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Infection control strategies for preventing the transmission of meticillin-resistant *Staphylococcus aureus* (MRSA) in nursing homes for older people (Review)

Hughes C, Tunney M, Bradley MC

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[Intervention Review]

Infection control strategies for preventing the transmission of meticillin-resistant *Staphylococcus aureus* (MRSA) in nursing homes for older people

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ABSTRACT

Background

Nursing homes for older people provide an environment likely to promote the acquisition and spread of meticillin-resistant *Staphylococcus aureus* (MRSA), putting residents at increased risk of colonisation and infection. It is recognised that infection prevention and control strategies are important in preventing and controlling MRSA transmission.

Objectives

To determine the effects of infection prevention and control strategies for preventing the transmission of MRSA in nursing homes for older people.

Search methods

In August 2013, for this third update, we searched the Cochrane Wounds Group Specialised Register, the Cochrane Central Register of Controlled Trials (CENTRAL, *The Cochrane Library*), Database of Abstracts of Reviews of Effects (DARE, *The Cochrane Library*), Ovid MEDLINE, OVID MEDLINE (In-process and Other Non-Indexed Citations), Ovid EMBASE, EBSCO CINAHL, Web of Science and the Health Technology Assessment (HTA) website. Research in progress was sought through Current Clinical Trials, Gateway to Reseach, and HSRProj (Health Services Research Projects in Progress).

Selection criteria

All randomised and controlled clinical trials, controlled before and after studies and interrupted time series studies of infection prevention and control interventions in nursing homes for older people were eligible for inclusion.

Data collection and analysis

Two review authors independently reviewed the results of the searches. Another review author appraised identified papers and undertook data extraction which was checked by a second review author.

Main results

For this third update only one study was identified, therefore it was not possible to undertake a meta-analysis. A cluster randomised controlled trial in 32 nursing homes evaluated the effect of an infection control education and training programme on MRSA prevalence. The primary outcome was MRSA prevalence in residents and staff, and a change in infection control audit scores which measured adherence

to infection control standards. At the end of the 12 month study, there was no change in MRSA prevalence between intervention and control sites, while mean infection control audit scores were significantly higher in the intervention homes compared with control homes.

Authors' conclusions

There is a lack of research evaluating the effects on MRSA transmission of infection prevention and control strategies in nursing homes. Rigorous studies should be conducted in nursing homes, involving residents and staff to test interventions that have been specifically designed for this unique environment.

PLAIN LANGUAGE SUMMARY

Infection control strategies for preventing the spread of meticillin-resistant *Staphylococcus aureus* (MRSA) in nursing homes for older people

MRSA is a bacterium that can cause infection in people, particularly those who are in hospital. MRSA is now becoming a problem for older people (residents) who live in nursing homes. Nursing homes are ideal places for MRSA to spread: the residents live close to each other, many have a number of medical conditions and may receive several prescriptions for antibiotics, and some may have pressure sores and medical devices such as catheters. All of these factors increase the risk of residents getting MRSA, and so increase their risk of dying.

Many different ways of preventing the spread of MRSA have been studied, particularly in hospitals; however, we found only one study that looked at whether an infection control education and training programme influenced the spread of MRSA in nursing homes for older people. This study showed there was no difference between the group that was involved in the programme and the comparison group which continued with their normal practice.

Although there is some evidence for techniques that work well to prevent the spread of MRSA in hospital, it is not clear if these approaches will work in nursing homes for older people. Further research is needed to establish what will work in nursing homes.

BACKGROUND

Meticillin- (the International Non-proprietary Name, and British Approved Name) or methicillin- (the United States Approved Name) resistant *Staphylococcus aureus* (MRSA) has been recognised since the 1980s as a major nosocomial (hospital-acquired) pathogen that has caused problems in hospitals and other health care institutions worldwide (Simor 2001). Transmission from colonised (presence and multiplication of organisms without tissue invasion), or infected (invasion of body tissues by pathogenic and opportunistic organisms with clinical signs of infection present) patients to others occurs mainly via the hands of healthcare personnel (Herwaldt 1999). Risk factors for colonisation and infection include advanced age, transfer between hospitals and nursing homes, extended length of stay in a healthcare facility, presence of a central venous or arterial catheter, tube feeding and anti-infective therapy (notably cephalosporins and fluoroquinolones; Graffunder 2002; Safdar 2002). The resistance of the bacterium to first-line antibiotics, such as penicillins, makes infection with MRSA difficult to treat, and it can represent a particular risk to immunocompromised patients. A review of death certificates in England and Wales revealed that, of those that mentioned Staphylococcal infection as the underlying cause of death, the proportion mentioning MRSA fell by 20% from 364 in 2011 to 292 in 2012, although In the period 2008–12, MRSA death rates increased with age and were higher for males than for females (Health Stats 2013). A meta-analysis has indicated that the mortality of patients with an invasive MRSA infection is twice that of patients with meticillin-susceptible *S. aureus* (MSSA) infection (Cosgrove 2003).

Since many hospitals report high MRSA colonisation rates among elderly patients (Hoefnagels 2002), and because it has been shown that *S. aureus* colonisation increases with advancing age (Bradley 1997; O'Sullivan 2000), there are concerns about the introduction of MRSA into nursing homes by MRSA-positive patients discharged from hospital. Once introduced, the subsequent spread of MRSA between patients would create a reservoir of MRSA within a nursing home (Mendelson 2003), providing the potential for an outbreak and further hospital outbreaks when affected nursing home residents require hospital treatment (Fraise 1997). Nursing homes provide an ideal environment for the acquisition and spread of MRSA, since residents have an increased risk of colonisation due to chronic illness and debilitation, multiple exposures to antimicrobial agents, and the presence of pressure ulcers and indwelling devices (Hsu 1991; Muder 1997; Rubin 1999; Strausbaugh 1996). MRSA colonisation is also a marker of mortality risk amongst nursing home residents (Muder 1997; Mulhausen 1996; Niclaes 1999).

It is likely that the prevalence of MRSA within nursing homes is increasing as a result of the increased prevalence of MRSA within hospitals (Trick 2001), which may have been compounded by the considerable movement of patients from long-stay hospitals to community-based nursing homes. A 1994 study in Birmingham reported a prevalence of 17% amongst 191 residents in 10 nursing homes (Fraise 1997). Interestingly, phage-typing of the strains revealed similarities with those circulating in Birmingham hospitals, suggesting direct transfer from hospital to nursing home. A 1999 study in Northamptonshire reported a prevalence of 4.7% amongst 275 residents in 17 nursing homes, with six of the 17 homes having colonised residents (Cox 1999). Similar studies in other countries have reported MRSA prevalence rates in nursing homes ranging from 1.1% in Germany (von Baum 2002), to 4.9% in Belgium (Hoefnagels 2002), 6.2% in Israel (Mendelson 2003), 8.6% in Ireland (O'Sullivan 2000) and 22.7% in the USA (Terpenning 1994), though why there is this range is unclear. More recent studies have confirmed continued high MRSA prevalence rates in nursing homes (Baldwin 2009; Smith 2008). Little attention has been given to infection prevention and control in nursing homes with respect to MRSA, unlike the situation in the hospital setting.

