Interventions to optimise prescribing for older people in care homes (Review)

Alldred DP, Raynor DK, Hughes C, Barber N, Chen TF, Spoor P

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[Intervention Review]

Interventions to optimise prescribing for older people in care homes

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ABSTRACT

Background

There is a substantial body of evidence that prescribing for care home residents is suboptimal and requires improvement. Consequently, there is a need to identify effective interventions to optimise prescribing and resident outcomes in this context.

Objectives

The objective of the review was to determine the effect of interventions to optimise prescribing for older people living in care homes.

Search methods

We searched the Cochrane Effective Practice and Organisation of Care (EPOC) Group Specialised Register; Cochrane Central Register of Controlled Trials (CENTRAL), *The Cochrane Library* (Issue 11, 2012); Cochrane Database of Systematic Reviews, *The Cochrane Library* (Issue 11, 2012); MEDLINE OvidSP (1980 on); EMBASE, OvidSP (1980 on); Ageline, EBSCO (1966 on); CINAHL, EBSCO (1980 on); International Pharmaceutical Abstracts, OvidSP (1980 on); PsycINFO, OvidSP (1980 on); conference proceedings in Web of Science, Conference Proceedings Citation Index - SSH & Science, ISI Web of Knowledge (1990 on); grey literature sources and trial registries; and contacted authors of relevant studies. We also reviewed the references lists of included studies and related reviews (search period November 2012).

Selection criteria

We included randomised controlled trials evaluating interventions aimed at optimising prescribing for older people (aged 65 years or older) living in institutionalised care facilities. Studies were included if they measured one or more of the following primary outcomes, adverse drug events; hospital admissions;mortality; or secondary outcomes, quality of life (using validated instrument); medication-related problems; medication appropriateness (using validated instrument); medicine costs.

Data collection and analysis

Two authors independently screened titles and abstracts, assessed studies for eligibility, assessed risk of bias and extracted data. A narrative summary of results was presented.

Main results

The eight included studies involved 7653 residents in 262 (range 1 to 85) care homes in six countries. Six studies were cluster-randomised controlled trials and two studies were patient-randomised controlled trials. The interventions evaluated were diverse and often multifaceted. Medication review was a component of seven studies, three studies involved multidisciplinary case-conferencing, two studies involved an educational element for care home staff and one study evaluated the use of clinical decision support technology. Due to heterogeneity, results were not combined in a meta-analysis. There was no evidence of an effect of the interventions on any of the primary outcomes of the review (adverse drug events, hospital admissions and mortality). No studies measured quality of life. There was evidence that the interventions led to the identification and resolution of medication-related problems. There was evidence from two studies that medication appropriateness was improved. The evidence for an effect on medicine costs was equivocal.

Authors' conclusions

Robust conclusions could not be drawn from the evidence due to variability in design, interventions, outcomes and results. The interventions implemented in the studies in this review led to the identification and resolution of medication-related problems, however evidence of an effect on resident-related outcomes was not found. There is a need for high-quality cluster-randomised controlled trials testing clinical decision support systems and multidisciplinary interventions that measure well-defined, important resident-related outcomes.

PLAIN LANGUAGE SUMMARY

Interventions to optimise prescribing for older people in care homes

Older people living in care homes (also called nursing homes, residential homes, skilled-nursing facilities, assisted-living facilities or aged-care facilities) have many complex physical and mental health problems. Care home residents are prescribed many medicines compared to people who live in their own homes, with an average of eight medicines being common. International research has shown that these medicines are often not well managed, with some residents prescribed medicines inappropriately. This has the potential to lead to harmful side effects and a loss of benefit. For these reasons, it is important to make sure that care home residents are prescribed the right medicines at the right doses.

This review found eight studies involving 7653 residents in 262 care homes in six countries that evaluated interventions to optimise prescribing for care home residents. Most of the interventions had several components, often involving a review of medicines with a pharmacist and doctor. Some interventions included a teaching component and one study used Information Technology.

There was no evidence of benefit of the interventions with respect to reducing adverse drug events (harmful effects caused by medicines), hospital admissions or death. None of the studies looked at quality of life. Problems relating to medicines were found and addressed through the interventions used in the studies. Prescribing was improved based on criteria used to assess the appropriateness of prescribing in two studies.

More high-quality studies need to be done to gather more evidence for these and other types of interventions. Further studies are needed to evaluate new technologies, including computer systems that support prescribing decisions. More work needs to be done to make sure that researchers are consistently measuring outcomes that are important to care home residents.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Medication review compared with usual GP care for optimising prescribing for care home residents

Patient or population: older people (aged 65 years or older) living in care homes
Settings: Institutionalised care facilities in Australia, Netherlands, Sweden, United Kingdom and USA and Canada
Intervention: Medication review as a single intervention or a component of a multi-faceted intervention
Comparison: Usual care by general practitioner

Outcomes	Impact	No of Participants (studies)	Quality of the evidence (GRADE)
Adverse drug events	There was no evidence of an effect on adverse drug events	110 in 85 care homes (1 study)	⊕⊕◯◯ **low**
Hospital admissions	There was no evidence of an effect on hospital admissions	4306 in 216 care homes (4 studies)	⊕⊕◯◯ **low**
Mortality	There was no evidence of an effect on mortality	4221 in 131 care homes (3 studies)	⊕⊕◯◯ **low**
Quality of life	No studies reported quality of life	0 (no studies)	-
Medication-related problems	Medication review may lead to the identification and resolution of medication-related problems	6281 in 250 care homes (6 studies)	⊕⊕◯◯ **low**
Medication appropriateness	Medication review may lead to an improvement in medication appropriateness	264 in 95 care homes (2 studies)	⊕⊕◯◯ **low**
Medicine costs	It is uncertain whether medication review decreases medication costs	4375 in 141 care homes (4 studies)	⊕◯◯◯ **very low**

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: 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: We are very uncertain about the estimate.

The Gurwitz 2008 study is not included in the 'Summary of findings' table as medication review was not a component of the intervention.

BACKGROUND

Globally, the proportion of older people in the population is increasing. The proportion of people aged 60 years and over was 11% in 2009 and this is projected to double by the middle of this

century (United Nations 2009), with developed countries experiencing the fastest rise in number of older people. In the United Kingdom (UK), it is estimated that by 2034 nearly a quarter of the population will be aged 65 years and over. The most rapid rise has been in the 'oldest old' that is those aged 85 years and over; it is projected that by 2034 there will be a 2.5 fold increase in the number of the oldest old, representing 5% of the population (Office for National Statistics 2010). As a consequence, there will continue to be an increasing demand for long-term care across the world.

Long-term care may be provided in people's homes or in institutional facilities such as nursing homes or hospitals. The terminology used to describe homes that provide care for older people (defined as 65 years or older (Department of Health 2001)) differs across the world. In the UK the homes are known as 'care homes', in the United States (US) 'long-term care facilities' and in Australia 'aged-care facilities'. Care homes are usually classified into two main categories, those that provide 24 hour nursing care (nursing homes in the UK, skilled-nursing facilities in the US and aged-care facilities providing high-level care in Australia); and those that provide personal care (residential homes in the UK, assisted-living in the US and aged-care facilities providing low-level care in Australia). Some care homes provide both types of care.

Older people living in care homes are often frail, and they are one of the most vulnerable groups in society. They have complex health needs due to multiple co-morbidities and age-related changes in pharmacokinetics and pharmacodynamics (Armour 2002). Polypharmacy, usually defined as greater than four or more medicines (Department of Health 2001; Rollason 2003; Patterson 2012), is common in this setting across the world with residents prescribed an increasing number of medicines over the last decade or so. In the UK, the mean number of medicines prescribed per resident was 4.9 in 1998 (Furniss 2000), 6.9 in 2003 (Zermansky 2006), and by 2007 this had risen to 8.0 (Barber 2009). Many care home residents also have cognitive impairment and this can impede their ability to communicate medicine-related problems (Matthews 2002; Alldred 2007a).

The complexity of prescribing for this population is compounded by multiple clinicians prescribing. This may involve family physicians and community-based consultants (for example old age psychiatrists and geriatricians) in primary care; and secondary care doctors from multiple specialties. In addition, the lack of representation of older people in clinical trials limits the evidence base and further increases the complexity (Beglinger 2008). It is, therefore, perhaps unsurprising that there is extensive evidence that prescribing is suboptimal for care home residents. Inappropriate prescribing, measured using validated, explicit and implicit definitions, has been found to be common in nursing and residential homes in several countries including the US (Beers 1992; Hanlon 1996; Sloane 2002; Gray 2003; Lau 2005; Perri 2005), Canada (Brymer 2003), the UK (Oborne 2003) and Australia (Crotty 2004). Perri 2005 found that over a one month duration, 47% of 1117 residents of 15 US nursing homes received at least one inappropriate medicine, with 13% of residents having at least one adverse health outcome. Inappropriate prescribing more than doubled the risk of a resident experiencing at least one adverse health outcome (odds ratio (OR) 2.34, 95% confidence interval (CI) 1.61-3.40). Lau 2005 reported that 50% of 3372 US nursing home residents were prescribed at least one inappropriate medicine over one year. The risks of hospitalisation and death were greater in those residents exposed to an inappropriate medicine (OR 1.27, 95% CI 1.09-1.47; OR 1.28, 95% CI 1.05-1.55, respectively). Gray 2003 found that 22% of 282 US residents of residential care facilities were prescribed at least one inappropriate medicine. There is also evidence that care home residents are under-prescribed beneficial drugs and are poorly monitored with respect to their long-term conditions and their medicines (Fahey 2003; Alldred 2007b; Barber 2009).

For the reasons discussed above, care home residents are particularly susceptible to adverse drug events. In two US long-term care facilities, Gurwitz 2005 found 9.8 adverse drug events per 100 resident-months, with 42% being judged as preventable. Drug-related problems have been found to be responsible for 3% to 31% of hospital admissions of older people, and up to half of these are potentially avoidable (Howard 2007).

Description of the condition

As described above, suboptimal prescribing for older people living in care homes is common and may occur due to the prescribing of inappropriate medicines, the omission of beneficial medicines or the failure to appropriately monitor residents and the effects of their medicines. There are a variety of instruments that can be employed to measure the appropriateness of prescribing in older people (Spinewine 2007). However, the predictive validity of these instruments on health outcomes such as adverse drug events and hospital admissions has not been unequivocally established (Spinewine 2007).

Description of the intervention

For this review, we were interested in interventions concerned with optimising the whole medication regime for care home residents, not those concentrating solely on isolated drugs or classes such as benzodiazepines or antipsychotics nor those concentrating on one disease state. Financial and regulatory interventions tend to fall into this latter category.

There are several types of interventions that can potentially optimise prescribing in this setting, including:

- professional interventions, for example educational programmes aimed at prescribers;

- organisational interventions, for example medication review services or specialist clinics, case conferencing, information and communication technology (ICT) interventions such as clinical decision support systems.

Medication review interventions may be aimed at specific drugs or the whole regime and can be uni- or multiprofessional, involving physicians, nurses and pharmacists.

How the intervention might work

Interventions designed to improve prescribing for care home residents may have an impact by discontinuing inappropriate medication; commencing beneficial medicines; and ensuring appropriate monitoring of long-term conditions and medicines. Consequently, this may lead to a reduction in adverse drug events, improved quality of life and a reduction in medicine costs.

Why it is important to do this review

There is a substantial body of evidence that prescribing for care home residents is suboptimal and requires improvement. As well, there are other Cochrane reviews being undertaken which address similar issues in different populations (Soe 2009; Christensen 2011). We evaluated the evidence for interventions to address suboptimal prescribing in this setting to identify how care can be improved for this frail and vulnerable population. We intended to achieve this by determining which interventions were effective and by identifying gaps in the evidence to inform future research.

OBJECTIVES

The objective of the review was to determine the effect of interventions to optimise overall prescribing for older people living in care homes.

METHODS

Criteria for considering studies for this review

Types of studies

We included patient-randomised controlled trials (P-RCT) and cluster-randomised controlled trials (C-RCT).

Types of participants

We included studies of older people (aged 65 years or older) living in institutionalised care facilities. Institutionalised care facilities include: nursing homes and residential homes (UK); skilled-nursing facilities and assisted-living facilities (US); and aged-care facilities providing low-level and high-level care (Australia). If there was any ambiguity in the description of the institution, we clarified this with the authors of relevant papers. We considered trials for inclusion if they had a majority (80% or more) of participants aged 65 years or more, or if the mean age was greater than 65 years. We excluded studies where the intervention focused on a single medical condition or a specific drug or class of drugs. We also excluded studies where the main focus was to reduce medication errors because such studies have a narrow focus and do not consider the whole medication regime. In addition, they do not seek to optimise prescribing, for example by adhering to evidence-based guidelines or by reducing inappropriate prescribing, but are designed to solely reduce errors.

Types of interventions

We assessed interventions aimed at optimising prescribing for care home residents compared with usual care as defined by the study. These interventions potentially included: educational interventions aimed at prescribers; medication review services (uni or multiprofessional, conducted by nurses, pharmacists or physicians); case conferencing; and ICT interventions such as clinical decision support systems. We excluded financial and regulatory interventions.

Types of outcome measures

We included a range of outcome measures including patient-related outcomes, health service utilisation, and economic outcomes. Studies were included if they reported at least one primary outcome measure or at least one secondary outcome measure.

Primary outcomes

The primary outcome measures for the review were:

1. adverse drug events;
2. hospital admissions;
3. mortality.

Secondary outcomes

Secondary outcome measures were:

1. quality of life (using validated instrument);
2. medication-related problems;
3. medication appropriateness (using validated instrument);
4. medicine costs.

Search methods for identification of studies

Pat Spoor developed the search strategies in consultation with the other authors and with Michelle Fiander, Trials Search Co-ordinator (TSC) for the EPOC Group. We searched the Cochrane Database of Systematic Reviews (Issue 11, 2012) for related systematic reviews, and the databases listed below for primary studies. Searches were conducted in November 2012. Exact search dates for each database are included with the search strategies in Appendix A. When we conducted the scoping searches to prepare for this systematic review, we did not identify any studies for inclusion prior to 1980. Also, since 1980 the care of older people in institutionalised facilities has changed significantly due to residents having greater levels of morbidity with an increase in polypharmacy, leading to greater complexity of care. For these reasons, we searched for studies from 1980 onwards to ensure we had studies of relevance to contemporary practice.

Electronic searches

- Cochrane Central Register of Controlled Trials (CENTRAL), *The Cochrane Library* (Issue 11, 2012)
- EPOC Group Specialised Register, Reference Manager
- MEDLINE, OvidSP (1980 on)
- EMBASE, OvidSP (1980 on)
- Ageline, EBSCO (1966 on)
- CINAHL (Cumulative Index to Nursing and Allied Health Literature), EBSCO (1980 on)
- International Pharmaceutical Abstracts, OvidSP (1970 on)
- PsycINFO, OvidSP (1980 on)
- Web of Science, Conference Proceedings Citation Index - SSH (ISI Web of Knowledge) (1990 on)
- Web of Science, Conference Proceedings Citation Index - Science (ISI Web of Knowledge) (1990 on)

Search strategies were comprised of keywords and, when available, controlled vocabulary such as MeSH (Medical Subject Headings). The finalised search strategies were developed using an iterative development process in which citations identified by various search terms were screened for relevance by the information specialist. In this manner, individual terms and combinations of terms were assessed as relevant or irrelevant and were included or omitted from the final search strategies. No language restrictions were used. All databases were searched from 1980 on with the exception of Ageline, which was run from 1966 on, and Web of Science Conference Proceedings indices which were searched from 1990 on.
A Cochrane filter was used to identify RCTs in MEDLINE (Lefebvre 2011). All search strategies, as run, are provided in Appendix 1.

