

Home-based geriatric rehabilitation after shortened inpatient rehabilitation: Cost-effectiveness analysis of the “Better@Home” multicentre prospective cohort study with a matched historical control group

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Abstract

Purpose

Geriatric rehabilitation (GR) is facing increased demand due to population ageing. Home-based GR could reduce reliance on resource-intensive inpatient care. However, evidence is limited regarding the cost-effectiveness of home-based GR. The aim of this study is to assess the cost-effectiveness of home-based GR following shortened inpatient GR, compared to conventional inpatient GR.

Methods

Eight GR facilities in the Netherlands implemented the Better@Home program, in which home-based GR following shortened inpatient GR is compared to a historical control group receiving conventional inpatient GR. The effect measure was independence in activities of daily living (ADL), assessed by the Barthel Index (BI). Costs were measured as healthcare and societal resource use. Data was gathered at GR-admission- and GR-discharge through semi-structured interviews, registration forms, and electronic patient files. Costs and effects were analyzed using linear mixed effects (LMM) and generalised linear (GLM) regression models, combined with multiple imputation and non-parametric bootstrapping. The primary analysis was conducted from a healthcare perspective valued using national unit sources.

Results

A total of 350 participants were included (intervention $n = 110$; control $n = 240$). The adjusted incremental effect was 0.44 BI-points (95% CI - 0.44 to 1.31), and incremental costs of -€722,63 (95% CI -€2.693,68 to €1.248,43). Uncertainty assessments using non-parametric bootstrapping demonstrated an average mean incremental effect of 0.44 BI-points (95% CI 0.27 to 0.61) and incremental costs of -€654,72 (95% CI -€1.035,66 to -€267,48), indicating an overall dominance of the Better@Home intervention.

Conclusions

The Better@Home program achieved levels of independence in ADL comparable to conventional inpatient GR while showing lower mean costs, suggesting that the program is cost-effective.

JEL classification codes

D61; I12; I18

Key summary points

Aim: To assess the cost-effectiveness of home-based GR following shortened inpatient GR, compared to conventional inpatient GR.

Findings: A total of 350 participants were included (Better@Home $n = 110$; control $n = 240$). Non-parametric bootstrapping assessments demonstrated an average mean incremental effect of 0.44 BI-

points (95% CI 0.27 to 0.61), and incremental costs of –€654,72 (95% CI –€1.035,66 to –€267,48).

Message: The Better@Home program achieved levels of independence in ADL comparable to conventional inpatient GR while showing lower mean costs, suggesting that the program is cost-effective.

Introduction

For community-dwelling older adults, an acute illness, injury, or exacerbation of chronic disease may lead to functional decline requiring admission to a geriatric rehabilitation (GR) facility [1]. GR is defined as “a multidimensional approach of diagnostic and therapeutic interventions, the purpose of which is to optimize functional capacity, promote activity and preserve functional reserve and social participation in older people with disabling impairments” [2]. With rapidly ageing populations, demand for GR services is increasing, straining the accessibility, quality, and sustainability of GR [3, 4]. In addition, post-acute institutional care, such as GR, represents a major contributor to healthcare spending among frail older adults [5, 6]. In response, there is growing interest in transitioning from inpatient to home-based rehabilitation models [7]. Policy initiatives such as “ageing in place” emphasize the importance of supporting older adults to remain living at home, reflecting the shift towards care delivery in home environments [8, 9].

One such approach is home-based GR, in which (part of) the rehabilitation trajectory is delivered in the patient’s home [1, 3]. Home-based GR typically involves rehabilitation at home, which can be supplemented by outpatient or remote care modalities, with patients residing at home throughout the rehabilitation period. Current evidence suggests that home-based GR may achieve outcomes comparable to conventional inpatient GR in terms of readmission- and mortality rates, functional performance, and quality of life [10, 11], while potentially reducing inpatient length-of stay, sedentary behaviour and promoting physical activity [10, 12]. However, the organisation and implementation of home-based GR varies across settings, with limited consensus on key components such as patient selection, rehabilitation intensity, and integration with inpatient care [1, 13]. A scoping review conducted in the Netherlands has shown that home-based GR is still in an early phase of development and requires substantial time, planning, resources and competence-building for successful implementation [14]. To address these challenges, we developed and implemented a structured GR program in which the inpatient GR phase is partly replaced by home-based GR [15]. This program, called Better@Home, is developed in co-creation with GR-professionals, based on current best practices in GR facilities in the Netherlands and evidence from previous research [1, 2, 10, 16–21]. The program strives to achieve outcomes in daily activities that are equivalent or superior to those of conventional inpatient GR, with similar or lower costs.