There has been much debate about how best to prevent and control the transmission of MRSA. The general consensus is that more appropriate and prudent use of antibiotics would help to address the rise in resistant bacteria (Sclaes 1997). It is also recognised that infection prevention and control procedures have a part to play in preventing and controlling the transmission of MRSA. These procedures can fall into a number of categories, as recommended by a number of guidelines (Coia 2006; Global 1999). These guidelines were developed for all healthcare settings, and are not specific to nursing homes. The recommended categories include:

1. Barriers: i.e. patient isolation, barrier precautions, and screening.
2. Skin: i.e. hand hygiene, skin decontamination, cleansing and antisepsis.
3. Environment: decontamination and disinfection, and the role of the environment and equipment.

Barrier precautions include separation of patients who are known to be colonised, or infected, with MRSA. This may be in a single room, or in a room shared with other patients (patient cohorting) who are also colonised or infected with MRSA. It is also recommended that, where possible, designated staff are confined to caring for patients with MRSA in order to avoid further transmission to non-colonised/infected patients (staff cohorting). Barrier precautions include the use of disposable gloves when touching patients, which should be changed between patients. Gowns and plastic aprons are also recommended to protect skin and clothes from more widespread contamination. There has been some debate about whether it is necessary for staff to use masks and hats (Coia 2006; Global 1999). Screening of staff and patients (via a range of microbiological techniques) is also recommended, particularly in an outbreak situation.

To prevent transmission via skin it is recommended that efforts should be directed towards hand hygiene with antiseptic agents (e.g. alcohol) and water, rather than simply soap and water. Antiseptic agents should be readily available and accessible to all healthcare workers in any setting. In the absence of sufficient or adequate handwashing facilities, an antiseptic product formulated for use without water should be used (e.g. alcohol gels).

Environmental infection prevention and control encompasses environmental hygiene of work areas including work surfaces in healthcare settings, cleanliness of equipment and disposal of items which may have come into contact with colonised/infected patients. Guideline recommend that each healthcare facility should clearly define their cleaning, disinfection and sterilisation procedures, monitor practice to ensure that procedures are applied consistently, and have sufficient staff who are committed to maintaining standards of hygiene (Coia 2006; Global 1999).

In addition, an approach known as 'search and destroy' in relation to MRSA has been applied in some European countries, notably in the Netherlands (Vos 2005; Wertheim 2004) which encompasses early detection, early identification and containment. This combines many of the strategies described above, i.e. screening of staff and patients for MRSA, isolation of patients, temporary removal of colonised staff, and eradication of MRSA usually with topical mupirocin applied to the nose (one of the main sites where MRSA is carried). This rigorous approach is also supported by a restrictive antibiotic prescribing policy within the Netherlands (Wertheim 2004).

Many of the strategies described above have been implemented in the hospital setting and numerous studies conducted to assess their effectiveness. A systematic review evaluated isolation policies in the hospital management of MRSA (Cooper 2003). Despite a number of methodological weaknesses in the studies assessed, there was some evidence that isolation in hospital could reduce MRSA. Whether isolation, or other interventions (e.g. hand washing, use of personal protective equipment such as gloves and aprons), would prove to be effective for preventing MRSA transmission in the nursing home setting is unclear.

This review will focus on older people (whom we have defined as being more than 65 years old), living in nursing homes (defined as facilities which provide nursing and personal care for older people and which also act as a 'home' environment) as they are at greater risk from MRSA. Risk factors known to increase the risk of MRSA colonisation and common amongst older people include: chronic illness and debilitation, multiple exposure to antibiotics, presence of pressure ulcers and indwelling devices. Although some of these factors may apply to younger residents (less than 65 years old), most residents in nursing homes are older than this. Furthermore, epidemiological work has indicated that there is an increased relative risk of dying within six months in nursing home residents who carry MRSA compared to non-carriers (Niclaes 1999).

OBJECTIVES

The objective of this review is to determine the effects of infection control strategies for preventing the transmission of MRSA in nursing homes for older people.

METHODS

Criteria for considering studies for this review

Types of studies

Prospective randomised controlled trials (RCTs), including cluster-randomised trials where the unit of randomisation is the nursing home, or non-randomised controlled clinical trials (CCTs), controlled before-and-after studies (CBAs), and interrupted time-series (ITS) analyses with at least three points before and after the intervention.

A RCT is one in which individuals, or groups of individuals (clusters), are randomised to an intervention or control group. Randomisation ensures that individuals/groups in either intervention or control groups should differ systematically only in their exposure to the treatment.

Non-randomised CCTs are individual or cluster trials where allocation to treatment and control groups is quasi-random (e.g. by alternate allocation).

Controlled before-and-after studies involve a non-randomised control group. Data are collected on the control and intervention groups before the intervention is introduced and then further data are collected after the intervention has been implemented.

Interrupted time-series analyses provide a way of measuring the effect of an intervention when randomisation or identification of a control group is impractical. Multiple data points (usually a minimum of three) are collected before and after the intervention. The intervention effect is measured against the pre-intervention trend.

Types of participants

1. Residents over the age of 65 years, living in nursing homes: this age was chosen as it is the conventional cut-off point for the categorisation of those considered to be 'older'. We accepted trials for inclusion if the majority of participants were over the age of 65 years or the mean age was more than 65 years.
2. Staff of nursing homes: we included all staff that work in nursing homes and may be a potential source of transmission of MRSA.
3. Nursing homes: in the UK context, nursing homes were defined as facilities in which qualified nursing care is available 24 hours a day. This excluded residential homes where qualified nursing care is not provided. In the US context, nursing homes may be termed skilled nursing facilities or long-term care facilities. Other descriptions such as aged-care facilities were considered if they appeared to meet the definitions used in the UK or USA. If there is any ambiguity with the description of the institution, clarification will be sought from the authors of the relevant papers.

Including these three types of participants will allow us to include studies that have considered interventions at the level of the residents/staff and at nursing home level.

Types of interventions

Eligible interventions include:

1. Barrier precautions including screening, individual isolation, patient cohort isolation, nurse cohorting, use of gloves, aprons and face masks.
2. Hand washing including the use of antiseptics with water or hand washing with alcohol gel in the absence of water.
3. Environmental hygiene including cleaning, disinfection and sterilisation procedures.

The interventions (whether singly or in combination) were compared against usual practice (as defined within the selected papers) in the nursing home. Usual practice may include some of the interventions listed above, so a definition of usual care will be sought by reading the paper carefully. If it is unclear, the authors were contacted for clarification.

The use of mupirocin in decolonisation regimes is excluded as this has been covered in a separate review (Loeb 2003). Antibiotic policies - as a means to reduce the incidence of MRSA - are also excluded.

Types of outcome measures

Precise details of the outcome and denominator will be reported. Where such outcomes can be derived from the data supplied in the papers, review authors will record the raw data only.

Primary outcomes

1. MRSA incidence.

Secondary outcomes

1. MRSA prevalence.
2. All-cause mortality.
3. Length of hospital stay.
4. Rates of antibiotic therapy.
5. Quality of life (e.g. effect of isolating residents for prolonged periods of time).

Search methods for identification of studies

Electronic searches

The search methods sections of the second update of this review can be found in Appendix 1

In August 2013, for this third update, we searched the following electronic databases for all relevant studies, regardless of language, date of publication or publication status:

- Cochrane Wounds Group Specialised Register (searched August 21st 2013)
- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2013, Issue 7).
- Ovid MEDLINE (2011 to August 2013).
- OVID MEDLINE (In-process and Other Non-Indexed Citations, August 2013)
- Ovid EMBASE (2011 to 2013 Week 33).
- EBSCO CINAHL (2011 to August 9th 2013).
- DARE (2011 to August 2013), Web of Science (from May 2011 to August 2013)
- Health Technology Assessment (HTA) website (May 2011 to August 2013).

