedside geriatric consultations. However, multiple systematic reviews have concluded that this is not an effective model of care. (6, 7)

In response, geriatric co-management programs that include CGA are emerging as care models for older acute-care hospital inpatients. (8) These involve primary care and geriatrics teams collaboratively managing patients through a shared decision making process. They also often include preoperative or early geriatric assessment and patient optimization, geriatric order sets, management of complications and comorbidities, focusing specifically on geriatric rehabilitation and discharge planning. (9, 10)

Systematic reviews have concluded that geriatric co-management reduces functional decline, complications, length of stay, and mortality rate. (11, 12) A recent European survey observed that one-third of participating hospitals had at least one geriatric co-management program, while another third indicated intentions to start one within five years. (13) Further, the Society for Perioperative Assessment and Quality Improvement recommends geriatric co-management of frail patients undergoing surgery. (14) However, evidence of these programs' effectiveness is currently limited to the hip fracture population. As numerous other patient populations have a high predisposing risk for complications, they would also potentially benefit from co-management.

Therefore, we implemented the first nurse-led geriatrics co-management program and evaluated whether it led to better functional status at hospital discharge for frail patients hospitalized on cardiac care units. Secondarily, we performed a process evaluation to determine the program's reach and fidelity. In addition, we clarified how and for whom the program worked best.

METHODS

As part of the Geriatric CO-management for ACute Hospitalisation (G-COACH) project, the reported program used a mixed-methods multi-phase design to develop the intervention and test its feasibility. (15) Its development began with a meta-analysis, (11) followed by a contextual analysis, (16) an international Delphi study to develop quality indicators, (10) and a cohort study to develop a prediction model for hospitalization-associated functional decline. (17) Its feasibility was tested in a one-group experimental pilot study (chapter 6). The protocol was registered on clinicaltrials.gov (NCT02890927) and the study approved by the Medical Ethics Committee UZ KU Leuven (s59543).

Design

This nonrandomized controlled study with before-and-after design was conducted on two cardiac care units of the University Hospitals Leuven. Patients in the control group were recruited between September 2016 and June 2017 before the program was implemented and its feasibility evaluated. (15) Patients in the intervention group were recruited between January 2018 and December 2018. (15) A consecutive sampling strategy was used for both groups. Patients aged 75 years or older were recruited within 72 hours of admission to the participating units. They were eligible if admitted for an acute cardiovascular disease or transcatheter aortic valve implantation with a length of stay of three days or longer, and if they were testable. Patients were excluded if they were admitted from another unit or hospital or were receiving palliative care. The study was designed to measure the intervention's effectiveness in patients at high risk for functional decline or experiencing acute complications. After informed consent was obtained, trained researchers performed the baseline assessment and collected daily data until hospital discharge. This information was used to stratify patients into three groups: 1) low risk for functional decline; 2) high risk for functional decline; or 3) experiencing acute complication (see supplementary text 1 for the prognostic and diagnostic criteria used). Patients at low risk for functional decline were excluded from the final sample.

At six months, patients were contacted for follow-up via a postal survey and telephone interview.

Usual care

The control group received acute care on their cardiac care units from a multidisciplinary team consisting of a medical supervisor, two medical residents, a head nurse, several registered nurses and healthcare assistants, a physical therapist, a dietician, and a social worker. Medical rounds took place daily, and patients were discussed weekly during a multidisciplinary team meeting. Geriatric consultations could be requested on a case-by-case basis (not systematically, at the discretion of the cardiac care team. A CGA was performed, the results recorded and oral recommendations given.

Intervention

The geriatric co-management program was implemented by a mobile geriatrics team. This included a geriatrician (0.1 FTE), a geriatrics nurse (0.5 FTE), and an occupational therapist (0.3 FTE). The geriatrics nurse visited patients within 24 hours of admission to the cardiac care unit. A geriatric assessment was performed to stratify patients into one of the three groups (independent of the research team; see also Design section). (17)

Patients at risk for functional decline or with acute complications were included for follow-up in the co-management program until hospital discharge. This included the drafting, in collaboration with the cardiac care team, of an interdisciplinary care plan. The care plan had three key components: initiation of discharge planning and physical rehabilitation within 48 hours of admission (including a patient exercise program performed independently three times a day to promote physical activity); promotion and training of self-care (in activities of daily living) by an occupational therapist; and evidence-based protocols for the prevention of geriatric syndromes and complications.

The geriatrics nurse who coordinated the program visited the units daily to provide follow-up, reassess patients and coach the cardiac care team on the interdisciplinary care plan implementation. As the person responsible for the management of new-onset geriatric syndromes and complications, the geriatrician discussed the patient's care with the cardiac care team's medical resident.

Outcomes

Our primary outcome was functional status at hospital discharge, measured using the 6-item Katz Index of independence in Activities of Daily Living (Katz ADL) with a 3-scale response scale (1 = independence; 2 = partial dependence; 3 = complete dependence). (18)

Four secondary outcomes were assessed during hospitalization: the occurrence of delirium (3D Confusion Assessment Method); (19) symptomatic nosocomial infections (clinical diagnoses); obstipation (nurse-recorded observations); and the occurrence of at least one fall incident (patient-reported or nurse-observed). At hospital discharge, seven more were assessed: decline of one or more points on the Katz ADL between hospital admission and hospital discharge (i.e. functional decline); physical performance (via the Short Physical Performance Battery); (20) grip strength (with hand dynamometer); cognitive status (via the Mini-Cog© instrument); (21) length of stay; quality of life (via the EQ-5D-3L); (22) and self-perceived health (via a VAS). (22) And at the six-month follow-up, the final eight secondary outcomes were assessed: functional status (via the Katz ADL scale); (2) survival; unplanned hospital readmissions; institutionalization; level of community mobility (via the Life Space Assessment); (23) occurrence of falls; quality of life; and self-perceived health.

A process evaluation was performed to observe the program's reach and fidelity, i.e. the start and timing of geriatric co-management and physical therapy, completion of the exercise program, ADL training by an occupational therapist, and the absence of physical restraints.

Sample size

The sample size was calculated for patients who were at high risk for functional decline or had acute complications and who were included for follow-up in the program. We assumed a minimal important difference (MID) of one point on the Katz ADL between the intervention groups at hospital discharge, with a standard deviation of three points (based on observations in a pilot study). (16) Accounting for 10% missing data, 159 patients were needed per group (alpha = 0.05, power = 0.8, two-sided test). We aimed to recruit 227 patients per group because we expected that 30% of recruited patients would be at low risk for functional decline and not be eligible for follow-up.

Statistical methods

Baseline characteristics were described and compared between the intervention and control group to evaluate the baseline equivalence (see Table 1; see supplement text 2). A missing data analysis was performed for baseline characteristics and outcomes. Multiple imputation was used for five baseline characteristics with missing data (< 6%; supplement text 3). The primary outcome, functional status at hospital discharge, was evaluated using an ANCOVA model. Baseline characteristics were included in the model to account for potential confounding (see supplement text 4).

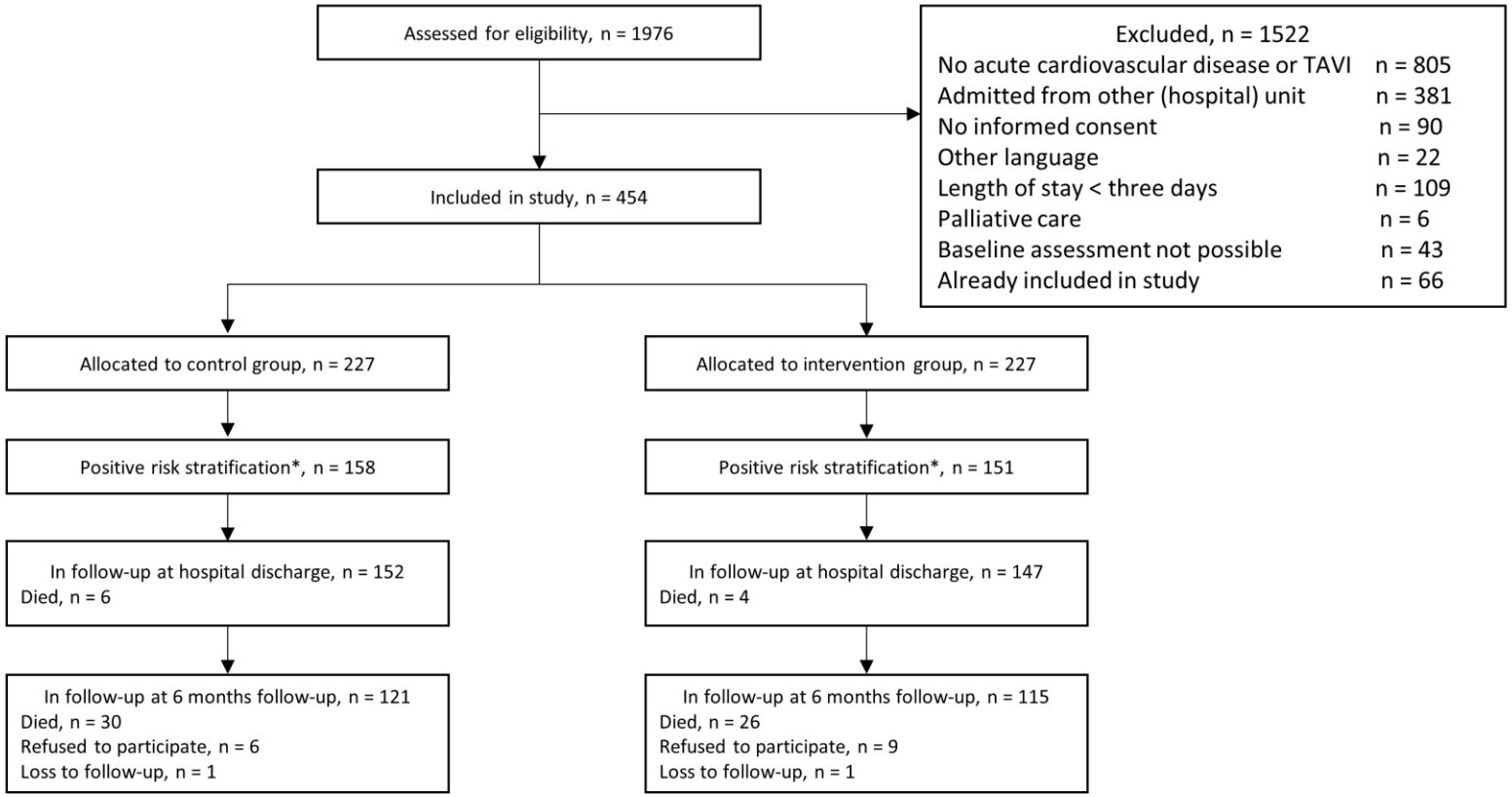
We hypothesized *a priori* that the intervention's effect on functional status would be higher, i.e. moderated, in patients with heart failure and in those at high risk for functional decline (see supplement text 5). Heart failure status was determined by a diagnosis recorded in the patient record by the cardiac care medical staff. The risk for functional decline was calculated for each patient based on a validated prediction score. Patients were divided in three groups (scores 0 – 11 = low risk; 12 – 17 medium risk; > 17 high risk) based on the quantiles of the distribution. We further hypothesized *a priori* that the effect would be similarly mediated when the intervention fidelity was high. We used propensity score matching to create equivalent groups of 'low and high fidelity patients' in the control group, and to estimate the average treatment effect of the treated for six intervention fidelity indicators (see supplement text 6). These hypotheses were tested by extending the ANCOVA model with subgroups for the moderator and mediator variables and testing their statistical interaction with the intervention groups. The indirect 'mediation' effect was quantified using a linear regression-based causal mediation analysis.