Economic evaluations provide insight into whether new models of care offer value for money, and are essential to inform decisions on resource allocation and implementation [22, 23]. However, despite growing interest in home-based GR, economic evaluations remain scarce and lag behind the clinical literature in this field [10]. In a recent systematic review of outpatient GR following inpatient GR by

Preitschopf et al. [10], only eight of the 24 included studies reported the cost-effectiveness, and although several studies suggested favourable economic outcomes, the evidence was burdened by heterogeneity in intervention content and methodology. Moreover, all eight studies were conducted over two decades ago and do not reflect contemporary GR practice of integrated care models. Consequently, up to date evidence on the cost-effectiveness of a home-based GR program following inpatient GR is needed. There is limited insight into the distribution of costs and effects, the impact of uncertainty around cost-effectiveness estimates, and the extent to which home-based GR represents an efficient allocation of healthcare resources. Therefore, the aim of this study was to evaluate the cost-effectiveness of the Better@Home program, in which home-based GR following shortened inpatient GR is compared to a historical control group receiving conventional inpatient GR.

Methods

Study design

The Better@Home study is a multicentre prospective cohort study with a matched historical control group, and includes an outcome- and economic evaluation. Additionally, the study incorporates a mixed methods feasibility study. Details on the study protocol, including the prespecified health economic analysis plan, and clinical outcomes are described elsewhere [15, 24].

In this paper, we present the results of the economic evaluation, to assess cost-effectiveness of the Better@Home program. The CHEERS (Consolidated Health Economic Evaluation Reporting Standards) 2022 statement was followed for reporting of the economic evaluation of the Better@Home study (Appendix A) [25].

The Better@Home study was assessed by the Medical Ethics Committee of University Hospital Maastricht/Maastricht University (reference number 2023–3744). The Medical Research Involving Human Subjects ACT (WMO) does not apply to this study, and an official approval of this study by the Medical Ethics Committee is not required. All procedures in this study involving human participants are in accordance with the recent version of the Declaration of Helsinki [26]. Written informed consent from all participants was obtained during inpatient rehabilitation before study inclusion and baseline assessment in the Better@Home cohort.

The Better@Home program

The Better@Home program was co-created by participating care facilities, based on previous research and current best practices in GR in the Netherlands, in close collaboration with a learning network [10]. The following five core components are present in the Better@Home program 1) Replacing part of inpatient GR by home-based GR [1, 2]; 2) Focusing on participation goals during GR [10, 18]; 3) Using eHealth to support rehabilitation [16, 17, 19]; 4) Promoting patients' self-management skills by applying reablement strategies [20, 21]; and 5) Close collaboration between all relevant care partners involved in

the GR trajectory. Further details of the Better@Home program can be found in Appendix B and the study protocol [15]. The Better@Home program was gradually implemented between December 2023 and February 2024, and continued until November 2024.

Setting and population

The Better@Home study was performed in eight GR facilities in the Netherlands. GR facilities were invited to participate if they were willing to co-create and implement the Better@Home program in their GR facility. Prior experience with home-based GR was not a prerequisite to join. Table 1 presents the inclusion criteria for participation in the prospective Better@Home cohort, displayed as criteria for the Better@Home program and additional criteria for inclusion in the Better@Home study.

The Better@Home study incorporated a historical control population, consisting of patients who received conventional inpatient GR. Control group patients were admitted to the participating GR facilities between January 2022 and June 2023. A minimum of six months prior to the implementation of the Better@Home program was adhered, thereby minimizing the risk of contamination bias while ensuring a similar context of care. Patients who received home-based GR were excluded from the historical control group, as several facilities had already introduced home-based GR on a limited scale. Participants of the historical control group were matched, based on the scores of independence in ADL, as measured by the Barthel Index (BI) at admission to the GR facility. BI strata (0–4; 5–9; 10–14; 15–19; 20) were constructed per diagnosis group in each facility. Subsequently, frequency matching was conducted, whereby patients for the historical control group were matched and randomly selected per facility from each BI stratum within a diagnosis group. An online randomisation tool with two arms, a permuted block algorithm, and a fixed block size of 1 was used to randomly select the matched participants of the historical control group. All patients' data in the historical control group were received anonymised from the GR facilities. Further details of the study procedures can be found in the study protocol [15].

Table 1
Inclusion criteria of the Better@Home program & study

Inclusion criteria of the Better@Home program
Primary criteria • Admission to one of the eight participating GR facilities to implement the Better@Home program; • Considered eligible for the Better@Home program judged by the facility's multidisciplinary team; based on physical, cognitive, and psychological functioning; • Living in the community prior to admission. Secondary criteria (based on organizational differences in local GR facility protocols) • Primary medical diagnosis designated by the local GR facility as eligible for the Better@Home program (ranging from a single diagnosis, e.g. trauma, to several diagnosis groups or all GR admissions); • Practical criteria, e.g. maximum travel distance between GR facility and patients' home; • Patient-related criteria, e.g. availability of professional home care.
Inclusion criteria of the Better@Home study
• Able to participate in an interview; • Able to speak and understand Dutch; • Able to provide informed consent.