We used the following strategy to search the Cochrane Central Register of Controlled Trials (CENTRAL):

#1 MeSH descriptor: [Staphylococcus aureus] explode all trees 663
#2 staphylococcus next aureus:ti,ab,kw 1680
#3 MeSH descriptor: [Staphylococcal Infections] explode all trees 956
#4 staphylococ* near/2 infect* 1097
#5 MeSH descriptor: [Methicillin Resistance] explode all trees 150
#6 (methicillin or meticillin) near/2 resist*:ti,ab,kw 516
#7 MeSH descriptor: [Penicillin Resistance] explode all trees 375
#8 penicillin near/2 resist*:ti,ab,kw 363
#9 MeSH descriptor: [Methicillin-Resistant Staphylococcus aureus] explode all trees139
#10 (mrsa or emrsa):ti,ab,kw 237
#11 (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10) 2555
#12 MeSH descriptor: [Homes for the Aged] explode all trees 426
#13 MeSH descriptor: [Nursing Homes] explode all trees 905
#14 MeSH descriptor: [Group Homes] explode all trees 41
#15 #13 or #14 946
#16 MeSH descriptor: [Aged] explode all trees 674
#17 ("aged" or "old people" or "older people" or "old person" or "older persons" or (old next resident*) or (older next resident*) or elders or elderly or geriatric):ti,ab,kw 271509
#18 #16 or #17 271509
#19 #15 and #18 867
#20 nursing near/2 (home* or "unit" or "units" or centre* or center* or facility or facilities):ti,ab,kw 2579
#21 group near/2 home*:ti,ab,kw 637
#22 extended next care next facilit*:ti,ab,kw 15
#23 ((long next term) or longterm) next care next facilit*:ti,ab,kw 205
#24 care near/2 (home* or facilit*):ti,ab,kw 4064
#25 rest near/2 home*:ti,ab,kw 29
#26 residential near/2 (home* or "care"):ti,ab,kw 310
#27 (geriatric near/2 (home* or "unit" or "units" or facilit* or institution*)):ti,ab,kw 250
#28 #20 or 21 or #22 or #23 or #24 or #25 or #26 or #27 81145
#29 #18 and #28 37339
#30 #12 or #19 or #29 37391
#31 #11 and #30 165

The search strategies for Ovid MEDLINE, Ovid EMBASE and EBSCO CINAHL can be found in Appendix 2, Appendix 3 and Appendix 4 respectively. The Ovid MEDLINE search was combined with the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE: sensitivity- and precision-maximizing version (2008 revision); Ovid format (Lefebvre 2011). The EMBASE and CINAHL searches were combined with the trial filters developed by the Scottish Intercollegiate Guidelines Network (SIGN 2009).

Research in progress was sought through the following resources (accessed August 2013):

- Current Clinical Trials (http://www.controlled-trials.com/).
- Gateway to Research (http://gtr.rcuk.ac.uk/)
- HSRProj (Health Services Research Projects in Progress) (http://wwwcf.nlm.nih.gov/hsr_project/home_proj.cfm)

Searching other resources

The reference lists of relevant articles were searched. For the original review key researchers in the field of MRSA infection-control were contacted to identify other possibly relevant trials.

Data collection and analysis

Selection of studies

Updated searches of MEDLINE, CENTRAL, the Cochrane Wounds Group Register, EMBASE and CINAHL retrieved 244 unique citations; the original searches using these databases had yielded 301 citations. Similarly, updated searches on Dare, Web of Science, HTA retrieved 43 unique papers while the original searches generated 179 citations. Following removal of all duplicates, two review authors screened the abstracts, titles, and descriptors of all potentially relevant trials in order to identify those that should be included in the full review. Because of the paucity of studies and to ensure that a comprehensive overview was completed, the full text of any study on MRSA (irrespective of study design) conducted in nursing homes for older people was reviewed in the first version of this review, although this activity was not repeated for the updates.

Data extraction and management

One independent review author extracted data as two of the review authors had been investigators on the included study, the fourth review author checked the data. Using a template, the following information was extracted: study design, type of intervention or interventions (carefully extracting as many details as possible about the nature of the intervention, presence of controls, participants, setting, methods, unit of allocation, unit of analysis, study power, risk of bias criteria), outcomes and results.

Assessment of risk of bias in included studies

The risk of bias was assessed by one review author and checked by a second, without blinding to journal or authorship, and reported in the "Risk of bias" tables.

The Cochrane Collaboration's tool for assessing risk of bias (Higgins 2011) was employed: 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. Three additional criteria, specified by EPOC (EPOC 2009), were used: similar baseline characteristics; reliable primary outcome measures; and adequate protection against contamination.

In future updates of this review, the following types of studies, if identified, will be assessed as described below:

1. For CBA studies, the quality criteria to be assessed are:
2. Baseline measurement (outcomes are measured prior to the intervention and no substantial differences are present across study groups).
3. Characteristics for studies using second site as control.
4. Reliable primary outcome measure(s) (see above).
5. Blinded assessment of primary outcomes (protection against detection bias).
6. Follow up of professionals (see above).
7. Follow up of patients (see above); and
8. Protection against contamination (see above).

For ITS studies, the quality criteria to be assessed are:

1. Protection against secular trends (judged to have been achieved if the intervention occurred independently of other changes over time).
2. Data were analysed appropriately (ARIMA models or time series regression models used to analyse data and serial correlation adjusted/tested for).
3. Reason for the number of points pre- and post-intervention given (usually require a minimum of three points each for pre- and post-intervention).
4. Shape of the intervention effect was specified (rational explanation for the shape of the intervention effect been provided).
5. Protection against detection bias (judged to have been achieved if it is reported that the intervention itself was unlikely to affect data collection e.g. sources and methods of data collection were the same before and after the intervention).
6. Completeness of data set (data set covers 80-100% of total number of participants or episodes of care in the study); and
7. Reliable primary outcome measures(s) (see above).

Assessments for inclusion will be done independently by two review authors. Review authors will not be blinded to study author and source institution. If disagreements arise, they will be resolved by consensus or third party involvement.

Unit of analysis issues

In the event of the review identifying studies with unit of analysis errors (e.g. randomisation by home with analysis by patients without adjustment for clustering), the results of these studies were to be presented as point estimates of the intervention effect, without presentation of any statistical analysis or confidence intervals.

Data synthesis

As only one study was identified, it was not possible to conduct a meta-analysis. Howevere, in future updates of this review, and if suitable studies are found, the following approach will be undertaken.

A comparison between intervention and control groups from RCTs and CCTs will be made. Data from RCTs and CCTs will be analysed using Review Manager 5.1.

