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Inpatient Rehabilitation Specifically Designed for Geriatric Patients: Systematic Review and Meta-Analysis of Randomised Controlled Trials

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Inpatient rehabilitation specifically designed for geriatric patients: systematic review and meta-analysis of randomised controlled trials

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ABSTRACT

Objective To assess the effects of inpatient rehabilitation specifically designed for geriatric patients compared with usual care on functional status, admissions to nursing homes, and mortality.

Design Systematic review and meta-analysis.

Data sources Medline, Embase, Cochrane database, and reference lists from published literature.

Review methods Only randomised controlled trials were included. Trials had to report on inpatient rehabilitation and report at least one of functional improvement, admission to nursing homes, or mortality. Trials of consultation or outpatient services, trials including patients aged <55, trials of non-multidisciplinary rehabilitation, and trials without a control group receiving usual care were excluded. Data were double extracted. Odds ratios and relative risks with 95% confidence intervals were calculated.

Results 17 trials with 4780 people comparing the effects of general or orthopaedic geriatric rehabilitation programmes with usual care were included. Meta-analyses of effects indicated an overall benefit in outcomes at discharge (odds ratio 1.75 (95% confidence interval 1.31 to 2.35) for function, relative risk 0.64 (0.51 to 0.81) for nursing home admission, relative risk 0.72 (0.55 to 0.95) for mortality) and at end of follow-up (1.36 (1.07 to 1.71), 0.84 (0.72 to 0.99), 0.87 (0.77 to 0.97), respectively). Limited data were available on impact on health care or cost. Compared with those in control groups, weighted mean length of hospital stay after randomisation was longer in patients allocated to general geriatric rehabilitation (24.5 v 15.1 days) and shorter in patients allocated to orthopaedic rehabilitation (24.6 v 28.9 days).

Conclusion Inpatient rehabilitation specifically designed for geriatric patients has the potential to improve outcomes related to function, admission to nursing homes, and mortality. Insufficient data are available for defining characteristics and cost effectiveness of successful programmes.

INTRODUCTION

As a complement to acute and curative medicine, rehabilitation medicine is recognised as an efficient tool in the treatment of patients in the Western world. According to the World Health Organization, the aim of rehabilitation is to maximise function and minimise limitation of activity and restriction of participation resulting from an underlying impairment or disease.1 WHO’s international classification of functioning, disability, and health (ICF) framework takes into account not just medical or biological dysfunction but the social aspects of disability as well. It shifts the focus of rehabilitation medicine from cause to impact and places all health conditions on an equal footing in assessing the impact of multiple domains on a person’s functioning.

Rehabilitation medicine is well accepted as a specialised medical discipline for the treatment of younger patients with organ specific neurological, musculoskeletal, orthopaedic, pulmonary, and cardiovascular diseases. In geriatric patients with special needs associated with ageing (such as cognitive problems, multiple comorbidities, polypharmacy, end of life decisions) the situation is less clear, and the impact of rehabilitation (for instance, effect on health outcomes, rates of readmission to hospital, healthcare cost benefit) is still controversial. Although it is well known that after an acute hospital stay older adults are at increased risk of death and admission to a nursing home,2,3 inpatient rehabilitation specifically designed for older adults to address the special aspects of ageing is not standard practice.

Specialised inpatient and outpatient treatment for older adults might have the potential to optimise health outcomes, notably by improving functional status. As a result, geriatric rehabilitation programmes might not only improve outcomes but might also generate long term cost savings by reducing admissions to nursing homes.4,5 Furthermore, delaying functional decline and avoiding such admissions might be instrumental not just in reducing healthcare costs but also in effectively maintaining quality of life in older adults.6
To the best of our knowledge there are no systematic reviews or meta-analyses focusing on the topic of inpatient rehabilitation of older adults based on the WHO framework. We summarised the short term (at discharge) and longer term (at end of follow-up) effects of inpatient rehabilitation specifically designed for geriatric patients on the key outcomes of functional improvement, admissions to nursing homes, and mortality. We also identified characteristics that might differentiate successful from unsuccessful rehabilitation programmes as well as their impact on health care. We hypothesised that inpatient rehabilitation programmes are more likely to be beneficial if they follow the WHO framework rehabilitation cycle. Such programmes include a multidimensional geriatric assessment, stringent assignment to therapies, regular team meetings with all health professionals involved in the care of the patient, goal setting tailored to the individual patient, interventions tailored to the patient’s needs, and regular treatment evaluation with the care team and the patient.

METHODS

Literature search and eligibility criteria
We searched for randomised controlled trials on the effects of inpatient rehabilitation specifically designed for geriatric patients. Rehabilitation was defined as inpatient multidisciplinary programmes with active physiotherapy or occupational therapy, or both, according the WHO ICF framework. Published studies were identified through searches in Medline, Embase (1 January 1970 to 31 July 2008), and the Cochrane Central Register of Controlled Trials (CENTRAL) database using the key words: geriatric, elderly, old, very old, aged, inpatient, rehabilitation, discharge, post(acute), hospitalisation, randomised, exercise, fitness, training, multidisciplinary therapy, ICF, physiotherapy, occupational therapy, geriatric evaluation, geriatric assessment, geriatric management, nursing home, mortality, Barthel, Functional Independence Measure (FIM), Mini mental, Timed-up-and-go test, function, functional, fit-to-walk, restoration, strength, maintenance.