Logistic regression was used for dichotomous outcomes, survival analyses for time to event variables (with mortality defined as a competing risk for the outcome readmission), and ANCOVA for mean inter-group differences (see supplement text 4). Effect estimates were adjusted for baseline characteristics. SPPS version 26 and STATA version 15 IC were used for the analyses. Statistical inference was based on 95% confidence intervals. See supplementary text for a detailed description of all statistical analyses.

RESULTS

A total of 1976 patients were screened, of which 544 fulfilled the preliminary requirements for participation (including informed consent). Following risk stratification (to determine eligibility for geriatric co-management), respectively 151 and 158 remained (see Figure 1). Minor baseline differences were observed between these groups regarding cognitive status (0.4 points on a 5-point scale), anxiety symptoms (0.8 points on a 21-point scale), and multimorbidity (1.7 points on a 56-point scale) (see Table 1). At six months, 115 intervention group patients and 121 in the control group were available for follow-up. Characteristics of the patients lost to follow-up are described in Supplementary table 1.

Figure 1. Flowchart



Legend: Patients aged 75 years or older and admitted for acute cardiovascular disease or transcatheter aortic valve implantation (TAVI) were recruited for the study; * Risk stratification determined if patients were eligible for geriatric co-management, i.e. patients at risk for functional decline or with acute complications.

Table 1. Baseline characteristics

Baseline characteristics	Control (n = 158)	Intervention (n = 151)	p-value
Age, mean (SD)	84.9 (4.8)	84.5 (5.2)	p = 0.482
Male gender, n (%)	82 (52)	82 (54)	p = 0.672
Living situation, n (%)			p = 0.840
- Home	140 (89)	131 (87)	
- Retirement home	5 (3)	4 (3)	
- Nursing home	13 (8)	13 (9)	
Reason for hospital admission, n (%)			
- Heart failure	60 (38)	65 (43)	p = 0.060
- Valvular heart disease	5 (3)	3 (2)	
- Ischemic heart problem	16 (10)	4 (3)	
- Heart rhythm disorders	22 (14)	15 (10)	
- Transcatheter Aortic Valve Implantation	38 (24)	39 (25)	
- Other	17 (11)	25 (17)	
Katz ADL (6 – 18), mean (SD)			
- Two weeks before admission	8.6 (2.3)	8.6 (2.6)	p = 0.981
- On hospital admission	9.0 (2.7)	9.6 (3.1)	p = 0.072
Mini Cog (0 – 5), mean (SD)	2.8 (1.5)	2.4 (1.5)	p = 0.032
Geriatric Depression Scale (0 – 10), mean (SD)	2.6 (2.3)	2.2 (2.3)	p = 0.163
Hospital Anxiety [a] (0 – 21), mean (SD)	4.2 (3.6)	3.4 (3.3)	p = 0.043
Mini Nutritional Assessment (0 – 14), mean (SD)	8.9 (2.4)	8.8 (2.4)	p = 0.790
Life Space Assessment (0 – 120), mean (SD)	39.9 (26.0)	39 (22.6)	p = 0.779
Short Physical Performance Battery (0 – 12), mean (SD)	3.8 (3.5)	4.1 (3.3)	p = 0.444
Grip strength (mmHg), mean (SD)	20.3 (9.5)	19.8 (7.6)	p = 0.624
Cumulative Illness Rating Scale (0 – 56), mean (SD)	20.9 (5.9)	19.2 (5.2)	p = 0.007
Number of medications, mean (SD)	8.8 (3.7)	9.2 (3.6)	p = 0.280

Legend: abbreviations: SD = Standard Deviation; ADL = Activities of Daily Living; Underlined values indicate the best scores on the respective scales. a The Hospital Anxiety subscale of the Hospital Anxiety and Depression Scale was used;

Fidelity to the intervention

The program was offered to 88.1% (133/151) of the patients assigned to the intervention group (see supplementary table 2). A total of 80.0% received a CGA and had an interdisciplinary care plan documented in their records (122 of 151). This was completed within 24 hours for 51.6% (63/122) of the patients. Of the patients eligible for the co-management program, 78% (118/151) received physical therapy; 36.4% (55 of 151) started within 48 hours of admission. Of the 58 who experienced acute functional decline during hospitalization, 35 (60%) received ADL training by an occupational therapist. Forty percent (61 of 151) of co-managed patients completed the individual exercise program; 19.2% (29 of 151) started within 48 hours of admission; and 21.2% (32 of 151) performed their exercises daily; 64.9% (98 of 151) remained free from physical restraints (including urinary catheters).

Effect on functional status

At hospital discharge, patients in the geriatric co-management group were less dependent than their control group counterparts regarding ADL, indicating better functional status (Katz ADL score = 8.9, 95% CI (8.7 to 9.3) versus 9.5, 95% CI (9.2 to 9.9); p = 0.019; mean difference = -0.6 points (95% CI, -1.0 to -0.1)).

The effect on the Katz ADL was significantly moderated by the baseline risk for developing functional decline: patients at highest risk for functional decline showed the largest mean control-minus-intervention difference regarding Katz ADL scores: -1.4 points (95% CI, -2.3 to -0.6), in comparison with -0.2 (95% CI, -1.0 to 0.5) for those at medium and 0.1 (95% CI, 0.8 to 1.1) for those at low risk. There was also a small non-significant moderation effect for heart failure (see Figure 2.)

Patients who performed their individual exercise programs daily also had a greater mean control-minus-intervention difference regarding their Katz ADL scores (-1.4 points (95% CI, -2.4 to -0.3)), compared to those who did not (-0.3 points (95%, -0.8 to 0.2)); however, the mediation effect was not significant (see Figure 2). Patients who received ADL training also had a greater mean control-minus-intervention difference regarding their Katz ADL scores (-1.0 points (95% CI, -2.0 to 0)), and demonstrated an indirect ‘mediation’ effect (beta = -0.21 (95% CI, -0.41 to -0.06); see Supplementary table 3).

Effect on secondary outcomes

The geriatric co-management group had 18% less functional decline (95% CI, -28% to -7%; number needed to treat (NNT) = 6); a 13% lower incidence of delirium (95% CI, -6% to -20%; NNT = 8); and 10% lower incidences both of nosocomial infections (95% CI, -3% to -17%; NNT = 11) and of obstipation (95% CI, -3% to -16%; NNT = 11). There was no effect on the number of fallers, length of stay, cognitive status, short physical performance battery scores, grip strength, quality of life or perceived health. The median hospital costs of the control group (€3446.56; IQR = 4648.75) and intervention group (€3292.83; IQR = 4423.85) were comparable, and there were no significant differences on the different quantiles (see supplementary text 7). The outcome data and adjusted effect sizes are reported in Table 2.

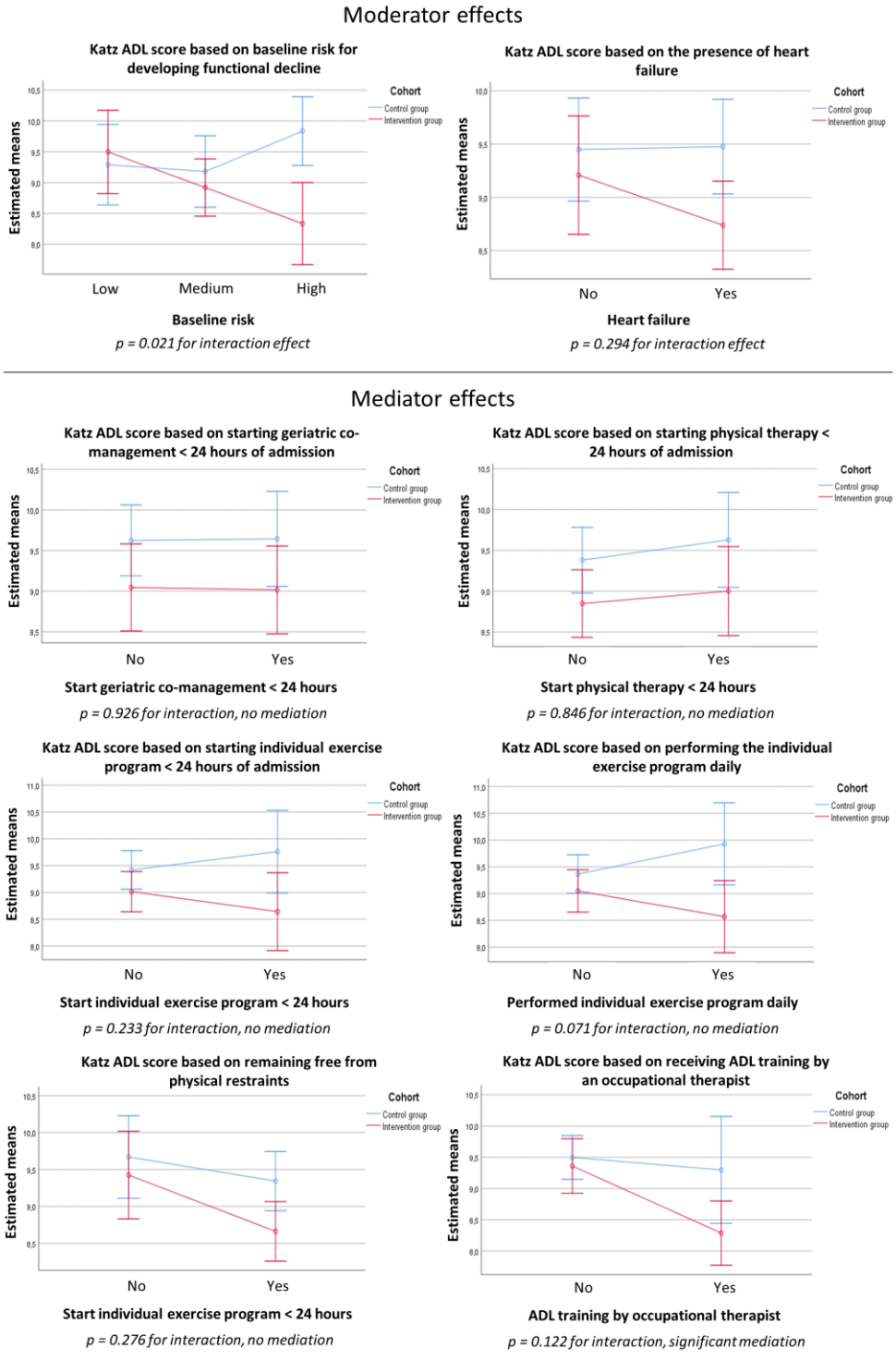
Patients in the geriatric co-management group continued to show better functional status at six months follow-up (Katz ADL = 8.69, 95% CI (8.34 to 9.03) versus 9.42, 95% CI (9.08 to 9.75); $p < 0.001$). They also indicated a higher quality of life (EQ-5D index = 0.50, 95% CI (0.46 to 0.55) versus 0.44, 95% CI (0.40 to 0.48); $p = 0.001$), and reported 18% fewer fallers (95% CI (-29% to -7%; NNT = 6). No effect was apparent on community mobility, perceived health, survival, hospital readmissions, or institutionalization.