Results will be presented with 95% confidence intervals (CI). Estimates for dichotomous outcomes (e.g. incidence of MRSA) will be reported as risk ratios (RR). Methods of synthesising the studies will depend upon quality, design and heterogeneity. Both clinical and statistical heterogeneity will be explored. In the absence of clinical and statistical heterogeneity, a fixed effect model will be applied to pooled data. Only groups of studies of the same design will be considered for pooling (e.g. RCTs and CCTs). Sensitivity analysis for pooled results will be performed based on risk of bias. In the presence of statistical heterogeneity (i.e. greater than 50% as estimated by the I^2) (Higgins 2003), a random effects model will be applied for meta-analysis. Where statistical analysis is inappropriate I^2 over 75%), a narrative overview will be undertaken, structured according to the study design that has been used.

Methods of analysis of all study types will be examined critically. In the case of ITS, the preferred method will be a statistical comparison of time trends with a minimum of three data points before and after the intervention. If the original paper does not include an analysis of this type, the data presented will be used to perform new analyses using the recommended EPOC methods, provided raw data are available.

RESULTS

Description of studies

One study was identified that met the criteria for inclusion (Baldwin 2010).

Study design

The identified study was a cluster randomised controlled trial. A power calculation was reported based on a 10% reduction in MRSA prevalence at 5% significance and 80% power and an ICC of 0.01 indicated that 12 intervention and 12 control homes were required.

Settings

The study was performed in nursing homes, in one of four (at the time of the study) geographically defined health administration areas, in Northern Ireland.

Participants

Sixteen matched pairs (n =32) of nursing homes comprising 793 residents and 338 staff were involved in the study. Fifty six percent of intervention nursing homes and 44% of control nursing homes were independently owned. The mean (range) number of beds in the intervention homes was 41(29 to 69) and 42 (23 to 80) in control homes. The mean (SD) infection control audit score (see below) as a measure of compliance with good infection control practice, at baseline, in the intervention homes was 56% (6.7) and 53% (6.3) in control homes. A score less than 75% was considered poor compliance. Seventeen percent of residents in the intervention and control homes were MRSA positive at baseline. Just over 1% (1.1%) of staff in intervention homes and 6% in control homes were MRSA positive at baseline.Twenty eight percent of intervention group residents and 32% of control group residents were male. Ethnicity was not reported. Fourteen percent of intervention residents and 12% of control residents had been exposed to antibiotics in the three months before the study began.

Interventions

Intervention homes received detailed information on their baseline infection control scores via a written report and verbal feedback from an infection control nurse which described infection control practice and how it could be improved. Detailed infection control training was provided to all intervention home staff by this same nurse. Practical demonstrations on hand hygiene and decontamination of equipment and the environment were also provided during the session. Selected staff from each intervention home were designated as infection control link workers, their role being to reinforce all aspects of good infection control throughout the study. These staff received additional training (5 hours during a period of one day).

Infection control audits were also carried out in each home at 3, 6 and 12 months using an audit tool adapted from one previously developed for community practice. These measured compliance with infection control standards by collecting information using a standardised data collection form. Practice was observed and recorded for the following ten standards of care.

Usual practice continued in the control sites with no training or feedback being delivered to staff, and no staff designated as infection control link workers.

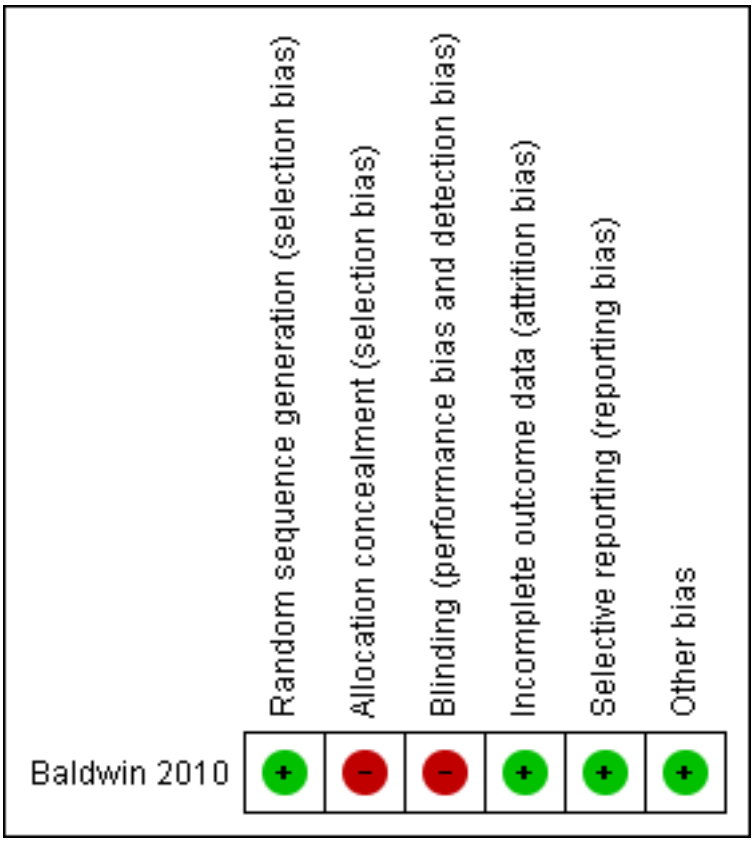
Outcomes

The primary outcome in the identified study was MRSA prevalence in residents and the secondary outcome was a change in infection control audit scores. MRSA prevalence was determined by calculating the proportion of residents and staff, positive for MRSA colonisation, at each home and these proportions were compared between intervention and control homes.

Risk of bias in included studies

Details of the risk of bias are presented in Figure 1 and in the Characteristics of included studies table.

Figure 1. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Adequate sequence generation

The randomisation sequence was computer generated by NQuery version 6 which generated a randomisation sequence in batches of two (for the pairs) with one home in each pair randomly allocated to the intervention or the control arm of the study.

Allocation concealment

From the paper, it is not clear if home allocation was concealed from the researchers; however, one of the study authors confirmed that home allocation was not concealed.

Blinding (all outcomes)

Blinding was not carried out for all outcomes. However, as the infection control audits were undertaken at the given time points by one researcher, another infection control nurse, blinded to allocation of homes, performed audits in two randomly selected nursing homes, at each time point, independent of the researcher, to try to minimise measurement bias. Results from each set of audits were similar for each time point

Incomplete outcome data addressed

Missing outcome data was balanced in numbers across intervention and control groups, with similar reasons for missing data across the groups. The total number of residents lost to follow-up was 158 in the intervention group and 157 in the control group. This was accounted for by the number of deaths in both arms (not unexpected in a nursing home population), particularly in the first three months of the study (winter).

Selective reporting

Primary (MRSA prevalence) and secondary (infection control audit scores) outcomes were fully reported.

Other biases

Baseline measurement: characteristics of participating nursing homes and residents were described at baseline.

Protection against contamination: contamination was unlikely as this study used a cRCT design in which the nursing home was the unit of randomisation. The intervention was tested in the intervention nursing homes for a period of 12 months while usual practice continued in the control homes.

Effects of interventions

No meta-analysis or narrative descriptive was possible due to the inclusion of only one study.

MRSA Prevalence

MRSA prevalence rates were similar in both intervention and control homes throughout the study. At 3 months 25% of residents in intervention homes were colonised compared with 26% in control homes and at 6 months, these figures were 20% and 25% respectively. After one year, MRSA was isolated in 44/234 (19%) and 47/244 (19%) of residents in intervention and control homes

respectively. The risk ratio (RR) of MRSA colonisation in intervention homes compared with control homes was 0.99 (95% CI: 0.69 to 1.42), after adjusting for clustering. The results were similar when new residents (those who entered the home after the study began) were included in the analysis. MRSA prevalence rates were similar among staff in intervention and control groups at 3 months (10% vs 8.5% respectively), 6 months (5.1% vs 4.1% respectively) and 12 months (7.3% vs 4.3% respectively).