Additional trials were identified by screening reference lists. No language restrictions were applied. Trials had to report on inpatient rehabilitation specifically designed for geriatric patients and report at least one of functional status, admissions to nursing homes, or mortality. We excluded studies that were not peer reviewed randomised controlled trials, studies offered to patients of all ages (that is, the study did not use an age threshold for including patients or the study used an age threshold of <55), interventions that were not an inpatient programme in a designated unit, interventions that were part of an acute care programme without rehabilitation in medically stable patients, interventions that did not include a multidisciplinary therapy programme including active physiotherapy or occupational therapy, or both, directed towards functional status of patients, studies that did not report on the predefined outcome data, and studies with a control group in which patients did not receive usual care (such as randomised controlled trials comparing two different forms of rehabilitation).

Data extraction and management
Two reviewers (SB and CF) independently screened titles, abstracts, and full texts. Discrepancies were resolved through discussion with a third reviewer (AES). We extracted information on the mean age of the study population, location of the intervention (such as separate ward in acute hospital, separate hospital for rehabilitation), mean length of stay in hospital under acute care before randomisation (for intervention and control groups combined), length of hospital stay after randomisation (separately for intervention and control group), length of follow-up for outcome evaluation, and whether or not patients in the intervention group entered an outpatient follow-up therapy programme after their stay in hospital. Most trials reported length of hospital stay after randomisation as a mean or median value without standard deviations. We therefore calculated means within groups weighted for sample size; statistical pooling of the data was not possible.

On the basis of search results, we classified studies as orthopaedic geriatric rehabilitation after hip fracture or general geriatric rehabilitation. We extracted all information on the key outcomes of functional status, admissions to nursing homes, and mortality at discharge (or within four weeks after discharge) and at the end of follow-up (preferably at one year or closest to one year). Our definition of functional status was based on activities of daily living (ADL), most commonly the Barthel index but also included other measures of functional ability as reported (for example, activities of daily living score, personal self maintenance scale). If more than one functional outcome was reported we used measures based on activities of daily living score. At discharge and at the end of follow-up we recorded the number of patients with functional improvement, the number admitted to nursing homes, and the number who died. Unpublished data were available from three studies. Lastly, we measured the impact of geriatric rehabilitation programmes on health care measured by rate of readmission to hospital and total programme costs.

Assessment of quality of intervention programme and methodological quality of trials
Two reviewers (SB and CF) independently assessed all included trials for quality of the intervention programme and the trial methods. Quality of the intervention programme was measured according to the WHO ICF framework rehabilitation cycle. It included whether or not studies performed multidimensional geriatric assessment and assigned patients (defined as assignment to therapy and care team meetings for individualised goal setting). Assessment of methodological quality was based on concealment of allocation (for instance, explicit report of a method of concealed random allocation), independence of assessors (for instance, explicit report...
that staff assessing functional status and nursing home outcomes were blinded to the patients’ allocation), and analyses by intention to treat (that is, participants were analysed within their randomised groups).21

**Statistical analysis**

For admission to a nursing home and mortality outcomes, we calculated relative risks with 95% confidence intervals. Functional outcomes (primarily reported as means (SD) of the Barthel or Katz index) were converted to odds ratios and 95% confidence intervals according to the method described by Chinn and Hasselblad and Hedges.33 This method, used in previously published meta-analyses,1,4 is based on the fact that with logistic distributions and equal variances in the two treatment groups the log odds ratio corresponds to a constant multiplied by the standardised difference between means.

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Table 1: Description of main characteristics of 17 included randomised controlled trials (listed alphabetically by type of rehabilitation) of inpatient rehabilitation specifically designed for geriatric patients. In all studies, patients in control group received standard inpatient care, except in study of Karppi et al.,22 in which they received usual supervised home care.