Data collection

Table 2 presents the baseline characteristics, effect measures and healthcare resource use (HRU) data collected during the study period, as well as the data collection method. Data were collected at two timepoints; at GR-admission and GR-discharge, using structured face-to-face interviews, registration forms and electronic patient files. For the Better@Home group, GR-discharge is the definitive ending of GR, following the combined duration of the inpatient and home-based phase. All interviews were performed by a trained researcher or research-assistant. Data were collected from a broad perspective, including healthcare and societal costs. However, due to limitations inherent to retrospective data collection from electronic patient files in the historical control group, only data on independence in ADL, inpatient length-of-stay and hospital (re)admissions could be acquired for this group (Table 2). Therefore, the main analysis was conducted assuming a healthcare cost perspective. No data on health-related quality of life was available for the historical control group, precluding direct estimation and comparison of quality-adjusted life-years (QALYs) between groups. Consequently, a cost-effectiveness framework using the BI as the effectiveness measure was adopted. As there is no scientific basis for a willingness-to-pay (WTP) threshold for non-QALY outcomes [27], no threshold-based interpretation was applied.

Table 2
Baseline characteristics, effect measure and healthcare resource use, per time point

	Measurement time points			
	GR admission		GR discharge	
	Better@Home	Control	Better@Home	Control
Baseline characteristics				
Age	FI	EPF		
Sex	FI	EPF		
Educational level	FI	-		
Living arrangement	FI	EPF		
Medical diagnosis (cause of admission)	RF	EPF		
Effect measures				
Independence in daily functioning (BI)	EPF	EPF	FI	EPF
Quality of life (EQ-5D-5L)	FI	-	FI	-
Healthcare resource use				
Length-of-stay, inpatient; <i>n</i> days	EPF	EPF	EPF	EPF
Length-of-stay, home-based; <i>n</i> days			EPF	-
Home-based GR treatment; <i>n</i> sessions			RF	-
Hospital care, (re)admissions ^a ; <i>n</i> days			EPF/FI	EPF
Medical care, other; <i>n</i> consultations			FI	-
GP care; <i>n</i> consultations			FI	-
Mental health care; <i>n</i> consultations			FI	-
Home-care ^b ; <i>n</i> hours per week			FI	-
Societal resource use				
Informal care ^c ; <i>n</i>			FI	-

EPF= Electronic Patient File; FI= Face-to-face interview patient; RF= registration form care professionals; BI= Barthel-index; EQ5D-5L= EuroQol health-related quality of life.

a = EPF collection method during inpatient GR and FI collection method during home-based GR; b= Includes household support and personal nursing care; c=Includes time and travel expenses.

Outcome measure

The primary outcome measure was independence in ADL, assessed with the BI [28]. The BI was measured within two weeks after GR-admission and GR-discharge by a care professional or trained research assistant. The BI, initially described by Mahoney and Barthel, is a 10-item measure of activities of daily living used in clinical practice to assess baseline abilities, quantify functional change after rehabilitation, and inform discharge planning [28]. The scoring on the modified version of the BI used in the present study ranges from 0 to 20. Higher scores indicate greater levels of independence [28]. The BI's structural validity, reliability, and interpretability are sufficient for measuring and interpreting changes in physical functioning of GR patients [28–30].

In two of the participating facilities, the Utrecht Scale for Evaluation of Rehabilitation (USER) was used as an alternative for the BI [31, 32], which is common practise in GR-facilities in the Netherlands. In these organizations, scores were converted from USER to BI [33]. This conversion is performed on a per-item level, as documented by Utrecht Rehabilitation Medicine Knowledge Center (Kenniscentrum Revalidatiegeneeskunde Utrecht), using a template file [34]. For each BI-item, relevant scores on USER-items are matched, with the derived BI-item scores summed to the BI-total score.

Healthcare resource use and costs

HRU was collected using data from the electronic patient files and a modified version of the iMTA Medical Consumption Questionnaire (iMCQ), adapted for the study (Appendix C) [35]. The questionnaires were assessed during face-to-face interviews with patients in the Better@Home group within two weeks after GR-discharge. The mean total cost per patient was calculated by multiplying the volume by the price of the unit, obtained from the Dutch Manual for Economic Evaluations in Healthcare: Methodology and Reference costs 2024 [27]. All costs were expressed in euros (€). Costs were distinguished as: 1) costs during inpatient GR; and 2) costs during home-based GR.

Costs during inpatient GR consisted of length-of-stay in the GR facility and potential (re)admissions to hospital, both noted as time in days. For both cohorts, this data was collected from the electronic patient files. The daily rate of inpatient GR was determined at €329. The daily rate of hospital admission was determined at €644 [27].