Infection Control practices

The infection control audit scores at baseline were comparable across intervention and control groups, with overall mean scores of 56% and 53% respectively. However, the mean audit score was higher in the intervention homes compared with the control homes at 3 months (74% vs 57% respectively, P=0.0001), 6 months (81% vs 63% respectively, P=0.0001) and 12 months (82% vs 64% respectively P=0.0001). The greatest increases in audit scores were reported at 12 months despite hand hygiene and decontamination of equipment still ranking poorly. Factors contributing to the poor hand hygiene score were the wearing of excess jewellery, false/long nails and a lack of hand decontamination after removal of gloves and aprons.

Excluded studies

Three studies were reviewed and excluded as shown in the Table of Excluded Studies (Chami 2012; Ho 2012; Horner 2012). The reason for exclusion in all cases was due to not meeting the inclusion criteria. None included staff as participants and/or did not report the outcome measures of interest for this review.

DISCUSSION

It is, perhaps, surprising that so few studies have been conducted on infection prevention and control strategies to prevent MRSA transmission in nursing homes, using any of the designs mentioned above. We identified one cluster RCT that was conducted in nursing homes in Northern Ireland which assessed the impact of an infection control and education programme on the prevalence of MRSA in residents and staff (Baldwin 2010). The intervention had no effect on MRSA prevalence, but appeared to improve infection control practice. A follow-up qualitative study with staff from the intervention sites reported that organizational factors (e.g. time, financial resources, environment,management and culture), external factors [e.g. hospitals, regulation and general practitioners (GPs)], and residents and families, influenced effective infection control (McClean 2012). It was reported that when workload was unmanageable, aspects of infection control were not adhered to and more financial resources were necessary. There was conflict in maintaining an environment that was both 'homely' and clinical, and it was difficult to achieve good infection control practices with confused residents, some families, GPs and members of staff who were resistant to change.

The latest searches revealed other studies that had been conducted in nursing homes, one of which examined MRSA prevalence as an outcome, but this study (Horner 2012) and others failed to meet all the inclusion criteria. Most studies do not include staff which may be seen as an oversight as staff have been considered as vectors, with the transmission of MRSA occurring via the hands of health care workers (Chamchod 2012. Other studies in nursing homes, using robust methodology, should be encouraged in order to build the evidence base for optimal infection prevention and control in a unique setting which provides care for frail and vulnerable residents.

The nursing home environment is highly conducive to the acquisition and spread of infection, with susceptible residents sharing sources of air, food, water and health care within an institutional setting. Visitors, staff and residents constantly come and go, thereby increasing the risk of transmission (Strausbaugh 2003). Several observational studies have shown that being a nursing home resident increases the risk of MRSA colonisation (Gopal 2007; Johnson 2003; Samad 2002; von Baum 2002). Others have shown that MRSA prevalence in nursing homes is increasing (Cox 1999; Drinka 2004), thereby posing a risk of increasing morbidity (and mortality) in a frail and vulnerable population (Lesse 2006). A meta analysis in 2003 demonstrated a significant increase in mortality in patients with MRSA bacteraemia compared with those with MSSA bacteraemia (Cosgrove 2003). There are no equivalent mortality data specifically for the nursing home population, but Capitano has reported that MRSA-colonised nursing home residents are up to six times more likely to develop infection than non-colonised patients, thereby potentially increasing the risk of mortality (Capitano 2003).

The quality of care provided to older people in nursing homes has been of concern for many years and in this context, infection prevention and control is a related issue that has not been adequately addressed. It has been suggested that comprehensive recommendations may be impractical to implement because of limited resources for infection prevention and control, and logistics (Trick 2001). There may be many factors that contribute to this situation, such as the ownership status of nursing homes (many are privately owned, thereby limiting resources available for infection prevention and control), lack of formal infection prevention and control advice to nursing homes (Stone 2001), and staffing levels. It has been reported that the average annual staff turnover in US nursing homes is 85% for nursing assistants and 55% for registered nurses (Castle 2005). This makes continuity of care, training in infection prevention and control and adherence to infection prevention and control policies difficult to achieve.

The USA has adopted an adversarial approach to nursing home regulation through the Omnibus Budgetary Reconciliation Act of 1987 known as OBRA 87 (OBRA 1987), which exerts its effect through regulation, inspection and sanctions (Elon 1992). There are specific regulations that state that the home must have an infection control programme under which it investigates, controls, and prevents infections, decides what procedures (e.g. isolation) should be applied to an individual resident, and maintains a record of incidents and corrective actions related to infections (OBRA 1987). In contrast, the UK has been much less demanding in terms of regulation. Guidance and a code of practice for infection prevention control in UK care homes have been published, but these are seen as recommendations rather than statutory requirements (Dept of Health 2006), and are not specifically targeted at MRSA.

In contrast to the lack of publications on MRSA in the nursing home environment, infection prevention and control in the hospital setting has generated much media interest and publicity (Simor 2001). A major systematic review published in 2003 examined the role of isolation policies in the hospital management of MRSA (Cooper 2003), and concluded that isolation, in conjunction with other interventions, can reduce MRSA - even when MRSA is

endemic. Tighter regulation has been suggested by some US states as a strategy for infection prevention and control in the hospital setting. In Maryland, proposed legislation would have required identification of MRSA - (and vancomycin-resistant enterococci) colonised or infected patients through active surveillance cultures, isolation of identified patients in an appropriate manner, and strict adherence to handwashing and hand hygiene guidelines (Weber 2007). The legislation proposed would have required the requirement for reporting cases of colonisation or infection to the state health department; these regulations would also have applied to the nursing home setting and would have complemented the broader OBRA regulations which are specific to this environment. However, the legislation did not pass in the State Senate. The Netherlands has adopted a 'search and destroy' policy within hospitals, but this has not been extended to nursing homes for older people (Goettsch 2000). In view of the current lack of evidence specific to nursing homes, only general advice based on the well-established principles of hygiene can be offered. This is outlined below.

General guidelines have recently been issued for the control and prevention of MRSA in UK health care facilities; most of the evidence reviewed came from the acute care setting, but the authors stated that many of the recommendations and principles would also apply to other environments (Coia 2006). The main recommendations are that there should be:

1. A systematic approach to the surveillance of MRSA, with routine feedback to staff.
2. Appropriate use of antibiotic therapy.
3. Screening for MRSA carriage in selected patients, which should be linked to the use of isolation and cohorting.
4. Decolonisation in certain categories of patients.
5. Adherence to the general principles of infection prevention and control such as hand hygiene, cleaning and decontamination.

Interestingly, routine screening of staff was not recommended.