| Type of hospital for initial acute care | Reason for initial hospital admission | Mean length of hospital stay before randomisation (days) | Main criteria for selection of study sample | Mean age (years) | No of patients (intervention/control) |
|----------------------------------------|---------------------------------------|--------------------------------------------------------|---------------------------------------------|-----------------|--------------------------------------|
| General geriatric rehabilitation       |                                       |                                                        |                                             |                 |                                      |
| Applegate 1990, USA†‡                  | Functional impairment from acute illness | 21                                                     | Age ≥65, at risk for admission to nursing home, reversible functional problem, medically stable, not terminally ill or severely demented | 78.8            | 78/77                                |
| Cohen 2002, USA‡                         | Acute medical or surgical illnesses   | NA                                                     | Age ≥65, admitted from home, not terminally ill or severely demented | 74.2            | 694/694                              |
| Fleming 2004, UK‡                        | Acute medical or orthopaedic disorders | 35                                                     | Age ≥65, admitted from home, at risk for admission to nursing home, not severely disabled or demented, medically stable | 81.5*           | 81/84                                |
| Karppi 1995, Finland‡                    | Medical problems with anticipated benefit from geriatric intervention | 0‡                                                     | Age ≥65, admitted from home, at risk for admission to nursing home, reversible functional problem | 78.5            | 104/208                              |
| Rubenstein 1984, USA‡                     | Acute medical or surgical illnesses   | ≥7                                                     | Age ≥65 (all men), at risk for admission to nursing home, reversible functional problem, not terminally ill or severely demented | 77.9            | 63/60                                |
| Saltvedt 2002, Norway†                   | Acute medical illnesses               | 0‡                                                     | Age ≥75, admitted from home, frail, not terminally ill or severely demented | 82.1            | 127/127                              |
| White 1994, UK‡                          | Acute medical or surgical illnesses   | 17                                                     | Age ≥65, at risk for admission to nursing home, reversible functional problem, not severely demented, medically stable | 76.5            | 20/20                                |
| Young 2007, UK‡                          | Acute medical or surgical illnesses   | 6*                                                     | Age ≥75, reversible functional problem, medically stable | 86.0*           | 280/210                              |
| Orthopaedic geriatric rehabilitation    |                                       |                                                        |                                             |                 |                                      |
| Cameron 1993, Australia†                 | Acute hip fracture‡                   | 2                                                      | Age ≥65                                      | 84.9            | 127/125                              |
| Gilchrist 1988, UK‡                      | Acute hip fracture‡                   | 10                                                     | Age ≥65 (all women), expected prolonged hospital stay | 81.3            | 97/125                               |
| Huusko 2002, Finland†                    | Acute hip fracture‡                   | ≥1                                                     | Age ≥65, admitted from home, good function before fracture, not terminally ill or severely demented | 80.0            | 120/123                              |
| Kennie 1988, UK†                         | Acute hip fracture‡                   | 5                                                      | Age ≥65 (all women), expected length of hospital stay >7 days | 82*             | 54/54                                |
| Naglie 2002, Canada‡                      | Acute hip fracture‡                   | 0‡                                                     | Age ≥70, admitted from home, good function before fracture, not terminally ill | 84.2            | 141/139                               |
| Shyu 2005, Thailand‡                      | Acute hip fracture‡                   | 0‡                                                     | Age ≥60, good function before fracture, not terminally ill or severely demented | 77.6            | 72/87                                |
| Stenvall 2007, Sweden‡                    | Acute hip fracture‡                   | 0‡                                                     | Age ≥70, good function before fracture | 82.2            | 102/97                               |
| Swanson 1998, Australia‡                  | Acute hip fracture‡                   | 0‡                                                     | Age ≥55, admitted from home, good function before fracture | 78.1            | 38/33                                |
| Vidan 2005, Spain‡                        | Acute hip fracture‡                   | 0‡                                                     | Age ≥65, admitted from home, good function before fracture, not terminally ill | 81.9            | 155/164                              |

NA=not available.

‡Zero (0) indicates patients were enrolled and randomised directly after hospital admission (in these studies, because of initial screening and informed consent procedures, though not explicitly reported, patients might have had few inpatient hospital days before randomisation).

§Most studies explicitly defined “acute hip fracture” as uncomplicated single sided proximal femur fracture (that is, no additional fractures, non-pathological fracture).
Table 2 | Description of inpatient rehabilitation programmes specifically designed for geriatric patients in 17 included randomised controlled trials

| Programme description | Location | Additional team members* | Multidimensional geriatric assessment | Assignment to therapy | Intervention team meetings for goal setting | Mean length of hospital stay after randomisation (days)
|-----------------------|----------|---------------------------|--------------------------------------|-----------------------|--------------------------------------------|--------------------------------------------|
| General geriatric rehabilitation | | | | | | |
| Applegate 1990 *Geriatric assessment unit* | Separate unit in acute care hospital complex | Physiotherapist, occupational therapist, psychologist, social worker, speech therapist, dietician | Yes | Yes | Weekly | 23.6 | No |
| Cohen 2002 *Geriatric evaluation and management unit* | Separate unit in acute care medical centre | Physiotherapist, occupational therapist, social worker, dietician | Yes | Yes | Twice a week | 23.2 | Yes (one subsample: outpatient care in VA geriatric programme) |
| Fleming 2004 *Care home rehabilitation services* | Separate institution for rehabilitation | Social worker, occupational therapist | No | No | No | 16.3 | No |
| Karppi 1995 *Geriatric inpatient unit* | Separate unit in acute care hospital | Physiotherapist, occupational therapist, social worker, psychologist | Yes | NA | NA | 16.5 | No |
| Rubenstein 1984 *Geriatric evaluation unit* | Separate unit in acute care medical centre | Physiotherapist, occupational therapist, social worker, psychologist, dietician | Yes | Yes | Weekly | 85.1 | Yes (continuing care in geriatric outpatient clinic) |
| Saltvedt 2002 *Geriatric evaluation and management unit* | Separate unit in acute care hospital | Physiotherapist, occupational therapist | Yes | Yes | Twice a week | 21.2 | No |
| White 1994 *Multidisciplinary geriatric care* | Separate unit in acute care hospital | Social worker, dietician, occupational therapist, pharmacist, physiotherapist | Yes | Yes | Yes | 7.7 | No |
| Young 2007 *Multidisciplinary geriatric care* | Separate hospital for rehabilitation | Physiotherapist, social worker | Yes | No | Yes | 22‡ | No |
| Orthopaedic geriatric rehabilitation | | | | | | |
| Cameron 1993 *Accelerated rehabilitation* | Combined acute/post-acute unit in acute care hospital | Physiotherapist, occupational therapist, social worker | Yes | No | Yes | 19.5 | Yes (day hospital or physiotherapy) |
| Gilchrist 1988 *Orthopaedic geriatric inpatient care* | Separate hospital for rehabilitation | Orthopaedic surgeon, physiotherapist, occupational therapist, social worker | No | No | Weekly | 33.8 | No |
| Huusko 2002 *Intensive geriatric rehabilitation* | Separate unit in acute care hospital | Physiotherapist, occupational therapist, social worker, psychologist | Yes | Yes | Weekly | 34 | Yes (physiotherapy for two months) |
| Kinnie 1988 *Geriatric rehabilitation* | Separate hospital for rehabilitation | Physiotherapist, occupational therapist | Yes | No | Yes | 24‡ | No |
| Naglie 2002 *Postoperative multidisciplinary care* | Separate unit in acute care hospital | Orthopaedic surgeon, physiotherapist, occupational therapist, social worker | Yes | No | No | 29.2 | No |
| Shyu 2005 *Multidisciplinary intervention programme* | Combined acute/post-acute unit in acute care hospital | Physiotherapist | Yes | Yes | Yes | 10.1 | Yes (geriatric nurse coordination of follow-up services and clinic visits) |
| Stenvall 2007 *Multidisciplinary postoperative rehabilitation* | Combined acute/post-acute unit in acute care hospital | Physiotherapist, occupational therapist, dietician | Yes | Yes | Yes | 30.0 | Yes |
| Swanson 1998 *Multidisciplinary rehabilitation intervention* | Combined acute/post-acute unit in acute care hospital | Orthopaedic surgeon, physiotherapist, occupational therapist, social worker | Yes | Yes | Weekly | 21.0 | Yes (follow-up visit one and six months after discharge) |
| Vidan 2005 *Comprehensive geriatric intervention* | Combined acute/post-acute unit in acute care hospital | Social worker, rehabilitation specialist | Yes | Yes | Weekly | 16‡ | No |