Costs during home-based GR consisted of treatment sessions with GR-professionals as well as additional HRU. Details of the treatment sessions during home-based GR were noted by the GR-professionals on a short registration form (Appendix D). Details include treatment frequency, treatment time and travel time. Furthermore, the nature of these treatment sessions (at home, outpatient (individually or group based), or remotely using eHealth) was also registered by the GR-professionals. Costs of treatment sessions during home-based GR were calculated by multiplying the treatment time noted in the registration form by the rate per minute for each GR-profession (Appendix E, Table 1). For treatment sessions performed at home, a standardised additional charge of €30,64 per treatment session was applied, which includes the cost for travel time, transportation, maintenance and

depreciation. Additional costs during home-based GR were assessed during structured face-to-face interviews with patients within two weeks after GR-discharge, and included the following HRU (Appendix C): 1) number and nature (home-based or in the practice) of GP consultations; 2) number and nature (e.g. admission, examination and/or outpatient consultations) of hospital care; 3) number and nature of mental health care; 4) average weekly number of hours of household support and/or personal nursing care. The unit description and associated costs are reported in Appendix E, Table 2.

Informal care costs were assessed during structured face-to-face interviews with patients within two weeks after GR-discharge (Appendix C). Informal care costs consisted of the average weekly number of hours of informal care, multiplied by a standardized rate of €18.80 per hour, in which informal care is valued at the price of professional household support [27]. Furthermore, travel expenses were calculated by multiplying the number of visits to a healthcare service (e.g. GP, hospital or allied health professional appointments) with standardised distances, transportation fees and parking fees, which are reported in Appendix E, Table 3 [27]. Given that the majority (94%) of participants were beyond the official retirement age of 65 years, productivity losses were considered negligible and were not included.

Development and training costs of the Better@Home program were excluded, as these represent one-off implementation costs that are not expected to recur during routine care delivery. The time horizon of this economic evaluation covered the full duration of the rehabilitation trajectory, from GR admission until definitive GR discharge. This horizon was considered appropriate since the intervention aimed to substitute part of inpatient GR with home-based GR. Therefore, discounting of costs and effects was not applied since the study time horizon was shorter than one year.

Statistical methods

Statistical analyses were performed using the statistical software package IBM SPSS Statistics version 29.0.2.0 and R version 4.5.2. Descriptive statistics were used to summarise baseline characteristics, HRU and associated costs from GR-admission to GR-discharge, and BI scores at GR-admission and GR-discharge. While the sample size of the Better@Home study was based on detecting differences in the primary clinical outcome [15], the study was not powered to detect differences in costs or cost-effectiveness. Non-parametric bootstrapping was applied to appropriately characterise uncertainty around cost and cost-effectiveness estimates.

A linear mixed-effects model (LMM) was used to estimate the average treatment difference on independence in ADL, as measured by the BI, replicating the same specifications used in the statistical analysis of the clinical outcome of the study [24]. The LMM allowed adjustment for relevant confounders and handled missing outcome data through a likelihood-based approach, which is valid under the missing at random (MAR) assumption [36]. Details on the LMM specifications and analyses can be found in the main clinical outcome paper [24].

A generalised linear regression (GLM) model was used to assess the difference in average total costs between GR-groups, assuming a Gamma distribution with log link function, while adjusting for *facility* and *treatment* variables. A stepwise model selection procedure was used to identify the relevant predictors included in the final model, where a comparison of alternative model specifications based on the Akaike Information Criterion (AIC) was used to select the final model choice, based on the fit of the observed data.

Base-case analysis

The main base-case analysis included the following HRU data: 1) Inpatient length-of-stay; 2) home-based GR treatments; and 3) hospital (re)admissions during both inpatient and home-based GR. In the base case analysis, the statistical approaches were implemented after missing data in all health economic variables were handled via multiple imputation by chained equation (MICE) methods, under a MAR assumption [37]. Missing data were imputed separately by treatment group, including all available (partially)-observed variables as possible auxiliary variables into the imputation model to improve the plausibility of MAR. Key variables included in the imputation model were: facility, age, sex, diagnosis, living situation, education level (only intervention), BI at GR-admission and GR-discharge, EQ-5D-5L index at GR-admission and GR-discharge (only intervention), costs of inpatient stay, costs of hospital admittance, costs of home-base GR (only intervention), costs of HRU excluding/including informal care (only intervention) and total costs excluding/including informal care. Predictive mean matching (PMM) was used as the imputation method for all outcomes. 20 data-sets were imputed, as a conservative choice with respect to the overall proportion of missing values (10%). Adjusted mean BI scores and total costs, as well as incremental differences between groups, were estimated by fitting the specified LMM (for BI) and GLM (for costs) within each imputed dataset. Estimates were pooled across imputations using Rubin's rules, and related measures of uncertainties were computed and reported as point estimates with corresponding 95% confidence intervals.