This document stresses that infection prevention and control has to be seen as an organisational responsibility and priority. However, it has been noted that care home and hospital staff differ in their perception of where most MRSA came from (Morrow 2012) Care home staff attributed most MRSA to hospital, while hospital staff identified a variety of sites as being the main source, including care homes. However, context is an important consideration, as nursing homes have a dual function; both to provide health care and a homely environment. It may not be possible to directly translate strategies adopted in the acute care setting to nursing homes. The published guidelines for care homes in England provide some pointers on this front, although these are not specific to MRSA (Dept of Health 2006). Hand hygiene was acknowledged as the most important activity for reducing the spread of infection. The use of gloves, aprons, masks, visors and eye protection was not universally recommended; the decision to use these should be based on an assessment of risk of transmission of a micro-organism to the resident and the risk of contamination of a healthcare worker's clothing and skin by the resident's blood or other fluids, excretions or secretions (Dept of Health 2006). Other recommendations included training in the safe handling and disposal of sharps, high standards of environmental cleaning, decontamination of commonly-used equipment, proper disposal of waste (clinical or otherwise), the optimal management of antibiotic therapy, and isolation. Drawing on evidence from the hospital setting, it was recognised that isolation may have adverse effects on a patient. Tarzi found that patients with MRSA isolated in hospital had higher levels of depression and anxiety than would be expected among older adults in general (Tarzi 2001). One study reported that patients, who were MRSA positive (colonisation or bacteraemia), and were isolated as an infection-control precaution, experienced more preventable adverse events, expressed greater dissatisfaction with their treatment and had less documented care i.e. vital signs were not accurately recorded and patients were less likely to have daily progress notes documented (Stelfox 2003). In the nursing home setting, isolation may not be an option due to the unavailability of single rooms in some homes (O'Sullivan 2000). Chamchod and Ruan undertook mathematical modelling to describe the transmission dynamics of MRSA in nursing homes (Chamchod 2012). They reported that the number of contacts between residents, and between residents and healthcare workers, admission of colonised residents, decolonisation, decontamination, hand hygiene compliance and the length of stay of colonised residents may be the best predictors of the prevalence of MRSA in nursing homes. They suggested that possible strategies to control MRSA included screening on admission, decolonisation of residents where appropriate, improving hand hygiene of staff and residents and decreasing the resident:staff ratio (Chamchod 2012).

It is also unclear whether a single intervention, or a number of interventions in combination, will have the greatest impact on preventing the transmission of MRSA in nursing homes. Tomic implemented a comprehensive infection prevention and control programme in a teaching hospital facility with 237 beds, including 14 intensive care unit beds, in Slovenia, in a before-and-after study (Tomic 2004). The intervention consisted of promotion of hand hygiene, active surveillance cultures at admission to identify MRSA, strict application of barrier precautions for patients with MRSA, decolonisation and continuous education of health care workers. This multi-component intervention was deemed to be successful in reducing MRSA transmission in a highly endemic setting. The authors, however, stated that they were unable to determine the effect of each individual intervention, as all measures were introduced at the same time. Despite this, they concluded that in a highly endemic setting, a combined multidisciplinary approach to preventing and controlling MRSA was essential.

Interventions are difficult to implement and maintain, irrespective of the setting and whether occurring under research or usual practice conditions. Non-performance bias will always be an issue (Burke 2003). It may be the case that the more complex an intervention, the more likely it is that non-performance bias will occur. Constant reminders to staff will be required to ensure adherence to an infection prevention and control protocol, and this may be difficult to achieve in a setting where there are staff shortages and rapid staff turnover (Burke 2003). Staffing issues in nursing homes have already been discussed. Despite educational efforts, health care workers continue to fail to adhere to standards for hand hygiene which is universally considered to be the single most important method of infection prevention and control. Barriers to hand hygiene compliance include under-staffing, poor design of facilities, confusing and impractical guidelines and policies, failure to apply behavioural change theory fully and insufficient commitment and enforcement by infection prevention and control personnel (Burke 2003). Gould recently reported

that there was little robust evidence available to guide how best to improve hand hygiene to prevent health care-associated infection, although educational interventions had some limited success (Gould 2010). MacDonald used performance feedback of hand hygiene with alcohol gel to all staff in a plastic surgery unit (MacDonald 2004). There was a significant reduction in the number of patients newly affected by MRSA, and a decrease in the use of teicoplanin in the year after the performance feedback was introduced. This approach, however, was adopted for one intervention only and may be even more difficult to implement in a setting where there are no dedicated infection-prevention and control personnel and no input from such individuals on a regular basis. Stone noted that nursing home staff lacked infection prevention and control expertise, and usually had no requirement or resources to enable such work to be undertaken by infection prevention and control staff (Stone 2001). A survey conducted in care homes in Northern Ireland found that visits from infection prevention and control nurses were infrequent, with under one-quarter of all respondents (74 from 318) receiving a visit (Tunney 2006). Only half of all care homes had a member of staff who was specifically responsible for infection prevention and control, with only 60% of these staff having undergone training for this role.

AUTHORS' CONCLUSIONS

Implications for practice

The current lack of research evidence, to inform practice in nursing homes, forces a reliance on evidence and guidelines derived in other settings. Screening those at risk of MRSA (e.g. recent admissions from hospital) may be part of any pragmatic approach adopted in the nursing home environment. Training key staff, who will then be responsible for training all other staff in infection prevention and control procedures should also be implemented, along with adherence to hand hygiene recommendations and high standards of environmental cleaning and decontamination. Isolation processes, although shown to be effective in hospital settings, may not be always practical in nursing homes. These recommendations should be reviewed in the light of ongoing and future research studies which are specific to this setting.

Implications for research

Only one RCT was found which met the inclusion criteria, and the intervention had no effect on MRSA prevalence, with a follow-up qualitative study providing some insight into why the intervention had not been successful. However, other studies in nursing homes, using robust methodology, should be encouraged in order to build the evidence base for optimal infection prevention and control in a unique setting which provides care for frail and vulnerable residents. Cooper highlighted the lack of rigorous study designs in infection control in his major Health Technology Assessment systematic review on isolation policies in the hospital management of MRSA (Cooper 2003). Major methodological weaknesses and inadequate reporting of studies mean that many plausible alternative explanations for MRSA reduction associated with interventions could not be excluded. Recommendations from the report included designs for infection control studies that would produce robust evidence (Cooper 2003). This has led to the production of guidelines (analogous to CONSORT for RCTs) for transparent reporting of Outbreak Reports and Intervention studies Of Nosocomial Infections, known as ORION (Stone 2007). In addition to improving the transparency of reporting, the ORION guidelines seek to help readers to relate studies to their situation, facilitate synthesis of evidence, and to provide a framework for reviewers and editors to assess papers and research grant applications (Stone 2007). ORION can be used to help plan and interpret study designs (RCTs, cohort studies, interrupted time series); ORION also encourages detailed reporting of the interventions undertaken, the infection-related outcomes under investigation and any potential confounders that may affect the internal validity of the study (Stone 2007). A paper highlighting the important factors to consider in designing and evaluating complex interventions commented that 'context is all important' (Campbell 2007). This is particularly relevant in the nursing home setting as it is a milieu which is 'medical' in nature, yet is also a 'home'. McClean 2012) reported this tension following interviews with nursing home staff who had taken place in the intervention study which has been included in this review (Baldwin 2010). This dichotomy will need to be considered when designing an intervention as it is unlikely that an intervention which has been developed for one setting (i.e. hospital) is directly transferable to another environment (nursing homes). Furthermore, the context will also need to be considered when the trial is being reported, with a clear explanation of the context and how the intervention was implemented. Non-performance bias is also an issue in research studies, particularly if the intervention contains a number of components that require the involvement and commitment of all staff. Future studies could also be designed which examine a specific component of infection prevention and control in the nursing home setting e.g. hand hygiene or isolation procedures versus usual care or a comprehensive infection prevention and control strategy. These types of intervention studies may demonstrate the most effective kind of intervention and a health economic evaluation embedded in such studies may also help to provide evidence on the most cost-effective approach.