NA=not available.
*All teams included geriatrician and nurse.
†Weighted for sample size.
‡Median.

We used the “metan” command for Stata statistical software (version 10, StataCorp, College Station, TX) to conduct random effects meta-analyses. Heterogeneity between trials was measured with the I² statistic, which indicates the proportion of the total variation in estimated effects caused by heterogeneity.
We also calculated the P value for the χ² test of heterogeneity. We explored the extent to which one or more study characteristics explained heterogeneity between trials using random effects meta-regression, with the Stata "metareg" command. According to an a priori statistical analysis plan we considered type of intervention programme (general geriatric/orthopaedic), mean (or median) age of total study population (≤80 vs >80), length of hospital stay after randomisation in the intervention group (≤21 vs >21 days), outpatient follow-up therapy after the trial for patients in the intervention group (yes/no), length of follow-up for outcome evaluation (≤6 vs >6 months), quality of the intervention programme (use of multidimensional geriatric assessment and assignment of patients), and methodological trial quality (concealment of allocation, blinding of outcome assessor, and analysis by intention to treat). For all outcomes we included the selected variables in meta-regression models and conducted random effects meta-analyses within each subgroup. We used funnel plots and Begg and Egger bias tests to check for small study effects.

**RESULTS**

**Identification of eligible trials**

We identified 932 potentially relevant publications. Twenty seven articles describing 17 trials met the predefined inclusion criteria and were included in our meta-analysis (fig 1).
Characteristics of trials, participants, and intervention programmes

Tables 1 and 2 describe the 17 trials and corresponding inpatient rehabilitation intervention programmes. We found eight trials on general geriatric rehabilitation\(^1\)\(^{12}\)\(^{14}\)\(^{16}\)\(^{19}\)\(^{21}\)\(^{22}\)\(^{27}\)\(^{30}\)\(^{43}\)\(^{44}\)\(^{48}\)\(^{49}\) and nine on orthopaedic geriatric rehabilitation after hip fracture. \(^11\)\(^{13}\)\(^{17}\)\(^{18}\)\(^{23}\)\(^{26}\)\(^{45}\)\(^{47}\) No trials reporting effects of rehabilitation programmes in other specialties (such as orthopaedic for other indications, neurological, cardiac, or pulmonary) met the inclusion criteria (randomised controlled trials of neurological rehabilitation, for example, often had no lower age cut-off and included younger patients). In the 17 included trials, 4780 people were allocated to intervention (n=2353) or control (n=2427) groups. Mean (or median) age of participants ranged from 74.2 to 86.0 (table 1). Type and duration of hospital care before the trial, reason for the initial hospital admission, and criteria for the selection of patients (such as age criteria, functional criteria) varied between studies (table 1). Table 2 shows the

**Table 4** Random effects meta-analysis for outcomes stratified by study characteristics in 17 trials of inpatient rehabilitation specifically designed for geriatric patients. Figures are odds ratios (for functional improvement) or relative risks (for nursing home admissions and mortality) with 95% confidence intervals