Table 2. Functional status and outcomes during hospitalization

Outcome	Control group	Intervention group	Effect size (95% CI)
Functional status (Katz ADL), mean (95% CI)	9.55 (9.23 to 9.86)	8.99 (8.67 to 9.31)	MD = -0.56 (-1.01 to -0.11)*
Functional decline (Katz ADL), n (%)	68/158 (43.04)	38/151 (25.17)	OR = 0.45 (0.26 to 0.80)*
Grip Strength (mmHg), mean (95% CI)	20.20 (19.58 to 20.83)	20.27 (19.62 to 20.93)	MD = 0.07 (-0.42 to 0.58)
Physical Performance (SPPB), mean (95% CI)	4.55 (4.16 to 4.94)	4.66 (4.27 to 5.05)	MD = 0.11 (-0.19 to 0.41)
Delirium (3D CAM), n (%)	30/158 (18.99)	9/151 (5.96)	OR = 0.28 (0.12 to 0.65)*
Nosocomial infections, n (%)	26/158 (16.46)	10/151 (6.62)	OR = 0.25 (0.10 to 0.62)*
Obstipation, n (%)	23/158 (14.56)	7/151 (4.64)	OR = 0.34 (0.13 to 0.88)*
Number of fallers, n (%)	13/158 (8.23)	12/151 (7.95)	OR = 0.64 (0.22 to 1.81)
Cognitive status (Mini-Cog), mean (95% CI)	2.93 (2.71 to 3.14)	2.78 (2.57 to 3.00)	MD = -0.14 (-0.31 to 0.02)
Quality of life (EQ-5D), mean (95% CI)	0.52 (0.49 to 0.55)	0.55 (0.52 to 0.58)	MD = 0.03 (-0.01 to 0.08)
Perceived health (VAS), mean (95% CI)	65.79 (63.21 to 68.38)	65.09 (62.31 to 67.88)	MD = -0.70 (-2.60 to 1.20)
Length of stay (days), mean (95% CI)	9.42 (8.53 to 10.30)	8.88 (7.98 to 9.79)	MD = -0.54 (-1.83 to 0.75)
Hospital costs (EUR), median (IQR)	3446.56 (4648.75)	3292.83 (4423.85)	na [a], p > 0.05

Legend: The effect sizes are based on ANCOVA and logistic regression models with adjustment for the baseline characteristics: age, gender, functional status two weeks before hospital admission and on hospital admission (Katz ADL), level of community mobility (Life Space Assessment), physical performance (Short Physical Performance Battery, grip strength), cognitive status (Mini-Cog), multimorbidity and severity (Cumulative Illness Rating Scale), number of medications, depressive symptoms (Geriatric Depression Scale), anxiety symptoms (anxiety subscale of the Hospital Anxiety and Depression Scale), and nutritional status (Mini Nutritional Assessment); Abbreviations: MD = Mean Difference; OR = Odds Ratio's; CI = Confidence Intervals; ADL = Activities of Daily Living; SPPB = Short Physical Performance Battery; IQR = Interquartile range; a Quantile regression estimated the difference in costs at Q1 (p = 0.482), Q25 (p = 0.221), Q5 (p = 0.648), Q75 (p = 0.783), and Q9 (p = 0.162); see supplementary text 7 for more information; * Statistically significant at p < 0.05.

Figure 2. Moderator and mediator analyses



Legend: The plots report the marginal estimated means for each subgroup from the ANCOVA model with the Katz ADL score on hospital discharge, with adjustment for baseline characteristics. Statistical interaction terms were added to test the significance of the moderator and mediator variables. Propensity score matching was used for the mediators start co-management, start physical therapy, and the individual exercise program because this data was not available in the control group. All models were adjusted for baseline characteristics: age, gender, functional status two weeks before hospital admission and on hospital admission (Katz ADL), level of community mobility (Life Space Assessment), physical performance (Short Physical Performance Battery, grip strength), cognitive status (Mini-Cog), multimorbidity and severity (Cumulative Illness Rating Scale), number of medications, depressive symptoms (Geriatric Depression Scale), anxiety symptoms (anxiety subscale of the Hospital Anxiety and Depression Scale), and nutritional status (Mini Nutritional Assessment). Supplementary text 7.

Table 3. Outcomes at 6 months follow-up

Outcome	Control group	Intervention group	Effect size (95% CI)
Functional status (Katz ADL), mean (95% CI)	9.42 (9.08 to 9.75)	8.69 (8.34 to 9.03)	MD = -0.73 (-1.03 to -0.43)*
Community mobility (Life Space Assessment), mean (95% CI)	41.62 (38.49 to 44.76)	41.19 (37.87 to 44.50)	MD = -0.43 (-3.31 to 2.45)
Quality of life (EQ-5D), mean (95% CI)	0.44 (0.40 to 0.48)	0.50 (0.46 to 0.55)	MD = 0.06 (0.02 to 0.10)*
Perceived health (VAS), mean (95% CI)	62.93 (59.73 to 66.14)	63.54 (60.41 to 66.67)	MD = 0.61 (-2.25 to 3.47)
Number of fallers, n (%)	47/119 (39.50)	24/113 (21.24)	OR = 0.54 (0.33 to 0.89)*
Time to death, median (IQR)	187 (8)	186 (10)	HR = 1.05 (0.55 to 2.01)
30 day readmission rate, n (%)	25/142 (17.61)	17/135 (12.59)	OR = 0.65 (0.29 to 1.47)
Time to readmission (days), median (IQR)	153.5 (144)	180 (151)	SHR = 0.90 (0.65 to 1.24)
Institutionalization, n (%)	9/121 (7.44)	8/112 (7.14)	OR = 1.21 (0.37 to 3.96)

Legend: The effect sizes are based on ANCOVA, survival analysis and logistic regression models with adjustment for the baseline characteristics: age, gender, functional status two weeks before hospital admission and on hospital admission (Katz ADL), level of community mobility (Life Space Assessment), physical performance (Short Physical Performance Battery, grip strength), cognitive status (Mini-Cog), multimorbidity and severity (Cumulative Illness Rating Scale), number of medications, depressive symptoms (Geriatric Depression Scale), anxiety symptoms (anxiety subscale of the Hospital Anxiety and Depression Scale), and nutritional status (Mini Nutritional Assessment). The reported means are the marginal estimated means from the ANCOVA model. Abbreviations: MD = Mean Difference; OR = Odds Ratio's; CI = Confidence Intervals; ADL = Activities of Daily Living; SPPB = Short Physical Performance Battery; IQR = Interquartille range; SHR =subdistribution hazard ratio; * Statistically significant at $p < 0.05$.

DISCUSSION

This is the first study to evaluate the effectiveness of a nurse-led geriatrics co-management program for frail older patients on cardiac care units. Patients who received geriatric co-management had better functional status at hospital discharge. A large clinical and significant effect was observed in the patient subgroup with the highest baseline risk for developing functional decline. The effect was also large and clinically significant—but not statistically significant—in patients who performed their exercise programs daily. Receiving ADL training by an occupational therapist mediated the intervention effect. Secondary effects included clinically and statistically significant reductions in functional decline, delirium, obstipation and nosocomial infections, and a higher quality of life. Direct hospital costs were comparable between the two groups. There was a reduction in length of stay and unplanned hospital readmissions; however, the effect was not statistically significant. There was no effect on survival.

A priori, we defined our MID as 1.0 point difference on the Katz ADL, but observed a difference of 0.6 points. The MID was only exceeded in patients at high risk for functional decline. However, recent research has demonstrated that a difference of 0.5 points is clinically relevant. (24) There were small imbalances in baseline characteristics between the intervention and control group for patients included in the primary analysis, and for patients lost to follow-up. Baseline characteristics were included in the analysis to control for potential confounding; propensity scores were used to create balanced subgroups for moderation and mediation analyses. These subgroup analyses suggest a dose-response causal relationship of our intervention; but the sample size was insufficient to generate precise estimates. The generalizability may be limited because we recruited our patient sample in a single academic center with an experienced geriatrics team. However, this sample is certainly representative of frail older patients on cardiac care units.

Our results add several new perspectives to the current evidence. This is not only the first nurse-led co-management program but also a low-cost strategy for dealing with the increasing shortage of geriatricians. This is congruent with at least two systematic reviews' common conclusion that nurse-led programs improve patient outcomes. (25, 26) It is also the first co-management program for older patients on a cardiac care unit. This frail population often experiences geriatric syndromes and adverse events while hospitalized, (27) and our program was effective in managing these patients' complex care needs. While co-management programs usually include all 'older' patients on a particular unit, our risk stratification was effective in managing the most appropriate patients while conserving limited resources. However, careful selection of prediction

models and decision criteria will be key to this intervention's successful implementation. Also, while most similar programs focus on medical management and demonstrate limited effects, our interdisciplinary focus likely resulted in larger effect sizes and impacts on multiple patient-centered outcomes including functional status and quality of life.

This study will require replication in a multicenter randomized controlled trial. A formal program theory with TIDiER description developed for this purpose has been reported elsewhere (chapter 6). Trends observed in our mediation analyses suggest that physical exercise and activity and ADL training may be important components to further optimize acute hospital care for older patients. Levels of physical activity are typically very low in hospitalized patients; and other programs promoting physical activity have demonstrated improved functional outcomes in older patients. (28) However, as we observed low fidelity to the physical exercise intervention component, additional strategies are needed to support the necessary behavioral change.

Also, our program focused solely on hospital care. While its impact on functional status and quality of life remained at the six-month follow-up, it lacked strong beneficial effects on readmission and mortality rates. As nurse-led transitional care programs with home visits have been effective in reducing both of these, (29, 30) merging co-management and transitional care programs could very well increase the benefits of both.