Searching other resources

Grey literature

We conducted a grey literature search to identify studies not indexed in the databases listed above, using the following source:

- Google Scholarscholar.google.com.

For search terms and number of results, see Appendix 2.

Trials registries

- International Clinical Trials Registry Platform (ICTRP), World Health Organization (WHO) (http://www.who.int/ictrp/en/)

For search terms and number of results, see Appendix 3.
We also:

- reviewed reference lists of all included studies, relevant systematic reviews and primary studies;

- contacted authors of relevant studies to clarify reported published information.

Data collection and analysis

Selection of studies

Two review authors (DPA and DKR) independently screened titles and abstracts to decide which studies met the inclusion criteria. Any papers not meeting the inclusion criteria were excluded at this stage. If there was uncertainty or disagreement, consensus was reached by discussion with co-review authors. Two review authors (DA and DKR) independently assessed the full text articles to ensure they still met the inclusion criteria. Full text articles not published in English were translated prior to being assessed for inclusion.

Data extraction and management

Two review authors (DPA and DKR) independently extracted details of articles included in the review, including the study design, the study population, the intervention, usual care, outcome measures used and length of follow-up data, using a specially designed data extraction form based on the EPOC template (EPOC 2009). Where necessary, we contacted authors for missing information or clarification. We intended to use information from the data extraction forms to guide extraction of numerical data for meta-analysis in Review Manager 5 (RevMan 2008). We intended to present data from P-RCTs and C-RCTs using the format in the EPOC working paper on presentation of data (EPOC 2009).

Assessment of risk of bias in included studies

The internal validity of each included study was assessed by two review authors (DPA and DKR). We used The Cochrane Collaboration's tool for assessing risk of bias (Higgins 2008) based on six standard criteria: adequate sequence generation; concealment of allocation; blinded or objective assessment of primary outcome(s); adequately addressed incomplete outcome data; freedom from selective reporting; freedom from other risk of bias. We used four additional criteria specified by EPOC (EPOC 2009): similar baseline outcome measurements; similar baseline characteristics; reliable primary outcome measures; and adequate protection against contamination. We assessed and reported all included studies in the Cochrane 'Risk of bias' tables.

Assessment of the quality of the evidence

The quality of the evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria (GRADE 2012).

Measures of treatment effect

We initially planned to conduct a meta-analysis, however, this was not possible due to heterogeneity (see Results). Therefore, we presented a narrative summary of the results. Wherever possible, we presented results with 95% confidence intervals.

Unit of analysis issues

We critically examined the methods of analysis of all study types. We may have identifed C-RCTs with unit of analysis errors (for example, randomisation by care home with analysis by residents without adjustments for clustering). If unit of analysis issues had been found, we intended to attempt to re-analyse the data and report the intra-cluster correlation co-efficient and adjust for clustering if possible. However, no unit of analysis errors were identified.

Dealing with missing data

We intended to exclude studies from a meta-analysis if there was differential loss to follow-up between groups, greater than 20%. However, as meta-analysis was not appropriate this did not apply.

Assessment of heterogeneity

See Data synthesis section.

Assessment of reporting biases

We intended to examine funnel plots corresponding to meta-analysis of the primary outcome in order to assess the potential for small study effects such as publication bias. However, this was not possible as meta-analysis was not undertaken.

Data synthesis

We intended to synthesise the results of the studies depending on the quality, design and heterogeneity, and we intended to pool the results of studies if at least two studies were homogeneous regarding the participants, interventions and outcomes. As stated above, this was not possible and, therefore, a narrative summary was undertaken. We described studies according to setting, type of intervention and study design together with an assessment of the evidence on the theoretical basis for each of the approaches described.

Subgroup analysis and investigation of heterogeneity

We intended to conduct subgroup analyses for professional and organisational interventions where possible. If we had found that one type of intervention was common, for example medication review, we intended to analyse this separately. If possible, we also planned to undertake subgroup analyses based on the specific nature of the intervention, for example pharmacist-led medication review. However, subgroup analyses were not possible due to heterogeneity.
See Data synthesis section for the investigation of heterogeneity.

Sensitivity analysis

We intended to perform sensitivity analysis for pooled results based on the risk of bias. However, as we could not pool results this did not apply.

RESULTS

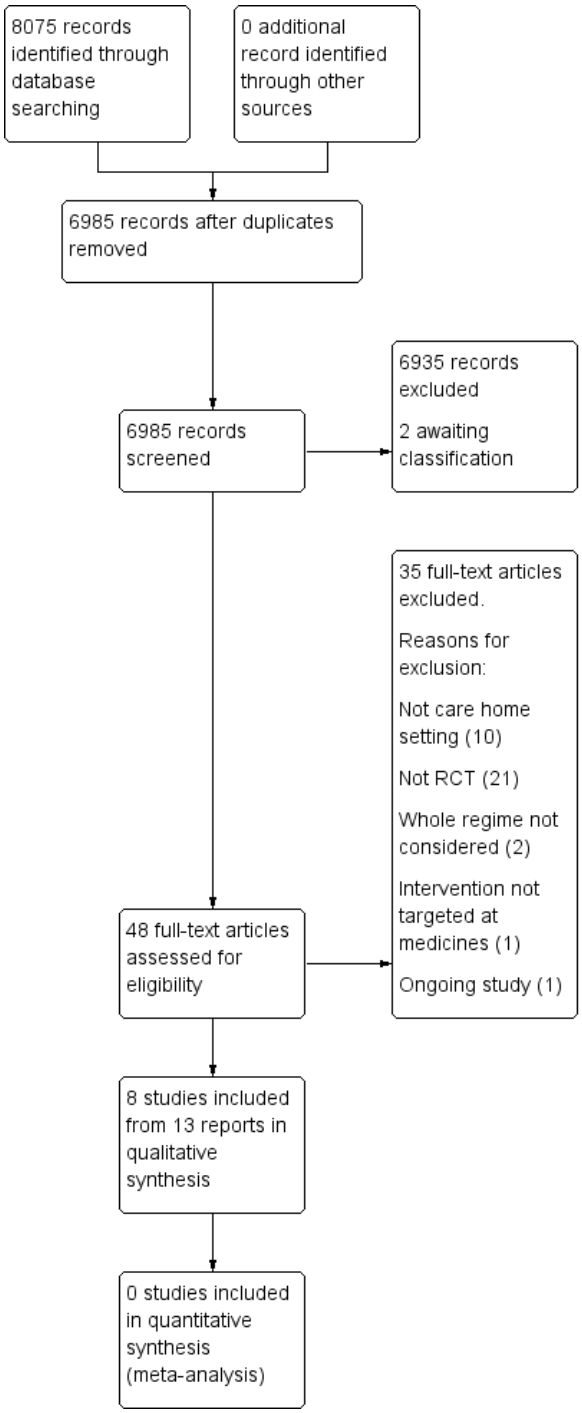
Description of studies

See: Characteristics of included studies; Characteristics of ongoing studies.
See: Characteristics of included studies; Characteristics of ongoing studies; Table 1

Results of the search

The search strategy identified 6985 articles for potential inclusion. Following independent screening of titles and abstracts by DPA and DKR, 48 full text articles were assessed for eligibility and eight studies met the inclusion criteria. Two studies are awaiting classification (Beer 2011; Lapane 2011). See Figure 1 (PRISMA flowchart) for details. The search yielded five related systematic reviews (Kaur 2009; Ostini 2009; Verrue 2009; LaMantia 2010; Loganathan 2011) and one narrative review (Markum 2010) and their references were reviewed; no further relevant studies were identified from these.

Figure 1. Study flow diagram.



Included studies

The eight included studies involved 7653 residents in 262 (range 1 to 85) care homes. Three studies were conducted in Australia (Roberts 2001; Crotty 2004a; Crotty 2004b), two in the UK (Furniss 2000; Zermansky 2006), one in Sweden (Claesson 1998), one in the Netherlands (Strikwerda 1994) and one in the USA and Canada (Gurwitz 2008).

Design

Six studies were C-RCTs (Strikwerda 1994; Claesson 1998; Furniss 2000; Roberts 2001; Crotty 2004a; Gurwitz 2008) and two studies were P-RCTs (Crotty 2004b; Zermansky 2006). There was a wide range of study duration and follow-up between the studies, ranging from six weeks to two years (see Table 1).

Participants

All studies involved older people living in care homes (long-term care facilities). Mean age ranged from 81.2 years (Furniss 2000) to 87.2 years (Gurwitz 2008) and the majority of residents were female (range 59.7% (Crotty 2004a) to 77% (Zermansky 2006)). The study by Roberts 2001 did not report mean age or gender.
Strikwerda 1994 studied 196 residents in one nursing home, Claesson 1998 studied 1854 residents in 33 nursing homes, Crotty 2004a studied 154 residents in 10 high-level residential facilities, Crotty 2004b studied 110 residents in 85 long-term care facilities, Furniss 2000 studied 330 residents in 14 nursing homes, Gurwitz 2008 studied 1118 residents in 29 units in two long-term care facilities, Roberts 2001 studied 3230 residents in 52 nursing homes and Zermansky 2006 studied 661 residents in 65 nursing and residential homes for older people.

Interventions

The interventions evaluated were diverse and often multifaceted. Medication review (conducted by various methods) was a component of seven studies (Strikwerda 1994; Claesson 1998; Furniss 2000; Roberts 2001; Crotty 2004a; Crotty 2004b; Zermansky 2006). Three studies involved multidisciplinary case-conferencing (Claesson 1998; Crotty 2004a; Crotty 2004b) and two studies involved an educational element for care home staff (Roberts 2001; Crotty 2004a). One study evaluated the use of clinical decision support technology (Gurwitz 2008). Other components of interventions included introducing a new professional role to stakeholders (Roberts 2001) and the transfer of medicines information (Crotty 2004b). Further descriptions of interventions are presented below.
Strikwerda 1994 evaluated the effect of community pharmacist feedback to GPs on their patients' prescriptions over a four week period.
Claesson 1998 evaluated the effectiveness of monthly multidisciplinary team meetings between the physician, pharmacist and nurse(s) over 12 months. The aim of the meetings was to discuss and improve the use of drugs. Pharmacists received a total of 65.5 hours of education and training prior to and during the intervention period.
Furniss 2000 investigated the effectiveness of pharmacist-conducted medication review (in addition to usual care by the GP) versus usual care by the GP. The intervention was a single medication review conducted by one pharmacist with access to medical and nursing home records. No details were provided on the education and training of the pharmacist.
The intervention evaluated by Roberts 2001 had three components: (i) introducing a new professional role and relationship building; (ii) nurse education; (iii) medication review by pharmacists holding a postgraduate diploma in clinical pharmacy. Medication reviews were undertaken for a non-random subsample of 500 residents (total intervention residents 905) selected by nursing staff. Most of the contact between pharmacists and GPs was indirect.
Crotty 2004a evaluated the effectiveness of an 'outreach medication advisory service'. This involved a medication review prepared by the pharmacist, followed by two multidisciplinary case conferences held six to 12 weeks apart (with the GP, geriatrician, pharmacist, care staff and an Alzheimer's Association of South Australia representative). No details were provided on the education and training of the pharmacist.
Crotty 2004b investigated the effectiveness of a pharmacist transition co-ordinator for residents who were being discharged from hospital to a long-term care facility. The intervention focused on the transfer of medicines information to the nursing home staff, GP and the community pharmacist. Following this, a medication review was conducted by the community pharmacist contracted to the care home. In addition, the transition pharmacist co-ordinated a multidisciplinary case conference 14 to 28 days after transfer involving him or herself, the GP, community pharmacist and a nurse.
Zermansky 2006 evaluated the effectiveness of a clinical medication review (in addition to usual care by the GP) undertaken by a pharmacist who held a post-graduate clinical pharmacy qualification versus usual care by the GP. The pharmacist reviewed the medicines with the medical and care home records in conjunction with a consultation with the resident (if possible) and a nurse or carer.

The intervention investigated by Gurwitz 2008 was a clinical decision support system in facilities that had computerised provider order entry systems. The clinical decision support system was designed based on previous research on preventable adverse drug events, criteria for suboptimal prescribing in older people and drug-drug interactions. Warning messages were displayed to prescribers in a pop-up box in real time when medicines were entered into the computer provider order entry system. Prescribers were free to either act on alerts or ignore them.

Outcomes

Outcomes were diverse with differing definitions, methods of data collection, varying time points and different reporting methods. Studies reported measures other than those specified for this review and these are listed in the Characteristics of included studies tables.

Primary outcome measures

Adverse drug events

Only two studies specified adverse drug events as an outcome measure (Crotty 2004b; Gurwitz 2008). However, Crotty 2004b did not define adverse drug events. Adverse drug events were the primary outcome measure in the Gurwitz 2008 study and were defined as 'an injury resulting from the use of a drug'; such adverse drug events may have resulted from medication errors or from adverse drug reactions in which there was no error.

Hospital admissions

Four studies included hospital admissions as an outcome measure (Furniss 2000; Roberts 2001; Crotty 2004b; Zermansky 2006). Furniss 2000 reported hospital admissions as the number of inpatient days. Roberts 2001 reported the proportion of residents hospitalised and Zermansky 2006 reported the mean number of non-elective hospitalisations per resident. Crotty 2004b grouped together emergency department visits and hospital readmissions.

Mortality

Three studies included mortality as an outcome measure (Furniss 2000; Roberts 2001; Zermansky 2006). Furniss 2000 and Zermansky 2006 reported mortality as the number of deaths over eight and six months, respectively. Roberts 2001 reported the proportion of residents who had died over 12 months together with cumulative survival.

Secondary outcome measures

Quality of life

No studies measured quality of life.

Medication-related problems

Medication-related problems were measured and classified in diverse ways in six studies. Strikwerda 1994 reported the number of pharmacists' recommendations and described their type. Claesson 1998 described the type and frequency of drug-related problems along with pharmacists' recommendations. Furniss 2000 measured the number of pharmacist's recommendations, accepted recommendations by the GP, and the number of treatment changes. Reasons were provided for the pharmacist's recommendations. Roberts 2001 measured the number of medicine changes likely to be due to medication review. Crotty 2004b identified medication-related problems and classified them into categories. Zermansky 2006 measured the number of changes in medication per participant as the primary outcome; pharmacist's recommendations were identified, collated and classified along with GPs' acceptance of the recommendations.

Medication appropriateness

Two studies assessed medication appropriateness using a validated tool (Crotty 2004a; Crotty 2004b). Both studies used the Medication Appropriateness Index (MAI) (Hanlon 1992).

Medicine costs

Four studies calculated medicine costs (Furniss 2000; Roberts 2001; Crotty 2004a; Zermansky 2006). Furniss 2000 calculated drug costs per resident throughout the observation and intervention phases of the study. Roberts 2001 collected yearly drug costs from prescription claims data based on the Australian Pharmaceutical Benefits Scheme. Crotty 2004a calculated monthly drug costs for all regular medicines based on the Australian Pharmaceutical Benefits Scheme. Zermansky 2006 calculated the 28 day net ingredient cost of repeat medicines per resident.