| Study characteristics | Short term (at discharge) | Longer term (at 3-12 month follow-up) |
|-----------------------|---------------------------|--------------------------------------|
|                       | Functional improvement    | Nursing home admission | Mortality    | Functional improvement | Nursing home admission | Mortality |
| Type of intervention programme: | | | | | | |
| General geriatric rehabilitation | 1.34 (1.12 to 1.60) | 0.53 (0.33 to 0.86) | 0.76 (0.54 to 1.06) | 1.02 (0.86 to 1.21) | 0.90 (0.71 to 1.13) | 0.88 (0.75 to 1.04) |
| Orthopaedic geriatric rehabilitation | 2.33 (1.62 to 3.34), P=0.04* | 0.72 (0.56 to 0.91) | 0.66 (0.42 to 1.04) | 1.79 (1.24 to 2.60), P=0.01* | 0.79 (0.61 to 1.02) | 0.77 (0.61 to 0.96) |
| Mean age of study population (years): | | | | | | |
| ≤80 | 1.88 (1.19 to 2.97) | 0.42 (0.27 to 0.64) | 1.01 (0.47 to 2.16) | 1.26 (0.87 to 1.82) | 0.82 (0.58 to 1.16) | 0.85 (0.62 to 1.16) |
| >80 | 1.74 (1.05 to 2.88) | 0.75 (0.58 to 0.96), P=0.04* | 0.68 (0.50 to 0.92) | 1.45 (1.08 to 1.94) | 0.88 (0.72 to 1.07) | 0.82 (0.70 to 0.95) |
| Intervention programme: length of hospital stay after randomisation in intervention group: | | | | | | |
| ≤21 days | 2.38 (1.53 to 3.70) | 0.67 (0.42 to 1.09) | 0.59 (0.29 to 1.22) | 1.43 (1.00 to 2.05) | 0.99 (0.69 to 1.42) | 0.84 (0.67 to 1.05) |
| >21 days | 1.52 (1.08 to 2.13) | 0.61 (0.45 to 0.83) | 0.76 (0.56 to 1.04) | 1.30 (0.95 to 1.78) | 0.81 (0.67 to 0.98) | 0.85 (0.73 to 0.99) |
| Outpatient follow-up after inpatient rehabilitation for patients in intervention group: | | | | | | |
| Yes | — | — | — | 1.49 (0.93 to 2.39) | 0.76 (0.64 to 0.92) | 0.84 (0.61 to 1.16) |
| No/ NR | — | — | — | 1.29 (1.00 to 1.66) | 0.88 (0.69 to 1.12) | 0.82 (0.71 to 0.96) |
| Length of follow-up for outcome evaluation (months): | | | | | | |
| ≤6 | — | — | — | 1.44 (0.94 to 2.21) | 0.82 (0.67 to 1.00) | 0.83 (0.66 to 1.05) |
| >6 | — | — | — | 1.32 (0.99 to 1.76) | 0.90 (0.68 to 1.19) | 0.85 (0.73 to 0.99) |
| Intervention programme quality: intervention included initial multidimensional geriatric assessment: | | | | | | |
| Yes | 1.75 (1.31 to 2.35) | 0.60 (0.46 to 0.78) | 0.75 (0.57 to 0.99) | 1.36 (1.07 to 1.71) | 0.81 (0.69 to 0.94) | 0.86 (0.77 to 0.97) |
| No/ NR | NA | 0.84 (0.54 to 1.29) | 0.40 (0.13 to 1.18) | NA | 1.23 (0.75 to 2.02) | 0.90 (0.61 to 1.33) |
| Intervention programme quality: intervention included patient assignment (to therapies and goal setting): | | | | | | |
| Yes | 1.81 (1.23 to 2.67) | 0.54 (0.37 to 0.78) | 0.68 (0.39 to 1.19) | 1.32 (0.90 to 1.92) | 0.88 (0.62 to 1.26) | 0.83 (0.68 to 1.00) |
| No/ NR | 1.80 (0.96 to 3.37) | 0.71 (0.53 to 0.94) | 0.74 (0.53 to 1.03) | 1.40 (1.02 to 1.90) | 0.86 (0.71 to 1.04) | 0.85 (0.71 to 1.02) |
| Methodological trial quality: concealed randomisation: | | | | | | |
| Yes | 1.61 (1.21 to 2.13) | 0.61 (0.45 to 0.83) | 0.75 (0.56 to 1.02) | 1.45 (1.02 to 2.06) | 0.78 (0.68 to 0.91) | 0.90 (0.79 to 1.03) |
| No/ NR | 2.91 (1.36 to 6.24) | 0.66 (0.40 to 1.07) | 0.54 (0.24 to 1.22) | 1.29 (0.99 to 1.68) | 1.05 (0.72 to 1.54) | 0.77 (0.60 to 0.98) |
| Methodological trial quality: data assessment by an independent assessor: | | | | | | |
| Yes | 1.39 (1.17 to 1.65) | 0.59 (0.33 to 1.06) | 0.63 (0.31 to 1.26) | 1.34 (0.97 to 1.85) | 0.81 (0.68 to 0.95) | 0.92 (0.80 to 1.06) |
| No/ NR | 2.43 (1.47 to 4.00) | 0.63 (0.47 to 0.85) | 0.72 (0.48 to 1.07) | 1.40 (0.97 to 2.03) | 0.93 (0.66 to 1.30) | 0.76 (0.62 to 0.93) |

NR=not reported, NA=not applicable (no studies in this category). *Exact P values for significant results in meta-regression analyses (P<0.05). If result of meta-regression was not significant (P≥0.05), no P value is listed.
Longer term effects at end of follow-up
At the end of follow-up, results on function were heterogeneous ($I^2=51.4\%$, $P=0.02$). Overall results for admissions to nursing homes and mortality were not heterogeneous ($I^2=22.6\%$, $P=0.22$, and $I^2=0.0\%$, $P=0.60$, respectively) (figs 2-4). Meta-analyses of longer term effects indicated an overall significant favourable effect of the intervention on all outcomes at the end of follow-up (combined odds ratio 1.36 (1.07 to 1.71) for function, relative risk 0.84 (0.72 to 0.99) for nursing home admission, relative risk 0.87 (0.77 to 0.97) for mortality). Stratified effects of functional improvement at end of follow-up significantly differed by intervention type (odds ratio 1.02 (0.86 to 1.21) for general v 1.79 (1.24 to 2.60) for orthopaedic, $P=0.01$). All other longer term effects (table 4) were similar across study characteristics hypothesised to influence longer term effects and not significant in meta-regression ($P>0.05$). In addition, heterogeneity between studies also varied by intervention type for both functional status and admissions to nursing homes (function: $I^2=0.0\%$, $P=0.95$, for general v $I^2=53.5\%$, $P=0.06$, for orthopaedic; nursing home admission: $I^2=42.8\%$, $P=0.11$, for general v $I^2=0.0\%$, $P=0.43$, for orthopaedic).