Sampling uncertainty using non-parametric bootstrapping

Following guidelines on trial-based health economic evaluations [27], an assessment of uncertainty around health economic results was conducted using a combination of non-parametric bootstrapping and multiple imputation techniques [38, 39]. A non-parametric bootstrapping procedure was used to generate a set of 5000 replications for each of the 20 imputed datasets generated via MICE to derive the base-case health economic results (bootstrapping embedded within MI). In each of the *bootstrapping x MI* datasets, the statistical approach used in the base-case analysis for the effect and total cost was fitted, and related estimates of interest were derived. Then, estimates were combined across imputations to obtain pooled bootstrap estimates, reflecting both sampling uncertainty and uncertainty due to missing data. These estimates were used for computing standard health economic measures, including the Incremental Cost-Effectiveness Ratio (ICER) and to construct the cost-effectiveness- plane.

All bootstrapped estimates were summarised as point estimates with corresponding 95% bootstrapped confidence intervals constructed using the percentile method.

Additional scenario analyses

Two additional scenario analyses were conducted to explore the impact of changes in the calculation of total costs, only for the Better@Home group: one where all HRU costs were included in the total cost calculation, but excluding informal care costs (scenario analysis 1); one where all HRU- and informal care costs were included in the total cost calculation (scenario analysis 2). The results of the scenario analyses are subject to asymmetrical data comparison, due to the aforementioned limitations in data collection for the historical control group.

Results

A total of 350 participants were included in this economic evaluation (intervention $n = 110$; control $n = 240$). Details on the study flowchart are reported in the clinical outcome paper [24]. Mean age was comparable between groups (78.4 vs 78.8 years), as well as all other baseline characteristics (see Appendix F, Table 1). Observed BI-scores were also comparable between groups at GR-admission (11.32 vs 11.50) and GR-discharge (16.99 vs 16.88). The results of the final LMM with details on the mean difference in BI-scores between the Better@Home and the historical control group are reported in Appendix F, Table 2. At GR-discharge, complete cost and effectiveness data were available for 74 (67%) participants in the Better@Home group, and for 166 (69%) participants in the control group.

Healthcare resource use, costs and effects

Table 3 provides summary statistics for the effect measure and all main categories of HRU, including associated costs, based on the unadjusted observed data at GR-discharge for both groups. Descriptive statistics for HRU variables during home-based GR are reported in Appendix F, Tables 3 and 4. Mean inpatient GR duration was 33.1 days in the Better@Home group and 37.6 days in the control group (mean difference 4.5 days; 95% CI 1.7 to 10.7; $p = .151$), whereas mean total rehabilitation duration was 64.8 and 37.6 days, respectively (mean difference 27.3 days; 95% CI -34.1 to -20.4; $p < .001$). Within the Better@Home group, the home-based GR phase lasted a mean of 36.3 days and comprised a mean of 9.7 treatment sessions per patient, of which 7.6 were travel-related (at home) visits. Mean observed total costs were €10.724,40 in the Better@Home group and €13.024,12 in the control group, corresponding to an unadjusted mean difference of €2.299,72 in favour of the intervention (95% CI -364,81 to 4.964,25; $p = .090$). The mean total cost results for both scenario analyses are reported in Appendix F, Table 5.

Base-case analysis after multiple imputation

Table 4 reports the base-case analysis results after multiple imputation. The estimated mean BI-score at GR-discharge was 17.96 in the Better@Home group and 17.52 in the control group. The adjusted incremental effect was 0.44 BI-points (95% CI -0.44 to 1.31; $p = .326$). The estimated mean total costs were €11.792,32 in the Better@Home and €12.514,95 in the control group, yielding an adjusted

incremental cost of €-722,63 (95% CI -2.693,68 to 1.248,43; p=.471). The results after multiple imputation for both scenario analyses are reported in Appendix F, Table 6.

Sampling uncertainty using non-parametric bootstrapping

Table 5 reports the assessment of uncertainty after pooling model results across imputations and non-parametric bootstrapping iterations. Results demonstrate a mean incremental effect of 0.44 BI-points (95% CI 0.27 to 0.61) and a mean incremental cost of €-654,72 (95% CI -€1.035,66 to -€267,48), indicating dominance of the Better@Home group. The mean ICER was -€1.490,68 per BI point gained, consistent with the dominance pattern of the Better@Home intervention. Figure 1 displays the cost-effectiveness plane, showing the joint distribution of the bootstrapped paired mean outcome differences (i.e. the dots), which indicate a pattern of dominance of the Better@Home group. The results for both scenario analyses are reported in Appendix F, Table 7.

Table 4

Mean effect, mean total costs and incremental outcomes between groups at GR-discharge, after multiple imputation.