Excluded studies

None reported.

Risk of bias in included studies

Studies were heterogeneous with regard to risk of bias (see Figure 2; Figure 3). Risk of bias is summarised below for each domain.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

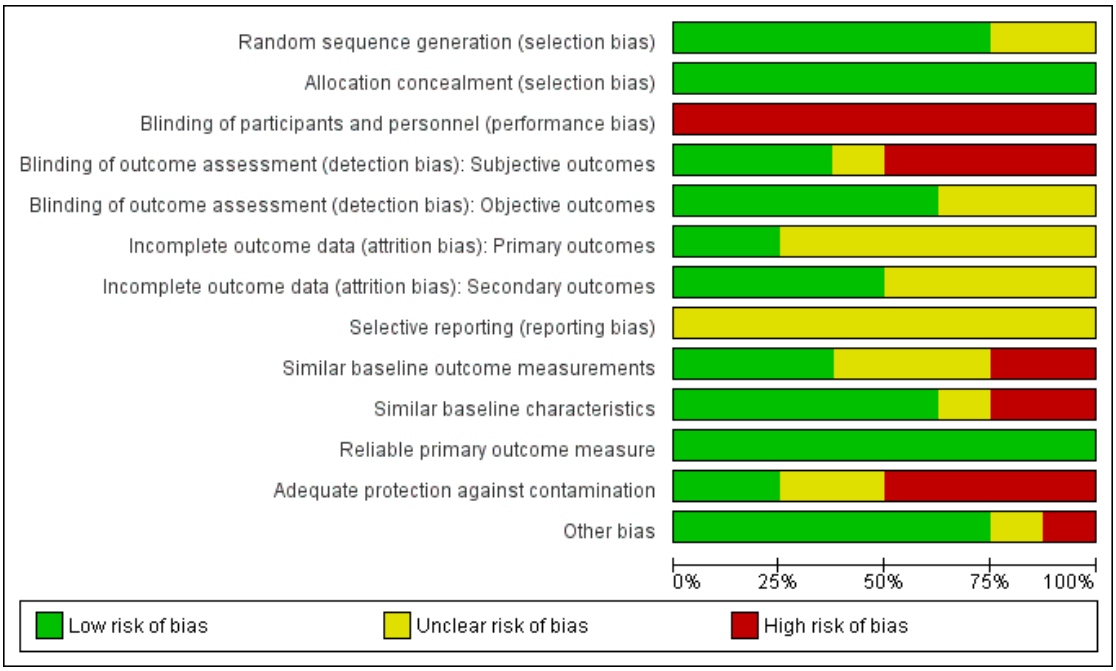


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

Allocation

Six studies were judged to have a low risk of bias based on random sequence generation (Furniss 2000; Roberts 2001; Crotty 2004a; Crotty 2004b; Zermansky 2006; Gurwitz 2008). The studies by Strikwerda 1994 and Claesson 1998 did not report how the sequence was generated. Four studies utilised computer-generated random or pseudo-random numbers (Furniss 2000; Crotty 2004a; Crotty 2004b; Zermansky 2006) and Roberts 2001 drew from a hat. Allocation was adequately concealed via centralisation in both of the P-RCTs (Crotty 2004b; Zermansky 2006). Due to the remaining six studies having a cluster design, they were deemed to be at low risk of bias with regard to allocation concealment (Strikwerda 1994; Claesson 1998; Furniss 2000; Roberts 2001; Crotty 2004a; Gurwitz 2008).

Blinding

Due to the nature of the interventions it was not possible to blind participants and personnel in any of the studies and, therefore, performance bias was judged to be high for each study. Three studies blinded outcome assessment for subjective outcomes (Crotty 2004a; Crotty 2004b; Gurwitz 2008) and, therefore, detection bias for these outcomes was low for these studies and high for the remainder. Detection bias was deemed to be low for objective outcomes for studies that reported them.

Incomplete outcome data

Three studies were deemed at low risk of attrition bias as they reported similar baseline characteristics with a similar number of dropouts for similar reasons (Crotty 2004a; Crotty 2004b; Zermansky 2006). The only outcome in the Claesson 1998 study was a description of medicine-related problems in the intervention group and attrition bias was not relevant. The risk of attrition bias was unclear for four studies due to a lack of information (Strikwerda 1994; Furniss 2000; Roberts 2001; Gurwitz 2008).

Selective reporting

Although there was no evidence of selective reporting in the studies, that is all outcome measures stated in the methods were reported, research protocols were not available and, therefore, there was insufficient information to permit judgement.

Other potential sources of bias

Similar baseline outcome measurements

Three studies (Roberts 2001; Crotty 2004b; Zermansky 2006) were deemed at low risk of bias as baseline outcome measurements were similar. Furniss 2000 was judged to be at high risk of bias because there were fewer deaths in the control group compared with the intervention group. Crotty 2004a was also judged to be at a high risk of bias because of baseline differences in the Medication Appropriateness Index. The three remaining studies were deemed to be at an unclear risk of bias as outcomes were not measured at baseline (Strikwerda 1994; Claesson 1998; Gurwitz 2008).

Similar baseline characteristics

Five studies reported similar baseline characteristics and were judged to be at low risk of bias (Claesson 1998; Roberts 2001; Crotty 2004a; Crotty 2004b; Zermansky 2006). The study by Strikwerda 1994 reported fewer males in group A and fewer medicines in group B compared to group C and was judged to be at high risk. The study by Furniss 2000 was deemed to be at high risk because in the control group the residents were younger and there were fewer females. Gurwitz 2008 was deemed to be at unclear risk because baseline characteristics of residents were not reported (although units were matched for general characteristics, bed size and general characteristics of residents).

Reliable primary outcome measure

All eight studies were deemed to have reliable primary outcome measures (although not all the outcome measures were included in this review).

Adequate protection against contamination

Two studies that were of a cluster design were assessed to be at an unclear risk of adequate protection against contamination because although they were randomised by care home it was unclear whether a GP may have serviced both intervention and control homes (Claesson 1998; Roberts 2001). The study by Crotty 2004a was deemed to be at low risk of contamination because in addition to the cluster design the GPs were checked to avoid contamination between intervention and control residents. The study by Strikwerda 1994 was at high risk because although residents were randomised by GP they all resided in the same nursing home. Furniss 2000 randomised care homes in different geographical areas and was therefore deemed at low risk of contamination. Gurwitz 2008 attempted to limit the crossover of prescribers between intervention and control units, however some prescribers worked simultaneously on both units and consequently the trial was judged to be at high risk of contamination. The two studies that were P-RCTs were deemed to be at high risk as contamination was possible (Crotty 2004b; Zermansky 2006).

Effects of interventions

See: **Summary of findings for the main comparison**

Due to the heterogeneity in interventions, outcomes and risk of bias, it was deemed inappropriate to conduct a meta-analysis. The effectiveness of the interventions are described below.

Primary outcome measures

Adverse drug events

Crotty 2004b found no evidence of an effect of a pharmacist transition coordinator on adverse drug events (relative risk 1.05, 95% CI 0.66 to 1.68). Gurwitz 2008 tested a clinical decision support system and found no evidence of an effect on all adverse drug events (adjusted rate ratio 1.06, 95% CI 0.92 to 1.23) or preventable adverse drug events (adjusted rate ratio 1.02, 95% CI 0.81 to 1.30).

Hospital admissions

Furniss 2000 found fewer inpatient days per resident in the intervention group compared with the control group during the four month intervention phase of the study (0.55 versus 1.26); however, small numbers precluded statistical analysis. In the Roberts 2001 study, no statistically significant difference was found in the mean proportion of residents hospitalised between the intervention and control groups. Crotty 2004b demonstrated a reduction in the combination of emergency room visits and hospital readmissions with a relative risk ratio of 0.38 (95% CI 0.15 to 0.99) when analysing residents who were alive at follow-up. When residents who had died were included, there was no evidence of an effect on hospital admissions (relative risk 0.58, 95% CI 0.28 to 1.21). Zermansky 2006 showed no evidence of an effect on the mean number of hospitalisations per resident (relative risk 0.75, 95% CI 0.52 to 1.07).

Mortality

Furniss 2000 found fewer deaths in the intervention group compared with the control group during the intervention phase of the study (4 versus 14, P = 0.028); however when the observation phase of the study was taken into account, the number of deaths in the control and intervention groups were 28 and 26 (P value not reported), respectively. In the Roberts 2001 study, no statistically significant difference was found in the mean proportion of residents who had died between the intervention and control groups. A survival analysis found a hazard ratio of 0.85 (95% CI 0.75 to 0.96) in favour of the intervention group when analysed by individual residents; however after accounting for the clustering effect this was no longer statistically significant (hazard ratio 0.85, 95% CI 0.68 to 1.06). Zermansky 2006 showed no evidence of an effect on the number of deaths (relative risk 1.06, 95% CI 0.70 to 1.64).

Secondary outcome measures

Quality of life

No studies evaluated the effect of interventions on this outcome.

Medication-related problems

Strikwerda 1994 reported that 122 potential medication-related problems were identified in 61 residents. As a result, nine medicines were discontinued and four medicines had a dose reduction. The most common medication-related problem was a potential interaction (51, 42%), followed by dose (31, 25%), indication (23, 19%) and duration of the prescription (17, 14%).

Claesson 1998 identified 819 drug-related problems in 395 residents (2.1 per resident). The most common problem was 'choice of drug' (348, 43%), with the majority of these being inappropriate according to Swedish Medical Product Agency guidelines. Two hundred and seventy-six (34%) problems were due to 'unclear indication' whereby the team did not know why a drug had been prescribed or the drug had not been adequately re-evaluated. Ninety per cent (737) of the problems discussed were acted upon, with 368 (45%) resulting in stopping the medicine and 162 (20%) led to a change of medicine. Five hundred and thirty-two medicine changes were evaluated with 404 (76%) still in place after a month, 59 (11%) discontinued and previous therapy room restored, and 69 (13%) were difficult to evaluate as partial changes had occurred.

Furniss 2000 made 261 recommendations of which 239 (92%) were accepted by the GP. This resulted in 144 actual treatment changes. Thirty residents did not require a change in therapy, and the mean number of recommendations per resident (for those who needed at least one recommendation) was 2.46 (range 0 to 7). The most common reasons for recommendations were 'indication for the medication no longer present' (85, 33%) and 'safer or more efficacious use of drug' (77, 30%).

Roberts 2001 followed up 137 of the 500 medication reviews conducted and found that 54 (39%) of the residents had changes likely to be due to the review. No further information was provided.

Crotty 2004b identified medicine-related problems at admission to the long-term care facility for intervention and control residents. The most common issue classified as a medicine-related problem by the authors was that a resident had been appointed a new physician. The next most common problems identified were: discrepancy between medication discharge summary and medication (32, 57% intervention; 26, 48% control); precaution with use (18, 32% intervention; 14, 26% control); no indication for medication (18, 32% intervention; 8, 15% control).

In the study by Zermansky 2006, at least one recommendation was made in 256 (77%, 95% CI 73.1 to 81.7) residents, with a mean of 2.3 recommendations per resident. Six hundred and seventy-two medication-related recommendations were made along with an additional 75 recommendations related to the residents' conditions. The most common recommendation was technical (for example generic switching, amending quantities, removing discontinued items from the repeat prescription) with 225 (30%) recommendations. Following technical reasons, the most common recommendations were to conduct a test to monitor therapy (161, 22%) and to stop a medicine (100, 13%). The GP accepted 565 (76%) of the pharmacist's recommendations and rejected 52 (7%); there was no response to the review or the resident died before the review could be actioned in the remaining cases. The GP actioned 433 (77%) of the accepted recommendations.

Medication appropriateness

Crotty 2004a found that, based on the Medication Appropriateness Index (MAI), medication appropriateness improved in the intervention group (MAI mean change 4.1, 95% CI 2.1 to 6.1) compared with the control group (MAI mean change 0.4, 95% CI -0.4 to 1.2). MAI scores were higher at baseline for intervention group residents compared with control residents (mean MAI 7.4, 95% CI 4.5 to 10.3 versus 4.1, 95% CI 2.4 to 5.7). There were no baseline differences in mean MAI scores between the control (3.7, 95% CI 2.2 to 5.2) and intervention groups (3.2, 95% CI 1.8 to 4.6) in the Crotty 2004b study. Following the intervention, there was no change in MAI in the intervention group (2.5, 95% CI 1.4 to 3.7) whereas the MAI in the control group had worsened (6.5, 95% CI 3.9 to 9.1). The difference in MAI scores at follow-up was statistically significant (P = 0.007). The effect of the intervention on MAI scores remained significant when controlled for baseline MAI, Charlson Comorbidity Index and the number of drugs discontinued during hospital admission.

Medicine costs

The cost of medicines per resident in the observation phase of the Furniss study was £142.53 in the control group and £159.01 in the intervention group (Furniss 2000). Following the intervention phase, costs were £141.24 in the control group versus £131.54 in the intervention group, representing a reduction in medicine costs of £27.47 per resident over a four month period. Accounting for the pharmacist's time, the cost saving on medicines in the intervention group was calculated to be £22/resident. Roberts 2001 calculated a drug cost saving of $AU64 per resident per year in the intervention group compared to the control group. When the cost of the intervention was accounted for, the net cost saving was $AU16 per resident per year. Crotty 2004a found no statistically significant difference in mean medicine costs per month per resident between the intervention and control groups (mean change $AU5.72 intervention versus $AU3.37 control, P = 0.837). Zermansky 2006 found no evidence of an effect of the intervention on the cost of 28 days repeat medicines per resident (mean difference £ -0.70, 95% CI £-7.28 to £5.71).

DISCUSSION

Summary of main results

Eight studies were included in the review and one ongoing study. There was no evidence of an effect of the interventions on any of the primary outcomes of the review that is adverse drug events (Crotty 2004b; Gurwitz 2008), hospital admissions (Furniss 2000; Roberts 2001; Crotty 2004b; Zermansky 2006) and mortality (Furniss 2000; Roberts 2001; Zermansky 2006). No studies included quality of life measures. There was evidence that the interventions led to the identification and resolution of medication-related problems (Strikwerda 1994; Claesson 1998; Furniss 2000; Roberts 2001; Crotty 2004b; Zermansky 2006). There was evidence from two studies that medication appropriateness was improved (Crotty 2004a; Crotty 2004b). However, the link between improved medication appropriateness based on the Medication Appropriateness Index and patient-related outcomes is not clear. The evidence for an effect on medicine costs was equivocal with two studies finding a reduction in costs (Furniss 2000; Roberts 2001) and two studies finding no difference (Crotty 2004a; Zermansky 2006).

Overall completeness and applicability of evidence

The review was designed to identify interventions that considered residents' whole medication regimens to optimise prescribing. Consequently, a broad range of interventions (professional and organisational) were eligible for the review and diverse, multifaceted interventions were ultimately implemented to address the objectives of the review.

The interventions were tested in the population of interest; however, there was considerable variability in the outcomes measured with quality of life not represented in any of the included studies. Current practice varies considerably internationally. However, multidisciplinary teams (involving physicians, nurses and pharmacists) play a significant role in optimising prescribing for care home residents and this was reflected in the studies; the majority of interventions involved multidisciplinary teamworking, usually with pharmacists conducting medication reviews. However, the effectiveness of this has not been demonstrated. Information and communication technology is increasingly being employed to optimise prescribing in many settings, and one study tested the impact of a clinical decision support system (Gurwitz 2008).