The proportion of people in control groups admitted to a nursing home varied between 10% and 30% in most studies, resulting in a number needed to treat between 9 and 28 to avoid one admission to a nursing home at hospital discharge, and between 21 and 63 to avoid one admission to a nursing home at follow-up. The number needed to treat to prevent on death at one year follow-up was 38, assuming a 20% one year mortality rate among controls.

Fig 2 | Effect of inpatient rehabilitation specifically designed for geriatric patients on functional improvement at hospital discharge and at follow-up

| Effects at hospital discharge | Odds ratio (95% CI) | Odds ratio (95% CI) |
|-----------------------------|---------------------|---------------------|
| General geriatric rehabilitation | Cohn 2002 | 1.35 (1.11 to 1.63) | Cohn 2002 |
|                              | White 1994 | 1.82 (0.59 to 5.65) | White 1994 |
|                              | Young 2007 | 1.22 (0.71 to 2.11) | Young 2007 |
| Subtotal: $I^2=0.0\%$, $P=0.821$ |                   |                    |
| Orthopaedic geriatric rehabilitation | Cohen 2002 | 1.34 (1.12 to 1.60) | Cohen 2002 |
|                              | White 2007 | 4.39 (1.57 to 12.27) | White 2007 |
|                              | Young 2007 | 2.25 (1.21 to 4.19) | Young 2007 |
| Subtotal: $I^2=0.0\%$, $P=0.428$ |                   |                    |
| Overall: $I^2=38.4\%$, $P=0.123$ |                   |                    |

| Effects at 3-12 month follow-up | Odds ratio (95% CI) | Odds ratio (95% CI) |
|---------------------------------|---------------------|---------------------|
| General geriatric rehabilitation | Applegate 1990 | 1.11 (0.51 to 2.39) | Applegate 1990 |
|                                  | Cohen 2002 | 0.97 (0.78 to 1.21) | Cohen 2002 |
|                                  | Karppi 1995 | 1.13 (0.73 to 1.72) | Karppi 1995 |
|                                  | Rubenstein 1984 | 1.08 (0.42 to 2.75) | Rubenstein 1984 |
|                                  | Saltved 2002 | 0.88 (0.39 to 1.95) | Saltved 2002 |
|                                  | Young 2007 | 1.28 (0.71 to 2.30) | Young 2007 |
| Subtotal: $I^2=0.0\%$, $P=0.949$ |                   |                    |
| Orthopaedic geriatric rehabilitation | Cameron 1993 | 1.02 (0.86 to 1.21) | Cameron 1993 |
|                                  | Kennie 1988 | 1.19 (0.69 to 2.08) | Kennie 1988 |
|                                  | Naglie 2002 | 3.82 (1.37 to 10.60) | Naglie 2002 |
|                                  | Shyu 2005 | 1.06 (0.63 to 1.79) | Shyu 2005 |
|                                  | Stenwal 2007 | 2.95 (1.54 to 5.63) | Stenwal 2007 |
|                                  | Vidan 2005 | 2.36 (1.18 to 4.72) | Vidan 2005 |
| Subtotal: $I^2=53.5\%$, $P=0.057$ |                   |                    |
| Overall: $I^2=51.4\%$, $P=0.020$ |                   |                    |

Impact of intervention programmes on healthcare
Compared with patients in control groups, the weighted mean length of hospital stay after randomisation was longer in patients allocated to general geriatric rehabilitation (24.5 v 15.1 days) and shorter in those allocated to orthopaedic rehabilitation (24.6 v 28.9 days). Six out of 17 trials reported on readmission to hospital after rehabilitation, 5-14 17 25 27 28 46 47. All six reported a lower or equal rate in intervention patients, but the overall range across the six trials was similar in intervention (21-51%) and control patients (31-55%). Six trials reported total costs of inpatient geriatric rehabilitation programmes, 10 27 29 43 47 49. Total programme costs adjusted for years survived or living in the community differed between the trials: one trial showed no cost difference between intervention and usual care, 10.
and five trials showed cost differences that were not significant. Three trials showed cost savings in the intervention group, and two trials showed the opposite.

**DISCUSSION**

This systematic review and meta-analysis of inpatient rehabilitation specifically designed for geriatric patients showed beneficial effects over usual care for functional improvement, preventing admissions to nursing homes, and reducing mortality. For all outcomes inpatient rehabilitation showed a short-term effect after discharge as well as a less pronounced longer-term effect at the end of follow-up. Multiple stratified analyses according to characteristics of the programme, patients, and quality of the study showed only two significant differences in effects between study subgroups: orthopaedic intervention programmes were more likely to be associated with functional improvement, and study populations with a younger mean age showed a more beneficial effect for the nursing home outcome than those with a higher mean age. Given our extensive search strategy we are confident that we have identified all published randomised controlled trials meeting our inclusion criteria so that we included only trials examining programmes in accordance with WHO’s definition of rehabilitation and the ICF framework.