Conclusion

A nurse-led geriatrics co-management program for frail older patients on cardiac care units was effective in preventing functional decline and complications, and resulted in a lasting increase in quality of life. Patients with the highest risk for functional decline demonstrated the largest benefits. Replication in a randomized controlled multicenter trial is recommended.

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CHAPTER 7

Supplementary materials

Supplementary text 1: Risk stratification and diagnostic assessment

Risk stratification

Patients were stratified in one of three groups: low risk for functional decline, high risk for functional decline, or acute complication present. The risk for functional decline was assessed using a validated risk prediction tool, and the presence of acute complications was assessed using standardized diagnostic instruments.

The prediction tool uses a score chart with five predictors to assess the risk for functional decline. Patients with a score of 10 or higher were considered at risk for functional decline. The validation study used a score of 13 or higher (based on the Youden Index), and observed a negative predictive value of 83% and a positive predicted value of 54%.

Predictor	Score
Mobility impairment: self-reported use of walking aid	9 points
Cognitive impairment: Mini Cog score < 3/5	7 points
Loss of appetite: self-reported for last three months	6 points
Depressive symptoms: Geriatric Depression Scale score > 3/10	5 points
Use of physical fixation, including urinary catheters	5 points

Diagnostic assessment

Diagnostic instruments were used to assess the presence of acute geriatric complications.

Assessment	Score
Behavioural problems related to dementia: observations	Sleep disturbance (night time waking), wandering, aggressive behaviour, shouting or screaming, refusal to eat, inappropriate behaviour
Delirium: Confusion Assessment Method	The presence of (acute onset OR fluctuating course) AND inattention AND (disorganized thinking OR altered level of consciousness)
Acute incontinence: self-reported	New incontinence that started after the acute illness or during hospitalization
Acute urinary retention: post-void residual	300 ml of higher
Malnutrition: Mini Nutritional Assessment	Score below 8 (of 14)

Supplementary text 2: Descriptive statistics

The following statistical tests were used.

Baseline characteristics	**Test**
Age, mean (SD)	Independent t test
Male gender, n (%)	Chi square test
Living situation, n (%)	Fisher's Exact test
Reason for hospital admission, n (%)	Fisher's Exact test
Katz ADL (6 – 18), mean (SD)	Independent t test
Mini Cog (0 – 5), mean (SD)	Independent t test
Geriatric Depression Scale (0 – 10), mean (SD)	Independent t test
Hospital Anxiety [a] (0 – 21), mean (SD)	Independent t test
Mini Nutritional Assessment (0 – 14), mean (SD)	Independent t test
Life Space Assessment (0 – 120), mean (SD)	Independent t test
Short Physical Performance Battery (0 – 12), mean (SD)	Independent t test
Grip strength (mmHg), mean (SD)	Independent t test
Cumulative Illness Rating Scale (0 – 56), mean (SD)	Independent t test
Number of medications, mean (SD)	Independent t test

Supplementary text 3: Missing data

A missing analysis was performed for baseline characteristics and outcomes. The following variables had missing data at baseline.

Variable	Cases (% missing data (excluding mortality))
Life Space Assessment	1 (0.2%)
Geriatric Depression Scale	2 (0.6%)
Anxiety scale	2 (0.6%)
Grip strength	9 (2.9%)
Short Physical Performance Battery	17 (5.5%)

We explored the mechanisms behind the missing data. The reasons for missing data were recorded by the research team during the study period.

Variable	Likely mechanisms for missing data
Life Space Assessment	Missing completely at random because of administrative error
Geriatric Depression Scale	Missing at random on ‘x’ related to cognitive impairment of patient
Anxiety scale	Missing at random on ‘x’ related to cognitive impairment of patient
Grip strength	Missing at random on ‘y’ related to poor functional status
Short Physical Performance Battery	Missing not at random

A multiple imputation model (k = 5) was build using the fully conditional specification method. All imputed values were within the normal range of the predictor scales.

Variables	**Role in imputation**	
	Predictor	***Dependent***
Intervention group	Yes	No
Risk stratification	Yes	No
Age	Yes	No
Katz ADL two weeks before admission	Yes	No
Katz ADL score on admission	Yes	No
Total Katz on discharge	Yes	No
Life Space assessment on admission	Yes	Yes
Short Physical Performance Battery on admission	Yes	Yes
Grip strength on admission	Yes	Yes
Mini-Cog hospital admission	Yes	No
Modified Cumulative Illness Rating Scale on a dmission	Yes	No
Number of medications prescribed on admission	Yes	No
Geriatric Depression Scale on admission	Yes	Yes
Subscale of the Hospital Anxiety and Depression Scale on admission	Yes	Yes
Mini Nutritional Assessment on admission	Yes	No

The following outcomes had missing data. Outcomes were not imputed.

Variable	**Cases (% missing data)** ***excluding mortality and loss to follow-up***
Short Physical Performance Battery on hospital discharge	35 (11.3%)
Grip strength on hospital discharge	29 (9.1%)
Self-perceived health on hospital discharge	18 (5.8%)
Self-perceived health at six months follow-up	13 (5.5%)
Mini Cog on hospital discharge	16 (5.2%)
Life Space Assessment at six months follow-up	8 (3.4%)
Institutionalized at six months follow-up	4 (1.7%)
Fall incident at six months follow-up	4 (1.7%)
Quality of life index at six months follow-up	2 (0.8%)
Katz ADL score at six months follow-up	1 (0.4%)
Quality of life index on hospital discharge	1 (0.3%)

Supplementary text 4: Statistical tests

The following statistical tests were used in the outcome analyses.

Outcome	Endpoint	Type of effect	Type of effect	Statistical control
Functional status	Hospital discharge	Main effect	ANCOVA	Baseline characteristics
		Moderation	ANCOVA with subgroups	Baseline characteristics
		Mediation	ANCOVA with subgroups Causal mediation analysis with linear regression	Propensity score matching + baseline characteristics
Functional decline	Hospital discharge	Main effect	Logistic regression	Baseline characteristics
Grip Strength	Hospital discharge	Main effect	ANCOVA	Baseline characteristics
Physical Performance	Hospital discharge	Main effect	ANCOVA	Baseline characteristics
Delirium	Hospital discharge	Main effect	Logistic regression	Baseline characteristics
Nosocomial infections	Hospital discharge	Main effect	Logistic regression	Baseline characteristics
Obstipation	Hospital discharge	Main effect	Logistic regression	Baseline characteristics
Number of fallers	Hospital discharge	Main effect	Logistic regression	Baseline characteristics
	6 months follow-up	Main effect	Logistic regression	Baseline characteristics
Cognitive status	Hospital discharge	Main effect	ANCOVA	Baseline characteristics
Length of stay (days)	Hospital discharge	Main effect	ANCOVA	Baseline characteristics

Quality of life index	Hospital discharge	Main effect	ANCOVA	Baseline characteristics
	6 months follow-up	Main effect	ANCOVA	Baseline characteristics
Perceived health (VAS)	Hospital discharge	Main effect	ANCOVA	Baseline characteristics
	6 months follow-up	Main effect	ANCOVA	Baseline characteristics
30 day readmission	30 day follow-up	Main effect	Logistic regression	Baseline characteristics
Time to readmission	6 months follow-up	Main effect	Competing risk regression	Baseline characteristics; Competing risk = Death
Time to death	6 months follow-up	Main effect	Cox proportional hazard	Baseline characteristics
Institutionalization	6 months follow-up	Main effect	Logistic regression	Baseline characteristics

The following baseline characteristics were used to control for potential baseline confounding: age, gender, functional status two weeks before hospital admission and on hospital admission (Katz ADL), level of community mobility (Life Space Assessment), physical performance (Short Physical Performance Battery, grip strength), cognitive status (Mini-Cog), multimorbidity and severity (Cumulative Illness Rating Scale), number of medications, depressive symptoms (Geriatric Depression Scale), anxiety symptoms (anxiety subscale of the Hospital Anxiety and Depression Scale), and nutritional status (Mini Nutritional Assessment.

The propensity score matching is explained on the next page.

Supplementary text 5: Moderator analysis

We a priori defined two groups of patients that we expected to have a larger intervention effect: patients with heart failure, and patients who had a high baseline risk for developing functional decline. To test this, we performed separate ANCOVA analyses for the two subgroups.

We added the covariate heart failure (yes or no) to the main effects model for the outcome functional status, and defined an interaction with the intervention group (control or intervention).

We added the covariate baseline risk (low, medium or high) to the main effects model for the outcome functional status, and defined an interaction with the intervention group (control or intervention). The baseline risk was determined for each patient using the prediction model detailed in the supplementary text 1. The distribution of the risk scores was used to create three groups: (score 0 – 11 = low risk; 12 – 17 medium risk; > 17 high risk).

Supplementary text 6: Mediator analysis with propensity score matching

We a priori defined that patients with a high fidelity to the program would experience a larger intervention effect. To test this, we defined six subgroups based on predefined fidelity protocols: 1) patients receiving geriatric co-management within 24 hours; 2) patients receiving physical therapy within 24 hours; 3) patients starting an individual exercise program within 24 hours; 4) patients performing the individual exercise program daily; 5) patients remaining free from physical restraints; 6) patients receiving ADL training by an occupational therapist.

Trained researchers monitored the fidelity based on registrations in the electronic patient record for the intervention group. Retrospectively, two intervention components could also be assessed for the control group: receiving ADL training and remaining free from physical restraints. There was no data for the remaining intervention protocols in the control group (and therefore no data to create subgroups in the control group)

First, we created propensity scores for these four intervention protocols: 1) patients receiving geriatric co-management within 24 hours; 2) patients receiving physical therapy within 24 hours; 3) patients starting an individual exercise program within 24 hours; 4) patients performing the individual exercise program daily. A logistic propensity score model was used and included the predictors measured at baseline: age, male sex, functional status (Katz ADL), community mobility (Life Space Assessment), physical performance (Short Physical Performance Battery, grip strength), cognitive status (Mini-Cog), depressive symptoms (Geriatric Depression Scale), Anxiety symptoms (Hospital Anxiety and Depression Scale), and nutritional status (Mini Nutritional Assessment). A full model approach was used. The propensity scores were used to predict which patients in the control group would have a high fidelity (or low fidelity) to the protocols. The propensity scores were then used to match

patients in the intervention group (with observed fidelity) and the control group (with predicted fidelity based on propensity scores). A greedy matching procedure with 1:1 matching without replacement was used with a tolerance of 0.02. Balance plots indicated an equal distribution of propensity scores after matching.

Second, we performed separate ANCOVA analyses for the six subgroups. In each analysis, we added the intervention protocol as a covariate to the main effects model for the outcome functional status, and defined an interaction with the intervention group (control or intervention). Testing these treatment variables was considered an exploratory analysis; and it should be noted that 1) the standard error is likely underestimated, and 2) the results do not support causality (Chen et al. Drug Information Journal 2005. 39: 373-383).