Quality of the evidence

Robust conclusions cannot be drawn from the evidence due to variability in design, interventions, outcomes and results. The review included eight studies of varying quality that included 7653 residents living in 262 care homes in six countries. As medication review was the main intervention or a component of the intervention in seven out of the eight studies, the effects of medication review were summarised in the 'Summary of findings' table (Summary of findings for the main comparison). The overall quality of the evidence for the outcomes reported was low or very low. The majority of the included studies were cluster-RCTs and this was appropriate given the complex nature of interventions, the difficulty of blinding and the consequential threat of contamination. The patient-RCTs did not adequately protect against contamination and, therefore, the effects of the intervention may have potentially been diluted. Some of the studies had short follow-up periods, which may have potentially limited the detection of effects on outcomes. None of the studies blinded participants and personnel, however this was unlikely to have been achievable due to the nature of the interventions. The interventions tested were complex and multifaceted and none of the studies attempted to disentangle the 'black box' effect, that is to understand the effects of the contributing components. Not all the studies attempted blinding of assessment for subjective outcomes, and this could have been implemented. A major limitation of the evidence was the diversity of outcome measures and the fact that they differed in the way they were defined (if at all), collected and analysed.

Potential biases in the review process

Bias was minimised when conducting this review by several methods. An extensive literature search was conducted which was guided by EPOC and the included studies from published systematic reviews were screened. Studies were not limited to those in the English language. Two review authors independently screened titles and abstracts, assessed studies for eligibility, evaluated risk of bias and extracted data.

Agreements and disagreements with other studies or reviews

Five previously published systematic reviews (Kaur 2009; Ostini 2009; Verrue 2009; LaMantia 2010; Loganathan 2011) and one narrative review (Markum 2010) related to the objectives of this review were identified. No further studies were identified from these reviews and the conclusions were similar, that is mixed results were obtained from the several intervention types tested in heterogeneous studies.

AUTHORS' CONCLUSIONS

Implications for practice

The interventions implemented in the studies in this review led to the identification of medication-related problems, confirming that suboptimal prescribing is prevalent in this context. The majority of medication-related problems were resolved through the interventions employed. In addition, evidence from two studies suggested that the appropriateness of medication could be improved through multifaceted interventions involving medication review by pharmacists, transfer of information and multidisciplinary case conferencing. Despite the identification and resolution of medication-related problems, and improvements in medication appropriateness, there is a lack of evidence on how this translates to improvements in resident-related outcomes, namely adverse drug events, hospital admissions, mortality and quality of life. The effect of interventions on medicine costs was unclear, with two studies showing a reduction in costs and two studies showing no difference.

Implications for research

High-quality, adequately powered RCTs, ideally using cluster designs, need to be conducted to identify effective interventions to optimise prescribing for older care home residents. More studies are needed to investigate the effectiveness of clinical decision support systems as well as multidisciplinary interventions in this context. Further work is required to develop consensus on identifying, defining, measuring, reporting and analysing important resident-related outcomes, including quality of life. This will enable meta-analyses to be conducted on future RCTs.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Claesson 1998

Methods	Cluster-RCT (randomised by nursing home) Total study duration: 14 months
Participants	1854 residents 33 nursing homes Setting: nursing homes Age: Average 83 years Gender: Intervention 70% female; control 67% female Country: Sweden Date of study: 1994/95
Interventions	The aim of the regular multidisciplinary meetings was to discuss and improve the use of drugs in nursing homes, and to decrease the use of drugs which, according to the advice of the workshop arranged by the Swedish Medical Products Agency, could cause confusion and impaired memory. In group discussions, the physician, pharmacist, one or more of the nursing home nurses, and in many cases, one or more of the assistant nurses and nurse aides reviewed the drug use of all residents on a monthly basis over a period of one year. The length and frequency of the meetings were adjusted by the participants to local conditions. The therapy changes that were discussed were thus based on the physician's medical knowledge, the pharmacist's pharmaceutical knowledge, and the nurses' and other staff's knowledge about the patients' social and functional status. The selected pharmacists were educated prior to and during the intervention period. This education took the form of lectures and workshops, which took place on five occasions, twice before the intervention started and three times during the intervention period, for a total of 65.5 hours. The lectures were given by recognised experts, including clinical pharmacists, geriatricians, gerontologists, nurses and two community pharmacists with experience in nursing home consulting. Topics covered were gerontology/geriatrics (12. 5 hours), drug use in the elderly (23.5 hours) and basic training in collaborative methods (18.5 hours). In addition, the pharmacists worked with patient cases in small groups, covering all the areas mentioned above (11 hours). In addition to the formal education, the pharmacists formed regional networks. The networking took place locally, whenever the pharmacist felt a need to have it. In order to make the networks constructive, the whole group was instructed by an educational specialist on one occasion
Outcomes	Medication-related problems Not used for this review: Drug use
Notes	Supported by the National Corporation of Swedish Pharmacies and the Swedish Pharmaceutical Society

Risk of bias

Bias	Authors' judgement	Support for judgement

Claesson 1998 (*Continued*)

Random sequence generation (selection bias)	Unclear risk	Homes were matched in pairs then each randomised to control or intervention. [Attempted to contact author for further information but unsuccessful]
Allocation concealment (selection bias)	Low risk	Cluster design
Blinding of participants and personnel (performance bias) All outcomes	High risk	Blinding not conducted
Blinding of outcome assessment (detection bias) Subjective outcomes	High risk	Blinding not conducted
Blinding of outcome assessment (detection bias) Objective outcomes	Unclear risk	No objective outcomes
Incomplete outcome data (attrition bias) Primary outcomes	Unclear risk	Not measured in this study
Incomplete outcome data (attrition bias) Secondary outcomes	Low risk	Medication-related problems described for residents receiving intervention
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	Unclear risk	Medication-related problems not measured at baseline
Similar baseline characteristics	Low risk	Similar baseline characteristics reported
Reliable primary outcome measure	Low risk	Drug use
Adequate protection against contamination	Unclear risk	Cluster design. [Attempted to contact author for further information but unsuccessful]
Other bias	Low risk	Appears to be free of other sources of bias

Crotty 2004a

Methods	Cluster-RCT (randomised by care facility) Total study duration: 3 months
Participants	10 facilities (5 intervention, 5 control). 154 residents (50 intervention, 54 control, 50 within-facility control) Setting: High-level residential aged-care facilities (nursing homes) Age: Intervention mean 85.3, control mean 83.6, within-facility control mean 84.6 Gender: Intervention male 22 (44%), control male 23 (43%), within-facility control male 17 (34%) Country: Australia Date of Study: 1999 [Author contacted]
Interventions	Outreach geriatric medication advisory service, case conferencing and medication review GPs were invited to attend two multidisciplinary case conferences conducted 6-12 weeks apart. The resident's GP, a geriatrician, a pharmacist, residential care staff and a representative of the Alzheimer's Association of South Australia attended the case conferences, which were held at the facility. Residential care staff expanded on any issues in the case notes that required discussion and the Alzheimer's Association of South Australia representative discussed non-pharmacological management of dementia-related behaviour. Each case conference was chaired by the GP, who used their medical records in addition to case notes from the facility. A problem list was developed by the GP in conjunction with the care staff and a medication review was conducted prior to each case conference. All facilities in the study, including those in the control group, received a half-day workshop provided by the Alzheimer's Association of South Australia, which examined the use of a toolkit in the management of challenging behaviours
Outcomes	Measured at baseline and three months post-intervention: Medication appropriateness (MAI) Drug costs (based on Australian Government Pharmaceutical Benefits Scheme) Not used in this review: Nursing Home Behaviour Problem Scale (NHBPS) Number of drugs
Notes	Funded by The Quality Use of Medicines Evaluation Programme 2000-2001, Health and Aged Care, General Practice National Innovations Funding Pool 1999-2000, Health and Aged Care

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Computer-generated random numbers used
Allocation concealment (selection bias)	Low risk	A researcher independent to the investigators generated the random sequence and cluster design. Staff were asked to "nominate" 20 residents from intervention sites and 10 residents from control sites. From

		the 20 intervention,10 were randomised to intervention and ten to within-facility control using sequential sealed opaque envelopes
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding conducted
Blinding of outcome assessment (detection bias) Subjective outcomes	Low risk	Assessed by independent pharmacist blinded to allocation [author contacted]
Blinding of outcome assessment (detection bias) Objective outcomes	Low risk	No blinding conducted, however outcomes not likely to be influenced by lack of blinding
Incomplete outcome data (attrition bias) Primary outcomes	Unclear risk	Not measured in this study
Incomplete outcome data (attrition bias) Secondary outcomes	Low risk	Reasons for attrition reported (all due to deaths) and no statistically significant difference found in the proportion of residents lost between groups. Described as intention-to-treat analysis by authors
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	High risk	There were differences in the Medication Appropriateness Index between groups at baseline: Control 4.1 (95% CI 2.4-5.7); Within-facility control 6.0 (95% CI 3.1-9.0); Intervention 7.4 (95% CI 4.5-10.3)
Similar baseline characteristics	Low risk	Similar baseline characteristics reported
Reliable primary outcome measure	Low risk	Medication Appropriateness Index
Adequate protection against contamination	Low risk	Cluster design. Randomised by care facility. GPs were checked to avoid contamination between intervention and control residents [author contacted]. No significant differences found between the within-facility control and the control groups, therefore no evidence of a carry-over effect of the intervention

Crotty 2004a (*Continued*)

Other bias	Low risk	Appears to be free of other sources of bias

Crotty 2004b

Methods	RCT (randomised by patient) Total study duration: 8 weeks
Participants	110 patients (56 intervention, 54 control) from three hospitals discharged to 85 long-term facilities Setting: Long-term care facilities Age: Mean 82.7, s.d. 6.4 Gender: 67 women (60.9%), 43 men (39.1%) Country: Australia Date of study: October 2002 to July 2003
Interventions	Pharmacist transition coordinator. The intervention focused on transferring information on medications to care providers in the long-term care facilities, including the nursing staff, the family physician and the accredited community pharmacist. On the patient's discharge from the hospital to the long-term care facility both the family physician and the community pharmacist were faxed a medication transfer summary compiled by the transition pharmacist and signed by the hospital medical officer. This communication supplemented the usual hospital discharge summary and included specific information on changes to medications that had been made in the hospital and aspects of medication management that required monitoring After transfer of the patient to the long-term care facility, the transition pharmacist co-ordinated an evidence-based medication review that was to be performed by the community pharmacist contracted to the facility within 10 to 14 days of the transfer. The transition pharmacist also coordinated a case conference involving him or herself, the family physician, the community pharmacist and a registered nurse at the facility within 14 to 28 days of the transfer. At this case conference, the transition pharmacist provided information concerning medication use and appropriateness The usual hospital discharge process received by the control group included a standard hospital discharge summary.
Outcomes	Measured at baseline and eight weeks post-discharge: Adverse drug events (not defined) Hospital admissions (emergency department visits and hospital readmissions) Medication-related problems Medication appropriateness (MAI) Not used for this review: Falls Worsening mobility Worsening behaviours Increased confusion Worsening pain

Crotty 2004b (*Continued*)

Notes	Funded by the Australian Commonwealth Department Of Health and Ageing National Demonstration Hospitals Program

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Study biostatician provided a computer-generated allocation sequence using block randomisation
Allocation concealment (selection bias)	Low risk	Randomisation was coordinated by a centralised hospital pharmacy service
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding conducted
Blinding of outcome assessment (detection bias) Subjective outcomes	Low risk	Independent pharmacists blinded to allocation assessed Medication Appropriateness Index (MAI)
Blinding of outcome assessment (detection bias) Objective outcomes	Low risk	No blinding conducted, however outcomes not likely to be influenced by lack of blinding
Incomplete outcome data (attrition bias) Primary outcomes	Low risk	Similar attrition in both groups with similar reasons for dropouts. Described as intention-to-treat by authors
Incomplete outcome data (attrition bias) Secondary outcomes	Low risk	Similar attrition in both groups with similar reasons for dropouts. Described as intention-to-treat by authors
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	Low risk	Similar Medication Appropriateness Index scores at baseline. Other outcomes not measured at baseline
Similar baseline characteristics	Low risk	Similar baseline characteristics reported except more pre-admission medications discontinued during hospitalisation in the control group
Reliable primary outcome measure	Low risk	Medication Appropriateness Index

Crotty 2004b (*Continued*)

Adequate protection against contamination	High risk	Randomised by patient therefore contamination possible
Other bias	Low risk	Appears to be free of other sources of bias

Furniss 2000

Methods	Cluster-RCT (randomised by care home) Total study duration: 8 months
Participants	330 residents (172 control, 158 intervention); 14 homes (7 matched pairs) Setting: Nursing homes Age: Control mean 78.9 sd 13.7; intervention mean 83.5 sd 9.2 Gender: Control 115 (67%) females; intervention 125 (79%) females Country: UK Date of study: Not stated
Interventions	Medication review by pharmacist Medication review by the study pharmacist in the GP's surgery, at the nursing home or (in exceptional circumstances) over the telephone. The pharmacist collected details of current medication for each resident from the medicines administration record chart in the home, together with a brief medical history and any current problems identified by the home staff. Three weeks after the medication review, the homes were revisited, to ascertain whether there had been any immediate problems with the changes in medication and to see if the suggested changes have been implemented
Outcomes	Measured at time 0 (beginning of study), time 1at four months (beginning of intervention) and at time 2 at eight months (end of intervention): Hospital admissions ("inpatient days") Mortality Medication-related problems (number of pharmacist recommendations, acceptance of recommendations by the GP, number of treatment changes) Medication costs (not defined, £ sterling) Not used for this review: Mini-Mental State Examination (MMSE) Geriatric Depression Scale (GDS) Brief Assessment Schedule Depression Cards (BASDEC) Crichton-Royal Behaviour Rating Scale (CRBRS) Number of drugs per resident Type of drugs Reason for neuroleptic use Use of primary and secondary care resources Number of accidents Falls
Notes	Funded by the North West NHS Executive

Risk of bias

Furniss 2000 (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated pseudo random numbers used
Allocation concealment (selection bias)	Low risk	Homes were randomised at the start of the start of a four-month observation phase. Cluster design
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding described
Blinding of outcome assessment (detection bias) Subjective outcomes	High risk	No blinding conducted
Blinding of outcome assessment (detection bias) Objective outcomes	Low risk	No blinding conducted, however outcomes not likely to be influenced by lack of blinding
Incomplete outcome data (attrition bias) Primary outcomes	Unclear risk	Insufficient reporting of attrition/exclusions to permit judgement
Incomplete outcome data (attrition bias) Secondary outcomes	Unclear risk	Insufficient reporting of attrition/exclusions to permit judgement
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	High risk	14 (8.1%) deaths in control group versus 22 (13.9%) deaths in intervention group at baseline. No baseline measurements of other primary outcomes of this review
Similar baseline characteristics	High risk	Slightly fewer residents in the intervention group (158) versus control (172). In the control group, residents were younger (mean 78.9 s.d. 13.7 versus mean 83.5 s. d. 9.2) and there were fewer females (67% versus 79%)
Reliable primary outcome measure	Low risk	Crichton-Royal Behaviour Rating Scale
Adequate protection against contamination	Low risk	Randomised by care home (which were in different geographical areas)