**Comparison with other studies**

To our knowledge this is the first study to show the effects of inpatient rehabilitation specifically designed for older adults. Earlier meta-analyses found favourable effects of geriatric rehabilitation compared with usual hospital care but grouped randomised controlled trials of inpatient rehabilitation together with those of acute geriatric units. One exception was a recent study that analysed the separate effects of acute geriatric units but not those of inpatient rehabilitation. Our meta-analysis now provides evidence for independent favourable effects of inpatient geriatric rehabilitation on function, admission to nursing homes, and mortality.

Our stringent definition of rehabilitation contrasts with recent literature on the topic of geriatric rehabilitation, where the term “rehabilitation” is used in various ways. For example, Gill et al performed a randomised controlled trial in an outpatient setting where a physiotherapy intervention (labelled rehabilitation) was compared with educational interventions. Wells et al used a definition of rehabilitation similar to ours but did not emphasise the assignment procedure with goal setting.

Our findings add to the existing literature evaluating the best methods of treating geriatric patients. They are in concordance with earlier meta-analyses showing favourable effects of other types of inpatient and outpatient programmes specifically designed for geriatric patients. They are also in concordance with criteria of successful geriatric programmes identified in earlier meta-analyses. These analyses showed that programmes were more successful if they used multidimensional geriatric assessment as a basis for problem identification, they had a geriatric team that formulated recommendations and controlled implementation of the recommendations, and inpatient geriatric care was combined with outpatient geriatric follow-up. These three criteria were at least in part met by the studies included in our meta-analysis.

**Limitations**

Given the number of stratified analyses, the more favourable effects in orthopaedic intervention programmes or populations with a younger mean age might be due to chance. Furthermore, given the limited number of included studies we might have missed true
differences between study subgroups. For example, the difference in effects at discharge between trials by length of hospital stay after randomisation did not reach significance but might reflect real differences. Another limitation was introduced by differences in length of stay after randomisation in intervention compared with control patients, potentially influencing the comparability of outcome data measured at hospital discharge. There was heterogeneity at the end of follow-up for the pooled effect of orthopaedic intervention programmes on functional status and general geriatric intervention programmes on admissions to nursing homes. Therefore, these pooled effects should be interpreted with caution because the true differences in effects between studies might be due to uncharacterised or unexplained underlying factors or the variability of outcome measures on functional status. Finally, we used aggregate data rather than data on individual patients for the meta-regression analyses. As a result we cannot exclude confounding of the analyses, and potentially key associations might have been missed, underestimated, or reversed.

Longer term effects of rehabilitation for all outcomes seemed to be less pronounced than short term effects. This might in part be explained by variable and potentially suboptimal treatments of intervention patients after hospital discharge. Additionally, outpatient treatments after the intervention were seldom described, making interpretation of their potential influences on longer term effects impracticable.

Implications

Surprisingly, among the trials included in this meta-analysis, we found only two types of geriatric rehabilitation programmes: general and orthopaedic for hip fracture. No rehabilitation study in any other clinical specialty (such as cardiac, stroke, or pulmonary) met our inclusion criteria of being designed specifically for the care of geriatric patients, thus indicating a need for programme development and research for other types of rehabilitation. Some other type of inpatient rehabilitation might produce similar favourable effects if they are specifically designed for geriatric patients and might actually change clinical practice in the future.

Difference in effects between subtypes of geriatric rehabilitation programmes is a potentially important focus for research with relevant practice implications. Firstly, further analysis should determine whether orthopaedic rehabilitation programmes truly reduce length of inpatient hospital stay and thereby potentially reduce healthcare costs and at the same time improve patients’ outcomes. If confirmed, this type of intervention might exhibit the rare combination of an intervention that reduced healthcare costs and improves patients’ outcomes, giving it a high priority for implementation in practice. In contrast, general geriatric rehabilitation programmes seemed to increase length of inpatient stay. In these programmes intervention patients were probably offered an additional intervention that reduced healthcare costs and at the same time improve patients’ outcomes. Further research should determine cost effectiveness based on a longer term time frame and should define criteria for targeting patients in clinical practice. Finally, research might find answers for other types of programmes that, until now, have not been adapted and tested for the specific needs of older patients.

Inpatient rehabilitation specifically designed for geriatric patients is a resource intensive, and therefore expensive, component of health care. We considered it important to assess the impact on health care of

**Effects at hospital discharge**

| Treatment                | Control                 | Relative risk (95% CI) | Relative risk (95% CI) |
|--------------------------|-------------------------|------------------------|------------------------|
| General geriatric rehabilitation |                        |                        |                        |
| Rubenstein 1984          | 9/63                    | 0.95 (0.41 to 2.24)    |                        |
| Saltvedt 2002            | 8/127                   | 0.47 (0.21 to 1.05)    |                        |
| Young 2007               | 38/280                  | 0.81 (0.53 to 1.24)    |                        |
| White 1994               | 0/20                    |                        | 0.76 (0.54 to 1.06)    |
| Subtotal: I²=0.0%, P=0.418 | 55/490                 |                        |                        |
| Orthopaedic geriatric rehabilitation |                      |                        |                        |
| Gilchrist 1988           | 4/97                    | 0.40 (0.13 to 1.18)    |                        |
| Huusko 2002              | 5/120                   | 1.02 (0.30 to 3.45)    |                        |
| Kenne 1988               | 5/54                    | 1.25 (0.35 to 4.40)    |                        |
| Naglie 2002              | 7/141                   | 0.53 (0.22 to 1.28)    |                        |
| Shyu 2005                | 1/72                    | 3.62 (0.15 to 87.45)   |                        |
| Stenvall 2007            | 6/102                   | 0.82 (0.28 to 2.34)    |                        |
| Swanson 1998             | 2/33                    | 0.87 (0.13 to 5.83)    |                        |
| Vidan 2005               | 1/155                   | 0.12 (0.02 to 0.92)    |                        |
| Subtotal: I²=0.0%, P=0.458 | 31/779                 |                        | 0.66 (0.42 to 1.04)    |
| Overall: I²=0.0%, P=0.563 | 86/1269                 |                        | 0.72 (0.55 to 0.95)    |