Third, we therefore performed separate causal mediation analyses for the six subgroups (Hicks et al. The STATA Journal 2011. 11(4): 605 – 619). The mediation model was defined as a linear regression model with functional status at hospital discharge as outcome, the intervention group as treatment, fidelity to the intervention protocol as mediator, and baseline characteristics as covariates for the mediator and outcome.

Supplementary table 1. Characteristics of patients loss to follow-up

Non-parametric tests were used to compare baseline characteristics between patients who were loss to follow-up for the control and intervention group.

Baseline characteristics	**Control (n = 37)**	**Intervention (n = 36)**	**p-value**
Age, median (IQR)	85 (6)	87 (9.5)	p = 0.222
Male gender, n (%)	21 (57)	25 (69)	p = 262
Living situation, n (%)			p = 0.044
- Home	32 (86)	29 (81)	
- Retirement home	0	1 (3)	
- Nursing home	5 (14)	6 (17)	
Reason for hospital admission			p = 0.098
- Heart failure	23 (62)	23 (64)	
- Valvular heart disease	2 (5)	1 (3)	
- Ischemic heart problem	5 (14)	0	
- Heart rhythm disorders	5 (14)	4 (11)	
- Transcatheter Aortic Valve Implantation	1 (3)	4 (11)	
Katz ADL (6 – 18), median (IQR)			
- Two weeks before admission	8 (4)	8 (4)	p = 0.596
- On hospital admission	9 (5)	11.5 (5.8)	p = 0.060
Mini Cog (0 – 5), median (IQR)	2 (1)	2 (2)	p = 0.131
Geriatric Depression Scale (0 – 10), median (IQR)	3 (5)	2 (4)	p = 0.028
Hospital Anxiety [a] (0 – 21), median (IQR)	5 (5.5)	2.5 (4.3)	p = 0.002
Mini Nutritional Assessment (0 – 14), median (IQR)	9 (3.5)	8 (3)	p = 0.881
Life Space Assessment (0 – 120), median (IQR)	31.5 (21.3)	29.5 (32.4)	p = 0.925

Baseline characteristics	**Control (n = 37)**	**Intervention (n = 36)**	**p-value**
Short Physical Performance Battery (0 – 12), median (IQR)	1 (3)	1 (4)	p = 0.860
Grip strength (mmHg), median (IQR)	17 (13.8)	18 (10.5)	p = 904
Cumulative Illness Rating Scale (0 – 56), median (IQR)	25 (27.5)	22 (8.5)	p = 0.049
Number of medications, median (IQR)	9 (7)	9 (4)	p = 0.799

Supplementary table 2. Fidelity indicators

Indicator	Fidelity score
Reach	133/151 (88.1%)
Patients who received a comprehensive geriatric assessment and had an interdisciplinary care plan	122/151 (80.8%)
Patients with an interdisciplinary care plan initiated within 24 hours of admission	63/122 (51.6%)
Patients receiving physical therapy	118/151 (78%)
Patients receiving physical therapy within 48 hours of admission	55/151 (36.4%)
Patients who experience acute functional decline receiving ADL training by an occupational therapist	35 of 58 (60.3%)
Patients performing an individual exercise program	61/151 (40%)
Patients starting an individual exercise program within 48 hours of admission	29/151 (19.2%)
Patients performing the individual exercise program on a daily basis	31/151 (21.2%)
Patients who remained free from physical restraints during hospitalization	98/151 (64.9)

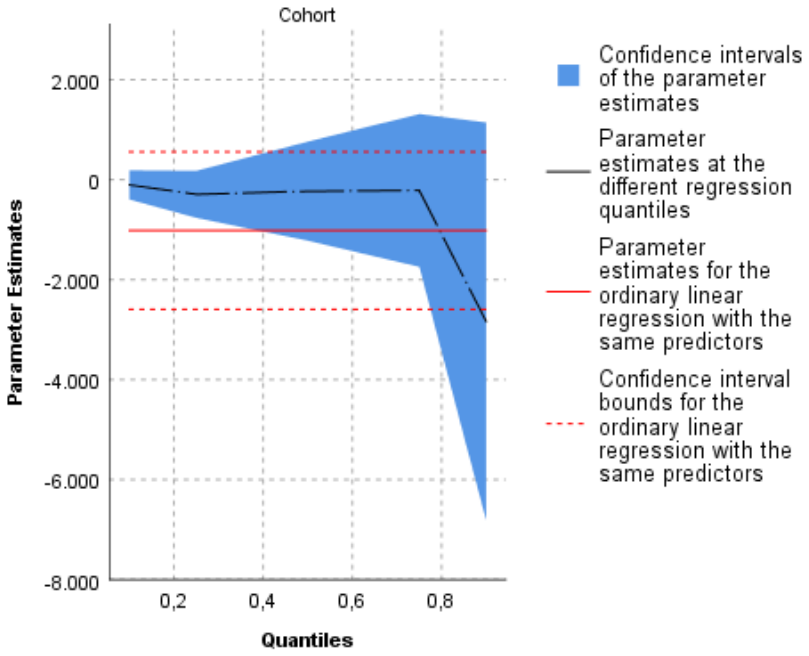
Supplementary table 3. Causal mediation analysis

Mediator	Indirect effect	Direct effect	Total effect
Start geriatric co-management < 24h	0.0013 (-0.0906 to 0.0861)	-0.6055 (-1.1112 to -0.0833)	-0.6042 (-1.1114 to -0.0480)
Start physical therapy < 24 hours	0.0077 (-0.0295 to 0.0667)	-0.5682 (-1.0232 to -0.0990)	-0.5605 (-1.0282 to -0.0560)
Start exercise program < 24 hours	-0.0001 (-0.0428 to 0.0422)	-0.5340 (-0.9933 to -0.0622)	-0.5341 (-0.9212 to -0.0478)
Performing exercise program daily	0.0032 (-0.0926 to 0.0964)	-0.5365 (-1.0010 to -0.0570)	-0.5332 (-0.9981 to -0.0142)
Free from physical restraints	-0.0152 (-0.0930 to 0.0498)	-0.5446 (-0.9965 to -0.0786)	-0.5596 (-0.9484 to -0.1377)
ADL training by occupational therapist	-0.2116 (-0.4121 to -0.0570)	-0.3458 (-0.8190 to 0.1423)	-0.5574 (-0.9754 to -0.0710)

The results are based on the causal mediation analysis and the values reflect the mean regression coefficient with 95% confidence intervals. The indirect effect reflects the association between the mediator variable and functional status at hospital discharge, while controlling for the intervention group and baseline confounders. This reflects the mediation effect, and statistical significance can be inferred from the 95% confidence intervals. Based on these results, ADL training demonstrates a mediation effect on functional status. The direct effect reflects the association between the intervention group and functional status at hospital discharge, while controlling for the mediator and baseline confounders.

Supplementary text 7. Quantile regression of cost data

Quantile regression was performed because of the highly skewed nature of the cost data. It has been observed that the traditional least-squares regression is biased under these circumstance *(Cody CS, et al. Comparing least-squares and quantile regression approaches to analyzing median hospital charges. Acad Emerg Med. 2012; 19:866–875)*. Furthermore, there may be important outlier effects, that may have clinical significance, which are not captured by the single regression coefficient of the least-squares regression. Quantile regression produces separates slopes of hospital costs across the distribution (from low to high cost). The difference in cost between the control and intervention group were assessed at Q1, Q25, Q50, Q75, and Q90. The costs were comparable for the majority of the quantiles, except for Q9 which had an outlier cost in the intervention group. The p-values for the parameter estimates were not statistically significant at Q1 (p = 482), Q25 (p = 0.221), Q5 (p = 0.648), Q75 (p = 0.783), Q9 (p = 0.162)



CHAPTER 8

Overall discussion

INTRODUCTION

The aim of this PhD was to develop, implement and evaluate a geriatric co-management programme for older patients admitted to the hospital. The acute cardiac care unit was chosen as the setting to establish a proof of concept. The framework of the Medical Research Council (MRC) was used to define a mixed-methods multi-phase design, and was embedded in the G-COACH project. Insights from implementation science were used to increase the likelihood that the implementation of the programme would be acceptable, feasible and sustainable. In the first phase, we created a theoretical framework based on three studies, i.e. a systematic review and meta-analysis to evaluate the current evidence (chapter 2), an international Delphi study to develop quality indicators (chapter 3), and a prospective cohort study to develop a clinical risk prediction model (chapter 4). This framework was operationalised using data from a context analysis, participatory observations and by engaging stakeholders in consensus decision-making procedures. In the second phase, the programme was implemented on two cardiac care units of the University Hospitals Leuven using a multifaceted implementation strategy, and the feasibility was evaluated (chapter 6). In the third phase, a quasi-experimental study evaluated if the programme resulted in a better functional status (chapter 7). A process evaluation was performed to describe how well the interventions were being performed and to determine for whom and how the programme was most effective.

MAIN RESULTS

A systematic review was performed to assess the effectiveness of geriatric co-management programmes in hospitalised older patients (Chapter 2). (1) We included twelve studies. Eight studies included patients with an orthopaedic problem, three included patients with a medical condition, and one included patients with cognitive or functional problems. We observed a reduced length of stay, and less functional decline and complications. There was a trend towards reduced in-hospital mortality, and there was no effect on post-discharge mortality, readmission rates, and discharge disposition. The GRADE of evidence was low to very low, indicating that there is a high uncertainty whether these results will be replicated in future studies. A subgroup analysis could not identify significant differences on the effect estimates between medical and surgical patients. However, the small sample of patients with medical conditions limited the statistical conclusion validity. The results support the evidence from other systematic reviews, which observed a reduced length of stay. (2-7)

However, the different reviews also demonstrated inconsistencies in their effect estimates for the outcomes survival, complications and readmission rates. (2-7) This is likely explained by the fact that the available reviews included different studies. For example, some reviews also included geriatric consultation programmes, or only orthogeriatric programmes. We believe that the absence of a clear definition and understanding of key structures and processes of co-management programmes contributes to the differences in inclusions between the systematic reviews.

The systematic review demonstrated that there is a potential to improve patient outcomes, but also that there is a lot of uncertainty about how large these improvements will be, and what patient populations will benefit from co-management. Because the programmes reported in the literature differed substantially from each other, the next step in the PhD was to find consensus on quality indicators for geriatric co-management programmes.