Effect at GR-discharge (BI)	Mean	P-value	95% CI - lower	95% CI - upper
Control group	17.52	-	15.79	19.23
Better@Home group	17.96	-	16.24	19.67
Incremental effect (Better@Home vs control)	0.44	0.326	-0.44	1.31
Total costs				
Control group	€12.514,95	-	€11.141,52	€14.057,68
Better@Home group	€11.792,32	-	€10.095,85	€13.773,86
Incremental costs (Better@Home vs control)	-€722,63	0.471	-€2.749,57	€1.191,79

All costs presented in EUR (€) currency; GR= Geriatric rehabilitation; BI= Barthel-index.

Table 5

Pooled results across imputations and bootstrap iterations between groups at GR-discharge

Effect at GR-discharge (BI)	Mean	95% CI - lower	95% CI - upper
<i>Control group</i>	17.44	17.26	17.62
<i>Better@Home group</i>	17.88	17.69	18.07
<i>Incremental effect (Better@Home vs control)</i>	0.44	0.27	0.61
Total costs			
<i>Control group</i>	€12.425,32	€12.155,91	€12.697,13
<i>Better@Home group</i>	€11.770,60	€11.460,13	€12.070,72
<i>Incremental costs (Better@Home vs control)</i>	-€654,72	-€1.035,66	-€267,48
ICER, per BI point	-€1.490,68		

All costs presented in EUR (€) currency; GR= Geriatric rehabilitation; BI= Barthel-index; ICER= Incremental cost-effectiveness ratio;

Figure 1. Cost-effectiveness plane for the probabilistic analysis.

Cost-effectiveness plane of incremental costs and effectiveness (Barthel Index) for the Better@Home (intervention) group, compared to the control group.

Discussion

This multicentre cohort study evaluated the cost-effectiveness of the Better@Home program, in which home-based GR following shortened inpatient GR is compared to a historical control group receiving conventional inpatient GR. The assessment of uncertainty using non-parametric bootstrapping indicated that the joint distribution of costs and effects consistently favoured the Better@Home program; a mean incremental effect of 0.44 BI-points (95% CI 0.27 to 0.61) and a mean cost difference of -€654,72 (95% CI -€1.035,66 to -€267,48), suggesting the overall cost-effectiveness of the program. Since the effect outcomes are well within the range of standard error of measurement and smallest detectable change for the BI [30], these findings indicate that the Better@Home group achieved comparable levels of independence in ADL with lower mean healthcare costs, supporting the partial substitution of inpatient GR by home-based GR using the Better@Home program.

Based on previous research, the evidence for the cost-effectiveness of home-based GR is limited, particularly for home-based GR following shortened inpatient GR. In the review by Preitschopf et al. [10], only eight of the 24 included studies reported the cost-effectiveness, of which six suggested favourable economic outcomes. The authors argued that a shorter inpatient stay and less care needs might be the

primary reasons for this effect [10]. However, the evidence was characterised as mostly outdated, with heterogeneity in intervention content and costing methodology. A systematic review with more recent economic evaluations of care delivered at home compared with institution-based care in older adults, likewise found that home-based care was cost-saving in seven of the 14 included studies and cost-effective in two [40]. Hospital-based care was cost-saving in two of the included studies, with the remaining three studies showing no significant differences. However, the authors highlighted major between-study heterogeneity as well, in particular in study populations, costing methodology, and intervention designs, limiting comparability of the studies and confidence in the results. Still, our findings are consistent with the overall evidence, indicating that home-based GR can achieve economically favourable results.

In contrast, the recent randomized controlled HERO trial by Prescott et al. [41], in which home-based rehabilitation for older people with frailty was compared to usual care, was found not cost-effective and demonstrated an ICER of £58,375 per QALY. However, the HERO trial applied an extended home-based intervention following discharge, whereas the Better@Home program was designed as a substitution model within the GR trajectory, replacing part of inpatient care with a structured home-based phase [41]. Specifically, the HERO-intervention was found not cost-effective since it yielded only marginal health gains with no substantial reduction in downstream healthcare consumption, thus increasing costs due to the add-on intervention design. Economically, this distinction may be impactful, as substitution models can offset community-based costs through shorter inpatient care, whereas add-on models cannot.