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CHARACTERISTICS OF STUDIES

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

Baldwin 2010

Methods	Randomised controlled trial. A (cRCT) design, in which the nursing home was a unit of randomisation, was used. Each group of residents in a participating home constituted one cluster. The intervention was tested in the intervention nursing homes for a period of 12 months while usual practice continued in the control homes. The study received ethical approval from the Office for Research Ethics Committees Northern Ireland. Baseline data were collected from residents and staff in all nursing homes at 3, 6 and 12 months. Resident data collected were age and gender, presence of wounds or indwelling devices, history of hospitalisation and antibiotic use in the previous 3 months and history of chronic illness. Consenting staff provided details on occupation, age and gender. Nursing home data such as number of beds (occupancy and capacity), staffing levels and ownership type were also collected. The participating nursing homes were then matched and paired using baseline data on number of beds per home, staffing levels, infection control audit scores and MRSA prevalence. NQuery version 6 produced the randomisation sequence in batches of two (for the pairs) with one home in each pair randomly allocated to the intervention or the control arm of the study.
Participants	Only facilities registered as general nursing homes with ≥20 residents, in one of four geographically defined health administration area in NI, and not participating in other studies were eligible to participate. All nursing home residents aged ≥ 65 years were eligible (excluding the terminally ill or those attending on a day-care basis only) 32 nursing homes, 792 residents and 333 staff randomised
Interventions	Homes randomly allocated to the intervention arm received detailed information on their baseline infection control scores via a written report and verbal feedback from an infection control nurse which detailed infection control practice and how it could be improved. In-depth infection control training, consisting of a 2 hour training session delivered via Powerpoint and DVD presentations, was provided to all intervention home staff by this same nurse. Practical demonstrations on hand hygiene and decontamination of equipment and the environment were also provided during the session. Selected staff from each intervention home were designated as infection control

Baldwin 2010 *(Continued)*

	link workers, their role being to reinforce all aspects of good infection control throughout the study. These staff received additional training (5 hour during a period of one day). Infection control audits were also carried out in each home at baseline, 3, 6 and 12 months using an audit tool adapted from one previously developed for community practice. These measured compliance with infection control standards by collecting information using a standardised data collection form. Practice was observed and recorded for the following ten standards: cleanliness of the environment, cleanliness of the kitchen environment, decontamination of equipment, linen management waste and sharps management, hand decontamination, use of personal protective equipment, urinary catheter management, management of enteral feeding and management of wounds. On completion of each audit, an overall percentage score was calculated to determine compliance with good infection control practice with a score <75% indicating poor compliance, a score 0f 76 to 84% partial compliance and a score of >85% indicating compliance as recommended. Usual practice continued in the control sites with no training or feedback being delivered to staff, and no staff designated as infection control link workers.
Outcomes	A swab of the anterior nares was obtained from each consenting resident and staff member at each sampling time point in order to detect MRSA. A specimen of urine was collected from residents with indwelling urinary catheters, and those with wounds and any other indwelling devices provided swabs of these sites as relevant. The primary outcome was MRSA prevalence in residents and the secondary outcome was a change in infection control audit scores. MRSA prevalence was determined by calculating the proportion of residents and staff with MRSA at each home. Binary outcomes such as the proportion of residents positive for MRSA colonisation were compared between intervention and control homes
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer generated NQuery version 6 produced a randomisation sequence in batches of two (for the pairs) with one home in each pair randomly allocated to the intervention or the control arm of the study.
Allocation concealment (selection bias)	High risk	The research team and nursing home staff were aware of home allocation.
Blinding (performance bias and detection bias) All outcomes	High risk	Infection control audits were undertaken at the time points by the researcher NB. Another infection control nurse blinded to allocation of homes performed audits in two randomly selected nursing homes at each time point, independent of the researcher to try to minimise measurement bias. Results from each set of audits were similar at each time point.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing outcome data balanced in numbers across the intervention and control groups, with similar reasons for missing data across groups. The total number of residents lost to follow-up was 158 in the intervention group and 157 in the control group due to deaths in the resident population.
Selective reporting (reporting bias)	Low risk	MRSA prevalence rates in both arms remained similar. The infection control audit scores were comparable.
Other bias	Low risk	Characteristics of participating nursing homes and residents were described at baseline

Baldwin 2010 *(Continued)*

	Contamination was unlikely as this study used a cRCT design in which the nursing home was the unit of randomisation. The intervention was tested in the intervention nursing homes for a period of 12 months while usual practice continued in the control homes. A power calculation was given " based on a 10% reduction in MRSA prevalence at 5% significance and 80% power and an ICC of 0.01 indicated that 12 intervention and 12 control homes were required".

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

Study	Reason for exclusion
Chami 2012	Did not include staff as participants and did not report MRSA incidence or prevalence
Ho 2012	Did not include residents and staff as participants. Did not report MRSA incidence as the primary outcome.
Horner 2012	Did not include staff as participants.

APPENDICES

Appendix 1. Search methods from the second update - 2011

Electronic searches

The search methods sections of previous versions of this review can be found in Appendix 1

For this second update we searched the following electronic databases for all relevant studies, regardless of language, date of publication or publication status:

- Cochrane Wounds Group Specialised Register (searched May 27th, 2011)
- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2011, Issue 2).
- Ovid MEDLINE (1950 to April Week 2 2011).
- OVID MEDLINE (In-process and Other Non-Indexed Citations, April 26th 2011)
- Ovid EMBASE (1980 to 2011 Week 16).
- EBSCO CINAHL (1982 to April 21st 2011).
- DARE (Database of Abstracts of Reviews of Effects) accessed via the Centre for Reviews and Dissemination website; (1992 to 2011, week 16).
- Web of Science (1981 to May 2011).
- Health Technology Assessment (HTA) website (to May 2011).

We used the following strategy to search the Cochrane Central Register of Controlled Trials (CENTRAL):

#1 MeSH descriptor Staphylococcus aureus explode all trees
#2 staphylococcus NEXT aureus:ti,ab,kw
#3 MeSH descriptor Staphylococcal Infections explode all trees
#4 staphylococ* near/2 infect*
#5 MeSH descriptor Methicillin Resistance explode all trees
#6 (methicillin or meticillin) near/2 resist*:ti,ab,kw
#7 MeSH descriptor Penicillin Resistance explode all trees
#8 penicillin near/2 resist*:ti,ab,kw
#9 MeSH descriptor Methicillin-Resistant Staphylococcus aureus explode all trees
#10 (mrsa or emrsa):ti,ab,kw