Hence, a Delphi study was performed to develop structure, process and outcome indicators for geriatric co-management programmes (Chapter 3). (8) First, a systematic review identified indicators that were reported in studies describing geriatric co-management programmes. Twenty-eight experts from Europe and the United States completed the two Delphi rounds, and 31 indicators were considered appropriate and feasible to measure. These included eight structure, seven process and sixteen outcome indicators. Daily and proactive care based on a comprehensive geriatric assessment and delivered by an interdisciplinary team focussing on the length of stay, time to surgery and the incidence of complications were key indicators. There was no evidence from intervention studies to support the validity of the indicators and the grade of evidence was limited to expert opinion.

The Delphi study created a first set of standards for geriatric co-management, but the indicators need further updating and specification. One of the structure indicators reflected an important question, i.e. what patient profiles would actually benefit from such a programme. The next step in the PhD was to develop and validate a clinical prediction model to detect patients who are at risk for hospitalisation-associated functional decline.

A prospective cohort study was performed to develop and validate a score chart that can be used in clinical practice to detect which patients are at risk for hospitalisation-associated functional decline (chapter 4). We recruited 189 patients from two cardiac care units of the University Hospitals Leuven (this cohort of patients was also used as the control group for the effectiveness evaluation in chapter 7). Five predictors were selected based on their clinical relevance and were measured on hospital admission.

The score chart discriminated adequately between patients with and without functional decline. The calibration was adequate but indicated an overall 'underprediction' of the risk for functional decline. After internal validation, the prediction model was comparable to other prediction models that were developed for internal medicine patients. However, all models generated false positive predictions, which warrant further attention. The model can be used in clinical practice but decision criteria for determining the risk status need further exploration. The data indicated that model updating will likely improve predictions. The cost of false predictions should also be considered.

The data from the first three PhD studies provided the empirical evidence to create a first theoretical framework for geriatric co-management. This served as the basis for the next step in the PhD, developing the programme and testing the feasibility. **A protocol paper describing the evaluation of the programme was published (chapter 5).**

A mixed-methods study was performed to develop and implement the geriatric co-management programme and to evaluate its feasibility (chapter 6). The purposeful programme theory was used to develop the geriatric co-management programme and was operationalised using consensus procedures with the stakeholders. A geriatrics nurse coordinated the programme, and the key interventions included a comprehensive geriatric assessment, risk stratification, early rehabilitation, early discharge planning, evidence-based protocols for the management of geriatric syndromes, and management of complications by a geriatrician. The programme was implemented using a standardised strategy. We recruited 151 patients to evaluate feasibility. The majority of the patients was included in the programme and received the core intervention components, with the exception of performing individual physical exercises, and follow-up by a geriatrician. The additional management by the geriatrics team was acceptable for patients but they indicated a lack of involvement in their care. A survey with 48 healthcare professionals indicated that the programme was acceptable for them, but that is was not sufficiently integrated in their routine practice. Interviews with 27 healthcare professionals indicated that staffing levels and role conflicts were important determinants for the feasibility. We concluded that geriatric co-management is feasible to implement, but the context should be considered a key determinant for success. Improving staffing levels, skills development and leadership support would likely improve the feasibility.

The results from the feasibility study demonstrated that the main components were adopted sufficiently and that the programme could be evaluated. The last step of the

PhD was to evaluate the effectiveness and explore for whom and how the interventions were most effective.

A quasi-experimental before-and-after study was performed on the two cardiac care units of the University Hospitals Leuven (chapter 7). Firstly, we evaluated if patients in the programme had a better functional status on hospital discharge, in comparison with patients who received standard of care with geriatric consultation. Secondly, we performed a process evaluation to describe how well the interventions were implemented and explore for whom and how the programme worked best. We recruited 454 patients for evaluation. There was less functional decline, delirium, obstipation, and nosocomial infections, and patients had a better functional status and quality of life. Patients at highest risk for functional decline demonstrated the largest benefit from the programme. Although not significant, mediation analysis potentially suggests that increasing the overall level of physical activity during hospitalisation might be an important intervention for managing the functional status of patients. There were improvements in length of stay and 30-day readmission rates but these were not statistically significant. We concluded that a nurse-led geriatric co-management programme is effective to prevent complications in frail older patients admitted to cardiac care units. Although we used statistical techniques to correct for potential confounding, replication in a randomised controlled trial is needed to support the validity.

STRENTHS AND LIMITATIONS

This PhD project has several strengths. The programme was designed using a systematic approach and was based on both empirical evidence and a programme theory. Stakeholders were engaged throughout the research process to make sure that the project addressed a relevant need in clinical practice. We supported the sustainability by integrating contextual information related to the implementation of the programme. The mixed methods approach allowed us to observe the value of the programme from the perspective of both the patients and the healthcare professionals. We explored variations in the observed effects in order to further define the core elements of a successful programme. This information should help to adjust and redefine the programme in order further increase its impact. Although we did not aim to perform an implementation study, we did explore potential determinants for implementation. This information can support the progression from evaluation to implementation, and reduce the time lag between evaluation and implementation.

Some limitations should also be noted. The systematic review excluded three studies based on language restrictions. Furthermore, we were not able to capture all the potential sources of heterogeneity in the systematic review. The residual heterogeneity could hold important information to better understand the variation in effectiveness of geriatric co-management. The Delphi study was a first attempt to define a set of quality indicators. The definition, operationalization and scoring of the indicators requires further updating for use in clinical practice. The sample size for the prediction model was adequate, although not large enough to accommodate a more complex model. Predictions can likely be improved by exploring non-linear link functions and interactions between the predictors. One of the challenges of the project was balancing the traditional research process with implementation science. Because we performed the studies in a research setting (with control over the intervention), our results regarding implementation should be considered within this context. Nonetheless the results can be considered as preliminary data to help progress faster towards the implementation in clinical practice. The intervention study used a nonrandomised design and the baseline data indicates that there is some potential for baseline confounding. We used statistical control to correct for this potential bias. Lastly, our main outcome in the intervention study did not reach the predetermined clinical significance. This was only observed in a subgroup of high-risk patients.

FUTURE PERSPECTIVES

This project provided the first proof of concept for geriatric co-management on cardiac care units. The results contribute to both the evidence and clinical practice. It addressed a clinical relevant problem, i.e. the complex care needs of older patients admitted to the hospital. A systematic approach was used to develop the programme and optimise the 'a priori' chance of having an impact on patient outcomes by building an empirical and theoretical foundation for the interventions. (9, 10) Stakeholders were involved in the development to match the programme to the context, and facilitate a perceived ownership, acceptability, feasibility and benefit by the participating healthcare professionals. (11) A multifaceted evaluation was performed to build a comprehensive evidence base by focussing on different aspects, i.e. the feasibility, implementation, improvement in patient outcomes, and understanding relevant subgroup effects. (12) The evaluation was performed on two cardiac care units and a nonrandomised design was chosen because this was the first prove of concept, and because the resources for the evaluation were limited. Both our study

findings and the methodological considerations can give guidance for conducting future research projects and inform clinical practice.

Implications for future research

Concept definition of co-management (and other care models)

Over the past decades, many models of care have been developed for geriatric patients in the hospital. At their core, most aim to implement comprehensive geriatric assessment, but they are often operationalised in different ways. While this can be expected to some extend, because the models of care are implemented in different settings and contexts, we have to be careful that care models do not become brands. For example, the Hospitalised Elder Life Program (13) and the Mobile Acute Care for Elders (14) are well known programmes and take treatment responsibility for older patients on non-geriatric units, and to such an extent engage in co-management of patients. A worthwhile approach would be to search for commonalities and differences between the 'different' care models and create clear concept definitions of effective models of care, overarching the individual and specific programmes. (15) This would also mean creating an operational definition of co-management beyond the point of 'shared decision making'.

Process evaluations to understand effective co-management

Process evaluations can support the concept definition of effective care programmes. The current evidence describes the effectiveness on patient outcomes, but the underlying mechanisms responsible for the impact remain largely concealed in the 'black box'. (12) Furthermore, the description of the interventions are often poor. (1) For example, our project developed an explicit programme theory, logic model, implementation strategy and TIDieR description, and used this to describe relevant implementation determinants, observe the fidelity to key interventions, and explored how these and patient characteristics influenced the effectiveness of the programme. (12, 16, 17) These elements are needed to build the evidence base of geriatric co-management and generate results that will support the implementation of these programmes in clinical practice.

High-grade evidence to support decision-making

A clear concept definition and process evaluation support the replication of programmes and build the evidence base. The current evidence is largely based on the evaluation of individual and isolated programmes, and not on replications of existing

concepts, models, services or programmes. It is therefore difficult to determine with relative certainty whether the results observed in studies can be replicated and what their true impact will be for clinical practice. (18, 19) Replication studies using a pragmatic, multicentre, and randomised controlled design are needed to generate valid results and to support decision making for large-scale implementation.

Co-management outside the hip fracture setting

While it is clear that not all older patients in the hospital need co-management, the current scope of co-management evaluation studies is mostly limited to the hip fracture setting. However epidemiological studies have observed a high prevalence of frailty and negative outcomes in other populations, e.g. cardiovascular disease, cardiac surgery, oncology and nephrology. (20-22) We reported the first evidence for co-management in patients admitted to cardiac care units. We believe that the effects are transferrable to other hospital services that are faced with a high prevalence of patients with geriatric syndromes and complex care needs. Replicating existing programmes outside the hip fracture setting could be useful to increase the evidence base for geriatric co-management programmes.

Comparative effectiveness against the Acute Care for Elders unit

Once high quality evidence is established, comparative effectiveness research will become relevant. The current consensus is that the geriatric units provide the strongest evidence for managing frail patients in the hospital. (23) However, their capacity is limited and insufficient to reach all frail older patients in the hospital. (24) To the best of our knowledge, no (cost-)effectiveness studies are available that compare geriatric co-management programmes against specialised geriatric units. Yet, this evidence will be crucial to support strategic decisions for future policy investments.

Implementation research to support scaling up of effective programmes

Apart from effectiveness studies and process evaluations, implementation science can further increase the quality of evidence. Our project was the first to define an implementation strategy for co-management programmes. The effectiveness of co-management programmes cannot be separated from the implementation process. (11) We therefore advice that future studies explicitly report their implementation strategy, preferably replicate existing strategies, and also evaluate implementation outcomes. (25) Implementation trials will become relevant to inform which strategies best support scaling up of the innovation.

Validation of risk prediction tool

The risk prediction model that we developed needs further validation and consideration. Our evaluation was limited to internal validation and a separate external validation is needed to confirm the predictive value. For our programme, we used a cut-off value of 10 points to determine 'risk status'. Our moderator analysis indicated that patients with the highest risk had the largest benefit. A higher cut-off score is therefore likely indicated. However, this exercise in a future study should also consider the 'cost' of prediction, i.e. what are the consequences of over and underpredicting the risk status for patients and society. One potential problem is the 'wild growth' of prediction models, which are usually developed for a specific sample, in a specific institution, and for one specific outcome. (26) However, a large and heterogeneous group of patients are at risk for a myriad of outcomes. An ambitious aim for future research would be to create a geriatric risk model using a standard set of parameters, but in a different combination with different weights depending on the setting, population and outcomes considered. One standardised assessment could then be used to determine the probability for multiple geriatric outcomes, and tailor the implementation of evidence-based protocols to the individual risk status.