**Effects at 3-12 month follow-up**

| Treatment                | Control                 | Relative risk (95% CI) | Relative risk (95% CI) |
|--------------------------|-------------------------|------------------------|------------------------|
| General geriatric rehabilitation |                        |                        |                        |
| Applegate 1990           | 16/78                   | 0.83 (0.46 to 1.49)    |                        |
| Cohen 2002               | 150/694                 | 1.02 (0.83 to 1.25)    |                        |
| Fleming 2004             | 22/81                   | 0.99 (0.60 to 1.63)    |                        |
| Karppi 1995              | 14/104                  | 1.12 (0.61 to 2.06)    |                        |
| Rubenstein 1984          | 15/63                   | 0.49 (0.29 to 0.82)    |                        |
| Saltvedt 2002            | 35/127                  | 0.81 (0.56 to 1.18)    |                        |
| Young 2007               | 73/280                  | 0.86 (0.64 to 1.14)    |                        |
| Subtotal: I²=24.1%, P=0.245 | 325/1427               |                        | 0.88 (0.75 to 1.04)    |
| Orthopaedic geriatric rehabilitation |                      |                        |                        |
| Gilchrist 1988           | 14/97                   | 0.78 (0.43 to 1.44)    |                        |
| Huusko 2002              | 18/120                  | 0.92 (0.51 to 1.66)    |                        |
| Kenne 1988               | 10/54                   | 0.56 (0.28 to 1.09)    |                        |
| Naglie 2002              | 17/141                  | 0.79 (0.44 to 1.44)    |                        |
| Shyu 2005                | 2/72                    | 2.42 (0.22 to 26.11)   |                        |
| Stenvall 2007            | 16/102                  | 0.85 (0.46 to 1.56)    |                        |
| Swanson 1998             | 3/38                    | 0.52 (0.13 to 2.02)    |                        |
| Vidan 2005               | 29/155                  | 0.73 (0.48 to 1.11)    |                        |
| Subtotal: I²=0.0%, P=0.917 | 109/779                |                        | 0.77 (0.61 to 0.96)    |
| Overall: I²=0.0%, P=0.601 | 434/2206                |                        | 0.87 (0.77 to 0.97)    |
Inpatient rehabilitation programmes specifically designed for patients with cardiac, neurological, pulmonary, or musculoskeletal problems have been shown to improve outcomes.

Older patients admitted to acute care hospitals are at increased risk for decline in functional status and admission to nursing homes.

WHAT THIS STUDY ADDS

Inpatient geriatric rehabilitation programmes specifically designed for older people show sustained effects on improving functional status and reducing admissions to nursing homes and mortality.

Such programmes might increase or decrease the overall length of hospital stay, depending on type and concept of the programme.

Reduction in admissions to nursing homes might result in cost savings or offset additional costs of the initial inpatient rehabilitation.

Interventions based on actual programme costs and efficacy measured by readmission rates after rehabilitation. Disappointingly, available cost and efficacy data provided insufficient evidence to draw substantial conclusions. Analyses published for trials included in this meta-analysis were few (that is, insufficient numbers for meta-regression) and variable (that is, results ranged from no difference in costs between intervention and control patients to lower costs for control patients). These limited results regarding the impact of programmes on health care do not provide robust evidence in favour of intensive inpatient rehabilitation programmes but provide preliminary evidence that inpatient rehabilitation might not be more expensive and potentially be more effective in reducing hospital readmissions than usual care for geriatric patients. Furthermore, even if general geriatric rehabilitation programmes truly increased length of hospital stay, this cost might be more than offset by savings because of a reduction in admissions to nursing homes.

Lastly, for practice implementation, we must determine the criteria for effective inpatient geriatric rehabilitation programmes. The subgroup analyses conducted as part of the present meta-analysis did not help to clarify them. Therefore, criteria for successful programmes must be gleaned from the characteristics of the programmes in the individually published studies. Most studies implemented programmes in specially designated units, involved multidisciplinary teams in patients’ care, and, in most cases, had a system of multidimensional geriatric assessment and assignment of patients. Unfortunately, however, detailed operational characteristics, such as intensity and frequency of physical therapy, were not available in the published materials.

Conclusion

Inpatient rehabilitation specifically designed for geriatric patients seems to have the potential to improve function, admissions to nursing homes, and mortality outcomes. Targeting the subgroup of patients who will benefit most from such programmes still remains unclear, as does the efficacy of characteristics of individual interventions and the impact on health care of such programmes (that is, cost-benefit and re-admission rates). Although we tried to clarify these questions with our work, the paucity of available evidence emphasises the need for further research to address these important questions.

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Ethical approval: Not required.

Data sharing: Funnel plots and a list of excluded trials are available from the corresponding author on request.

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