The economic advantage of the Better@Home program was primarily driven by the substitution of inpatient rehabilitation with a lower-intensity home-based phase. The Better@Home group reported a reduction of approximately 4.5 inpatient days (33.1 vs 37.6 days), corresponding to a mean decrease in inpatient costs of €1,481.58, accounting for 62% of the observed base-case cost difference. Although the home-based phase (mean 36.3 days) lasted substantially longer than the time gained from the reduced inpatient phase, it was characterised by relatively low treatment intensity (mean 9.7 total sessions per patient), with an associated intervention cost of only €799,80. This pattern indicates that the Better@Home program operates as a low-intensity substitution model, in which a structured GR program delivered in the home setting replaces a more resource-intensive inpatient trajectory. These findings are consistent with existing economic evidence from a Cochrane review [42], showing that home-based care models have the potential to be cost-saving when they substitute institutional care. However, the uncertainty of the results due to between-study heterogeneity was emphasized, as well as the possibility that early discharge to home may offset any reduction in costs from shortened institutional length-of-stay [42]. Namely, early discharge from inpatient rehabilitation may shift care demands to the community, potentially increasing the complexity and intensity of care delivered at home [43]. While such strategies may reduce institutional length-of-stay, these gains may be partly offset by increased healthcare resource consumption at home, particularly in populations with higher levels of frailty. In the present study, scenario analyses were conducted to account for healthcare resource use and informal care during the home-based phase. However, the scenario results should be interpreted with caution, as comparable data on resource use were not available for the control group and were

therefore assumed to be zero. Given that healthcare consumption is known to occur in the weeks following discharge from conventional inpatient GR [44], this approach likely underestimates true costs in the control group and may introduce bias in the comparative scenario estimates. Therefore, while the current study provides insights into the community costs of the home-based phase, the extent to which reduced inpatient stay is offset by the potentially increased use of community-based healthcare consumption is not fully known.

Importantly, the shift in setting and lower treatment intensity of the home-based phase for the Better@Home group did not compromise clinical outcomes. While the observed BI scores at discharge were nearly identical between groups (16.99 vs 16.88), the estimated incremental effect after adjusting for confounders shifted modestly in favour of Better@Home (+ 0.44 BI points, 95% CI – 0.44 to 1.31), demonstrating that the reduction in inpatient days still translated into comparable or potentially superior functional recovery. These findings are consistent with current evidence indicating that home-based GR can achieve functional outcomes comparable to usual care [10].

The results of the present study may raise several considerations. By substituting part of inpatient GR with home-based care, pressure on limited inpatient capacity may be alleviated, contributing to a more efficient resource allocation within ageing healthcare systems. Additionally, by stimulating active behaviour and engagement in meaningful activities in the home environment through the Better@Home program, home-based GR may assist in reaching participation-oriented goals [18, 45]. Interventions that can achieve comparable outcomes while reducing reliance on high-cost inpatient resources are therefore of considerable interest.

Strengths and limitations

This study has several strengths. The Better@Home study is a comprehensive multicentre evaluation of a structured home-based GR program developed in co-creation with care professionals, evidence-based literature and best practices. Key strengths include the multicentre design across eight GR facilities, the inclusion of a broad range of medical diagnostic categories and a relatively large sample size of a geriatric population with increased vulnerability, which enhances the generalizability of the findings.

Some limitations must also be addressed. First, the use of a historical control group restricted the availability of various comparable data across groups. However, a prospective controlled design was not ethically possible, as home-based GR was already implemented in usual care by several participating facilities, and withholding this treatment option from eligible patients could not be enforced. As a consequence, the lack of health-related quality-of-life data precluded the evaluation in QALYs as recommended by guidelines for economic evaluations, and the cost-effectiveness analysis had to be performed using the BI as the effect measure. While the absence of a validated WTP threshold for the BI indicates that results should be interpreted with caution, the dominance pattern established in the cost-effectiveness analysis reduces dependency on any single threshold choice. As such, the conclusion of economic favourability of the Better@Home intervention is robust. Additionally, with data on informal

care and several healthcare resource services being unavailable retrospectively, the primary analysis was restricted to a healthcare perspective. However, all costs from a societal perspective were included in the additional scenario analyses for the Better@Home group. Yet, these analyses should be interpreted with caution, as comparable data were not available for the control group, resulting in an asymmetric comparison.

Furthermore, this study was powered for the primary clinical outcome rather than for cost-effectiveness. However, this reflects common practice in economic evaluations conducted alongside empirical studies, and uncertainty surrounding cost-effectiveness was quantified using non-parametric bootstrapping [23]. Lastly, although the Better@Home study included a 3-month follow-up to assess long(er)-term outcomes [15], these data were not incorporated in the present economic evaluation, as follow-up data were not available for the historical control group due to limitations with retrospective data collection. Consequently, the current analysis is restricted to the period of GR-admission up to GR-discharge, and does not capture potential long(er)-term costs and effects.

Conclusion

The Better@Home program achieved levels of independence in ADL comparable to conventional inpatient GR while showing lower mean costs, suggesting that the program is cost-effective. These findings support the partial substitution of inpatient GR by home-based GR.

Future studies should aim to apply a broader cost perspective including societal costs, as well as utility-based outcomes for both study groups to enable QALY-based analyses. In addition, longer follow-up time with comparable data is required to determine whether home-based GR following shortened inpatient GR leads to sustained effects on healthcare resource consumption, costs and independence in ADL.