Implications for clinical practice

One of the challenges of clinical practices is making decisions in the absence of high quality evidence, especially when there is evidence of negative outcomes for patients receiving 'standard care' in the hospital. We believe that it would be wrong to ignore the care needs of older patients in the hospital in the absence of a randomised controlled trial. This is also reflected by the latest survey on the implementation of geriatric care programmes. (27) Currently, geriatric consultation remains the favoured model of care, but one in three hospitals plan to implement geriatric co-management within the next five years. A consensus statement for the management of frail patients undergoing surgery now also recommends geriatric co-management as the favoured model of care. (28) Several suggestions can be made to support this trend in clinical practice.

Implementation within UZ Leuven

The project focussed on initiating the geriatric co-management programme on the cardiac care units of the University Hospitals Leuven. Our results support the continuation of this model of care. Several actions can be suggested for this purpose. First, a strategy to support the sustainability and maintenance of the programme on the cardiac care units is needed. Second, the strategy defined in this project can be

replicated to implement the programme on other hospital units. Third, the clinical outcomes that were observed in the evaluation can be used as a benchmark for future evaluation and improvement purposes (e.g. audit and feedback on the performance).

Changing national care programmes

National care programmes and legislative norms in several countries, e.g. Belgium, Netherlands, France, Denmark and Ireland, regulate the organisation of acute geriatric care. (24, 27) These external contextual factors can act as both a facilitator and a barrier for the implementation of co-management. The presence of geriatric care professionals is a key structure for establishing a programme. However, their activities are often limited by legislative norms. Data from our feasibility study indicated that staffing levels of the geriatrics team and having a dedicated co-management role were key determinants for the feasibility of the programme. We therefore advice that norms and financial structures should be updated to allow co-management of patients and facilitate more intensive follow-up of patients and to engage more with healthcare professionals on non-geriatrics units.

Creating international standards

The major barrier for supporting national care programmes, including geriatric co-management, is the current lack of standards. Our systematic reviews identified large differences between structures and operationalisations of co-management programmes. Our project aimed to create a first proof of concept of a standardised co-management programme. We believe that national and international stakeholder groups should promote the 'organisation of acute care for older patients on non-geriatrics units' as a priority for practice. We need a clear consensus on the minimal quality of care standards for older patients in the hospitals. (11) This would also entail defining when consultation would be sufficient and when co-management would be more valuable.

Targeting the right patients for co-management

The large majority of co-management programmes include all older patients, while some will have no benefit from it. We observed the largest effect of co-management on functional status was present in patients with the highest risk for functional decline. Our moderator analysis supports the approach of targeting the right patients. But the implementation of prediction tools in clinical practice is challenging because prediction scores are nested within specific samples, outcomes and contexts. We therefore aimed to include predictors that are potentially 'generic' for many older populations, but our

risk score has not been validated in other samples. A different approach is to define patient subpopulations who have in general an increased risk for negative outcomes. For example, the large majority of patients with heart failure is frail. (29) Furthermore, our moderator analysis identified that patients with heart failure had a larger benefit from the programme. However, the study was not designed to find a difference in this subgroup and the effect on functional status was not statistically significant. Nonetheless, we do believe that the observation warrants further investigation. This discussion is closely related to creating international standards, i.e. defining patient groups who would benefit most from interdisciplinary geriatric care.

Advanced nursing roles

An important barrier for the upscaling of geriatric co-management as a model of care is the lack of geriatric expertise in the healthcare workforce. Most co-management programmes are run by a geriatrician, and only a small portion uses an interdisciplinary team. There are certainly not enough geriatricians available to manage all frail patients in the hospitals. (24) To date, population numbers on the prevalence of frailty in the hospital are missing, but smaller samples indicate a range between 10% and 80%. (30-32) Additional geriatrics expertise is needed if we are to face the geriatric needs of hospitalised patients. The key component of our programme was the nurse-led co-management approach of preventing complications in high-risk patients. Several conceptual models suggest that functional decline and complications result as an interaction between the frailty profile of the patient, the illness, and exposure to hospitalisation processes and care. (33) An extensive body of evidence demonstrates that advanced practice nurses improve outcomes in different settings. (34, 35) Advanced practice nurses have a broad range of competencies that are relevant for co-managing complex patients, e.g. specialist clinical expertise, teamwork and collaboration, ethical reflection, coaching, and providing local leadership. (36) Data from our feasibility study confirmed that skills development of the geriatrics nurse was an important factor for implementation, and that more formal training was needed. However, the lack of nurses specialised in geriatric care may also prove to be an important barrier. (37)

Co-management within evolving health systems

Patients are being discharged home sooner, and more care needs have to be addressed in the primary care settings. With these evolutions, it has become more important than ever to incorporate the individual needs and wishes of patients and their family members in the organisation of acute care. In particular, transitioning home after an acute illness can provide several challenges. Patients lose the support they had during their hospital stay, and often suffer fatigue, stiffness, muscle weakness, and poor appetite when they are back home. (38) This may contrast and challenge patients' goals, who often value living at home with full independence in their activities of daily living and leisure activities. (39) Despite decades of research, the functional status of patients is still too often neglected. (40) Informal caregiver will most often be responsible for addressing the unresolved care needs after hospitalisation. This also requires health systems to provide sufficient support. A systematic review identified four areas that require more attention to further support informal caregivers, i.e. information needs, support needs, organizational needs, and societal recognition. (41)

This challenges health systems to adapt and evolve, e.g. by delivering hospital care at home. A Cochrane review about hospital at home observed a reduced length of stay and a potential to decrease hospital readmissions and institutionalisation with equal health outcomes. (42) However, strong evidence for frail patients is currently missing. To the best of our knowledge, co-management in the primary care setting is still very limited. One study evaluated co-management between a nurse practitioner and primary care physician, and observed large improvements on quality indicators for falls, urinary incontinence, and dementia management. (43) However, comprehensive co-management models in primary care are lacking. Efforts have focussed largely on providing comprehensive geriatric assessment in outpatient clinics, and at the patients' home. (44, 45) However, most of these programmes operate in isolation and have no or little integration with primary care practices.

OVERALL CONCLUSION

A mixed-methods multi-phase project methodology, based on the MRC framework, was effective in developing a geriatric co-management programme. Using a standardised implementation strategy, the G-COACH programme was introduced on two cardiac care units and considered acceptable and feasible to perform. However, concerns were raised regarding the long-term sustainability. Patients included in the programme had a better functional status, suffered less complications, and had a higher quality of life at equal hospital cost of usual care with geriatric consultation. Replication is recommended to support the validity of the results.

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CHAPTER 9

Summary PhD

SUMMARY PHD

This PhD project developed, implemented and evaluated a geriatric co-management programme for older patients admitted to the hospital. A multi-phase mixed methods methodology was used based on the framework of the Medical Research Council and based on insights from implementation science. First, a systematic review and meta-analysis with twelve experimental studies was performed to determine the current GRADE of evidence. There was less functional decline and complications, and the length of stay was reduced. The estimates for the outcomes mortality, hospital readmissions and discharge disposition were not precise enough to make a conclusion. The GRADE of evidence was low to very low and limited to patients with a hip fracture, but the results indicated a potential to improve outcomes in clinical practice. Second, an international two-round Delphi study was performed, based on a systematic review, and with 31 international experts who were asked to rate indicators for their appropriateness and feasibility. There was consensus on eight structure, seven process and sixteen outcome indicators. Third, a clinical model was developed for the prediction of hospitalisation-associated functional decline in a prospective cohort study on two cardiac care units of the University Hospitals Leuven. A total of 189 patients were recruited, and a score chart with five predictors was developed. The model demonstrated an adequate discrimination and calibration, and performed equal to similar prediction models. Fourth, based on these results and insights from other published literature, a conceptual co-management model for geriatric patients was developed. A nurse-led geriatric co-management programme was operationalised for the cardiac care units of the University Hospitals Leuven, using consensus procedures and by involving stakeholders. A geriatrics nurse coordinated the programme, and the key interventions included a comprehensive geriatric assessment, risk stratification, early rehabilitation, an individualised exercise programme, early discharge planning, evidence-based protocols for the management of common geriatric syndromes, and management of complications by a geriatrician. Fifth, the program was implemented and the feasibility was evaluated in a one-group experimental study (n = 151 patients). The majority of the patients was included in the programme and received the core intervention components. However, there was low adherence to the interventions performing individual physical exercises, and follow-up by a geriatrician. The programme was considered acceptable and feasible to perform, but the context was an important barrier for the implementation and maintenance. Sixth, a quasi-experimental before-and-after study evaluated the programme on two cardiac care units of the University Hospitals Leuven (n = 454 patients). The primary outcome was functional status at hospital discharge. Patients in the co-management programme had

a better functional status compared to patients receiving routine care with geriatric consultations. The programme was more effective in patients who had a high risk for developing functional decline. Other effects included less functional decline, delirium, obstipation, and nosocomial infections, and a higher quality of life. There were improvements in length of stay and 30-day readmission rates but these were not statistically significant. The hospital cost of patients in the co-management programme was equal to those of patients receiving usual care with geriatric consultation. Overall, this PhD project demonstrated that geriatric co-management is effective in improving outcomes at equal costs in patients admitted to the hospital, in comparison with the current standard of care. This has implications for clinical practice because the current legislative norms are not up to date to support implementation of this model of care in clinical practice. Future endeavours can focus on replicating this programme in multicentre studies and implementation projects.

CHAPTER 10

Acknowledgements, personal contribution and conflict of interest

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The G-COACH project consisted of an interdisciplinary consortium: dr. Mieke Deschodt, dr. Els Devriendt, prof. dr. Bernadette Dierckx de Casterlé, prof. dr. Christophe Dubois, dr. Katleen Fagard, prof. dr. Johan Flamaing, prof. dr. Marie-Christine Herregods, dr. Miek Hornikx, Anthony Jeuris, Maren Jonckers, prof. dr. Bart Meuris, prof. dr. Koen Milisen, prof. dr. Steffen Rex, prof. dr. Jos Tournoy, Bastiaan Van Grootven.

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Chapter 2: Effectiveness of in-hospital geriatric co-management: A systematic review and meta-analysis

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Other contributions: Marleen Michels (Information specialist Biomedical library, 2Bergen, University Library, KU Leuven, Leuven, Belgium) supported the consortium with the development of the search string.