Furniss 2000 (*Continued*)

Other bias	Low risk	Appears to be free of other sources of bias

Gurwitz 2008

Methods	Cluster-RCT (randomised by care unit within two long-term care facilities) Total study duration: 12 months
Participants	1,118 resident in 29 units in two long-term care facilities Setting: Long-term care facilities Age: Average 87.2 years Gender: 71.3% female Country: US and Canada Date of study: 2006-7 [Author contacted]
Interventions	Computerised provider order entry with clinical decision support A team of geriatricians, pharmacists, health services researchers and information system specialists designed the clinical decision support system The team reviewed the types of preventable adverse drug events based on previous research and widely accepted published criteria for suboptimal prescribing in elderly people available at the time of this study. All serious drug-drug interactions from a standard pharmaceutical drug interaction database were also reviewed and alerts were included for a limited number of more than 600 potentially serious interactions that were reviewed. For residents on the intervention units, the alerts were displayed in a pop-up box to prescribers in real time when a drug order was entered. The pop-up boxes were informational; they did not require specific actions from the prescriber and did not produce or revise orders automatically. On the control units, the alerts were not displayed to the prescribers
Outcomes	Measured throughout study period (resident-months): Adverse drug event ("an injury resulting from the use of a drug" includes medication error and adverse drug reaction) Severity of adverse drug event Preventability of adverse drug event
Notes	Supported by the Agency for Healthcare Research and Quality.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Block randomisation used. Within each block, units were randomly assigned using the random function in Microsoft Excel®. [Author contacted]
Allocation concealment (selection bias)	Low risk	Cluster design

Blinding of participants and personnel (performance bias) All outcomes	High risk	Not conducted
Blinding of outcome assessment (detection bias) Subjective outcomes	Low risk	Outcome assessors were blind to allocation
Blinding of outcome assessment (detection bias) Objective outcomes	Unclear risk	No objective outcomes
Incomplete outcome data (attrition bias) Primary outcomes	Unclear risk	Insufficient reporting of attrition/exclusions to permit judgement
Incomplete outcome data (attrition bias) Secondary outcomes	Unclear risk	Not measured in this study
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	Unclear risk	No baseline measurements of adverse drug effects
Similar baseline characteristics	Unclear risk	Baseline characteristics not reported, however, units were matched for bed size and general characteristics of residents and the unit
Reliable primary outcome measure	Low risk	Number of adverse drug events
Adequate protection against contamination	High risk	Cluster design. Efforts were made to limit crossover of prescribers between intervention and control units, however, some prescribers worked simultaneously on both intervention and control units. In an effort to assess the possibility that this may have led to changes in behaviour in the control group, the rate of responses to "unseen" alerts in the control units during the first versus the last quarter of the study was assessed at one of the study sites. The rate of response was lower in the last quarter, suggesting that prescribers did not adopt new habits due to seeing alerts on intervention units
Other bias	Low risk	Appears to be free of other sources of bias

Roberts 2001

Methods	Cluster-RCT (randomised by care home) Total study duration: Two years
Participants	3230 residents (905 intervention, 13 homes); 2325 control, 39 homes) Setting: Nursing homes Age: Intervention <60 2.0%, 60-69 6.6%, 70-79 21.9%, 80-89 47.4%, 90-99 20.7%, ≥ 100 1.7% Control <60 2.6%, 60-69 5.4%, 70-79 22.3%, 80-89 46.7%, 90-99 21.1%, ≥ 100 1. 6% Gender: Not reported Country: Australia Date of Study: Not reported
Interventions	Three phase intervention: introducing a new professional role to stakeholders with relationship building; nurse education; and medication review by pharmacists. The clinical pharmacy service model introduced to each nursing home was supported with activities such as focus groups facilitated by a research nurse, written and telephone communication, and face-to-face professional contact between nursing home staff and clinical pharmacists on issues such as drug policy and specific resident problems, together with education and medication review by pharmacists holding a postgraduate diploma in clinical pharmacy. This was a multifaceted intervention directly targeting nursing homes. Most of the contact with GPs was indirect, using the existing relationships between nursing homes and visiting GPs. A number of focus groups and personal interviews about the project were conducted with GPs. In intervention homes, problem-based education sessions (6±9 seminars totalling approximately 11 h per home) were provided to nurses. Sessions addressed basic geriatric pharmacology and some common problems in long-term care (depression, delirium and dementia, incontinence, falls, sleep disorders, constipation and pain). Sessions were supported by wall charts, bulletins, telephone calls and clinical pharmacy visits, averaging 26 h contact per home over the study. Written, referenced drug regimen reviews were prepared by the clinical pharmacists for 500 individual residents selected by the nursing home staff. The reviews highlighted the potential for: (1) adverse drug effects, (2) ceasing one or more drugs, (3) adding drugs, (4) better use of specific drug therapy, particularly psychoactive drugs, (5) nondrug interventions, and (6) adverse effect and drug response monitoring. Initial reports (61% of total) were audited by a geriatrician before dissemination. Reports were placed in each resident's nursing home records, made available to the resident's GP and discussed with nursing staff. Drugs commonly targeted in reviews and education sessions included laxatives, histamine H2-receptor antagonists, allopurinol, quinine, antibacterials, paracetamol, nonsteroidal anti-inflammatory drugs (NSAIDs) and psychoactive drugs
Outcomes	Measured at baseline and 12 months post-intervention: Hospital admissions (not defined) Mortality (survival also assessed at 22 months) Medication-related problems Medication costs (per resident per year based on prescription claims data) Not used for this review: Adverse events (from incident reports) Resident Classification Instrument (RCI)

	Drug use	
Notes	Supported by the Commonwealth Government of Australia under the Pharmaceutical Education Program	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Homes were assigned to intervention or control by being "drawn from a hat"
Allocation concealment (selection bias)	Low risk	Cluster design
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding conducted
Blinding of outcome assessment (detection bias) Subjective outcomes	High risk	No blinding reported
Blinding of outcome assessment (detection bias) Objective outcomes	Low risk	No blinding reported, however outcomes not likely to be influenced by lack of blinding
Incomplete outcome data (attrition bias) Primary outcomes	Unclear risk	Insufficient reporting of attrition/exclusions to permit judgement
Incomplete outcome data (attrition bias) Secondary outcomes	Unclear risk	Insufficient reporting of attrition/exclusions to permit judgement
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	Low risk	Slight imbalance in mortality and hospitalisations at baseline; however this was accounted for in the analysis
Similar baseline characteristics	Low risk	Similar baseline characteristics reported
Reliable primary outcome measure	Low risk	Mortality and Resident Classification Instrument (RCI)
Adequate protection against contamination	Unclear risk	Cluster design. [Attempted to contact author for further information but no response]

Roberts 2001 (*Continued*)

Other bias	High risk	Medication reviews were undertaken for a non-random subsample of 500 residents (total intervention residents 905) selected by nursing staff

Strikwerda 1994

Methods	RCT (randomised by GP) Total study duration: 6 weeks
Participants	196 residents One nursing home Age: mean 84.5 years (59-100) Gender: 25% male Country: Netherlands Date of study: 1993
Interventions	Feedback on GP prescribing from community pharmacist Group A received usual care, group B GPs issued with a medication list used by their patients, group C GPs received a medication list plus feedback from community pharmacist
Outcomes	Medication-related problems Not used for this review: drug use
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information to permit judgement
Allocation concealment (selection bias)	Low risk	Cluster design
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding conducted
Blinding of outcome assessment (detection bias) Subjective outcomes	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (detection bias) Objective outcomes	Unclear risk	Not measured in this study

Strikwerda 1994 (*Continued*)

Incomplete outcome data (attrition bias) Primary outcomes	Unclear risk	Not measured in this study
Incomplete outcome data (attrition bias) Secondary outcomes	Unclear risk	Insufficient information to permit judgement
Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	Unclear risk	No baseline measurements of medication-related problems
Similar baseline characteristics	High risk	Most baseline characteristics similar, however fewer males in group A and fewer medicines per resident in group B
Reliable primary outcome measure	Low risk	Drug use
Adequate protection against contamination	High risk	Randomised by GP, however control and intervention residents resided in the same nursing home
Other bias	Low risk	Appears to be free of other sources of bias

Zermansky 2006

Methods	RCT (randomised by patient) Total study duration: 6 months
Participants	661 (331 intervention, 330 control) care home residents, 65 care homes Setting: Nursing and residential homes for older people Age: Intervention mean 85.3 (IQR 81-90); control mean 84.9 (IQR 80-90) Gender: Intervention 75 (22.7%) male; control 79 (23.9%) male Country: UK Date of study: 2002
Interventions	Medication review by a single pharmacist. A clinical medication review was conducted by the study pharmacist who held a postgraduate qualification in clinical pharmacy within 28 days of randomisation. It comprised a review of the GP clinical record and a consultation with the resident and carer. The pharmacist formulated recommendations with the resident and carer and passed them on a written proforma to the GP for acceptance and implementation. GP acceptance was signified by ticking a box on the proforma. Control patients received usual GP care
Outcomes	Measured at baseline and six months ± three weeks post-randomisation: Hospital admissions (non-elective) Mortality

	Medication-related problems Medicine costs (cost of 28 days of repeat medicines per participant) Not used for this review: Number of changes in medicines per participant Number of medicines per participant Recorded medication reviews Falls SMMSE Barthel index Number of GP consultations
Notes	Funded by The Health Foundation, 90 Long Acre, London WC2 9RA (Registered Charity Number 286967)

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Patients were randomised in randomly sized blocks of 2 to 8 patients using an algorithm written in Visual Basic in Microsoft Access
Allocation concealment (selection bias)	Low risk	Not reported in paper. Allocation was concealed to the research pharmacist and nurse data collector by statistician [Author contacted]
Blinding of participants and personnel (performance bias) All outcomes	High risk	Open design, no blinding attempted
Blinding of outcome assessment (detection bias) Subjective outcomes	High risk	No blinding conducted
Blinding of outcome assessment (detection bias) Objective outcomes	Low risk	No blinding conducted, however outcomes not likely to be influenced by lack of blinding
Incomplete outcome data (attrition bias) Primary outcomes	Low risk	Similar attrition in both groups with similar reasons for dropouts. Described as intention-to-treat by authors
Incomplete outcome data (attrition bias) Secondary outcomes	Low risk	Similar attrition in both groups with similar reasons for dropouts. Described as intention-to-treat by authors

Selective reporting (reporting bias)	Unclear risk	Insufficient information to permit judgement
Similar baseline outcome measurements	Low risk	Similar baseline measurements for hospital admissions and medicine costs
Similar baseline characteristics	Low risk	Similar baseline characteristics reported
Reliable primary outcome measure	Low risk	Number of changes in medication
Adequate protection against contamination	High risk	Randomised by patient therefore contamination possible
Other bias	Unclear risk	Sample size calculation indicated that 1600 residents were required, however, only 661 residents were recruited

Characteristics of ongoing studies *[ordered by study ID]*

Desborough

Trial name or title	Multi-professional clinical medication reviews in care homes for the elderly: study protocol for a randomised controlled trial with cost effectiveness analysis
Methods	Cluster RCT (randomised by care home) Total Study Duration: 12 months
Participants	Residents of 30 care homes for older people (average age >65)
Interventions	Intervention homes will receive a multi-professional medication review at baseline and at 6 months, with follow-up at 12 months. Control homes will receive usual care (support they currently receive from the National Health Service), with data collection at baseline and 12 months
Outcomes	Emergency hospital admissions and Accident and Emergency (A&E) visits (number of admissions in six months per patient) Mortality Potentially inappropriate prescribing (number of drugs which match the STOPP criteria at each data collection point) Medication costs (mean drug costs per patient - net ingredient costs for 28 days) Not used for this review: Number of falls (mean per patient per month) Utilisation of primary care, secondary care and personal social services health professional time (GP, nurse and other)
Starting date	2011
Contact information	

Desborough (*Continued*)

Notes	

DATA AND ANALYSES

This review has no analyses.

ADDITIONAL TABLES

Table 1. Summary of study characteristics

Study,Country, Design	Participants	Intervention	Outcome measures	Duration
Claesson 1998 Sweden Cluster-RCT	1854 residents in 33 nursing homes	Multidisciplinary meetings with physician, pharmacist and nurse(s)	Medication-related problems	14 months
Crotty 2004a Australia Cluster-RCT	154 residents in 10 nursing homes	Multidisciplinary case conferencing with GP, a geriatrician, a pharmacist, residential care staff and an Alzheimer's Association representative	Medication Appropriateness Index	3 months
Crotty 2004b Australia Patient-RCT	110 patients discharged to 85 long-term care facilities	Pharmacist transition co-ordinator. Transfer of medicines information to nursing staff, family physician and community pharmacist plus medication review and case conferencing	Adverse drug events Hospital admissions Medication-related problems Medication Appropriateness Index	8 weeks
Furniss 2000 UK Cluster-RCT	330 residents in 14 nursing homes	Medication review by a single pharmacist	Hospital admissions Mortality Medication-related problems Medicine costs	8 months
Gurwitz 2008 USA/Canada Cluster-RCT	1118 residents in 29 units in 2 long-term care facilities	Computerised provider order entry with clinical decision support	Adverse drug events	12 months
Roberts 2001 Australia Cluster-RCT	3230 residents in 52 nursing homes	Introduction of new professional role, nurse education and medication review by pharmacists	Hospital admissions Mortality Medication-related problems Medicine costs	24 months
Strikwerda 1994 Netherlands Cluster-RCT	196 residents in 1 nursing home	Feedback on GP prescribing from community pharmacist	Medication-related problems	6 weeks

Table 1. Summary of study characteristics (*Continued*)

Zermansky 2006 UK Patient-RCT	661 residents in 65 care homes	Medication review by a single pharmacist	Hospital admissions Mortality Medication-related problems Medicine costs	6 months

APPENDICES

Appendix 1. Electronic database search strategies

Cochrane Database of Systematic Reviews Issue 11, 2012, Wiley
Search run 16th November 2012
Number of results: 6
#1 MeSH descriptor Polypharmacy, this term only (71)
#2 (polypharm*):ti,ab,kw (158)
#3 (multi-drug* or multidrug*) NEAR/2 (therapy or therapies or prescribing or treatment or regime*):ti,ab,kw (263)
#4 (beer NEAR/2 criter*):ti,ab,kw (9)
#5 (appropriate or optim* or inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excessive or multiple or concurrent*) NEAR/2 (medicine* or medication* or prescription* or drug*):ti,ab,kw (1415)
#6 (over NEAR/1 prescript*) or (overprescrib* or overprescript*):ti,ab,kw (29)
#7 (under NEAR/1 prescript*) or (underprescrib* or underprescript*):ti,ab,kw (6)
#8 "medication appropriateness index":ti,ab,kw (15)
#9 (quality NEAR/1 (prescribing or prescription* or medication*)):ti,ab,kw (30)
#10 (improv* NEAR/1 (prescrib* or prescription* or pharmaco*)):ti,ab,kw (147)
#11 "case conferencing":ti,ab,kw (9)
#12 MeSH descriptor Medication Therapy Management, this term only (18)
#13 "medication* management":ti,ab,kw or "medication* therapy management":ti,ab,kw or "medication* strategy":ti,ab,kw or "medication* strategies":ti,ab,kw or (medication* NEAR/2 review*):ti,ab,kw (408)
#14 "drug regimen review*":ti,ab,kw or (drug NEAR/1 utili?ation NEAR/2 (review* or evaluat*)):ti,ab,kw (126)
#15 MeSH descriptor Drug Utilization Review, this term only (102)
#16 "drug related problem*":ti,ab,kw or (prescription* NEAR/2 pattern*):ti,ab,kw or "Assessing care of vulnerable elders":ti,ab,kw or (acove):ti,ab,kw or (stopp):ti,ab,kw (122)
#17 "start screening tool":ti,ab,kw or "Screening Tool of Older Person's Prescriptions":ti,ab,kw or "Screening Tool to Alert doctors to Right Treatment":ti,ab,kw (0)
#18 MeSH descriptor Medication Errors, this term only (163)
#19 (pharmaceutical* or pharmacist* or prescrib*):ti,ab,kw (11159)
#20 MeSH descriptor Pharmaceutical Preparations, this term only (225)
#21 MeSH descriptor Pharmacists, this term only (325)
#22 MeSH descriptor Pharmacists' Aides, this term only (5)
#23 MeSH descriptor Prescription Drugs, this term only (45)
#24 MeSH descriptor Drug Prescriptions, this term only (402)
#25 MeSH descriptor Pharmaceutical Services, this term only (93)
#26 MeSH descriptor Drug Toxicity, this term only (359)
#27 (pharmacotherap*):ti,ab,kw (6758)
#28 MeSH descriptor Drug Therapy, this term only (425)