Declarations

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Ethics declaration

The Better@Home study was assessed by the Medical Ethics Committee of University Hospital Maastricht/Maastricht University (reference number 2023-3744). All procedures in this study involving human participants are in accordance with the recent version of the Declaration of Helsinki [26]. Written informed consent from all participants was obtained. All patients' data in the historical control group were received anonymised from the GR facilities.

Competing interests

The authors declare that they have no conflicts of interest.

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Table 3

Table 3 is available in the Supplementary Files section.

Figures

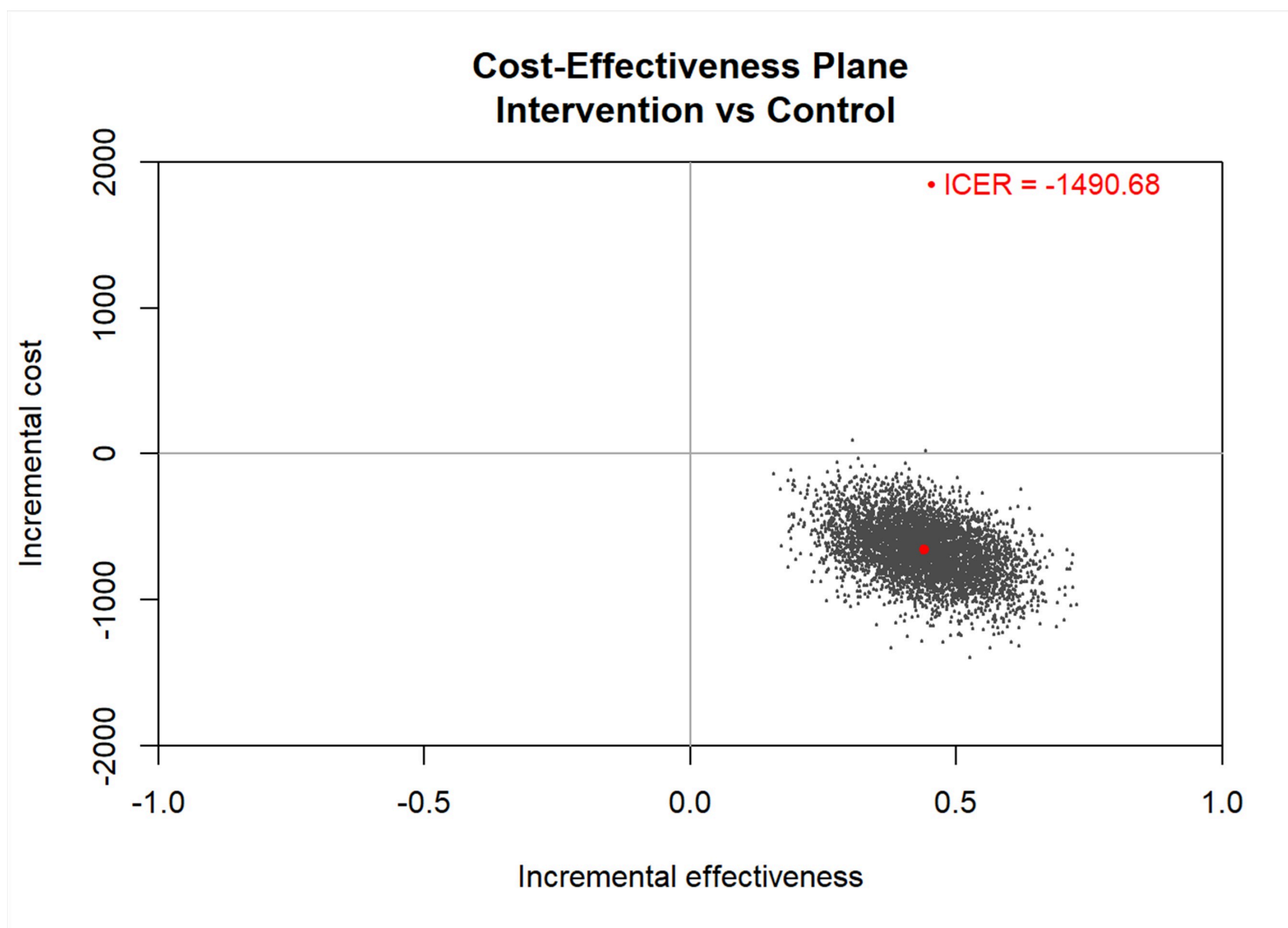


Figure 1

Cost-effectiveness plane for the probabilistic analysis.

Cost-effectiveness plane of incremental costs and effectiveness (Barthel Index) for the Better@Home (intervention) group, compared to the control group.

Supplementary Files

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- [CosteffectivenessHomebasedGRAppendices.docx](#)
- [Table3.docx](#)