Chapter 3: Quality indicators for in-hospital geriatric co-management programmes: a systematic literature review and international Delphi study

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Critical revision of the manuscript: All authors

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Other contributions: The G-COACH consortium provides methodological guidance

Chapter 4: Predicting hospitalisation-associated functional decline in older patients admitted to a cardiac care unit with cardiovascular disease: a prospective cohort study

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Chapter 5: Geriatric CO-mAnagement for Cardiology patients in the Hospital (G-COACH): study protocol of a prospective before-after effectiveness-implementation study

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Obtaining funding: Mieke Deschodt, Koen Milisen, Johan Flamaing

Other contributions: None

Chapter 6: The implementation of the Geriatric CO-management for ACute Hospitalisation programme: development and feasibility of G-COACH

Authors: Bastiaan Van Grootven, Anthony Jeuris, Maren Jonckers, Els Devriendt, Bernadette Dierckx de Casterlé, Christophe Dubois, Katleen Fagard, Marie-Christine Herregods, Miek Hornikx, Bart Meuris, Steffen Rex, Jos Tournoy, Koen Milisen, Johan Flamaing, Mieke Deschodt

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Obtaining funding: Koen Milisen, Johan Flamaing, Mieke Deschodt

Other contributions: The healthcare professionals of the Geriatric Support Team and the cardiac care units participated in the development of the programme, and performed the programme on their units.

Chapter 7: Effectiveness of the Geriatric CO-mAnagement for Cardiology patients in the Hospital (G-COACH) program: a nonrandomized controlled trial

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Other contributions: dr. Steffen Fieuws and dr. Annouschka Laenen (Statisticians, Department of Public Health and Primary Care, KU Leuven, Leuven, Belgium) were consulted for the statistical analysis. The healthcare professionals of the Geriatric Support Team and the cardiac care units performed the programme on their units.

PERSONAL CONTRIBUTION

Bastiaan Van Grootven helped draft the grant proposal of the G-COACH project. He drafted the protocols for the ethical commission and trial registers. Bastiaan was personally involved in the completion of all reported studies, including the daily project management, recruiting study participants, data acquisition, statistical analysis, interpretation of the results, and writing and revising the manuscript. No data was used from sources outside the project.

CONFLICT OF INTEREST

Collaborator	**Potential conflict of interest**
Bastiaan Van Grootven	No conflict of interest
Anthony Jeuris	No conflict of interest
Maren Jonckers	No conflict of interest
Els Devriendt	No conflict of interest
Bernadette Dierckx de Casterlé	No conflict of interest
Christophe Dubois	No conflict of interest
Katleen Fagard	No conflict of interest
Marie-Christine Herregods	No conflict of interest
Miek Hornikx	No conflict of interest
Bart Meuris	No conflict of interest
Steffen Rex	Fees from Orion Pharma, B Braun, AirLiquide Medical and Edwards Lifesciences (outside the submitted work)
Jos Tournoy	No conflict of interest
Koen Milisen	No conflict of interest
Johan Flamaing	Fees for consultancy services to pharmaceutical companies (Pfizer, GSK, SPMSD) (outside the submitted work)
Mieke Deschodt	No conflict of interest
Annouschka Laenen	No conflict of interest
Lynn McNicoll	No conflict of interest
Daniel Mendelson	co-PI of a John A. Hartford Foundation grant for pilot study to disseminate geriatric co-management programmes (8/2015 – 8/2016). DM is Secretary of the Board of the International Geriatric Fracture Society (IGFS).
Susan Friedman	No conflict of interest

CHAPTER 11

Professional career and publications

PROFESSIONAL CAREER

In 2014, Bastiaan Van Grootven completed his Master's degree in Nursing at the KU Leuven, and he received the Award Professor Evers for Nursing and Midwifery by the Academic Centre for Nursing and Midwifery for best thesis in nursing science. After his graduation, Bastiaan started working as a registered nurse on an acute geriatric unit of the University Hospitals Leuven. One year later, he was accepted as a PhD student and committed to a full time research position as project manager of the G-COACH project. This project was awarded the Viviane Conraads Award for the most innovating project focusing on cardiology patients from a multidisciplinary perspective. After two years, he received a full PhD fellowship by the Research Foundation Flanders. During his PhD, Bastiaan collaborated with the Brown University during a research visit, and completed a research stay for six months at the Academic Medical Center of the University of Amsterdam. During his PhD, Bastiaan received several awards including best poster presentation by the Belgian Society of Gerontology and Geriatrics, best oral presentation by the Association of Cardiovascular Nursing and Allied Professions, second laureate of the Belgian Working Group on Cardiovascular Nursing Award 2019, best quality improvement project by the Belgian Society of Gerontology and Geriatrics, and second laureate of the Mieke Grypdonck award by Ghent University Hospitals.

PUBLICATIONS

Publications in peer reviewed journals

Van Grootven, B., Jeuris, A., Jonckers, M., Devriendt, E., Dierckx de Casterlé, B., Dubois, C., Fagard, K., Herregods, MC., Hornikx, M., Meuris, B., Rex, S., Tournoy, J., Milisen, K., Flamaing, J., Deschodt, M. (2020). Predicting hospitalisation-associated functional decline in older patients admitted to a cardiac care unit with cardiovascular disease: a prospective cohort study. BMC Geriatrics, 20(1), 112.

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Van Grootven, B., Mendelson, D., Deschodt, M. (2019). Impact of geriatric co-management programmes on outcomes in older surgical patients: update of recent evidence. Current Opinion In Anesthesiology, 32, 1-8. doi: 10.1097/ACO.0000000000000815

Deschodt, M., **Van Grootven, B.**, Devriendt, E., Dierckx de Casterlé, B., Dubois, C., Herregods, M-C., Hornickx, M., Jeuris, A., Meuris, B., Rex, S., Tournoy, J., Milisen, K., Flamaing, J. with Van Grootven, B. (joint first author) (2018). Geriatric CO-mAnagement for Cardiology patients in the Hospital (G-COACH): study protocol of a prospective before-after study. BMJ Open, 8, Art.No. e023593. doi: 10.1136/bmjopen-2018-023593

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Van Grootven, B., Flamaing, J., de Casterle, B.D., Dubois, C., Fagard, K., Herregods, M-C., Hornikx, M., Laenen, A., Meuris, B., Rex, S., Tournoy, J., Milisen, K., Deschodt, M. (2017). Effectiveness of in-hospital geriatric co-management: a systematic review and meta-analysis. Age and Ageing, 46 (6), 903-910. doi: 10.1093/ageing/afx051

Van Grootven, B., van Achterberg, T. (2016). The European Union's Ambient and Assisted Living Joint Programme: An evaluation of its impact on population health and well-being. Health Informatics Journal, 25 (1), 27-40. doi: 10.1177/1460458216683535

Van Grootven, B., Detroyer, E., Devriendt, E., Sermon, A., Deschodt, M., Flamaing, J., Dubois, C., Milisen, K. (2016). Is preoperative state anxiety a risk factor for postoperative delirium among elderly hip fracture patients? Geriatrics and Gerontology International, 16 (8), 948-955. doi: 10.1111/ggi.12581

Deschodt, M., Claes, V., **Van Grootven, B.**, Van den Heede, K., Flamaing, J., Boland, B., Milisen, K. (2016). Structure and processes of interdisciplinary geriatric consultation teams in acute care hospitals: A scoping review. International Journal of Nursing Studies, 55, Art.No. S0020-7489(15)00300-4, 98-114.

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Deschodt, M., **Van Grootven, B.**, Milisen, K., Flamaing, J., voor het COACH consortium, (2017). G-COACH: geriatrisch comanagement voor cardiologische patiënten in het ziekenhuis. *Verpleegkunde*, (4), 4-7.

Conference abstracts

Van Grootven, B., Jeuris, A., Dubois, C., Herregods, M-C., Milisen, K., Flamaing, J., Deschodt, M. (2019). Effectiveness of a geriatric co-management program for cardiac in-hospital patients: a quasi-experimental study. Presented at the EuroHeartCare, Milan, Italy.

Deschodt, M., **Van Grootven, B.** (2019). Geriatric CO-mAnagement for Cardiology patients in the Hospital (G-COACH): methods and preliminary results of a hybrid effectiveness-implementation study. Presented at the Special Interest Group Geriatric Co-Management American Geriatrics Society, Portland, Oregon.

Van Grootven, B., Jeuris, A., Milisen, K., Flamaing, J., Deschodt, M. (2019). Effectiveness of a Geriatric CO-mAnagement program for Cardiology patients in the Hospital (G-COACH): a quasi-experimental before-after study. Presented at the Annual Scientific Meeting of the American-Geriatrics-Society (AGS), Portland, Oregon.

Van Grootven, B., Jeuris, A., Milisen, K., Flamaing, J., Deschodt, M. (2019). Evaluating the implementation of G-COACH, a geriatrics co-management program for cardiology patients in the hospital, using the PDCA cycle. Presented at the 42ste Wintermeeting, Ostend, Belgium.

Jeuris, A., **Van Grootven, B.**, Milisen, K., Flamaing, J., Deschodt, M. (2019). Identifying vulnerable older adults in cardiac care wards: time to shift the paradigm. Presented at the 42ste Wintermeeting, Ostend, Belgium.

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Van Grootven, B., Flamaing, J., Devriendt, E., Dierckx de Casterlé, B., Dubois, C., Fagard, K., Herregods, M-C., Hornikx, M., Meuris, B., Rex, S., Tournoy, J., Milisen, K., Deschodt, M. (2018). Developing and evaluating a complex Geriatric CO-mAnagement program for Cardiology patients admitted to the Hospital (G-COACH). Presented at the 41st Wintermeeting, Ostend, Belgium.

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Deschodt, M., **Van Grootven, B.**, Jeuris, A., Herregods, M-C., Dubois, C., Hornikx, M., Fagard, K., Devriendt, E., Tournoy, J., Dierckx de Casterlé, B., Meuris, B., Rex, S., Milisen, K., Flamaing, J. (2017). G-COACH: Geriatric CO-Management for Cardiology Patients in the hospital. Presented at the Symposium Veerkrachtig Ouder Worden, Leuven, Belgium.

Van Grootven, B., Flamaing, J., Milisen, K., Deschodt, M. (2017). Geriatric Co-Management Programs: How Are They Organized and Evaluated? A Systematic Review. Presented at the 21st International Association of Gerontology and Geriatrics (IAGG) World Congress, San Francisco, California.

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Van Grootven, B., De Graeve, L., Willemyns, E., Hornikx, M., Dubois, C., Herregods, M-C., Flamaing, J., Milisen, K., Deschodt, M. (2016). Incidence and risk factors for hospitalization-associated functional decline in older patients with valvular heart disease. Presented at the 39th Wintermeeting, Ostend, Belgium.

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Van Grootven, B., Deschodt, M., Devriendt, E., Wils, M., Flamaing, J., Milisen, K. (2015). Advance care planning within residential care for older people, a review. Presented at the 38th Wintermeeting, Ostend, Belgium.

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