#29 MeSH descriptor Drug Monitoring, this term only (907)
#30 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29) (21231)
#31 MeSH descriptor Homes for the Aged, this term only
#32 "home* for the aged":ti,ab,kw or (aged NEAR/2 (care or nursing or healthcare or residential) NEAR/2 (facility or facilities or home*)):ti,ab,kw or (geriatric or elderly) NEAR/2 (facility or facilities or care home*):ti,ab,kw
#33 MeSH descriptor Nursing Homes explode all trees (401)
#34 MeSH descriptor Hospitals, Veterans, this term only (274)
#35 (#31 OR #32 OR #33 OR #34) (1525)
#36 (care or convalescent) NEXT (home or homes or center* or centre* or facility or facilities):ti,ab,kw (2086)
#37 (skilled or intermediate) NEXT (nursing facility or nursing facilities):ti,ab,kw (0)
#38 (resident* NEAR/2 (care or facility or facilities)):ti,ab,kw (466)
#39 (nursing or group or residential) NEXT (home or homes):ti,ab,kw (1763)
#40 (longterm or long term) NEAR/3 (care or facility or facilities):ti,ab,kw (1904)
#41 MeSH descriptor Long-Term Care, this term only (963)
#42 MeSH descriptor Residential Facilities, this term only (116)
#43 (assisted living):ti,ab,kw (437)
#44 MeSH descriptor Halfway Houses, this term only (17)
#45 (#36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44) (5838)
#46 MeSH descriptor Aged explode all trees (499)
#47 MeSH descriptor Geriatrics, this term only (175)
#48 (gerontol* or ageing or aging or elder* or geriatric* or seniors or old age or older or late* life):ti,ab,kw (310000)
#49 (older NEXT (person* or people or adult* or patient* or inpatient* or outpatient*)):ti,ab,kw (5427)
#50 MeSH descriptor Veterans explode all trees (379)
#51 (veteran*):ti,ab,kw (1874)
#52 (#46 OR #47 OR #48 OR #49 OR #50 OR #51) (310561)
#53 (#45 AND #52) (4152)
#54 (#30 AND (#35 OR #53)) (6)

Cochrane Central Register of Controlled Trials (CENTRAL) Issue 11, 2012, Wiley
Search run 16^{th} November 2012
Number of results: 281
#1 MeSH descriptor Polypharmacy, this term only (71)
#2 (polypharm*):ti,ab,kw (158)
#3 (multi-drug* or multidrug*) NEAR/2 (therapy or therapies or prescribing or treatment or regime*):ti,ab,kw (263)
#4 (beer NEAR/2 criter*):ti,ab,kw (9)
#5 (appropriate or optim* or inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excessive or multiple or concurrent*) NEAR/2 (medicine* or medication* or prescription* or drug*):ti,ab,kw (1415)
#6 (over NEAR/1 prescript*) or (overprescrib* or overprescript*):ti,ab,kw (29)
#7 (under NEAR/1 prescript*) or (underprescrib* or underprescript*):ti,ab,kw (6)
#8 "medication appropriateness index":ti,ab,kw (15)
#9 (quality NEAR/1 (prescribing or prescription* or medication*)):ti,ab,kw (30)
#10 (improv* NEAR/1 (prescrib* or prescription* or pharmaco*)):ti,ab,kw (147)
#11 "case conferencing":ti,ab,kw (9)
#12 MeSH descriptor Medication Therapy Management, this term only (18)
#13 "medication* management":ti,ab,kw or "medication* therapy management":ti,ab,kw or "medication* strategy":ti,ab,kw or "medication* strategies":ti,ab,kw or (medication* NEAR/2 review*):ti,ab,kw (408)
#14 "drug regimen review*":ti,ab,kw or (drug NEAR/1 utili?ation NEAR/2 (review* or evaluat*)):ti,ab,kw (126)
#15 MeSH descriptor Drug Utilization Review, this term only (102)
#16 "drug related problem*":ti,ab,kw or (prescription* NEAR/2 pattern*):ti,ab,kw or "Assessing care of vulnerable elders":ti,ab,kw or (acove):ti,ab,kw or (stopp):ti,ab,kw (122)
#17 "start screening tool":ti,ab,kw or "Screening Tool of Older Person's Prescriptions":ti,ab,kw or "Screening Tool to Alert doctors to Right Treatment":ti,ab,kw (0)

#18 MeSH descriptor Medication Errors, this term only (163)
#19 (pharmaceutical* or pharmacist* or prescrib*):ti,ab,kw (11159)
#20 MeSH descriptor Pharmaceutical Preparations, this term only (225)
#21 MeSH descriptor Pharmacists, this term only (325)
#22 MeSH descriptor Pharmacists' Aides, this term only (5)
#23 MeSH descriptor Prescription Drugs, this term only (45)
#24 MeSH descriptor Drug Prescriptions, this term only (402)
#25 MeSH descriptor Pharmaceutical Services, this term only (93)
#26 MeSH descriptor Drug Toxicity, this term only (359)
#27 (pharmacotherap*):ti,ab,kw (6758)
#28 MeSH descriptor Drug Therapy, this term only (425)
#29 MeSH descriptor Drug Monitoring, this term only (907)
#30 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29) (21231)
#31 MeSH descriptor Homes for the Aged, this term only
#32 "home* for the aged":ti,ab,kw or (aged NEAR/2 (care or nursing or healthcare or residential) NEAR/2 (facility or facilities or home*)):ti,ab,kw or (geriatric or elderly) NEAR/2 (facility or facilities or care home*):ti,ab,kw
#33 MeSH descriptor Nursing Homes explode all trees (401)
#34 MeSH descriptor Hospitals, Veterans, this term only (274)
#35 (#31 OR #32 OR #33 OR #34) (1525)
#36 (care or convalescent) NEXT (home or homes or center* or centre* or facility or facilities):ti,ab,kw (2086)
#37 (skilled or intermediate) NEXT (nursing facility or nursing facilities):ti,ab,kw (0)
#38 (resident* NEAR/2 (care or facility or facilities)):ti,ab,kw (466)
#39 (nursing or group or residential) NEXT (home or homes):ti,ab,kw (1763)
#40 (longterm or long term) NEAR/3 (care or facility or facilities):ti,ab,kw (1904)
#41 MeSH descriptor Long-Term Care, this term only (963)
#42 MeSH descriptor Residential Facilities, this term only (116)
#43 (assisted living):ti,ab,kw (437)
#44 MeSH descriptor Halfway Houses, this term only (17)
#45 (#36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44) (5838)
#46 MeSH descriptor Aged explode all trees (499)
#47 MeSH descriptor Geriatrics, this term only (175)
#48 (gerontol* or ageing or aging or elder* or geriatric* or seniors or old age or older or late* life):ti,ab,kw (310000)
#49 (older NEXT (person* or people or adult* or patient* or inpatient* or outpatient*)):ti,ab,kw (5427)
#50 MeSH descriptor Veterans explode all trees (379)
#51 (veteran*):ti,ab,kw (1874)
#52 (#46 OR #47 OR #48 OR #49 OR #50 OR #51) (310561)
#53 (#45 AND #52) (4152)
#54 (#30 AND (#35 OR #53)) (281)

Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE: sensitivity-maximizing version (2008 revision); Ovid format

1 randomized controlled trial.pt.
2 controlled clinical trial.pt.
3 randomized.ab.
4 placebo.ab.
5 drug therapy.fs.
6 randomly.ab.
7 trial.ab.
8 groups.ab.
9 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10 exp animals/ not humans.sh.
11 9 not 10

MEDLINE, 1980-, OvidSP

Search run 16th November 2012 [database last updated November, week 2, 2012]
Number of results: 1381
1 polypharmacy/ (1998)
2 polypharm*.ti,ab. (2606)
3 ((multi-drug* or multidrug*) adj2 (therapy or therapies or prescribing or treatment or regime*).ti,ab. (2285)
4 (beer* adj1 criter*).ti,ab. (187)
5 ((appropriate or optim* or inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excessive or multiple or concurrent*) adj2 (medicine? or medication? or prescription* or drug*)).ti,ab. (16485)
6 ((over adj1 prescript*) or (overprescrib* or overprescript*)).ti,ab. (542)
7 ((under adj prescript*) or (underprescrib* or underprescript*)).ti,ab. (215)
8 medication appropriateness index.ti,ab. (52)
9 (quality adj (prescribing or prescription? or medication?)).ti,ab. (70)
10 (improv* adj (prescrib* or prescription? or pharmaco*)).ti,ab. (1512)
11 case conferencing.ti,ab. (40)
12 medication therapy management/ (445)
13 (medication? management or medication? therapy management or medication? strategy or medication? strategies or (medication? adj2 review*)).ti,ab. (2391)
14 drug regimen review*.ti,ab. (52)
15 drug utilization review/ (2780)
16 (drug adj utili?ation adj2 (review* or evaluat*)).ti,ab. (348)
17 drug related problem?.ti,ab. (702)
18 ((prescribing or prescription?) adj2 pattern?).ti,ab. (2205)
19 Assessing care of vulnerable elders.ti,ab. (43)
20 acove.ti,ab. (30)
21 stopp.ti,ab. (43)
22 start screening tool.ti,ab. (10)
23 Screening Tool of Older Person's Prescriptions.ti,ab. (11)
24 Screening Tool to Alert doctors to Right Treatment.ti,ab. (9)
25 Medication Errors/ (9580)
26 (pharmaceutical? or pharmacist? or prescrib*).ti,ab. (142522)
27 pharmaceutical preparations/ (45187)
28 Pharmacists/ (9723)
29 Pharmacists' Aides/ (489)
30 Prescription Drugs/ (2261)
31 Drug Prescriptions/ (20951)
32 Pharmaceutical Services/ (3895)
33 drug toxicity/ (5710)
34 pharmacotherap*.ti,ab. (18959)
35 drug therapy/ (33168)
36 drug monitoring/ (12728)
37 or/1-36 [Prescribing/medication terms] (279642)
38 Homes for the Aged/ or "homes for the aged".tw. (10633)
39 exp Nursing Homes/ or nursing home?.tw. (30522)
40 (aged adj2 (care or nursing or healthcare or residential) adj2 (facility or facilities or home?)).ti,ab. (268)
41 ((geriatric or elderly) adj2 (facility or facilities or care home?)).ti,ab. (296)
42 Hospitals, Veterans/ (5454)
43 or/38-42 [Care facilities- aged terms] (40335)
44 ((care or convalescent) adj (home? or center? or centre? or facility or facilities)).ti,ab. (26613)
45 ((skilled or intermediate) adj (nursing facility or nursing facilities)).ti,ab. (1272)
46 (resident* adj2 (care or facility or facilities)).ti,ab. (4925)
47 ((nursing or group or residential) adj home?).ti,ab. (20829)
48 Long-Term Care/ (20740)
49 ((longterm or long term) adj3 (care or facility or facilities)).ti,ab. (14906)

50 (healthcare adj2 (facility or facilities)).ti,ab. (1717)
51 Residential Facilities/ (4463)
52 Assisted Living Facilities/ (772)
53 assisted living.ti,ab. (1104)
54 Halfway houses/ (1011)
55 or/44-54 [Other residential care terms] (78047)
56 exp aged/ (2179029)
57 Geriatrics/ (26019)
58 (gerontol* or ageing or aging or elder* or geriatric* or seniors or old age or older or late* life).ti,ab. (466530)
59 (older adj (person* or people or adult* or patient* or inpatient* or outpatient*)).ti,ab. (63257)
60 veterans/ (8246)
61 veteran*.ti,ab. (18509)
62 or/56-61[Elderly terms] (2404467)
63 randomized controlled trial.pt. (342057)
64 controlled clinical trial.pt. (85675)
65 random*.ti,ab. (586198)
66 drug therapy.fs. (1586933)
67 trial.ab. (253559)
68 groups.ab. (1144975)
69 or/63-68 (3059105)
70 exp animals/ not humans.sh. (3811050)
71 69 not 70 [RCT filter] (2598604)
72 37 [Prescribing/medication terms] and 43 [Care facilities- aged terms] (2126)
73 37 [Prescribing/medication terms] and 55 [Other residential care terms] (4013)
74 73 [Prescribing/medication terms and Other residential care terms] and 62 [Elderly terms] (2258)
75 (72 or 74) and 71 [RCT filter] (1399)
76 limit 75 to yr="1980 -Current" (1381)

EMBASE, 1980- , OvidSP

Search run 16th November 2012 [Database last updated week 45, 2012]

Number of results: 3530

1 polypharmacy/ (5545)
2 polypharm*.ti,ab. (4282)
3 ((multi-drug* or multidrug*) adj2 (therapy or therapies or prescribing or treatment or regime*)).ti,ab. (3512)
4 (beer* adj1 criter*).ti,ab. (338)
5 ((appropriate or optim* or inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excessive or multiple or concurrent* or adverse) adj2 (medicine? or medication? or prescription* or prescrib* or drug*)).ti,ab. (46912)
6 ((over adj1 prescript*) or (over adj1 prescrib*) or (overprescrib* or overprescript*)).ti,ab. (1197)
7 ((under adj prescript*) or (under adj prescrib*) or (underprescrib* or underprescript*)).ti,ab. (488)
8 medication appropriateness index/ or medication appropriateness index.ti,ab. (74)
9 (quality adj (prescribing or prescription? or medication?)).ti,ab. (103)
10 (improv* adj (prescrib* or prescription? or pharmaco*)).ti,ab. (2123)
11 case conferencing.ti,ab. (53)
12 medication therapy management/ (1228)
13 (medication? management or medication? therapy management or drug therapy management or medication? strategy or medication? strategies or (medication? adj2 review*)).ti,ab. (4178)
14 drug regimen review*.ti,ab. (84)
15 (drug adj utili?ation adj2 (review* or evaluat*)).ti,ab. (574)
16 drug utilization/ (15587)
17 ((drug or medication) adj related problem?).ti,ab. (1548)
18 ((prescribing or prescription?) adj2 pattern?).ti,ab. (3426)
19 Assessing care of vulnerable elders.ti,ab. (50)
20 Assessing care of vulnerable elders.mp. (50)

21 "Assessing Care of Vulnerable Elders"/ (1)
22 acove.ti,ab. (46)
23 stopp.ti,ab. (130)
24 start screening tool.ti,ab. (22)
25 Screening Tool of Older Person's Prescriptions.ti,ab. (25)
26 Screening Tool to Alert doctors to Right Treatment.ti,ab. (21)
27 medication error/ (11089)
28 (pharmaceutical? or pharmacist? or prescrib*).ti,ab. (247238)
29 drug/ (40640)
30 pharmacist/ or pharmacy technician/ (41871)
31 prescription drug/ (2125)
32 prescription/ (98072)
33 pharmacy/ (47765)
34 pharmacotherap*.ti,ab. (30503)
35 exp drug therapy/ (1657001)
36 drug monitoring/ (38809)
37 drug toxicity/ (51048)
38 "drug use"/ (65381)
39 or/1-38 [Prescribing/medication terms] (2094786)
40 home for the aged/ or "home? for the aged".ti,ab. (11978)
41 ((care or convalescent) adj (home? or center? or centre? or facility or facilities)).ti,ab. (36574)
42 public hospital/ (27380)
43 exp Nursing Homes/ (39622)
44 ((skilled or intermediate) adj (nursing facility or nursing facilities*)).ti,ab. (1585)
45 ((aged or geriatric or elderly) adj2 (care home? or facility or facilities or residential)).ti,ab. (1081)
46 or/40-45 [Care facilities -aged terms] (104001)
47 (resident* adj2 (care or facilit*)).ti,ab. (6504)
48 ((nursing or group or residential) adj home*).ti,ab. (27136)
49 long term care/ (83560)
50 ((longterm or long term) adj3 (care or facilit*)).ti,ab. (20505)
51 residential home/ (5457)
52 residential home*.ti,ab. (926)
53 assisted living facility/ (953)
54 assisted living.ti,ab. (1356)
55 (life care cent* or continued care cent* or extended care facilit*).ti,ab. (523)
56 halfway house/ (1240)
57 or/40-55 [Care facilities - general] (200251)
58 exp aged/ (2136072)
59 GERIATRICS/ (34537)
60 (aged or elder* or geriatric* or seniors or old age or older or late* life).ti,ab. (904844)
61 (old* adj (person* or people or adult* or patient* or inpatient* or outpatient*)).ti,ab. (127968)
62 veteran/ (8498)
63 veteran*.ti,ab. (23699)
64 or/58-63 [Elderly terms] (2696684)
65 57 and 64 (70919)
66 clinical trial/ (882811)
67 randomized controlled trial/ (335600)
68 randomization/ (60313)
69 single blind procedure/ (16719)
70 double blind procedure/ (116669)
71 Crossover procedure/ (35906)
72 randomi?ed controlled trial*.ti,ab. (81408)
73 RCT.tw. (10604)

74 random allocation.ti,ab. (1267)
75 randomly allocated.ti,ab. (18323)
76 allocated randomly.ti,ab (1885)
77 (allocated adj2 random).ti,ab. (869)
78 single blind*.ti,ab. (13170)
79 double blind*.ti,ab. (142385)
80 ((treble or triple) adj2 blind*).ti,ab. (388)
81 prospective study/ (220972)
82 or/66-81 (1227757)
83 case study/ or case report.ti,ab. (287404)
84 abstract report/ or letter/ (870000)
85 or/83-84 (1153094)
86 82 not 85 [SIGN RCT filter minus placebo] (1196147)
87. 39 and (46 or 65) and 86 (3579)
88 limit 87 to yr="1980 -Current (3530)

EPOC Group, Specialised Register, Reference Manager

Search run November 2012
Number of results: 565

1		All Non-Indexed	{prescrib*} OR {prescription*} OR {medication* use} OR {drug therapy*} OR {polypharmacy}
2	AND	Title, primary	{improv*} OR {optimi*} OR {rational} OR {irrational} OR {evidence*}
3	OR	Keywords [7]	{prescrib*] AND {practice*}
4	OR	Keywords [7]	{prescrib*} AND {improv*}
5	OR	Keywords [7]	{prescrib*} AND {compliance*}
6	OR	Abstract [25]	{rational} AND {prescrib*}
7	OR	Abstract [25]	{irrational} AND {prescrib*}
8	OR	Abstract [25]	{improv* prescrib*} OR {optim*prescrib*} OR {rational prescrib*} OR {irrational prescrib*} OR {reduc*overprescrib*}
9	OR	Abstract [25]	{reduc*} AND {medication*use*}
10	OR	Title, primary	{improv*} AND {medicine*}
11	OR	All Non-Indexed	unnecessary prescrib*
12	OR	Abstract [25]	{polypharmacy*} AND {reduc*}
13	OR	Keywords [7]	{prescrib*} AND {adher*}
14	OR	Keywords [7]	medication adherence*

OR ALL Non-Indexed fields : ACOVE or STARTT found one more citation; total 565 -

Ageline,1966-, EBSCO

Search run November 2012
Number of results: 186

S1 TI (prescribing or polypharm* or pharmacist*) or SU (prescribing or polypharm*)
S2 TX (appropriat* w2 prescrib*) OR (inappropriat* w2 prescrib*) or (optim* w2 prescrib*) or (suboptim* w2 prescrib*) or (sub-optim* w2 prescrib*) or (unnecessary n2 medicat*) or (unnecessary n2 prescrib*) or TX medication* w2 appropriat* or (appropriat* w2 medicat*) OR (inappropriat* w2 medicat*) or (optim* w2 medicat*) or (suboptim* w2 medicat*) or (sub-optim* w2 medicat*) or overprescrib* or overmedicat* or "over-medicat*"
S3 TX "Assessing care of vulnerable elders" or TX "Screening Tool of Older Person's Prescriptions" OR TX "Screening Tool to Alert doctors to Right Treatment" OR TX "start screening tool" or "beers criteria" or "beer's criteria"
S4 TX overprescrib* or inappropriat* prescribe*
S5 DE "Nursing Homes" OR TX "nursing home" or TX "nursing homes"

S6 TX (care w2 home* OR care w2 facility or care w2 facilities) or TX (”homes for the aged“ or ”old age home*“) or TX (”geriatric homes“)
S7 TX nursing w2 home*
S8 S5 or S6 or S7
S9 (drug w1 therap*) or (drug w2 utili*)
S10 SU (prescription or prescriptions or pharma*)
S11 DE ”Medication Errors“
S12 SU drug OR SU drugs or SU medication*
S13 TI medication error*
S14 (S9 or S10 or S11 or S12 or S13) AND S8
S15 (S1 or S2 or S3 or S4) and S8
S16 SU (trial or trials) or SU studies or TI (study or trial) or TX (control w3 area or control w3 cohort* or control w3 compar* or control w3 condition* or control w3 group* or control w3 intervention* or control w3 participant* or control* w3 study) or TX (random* OR controlled)
S17 (S14 OR S15) AND S16

CINAHL (Cumulative Index to Nursing and Allied Health Literature), 1980- , EBSCO

Search run 16th November 2012
Number of results: 407

S1 MH polypharmacy (1,327)
S2 TI polypharmacy or AB polypharmacy (784)
S3 TI beer* n1 criter* or AB beer* n1 criter* (113)
S4 TI (appropriate N2 medici* or optim* N2 medici* or inappropriat* N2 medici* or suboptim* N2 medici* or sub-optim* N2 medici* or unnecessary N2 medici*or incorrect* N2 medici* or in-correct* N2 medici*or excess* N2 medici*or multip* N2 medici* or concurrent* N2 medici*) or AB (appropriate N2 medici* or optim* N2 medici* or inappropriat* N2 medici* or suboptim* N2 medici*or sub-optim* N2 medici* or unnecessary N2 medici*or incorrect* N2 medici* or in-correct* N2 medici*or excess* N2 medici*or multip* N2 medici* or concurrent* N2 medici*) or TI (appropriate N2 medicat* or optim* N2 medicat* or inappropriat* N2 medicat* or suboptim* N2 medicat* or sub-optim* N2 medicat* or unnecessary N2 medicat* or incorrect* N2 medicat* or in-correct* N2 medicat* or excess* N2 medicat* or multip* N2 medicat* or concurrent* N2 medicat*) or AB (appropriate N2 medicat* or optim* N2 medicat* or inappropriat* N2 medicat* or suboptim* N2 medicat* or sub-optim* N2 medicat* or unnecessary N2 medicat* or incorrect* N2 medicat* or in-correct* N2 medicat* or excess* N2 medicat* or multip* N2 medicat* or concurrent* N2 medicat*) or TI (appropriate N2 prescription* or optim* N2 prescription* or inappropriat* N2 prescription* or suboptim* N2 prescription* or sub-optim* N2 prescription* or unnecessary N2 prescription* or incorrect* N2 prescription* or in-correct* N2 prescription* or excess* N2 prescription* or multip* N2 prescription* or concurrent* N2 prescription*) or AB (appropriate N2 prescription* or optim* N2 prescription* or inappropriat* N2 prescription* or suboptim* N2 prescription* or sub-optim* N2 prescription* or unnecessary N2 prescription* or incorrect* N2 prescription* or in-correct* N2 prescription* or excess* N2 prescription* or multip* N2 prescription* or concurrent* N2 prescription*) or TI (appropriate N2 drug* or optim* N2 drug* or inappropriat* N2 drug* or suboptim* N2 drug* or sub-optim* N2 drug* or unnecessary N2 drug* or incorrect* N2 drug* or in-correct* N2 drug* or excess* N2 drug* or multip* N2 drug* or concurrent* N2 drug*) or AB (inappropriat* N2 drug* or suboptim* N2 drug* or sub-optim* N2 drug* or unnecessary N2 drug* or incorrect* N2 drug* or in-correct* N2 drug* or excess* N2 drug* or multip* N2 drug* or concurrent* N2 drug*) (2,747)
S5 TI (over n2 prescript* or overprescrib* or overprescript*) or AB (over n2 prescript* or overprescrib* or overprescript*) (369)
S6 TI (”under prescript*“ or underprescrib* or underprescript*) or AB (”under prescript*“ or underprescrib* or underprescript*) (55)
S7 TI ”medication appropriateness index*“ or AB ”medication appropriateness index*“ (19)
S8 TI (quality n2 prescription* or quality n2 medication*) or AB (quality n2 prescription* or quality n2 medication*) (234)
S9 TI (improv* n2 prescription* or improv* n2 pharmaco*) or AB (improv* n2 prescription* or improv* n2 pharmaco*) (458)
S10 TI ”Assessing care of vulnerable elders“ or AB ”Assessing care of vulnerable elders“ (31)
S11 TI acove or AB acove (20)

S12 TI (multi-drug* N3 therap* or multi-drug* N3 treatment or multi-drug* N3 regime*) or AB (multi-drug* N3 therap* or multi-drug* N3 treatment or multi-drug* N3 regime*) or TI (multidrug* N3 therap* or multidrug* N3 treatment or multidrug* N3 regime*) or AB (multidrug* N3 therap* or multidrug* N3 treatment or multidrug* N3 regime*) (236)
S13 MH Medication Errors (7,779)
S14 TI (pharmaceutical* or prescribing) or AB (pharmaceutical* or prescribing) (13,361)
S15 MH Pharmacists (4,050)
S16 (MH "Pharmacy Technicians") (175)
S17 (MH "Drugs, Prescription") (9,130)
S18 (MH "Prescriptions, Drug") (3,631)
S19 (MH "Pharmacy Service") or (MH "Pharmaceutical Care") (2,408)
S20 TI pharmacist* or AB pharmacist* (4,235)
S21 (MH "Medication Management (Iowa NIC)") OR (MH "Medication Managements (Iowa NIC) (Non-Cinahl)") (2)
S22 MH drug toxicity (2,766)
S23 TI (stopp or start screening tool) or AB (stopp or start screening tool) (18)
S24 TI "Screening Tool of Older Person's Prescriptions" or AB "Screening Tool of Older Person's Prescriptions" (0)
S25 TI "Screening Tool to Alert doctors to Right Treatment" or AB "Screening Tool to Alert doctors to Right Treatment" (2)
S26 TI medication* N2 management or AB medication* N2 management or TI medication N2 review* or AB medication N2 review* or TI medication* N2 strateg* or AB medication* N2 strateg* (1,888)
S27 TI pharmacotherap* or AB pharmacotherap* (3,118)
S28 (MH "Drug Therapy") (4,741)
S29 (MH "Drug Utilization") (3,385)
S30 TI "drug utili*ation" N2 review* or AB "drug utili*ation" N2 review* or TI "drug utili*ation" N2 evaluat* or AB "drug utili*ation" N2 evaluat* (64)
S31 MH drug monitoring (3,216)
S32 TI "drug regimen review*" or AB "drug regimen review*" (11)
S33 "case conferencing" (18)
S34 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30 or S31 or S32 or S33 (54,600)
S35 TI "homes for the aged" or AB "homes for the aged" or MH Housing for the elderly (1,713)
S36 TI (care W1 home*) or AB (care W1 home*) or TI (care W1 center*) or AB (care W1 center*) or TI (care W1 centre*) or AB (care W1 centre*) or TI (care W1 facilit*) or AB (care W1 facilit*) or TI (convalescent W1 home*) or AB (convalescent W1 home*) or TI (convalescent W1 center*) or AB (convalescent W1 center*) or TI (convalescent W1 centre*) or AB (convalescent W1 centre*) or TI (convalescent W1 facilit*) or AB (convalescent W1 facilit*) (13,654)
S37 (MH "Hospitals, Veterans") (2,768)
S38 MH Nursing Homes+ or MW Nursing Home (30,352)
S39 TI skilled W1 "nursing facilit*" or AB skilled W1 "nursing facilit*" or TI intermediate W1 "nursing facilit*" or AB intermediate W1 "nursing facilit*" (788)
S40 TI aged N2 "care facilit*" or AB aged N2 "care facilit*" or TI aged N2 "care home*" or AB "aged care home*" or TI aged N2 "nursing facilit*" or AB aged N2 "nursing facilit*" or TI "aged nursing home*" or AB "aged nursing home*" or TI aged N1 "healthcare facilit*" or AB aged N1 "healthcare facilit*" (374)
S41 TI resident* N2 care or AB resident* N2 care or TI resident* N2 facilit* or AB resident* N2 facilit* (4,317)
S42 TI (nursing N1 home* or group N1 home* or residential N1 home*) or AB (nursing N1 home* or group N1 home* or residential N1 home*) (14,133)
S43 TI aged N2 "residential facilit*" or AB aged N2 "residential facilit*" or TI "aged residential home*" or AB "aged residential home*" or Ti geriatric N2 facilit* or AB geriatric N2 facilit* or TI geriatric* N1 "care home*" or AB geriatric* N1 "care home*" or TI elderly N2 facilit* or AB "elderly facilit*" or Ti elderly N2 "care home*" or AB elderly N2 "care home*" (188)
S44 TI (longterm N3 care or longterm N3 facilit*) or AB (longterm N3 care or longterm N3 facilit*) or TI (long-term N3 care or long-term N3 facilit*) or AB (long-term N3 care or long-term N3 facilit*) (9,794)
S45 MH Residential Facilities or MH Long Term Care (17,180)
S46 "residential home*" or healthcare N2 facilit* (1,263)
S47 MH Assisted Living (1,674)
S48 TI "Assisted Living" or AB "Assisted Living" (1,179)

S49 TI ("life care cent*" or "continued care cent*" or "extended care facilit*") or AB ("life care cent*" or "continued care cent*" or "extended care facilit*") (143)
S50 (MH "Halfway Houses") (91)
S51 S36 or S39 or S41 or S42 or S44 or S45 or S46 or S47 or S48 or S49 or S50 (45,450)
S52 (MH "Aged+") (296,100)
S53 MH Geriatrics (2,120)
S54 TI (ageing or aging or gerontol* or elder* or geriatric* or seniors or "old age" or "late* life") or AB (ageing or aging or gerontol* or elder* or geriatric* or seniors or "old age" or "late* life") (70,753)
S55 TI (old* N1 person* or old N1 people or old N1 adult* or old N1 patient* or old N1 inpatient* or old N1 outpatient*) or AB (old* N1 person* or old N1 people or old N1 adult* or old N1 patient* or old N1 inpatient* or old N1 outpatient*) (6,592)
S56 MH veterans (5,462)
S57 TI veterans or AB veterans (5,981)
S58 (S35 or S37 or S38 or S40 or S43) (34,427)
S59 S52 or S53 or S54 or S55 or S56 or S57 (323,035)
S60 S51 and S59 (21,251)
S61 S58 or S60 (45,614)
S62 (MH "Clinical Trials") (76,194)
S63 PT clinical trial (51,892)
S64 TX clinic* n1 trial* (109,676)
S65 TX ((singl* n1 blind*) or (singl* n1 mask*)) or TX ((doubl* n1 blind*) or (doubl* n1 mask*)) or TX ((tripl* n1 blind*) or (tripl* n1 mask*)) or TX ((trebl* n1 blind*) or (trebl* n1 mask*)) (541,676)
S66 TX "randomi* control* trial*" (33,534)
S67 MH Random Assignment (28,601)
S68 TX "random* allocat*" (2,249)
S69 MH Quantitative Studies (8,242)
S70 TX "allocat* random*" (111)
S71 S62 or S63 or S64 or S65 or S66 or S67 or S68 or S69 or S70 (647,032)
S72 S34 and S61 and S71 (407)

International Pharmaceutical Abstracts, 1980-, OvidSP

Search run 16th November 2012
Number of results: 703

1 polypharm*.ti,ab,hw. (810)
2 (beer* adj1 criter*).ti,ab,hw. (108)
3 ((appropriate or optim* or adverse or inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excess* or multip* or concurrent*) adj2 (medicine? or medication? or prescription* or drug*)).ti,ab,hw. (25362)
4 ((over adj1 prescript*) or (overprescrib* or overprescript*)).ti,ab,hw. (17859)
5 ((under adj1 prescript*) or (underprescrib* or underprescript*)).ti,ab,hw. (17835)
6 medication appropriateness index*.ti,ab,hw. (34)
7 (quality adj1 (prescription* or medication*)).ti,ab,hw. (237)
8 (improv* adj1 (prescription* or pharmaco*)).ti,ab,hw. (339)
9 prescrib*.ti,ab,hw. (17663)
10 Assessing care of vulnerable elders.ti,ab. (2)
11 acove.ti,ab. (0)
12 ((multi-drug* or multidrug*) adj2 (therapy or therapies or treatment or regime*)).ti,ab,hw. (217)
13 Medication Error?.ti,ab,hw. (3154)
14 pharmaceutical*1.ti,ab. (32258)
15 pharmacist*.ti,ab,hw. (47739)
16 (pharmacy adj (technician? or aide?)).ti,ab,hw. (1661)
17 (Prescription adj2 drug?).ti,ab,hw. (4857)

18 Drug distribution system?.ti,ab,hw. (1890)
19 (medication? management or medication? therapy management or medication? strategy or medication? strategies or (medication? adj2 review?)).ti,ab,hw. (1868)
20 drug toxicity.ti,ab,hw. (456)
21 Screening Tool of Older Person's Prescriptions.ti,ab. (3)
22 Screening Tool to Alert doctors to Right Treatment.ti,ab. (6)
23 (pharmaceutical adj (preparation? or care)).ti,ab,hw. (7739)
24 pharmacotherap*.ti,ab,hw. (3820)
25 drug therap*.ti,ab,hw. (8197)
26 (drug adj utili?ation adj2 (review* or evaluat*)).ti,ab,hw. (4848)
27 drug monitoring.ti,ab,hw. (1813)
28 drug regimen review*.ti,ab,hw. (194)
29 case conferencing.ti,ab,hw. (0)
30 or/1-29 [Prescribing/medication terms] (122563)
31 Home? for the Aged.ti,ab,hw. (13)
32 (aged adj2 (care or nursing or healthcare or residential) adj2 (facility or facilities or home?)).ti,ab,hw. (30)
33 ((geriatric or elderly) adj2 (facility or facilities or care home?)).ti,ab,hw. (44)
34 or/31-33 [Aged care homes] (82)
35 ((skilled or intermediate) adj nursing facilit*).ti,ab,hw. (207)
36 (resident* adj2 (care or facilit*)).ti,ab. (371)
37 ((nursing or group or residential) adj home?).ti,ab. (1296)
38 ((longterm or long term) adj3 (care or facilit*)).ti,ab. (1407)
39 residential home?.ti,ab,hw. (52)
40 assisted living.ti,ab,hw. (101)
41 (life care cent* or continued care cent* or extended care facilit*).ti,ab,hw. (64)
42 Halfway house*.ti,ab. (3)
43 or/31-40 [Other residential care] (2911)
44 (ageing or aging or gerontol* or elder* or geriatric* or seniors or old age or late? life).ti,ab,hw. (13967)
45 (old* adj (person* or people or adult* or patient* or inpatient* or outpatient*)).ti,ab. (3200)
46 veteran*.ti,ab. (1377)
47 or/44-46 [Elderly terms] (17017)
48 43 and 47 (1089)
49 30 and (34 or 48) (720)
50 limit 49 to yr="1980 -Current" (703)

PsycINFO, 1980-, OvidSP
Search run 19th November 2012 [Database last updated November, week 2, 2012]
Number of results: 905

1 Polypharmacy/ (639)
2 polypharm*.ti,ab. (1043)
3 (beer* adj1 criter*).ti,ab. (57)
4 ((appropriate or optim* or adverse or inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excess* or multip* or concurrent*) adj2 (medicine? or medication? or prescription* or drug*)).ti,ab. (3911)
5 ((over adj1 prescript*) or (overprescrib* or overprescript*)).ti,ab. (136)
6 ((under adj1 prescript*) or (underprescrib* or underprescript*)).ti,ab. (35)
7 medication appropriateness index*.ti,ab. (14)
8 (quality adj1 (prescription* or medication*)).ti,ab. (39)
9 (improv* adj1 (prescription* or pharmaco*)).ti,ab. (94)
10 (drug related problem? or (prescription adj2 pattern?)).ti,ab. (509)
11 Assessing care of vulnerable elders.ti,ab. (37)
12 acove.ti,ab. (25)

13 ((multi-drug* or multidrug*) adj2 (therapy or therapies or treatment or regime*)).ti,ab. (57)
14 Medication Errors.ti,ab. (259)
15 (pharmaceutical? or pharmacist? or prescrib*).ti,ab. (23625)
16 Pharmacists/ (721)
17 (pharmacy adj (technician? or aide?)).ti,ab. (14)
18 Prescription Drugs/ (2137)
19 drug therapy/ (97624)
20 "Prescribing (Drugs)"/ (2486)
21 medication? related problem?.ti,ab. (35)
22 stopp.ti,ab. (12)
23 (medication? management or medication? therapy management or medication strategy or medication? strategies or (medication adj2 review?)).ti,ab. (1031)
24 Toxicity/ (2181)
25 start screening tool.ti,ab. (3)
26 Screening Tool of Older Person's Prescriptions.ti,ab. (4)
27 Screening Tool to Alert doctors to Right Treatment.ti,ab. (3)
28 (medication adj2 (management or review*)).ti,ab. (1136)
29 pharmacotherap*.ti,ab. (9354)
30 ((drug adj utili?ation adj2 (review* or evaluat*)) or drug related problem?).ti,ab. (353)
31 Monitoring/ (4623)
32 drug regimen review*.ti,ab. (3)
33 case conferencing.ti,ab. (22)
34 or/1-33 [Medication or prescribing terms] (126093)
35 Treatment Facilities/ (947)
36 Homes for the Aged.ti,ab. (168)
37 (aged adj2 (care or nursing or healthcare or residential) adj2 (facility or facilities or care home?)).ti,ab. (192)
38 ((geriatric or elderly) adj2 (facility or facilities or care home?)).ti,ab. (121)
39 exp Nursing Homes/ (6128)
40 or/36-39 [Aged care facilities tems] (6489)
41 ((care or convalescent) adj (home? or center? or centre*? or facility or facilities)).ti,ab. (6787)
42 ((skilled or intermediate) adj nursing facilit*).ti,ab. (292)
43 (resident* adj2 (care or facilit*)).ti,ab. (4850
44 ((nursing or group or residential) adj home*).ti,ab. (9558)
45 Long Term Care/ (2840)
46 ((longterm or long term) adj3 (care or facilit*)).ti,ab. (5467)
47 Residential Care Institutions/ (7893)
48 residential home*.ti,ab. (376)
49 Assisted Living/ (457)
50 assisted living.ti,ab. (675)
51 (life care cent* or continued care cent* or extended care facilit*).ti,ab. (56)
52 Halfway Houses/ (271)
53 or/41-52 [Other care homes] (28264)
54 exp Aging/ (33115)
55 Geriatrics/ (6190)
56 Geriatric Patients/ (10088)
57 Gerontology/6870
58 (gerontol* or ageing or aging or elder* or geriatric* or seniors or "old age" or older or late* life).ti,ab. (157409)
59 (old* adj (person* or people or adult* or patient* or inpatient* or outpatient*)).ti,ab. (41520)
60 veteran*.ti,ab. (11445)
61 or/54-60 [Aged terms] (176363)
62 53 and 61 (9117)
63 34 and (40 or 62) (921)
64 limit 63 to yr="1980 -Current" (905)

Web of Science, Conference Proceedings Citation Index- Science, 1990-, (ISI Web of Knowledge)

Search run 16th November 2012
Number of results: 50

#1 Topic=(polypharm* or (beer* SAME criter*)) OR Topic=(((((inappropriat* or suboptim* or sub-optim* or unnecessary or incorrect* or in-correct* or excess* or multip* or concurrent*) SAME (medici* or medicat* or prescrib* or prescription* or drug*)))) OR Topic=(((((over SAME (prescrib* or prescript*)) or (overprescrib* or overprescript*)))) OR Topic=(((((under SAME (prescrib* or prescript*)) or (underprescrib* or underprescript*)))) OR Topic=((medication appropriateness index*)) OR Topic=(((quality SAME (prescribing or prescription* or medication*)))) OR Topic=(((improv* SAME (prescrib* or prescription* or pharmaco*)))) OR Topic=((prescrib* SAME cascade*)) (19750)
#2 Topic=(Assessing care of vulnerable elders) OR Topic=(acove) OR Topic=((multi-drug* or multi drug or multidrug*)) OR Topic=(Medication Errors) OR Topic=(pharmaceutical preparations) OR Topic=((pharmaceutical or pharmaceuticals)) OR Topic=((pharmacist* or pharmacy technician*)) OR Topic=(Prescription Drugs or Drug Prescriptions) OR Topic=(medication therapy management) OR Topic=(drug toxicity) OR Topic=(stopp start) OR Topic=(Screening Tool of Older Person's Prescriptions) OR Topic=(Screening Tool to Alert doctors to Right Treatment) OR Topic=((medication SAME (management or review*))) OR Topic=((pharmacotherap*)) OR Topic=(drug therapy) OR Topic=((drug utili?ation SAME (review* or evaluat*))) OR Topic=(drug monitoring) OR Topic=(drug regimen review*) OR Topic=(case conferencing) (31664)
#3 #2 OR #1 (46729)
#4 TS=("homes for the aged") OR TS=(("care home" or "convalescent home" or "care center*" or "convalescent center*" or "care centre*" or "convalescent center*" or "care facilit*" or "convalescent facilit*")) OR TS=(("nursing home*" or "group home*" or "residential home*")) OR TS=(("skilled nursing facilit*" or "intermediate nursing facilit*")) OR TS=("aged care facilit*") OR TS=(resident* SAME (care or facilit*)) OR TS=(((longterm or long term or long-term) SAME (care or facilit*))) OR TS=("assisted living") OR TS=(("life care cent*" or "continued care cent*" or "extended care facilit*")) OR TS=(Halfway houses) (13434)
#5 TS=((aged or elder* or geriatric* or seniors or "old age" or older or "late* life")) OR TS=(("old* person*" or "old* people" or "old* adult*" or "old* patient*" or "old* inpatient*" or "old* outpatient*")) OR TS=("veteran*") (68647)
#6 TS=(random* or RCT*) (152549)
#7 #6 AND #5 AND #4 AND #3 Databases=CPCI-S, CPCI-SSH Timespan=1990-01-01 - 2012-11-28 Lemmatization=Off (50)

Appendix 2. Google scholar search strategy

Searched 16th November 2012
Number of results: 59
(prescription* or prescribing or drug* or medicine* or medication* or pharma* or polypharmacy) and (residential or care home* or care facilit* or nursing home*) and (elder* or aged* or old* or seniors or geriatric* or gerontol*) Books excluded. No date limit.

Appendix 3. WHO trial registry search strategy

Search run 26th November 2012 [Database last updated 26th November 2012]
Number of results: 2
Each term 1 was searched with each possible combination of the other terms (2-4). Terms were combined using AND

Term 1	Term 2	Term 3	Term 4
Randomised	Nursing homes	elderly	drugs
Randomized	Residential homes	old	medication
RCT			pharmacy
Randomly			polypharmacy

CONTRIBUTIONS OF AUTHORS

David Alldred conceived and co-ordinated the review and is the guarantor of the review. David Alldred prepared the protocol with support and advice from Carmel Hughes, Nick Barber, David Raynor, Pat Spoor and Tim Chen. Pat Spoor designed the search strategy with input from David Alldred and ran the searches. All authors were involved in the retrieval of papers. David Alldred and David Raynor screened the search results, assessed retrieved papers against the eligibility criteria, appraised the quality of the papers and extracted data from the papers. David Alldred was responsible for entering data into RevMan and drafting the review with input from all authors.

DECLARATIONS OF INTEREST

David Alldred and David Raynor are co-authors on a study that was included in this review (Zermansky 2006).

SOURCES OF SUPPORT

Internal sources

- School of Healthcare, University of Leeds, UK.

Funding was provided for the services of Ms Pat Spoor to develop the search strategy and run the searches.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We intended to pool results and conduct meta-analyses if studies were homogeneous. However, as studies were heterogeneous, this was not undertaken. Similarly, subgroup analyses were not possible.

INDEX TERMS

Medical Subject Headings (MeSH)

*Homes for the Aged; *Nursing Homes; Drug Prescriptions [*standards]; Inappropriate Prescribing [*prevention & control]; Medication Reconciliation; Quality Improvement [*standards]; Randomized Controlled Trials as Topic

MeSH check words

Aged; Humans