#11 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10)
#12 MeSH descriptor Homes for the Aged explode all trees
#13 MeSH descriptor Nursing Homes explode all trees
#14 MeSH descriptor Group Homes explode all trees
#15 (#13 OR #14)
#16 MeSH descriptor Aged explode all trees
#17 ("aged" or "old people" or "older people" or "old person" or "older persons" or (old NEXT resident*) or (older NEXT resident*) or elders or elderly or geriatric):ti,ab,kw
#18 (#16 OR #17)
#19 (#15 AND #18)
#20 nursing near/2 (home* or "unit" or "units" or centre* or center* or facility or facilities):ti,ab,kw
#21 group near/2 home*:ti,ab,kw
#22 extended NEXT care NEXT facilit*:ti,ab,kw
#23 ((long NEXT term) or longterm) NEXT care NEXT facilit*:ti,ab,kw
#24 care near/2 (home* or facilit*):ti,ab,kw
#25 rest near/2 home*:ti,ab,kw
#26 residential near/2 (home* or "care"):ti,ab,kw
#27 geriatric near/2 (home* or "unit" or "units"* or facilit* or institution*):ti,ab,kw
#28 (#20 OR 21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27)
#29 (#18 AND #28)
#30 (#12 OR #19 OR #29)
#31 (#11 AND #30)

The search strategies for Ovid MEDLINE, Ovid EMBASE and EBSCO CINAHL can be found in Appendix 2, Appendix 3 and Appendix 4 respectively. The Ovid MEDLINE search was combined with the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE: sensitivity- and precision-maximizing version (2008 revision); Ovid format (Lefebvre 2011). The EMBASE and CINAHL searches were combined with the trial filters developed by the Scottish Intercollegiate Guidelines Network (SIGN 2009).

Research in progress was sought through the following resources (accessed May 2011):

- Current Clinical Trials (www.controlled-trials.com).
- Medical Research Council Research portfolio (www.mrc.ac.uk)
- HSRPRoj (current USA projects; wwwcf.nlm.nih.gov/hsr_project/home

Searching other resources

The reference lists of relevant articles were searched. For the original review key researchers in the field of MRSA infection-control were contacted to identify other possibly relevant trials.

Appendix 2. Ovid MEDLINE search strategy

1 exp Staphylococcal Infections/ (24387)
2 exp Staphylococcus aureus/ (31753)
3 staphylococcus aureus.ti,ab. (39174)
4 (staphylococ* adj2 infect*).ti,ab. (3331)
5 exp Methicillin Resistance/ (8087)
6 ((methicillin or meticillin) adj2 resist*).ti,ab. (14701)
7 exp Penicillin Resistance/ (10646)
8 (penicillin adj2 resist*).ti,ab. (3403)
9 exp Methicillin-Resistant Staphylococcus aureus/ (5770)
10 (mrsa or emrsa).ti,ab. (10693)
11 or/1-10 (57995)
12 exp Homes for the Aged/ (5791)
13 exp Nursing Homes/ (16338)
14 exp Group Homes/ (591)
15 or/13-14 (16876)
16 exp Aged/ (1329545)
17 (aged or old people or older people or old persons or older persons or old resident* or older resident* or elders or elderly or elderly people or elderly persons or elderly residents or geriatric or old resident* or older resident* or elderly resident*).ti,ab. (326747)
18 or/16-17 (1489058)
19 15 and 18 (11344)
20 (group adj2 home*).ti,ab. (1081)
21 (extended care adj2 facilit*).ti,ab. (150)

22 (long-term care adj2 facilit*).ti,ab. (2516)
23 (care adj2 (home* or facilit*)).ti,ab. (21437)
24 (rest adj2 home*).ti,ab. (118)
25 (residential adj2 (home* or care)).ti,ab. (2155)
26 (geriatric adj2 (home* or unit* or facilit* or institution*)).ti,ab. (928)
27 (nursing adj2 (home*1 or unit*1 or center*1 or centre*1)).ti,ab. (14371)
28 or/20-27 (35889)
29 18 and 28 (19456)
30 12 or 19 or 29 (24090)
31 11 and 30 (342)

Appendix 3. Ovid EMBASE search strategy

1 exp Staphylococcus Aureus/ (76428)
2 exp Staphylococcus Infection/ (22621)
3 staphylococcus aureus.ti,ab. (56655)
4 (staphylococ* adj2 infect*).ti,ab. (4790)
5 exp Methicillin Resistant Staphylococcus Aureus/ (25968)
6 exp Penicillin Resistance/ (6618)
7 ((methicillin or meticillin) adj2 resist*).ti,ab. (21346)
8 (penicillin adj2 resist*).ti,ab. (4612)
9 (mrsa or emrsa).ti,ab. (17557)
10 or/1-9 (98291)
11 exp Home for the Aged/ (4621)
12 exp Nursing Homes/ (23054)
13 exp Group Homes/ (3486)
14 or/12-13 (26176)
15 exp Aged/ (1510529)
16 (aged or old people or older people or old persons or older persons or old resident$ or older resident$ or elders or elderly or elderly people or elderly persons or elderly residents or geriatric or old resident$ or older resident$ or elderly resident$).ti,ab. (487947)
17 or/15-16 (1780919)
18 14 and 17 (14574)
19 (nursing adj2 (home$1 or unit$1 or center$1 or centre$1)).ti,ab. (19933)
20 (group adj2 home$).ti,ab. (1533)
21 (extended care adj2 facilit$).ti,ab. (231)
22 (long-term care adj2 facilit$).ti,ab. (3564)
23 (care adj2 (home$ or facilit$)).ti,ab. (29459)
24 (rest adj2 home$).ti,ab. (207)
25 (residential adj2 (home$ or care)).ti,ab. (3024)
26 (geriatric adj2 (home$ or unit$ or facilit$ or institution$)).ti,ab. (1540)
27 or/19-26 (49950)
28 17 and 27 (23841)
29 11 or 18 or 28 (30105)
30 10 and 29 (410)

Appendix 4. EBSCO CINAHL search strategy

S30 S9 and S29
S29 S10 or S18 or S28
S28 S17 and S27
S27 S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26
S26 TI (geriatric home* or geriatric unit* or geriatric facilit* or geriatric institution*) or AB (geriatric home* or geriatric unit* or geriatric facilit* or geriatric institution*)
S25 TI (residential N2 home* or residential N2 care*) or AB (residential N2 home* or residential N2 care*)
S24 TI rest N2 home* or AB rest N2 home*
S23 TI (care home* or care facilit*) or AB (care home* or care facilit*)
S22 TI long-term care N2 facilit* or AB long-term care N2 facilit*
S21 TI extended care N2 facilit* or AB extended care N2 facilit*
S20 TI group N2 home* or AB group N2 home*
S19 TI (nursing home* or nursing unit* or nursing center* or nursing centre*) or AB (nursing home* or nursing unit* or nursing center* or nursing centre*)
S18 S13 and S17
S17 S14 or S15 or S16

S16 AB aged or old people or older people or old persons or older persons or old resident* or older resident* or elders or elderly or elderly people or elderly persons or elderly residents or geriatric or old resident* or older resident* or elderly resident*
S15 TI aged or old people or older people or old persons or older persons or old resident* or older resident* or elders or elderly or elderly people or elderly persons or elderly residents or geriatric or old resident* or older resident* or elderly resident*
S14 (MH "Aged+")
S13 S11 or S12
S12 (MH "Residential Facilities+")
S11 (MH "Nursing Homes+")
S10 (MH "Housing for the Elderly")
S9 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8
S8 TI (mrsa or emrsa) or AB (mrsa or emrsa)
S7 TI penicillin N2 resist* or AB penicillin N2 resist*
S6 TI (methicillin resist* or meticillin resist*) or AB (methicillin resist* or meticillin resist*)
S5 (MH "Methicillin Resistance")
S4 TI staphylococ* N2 infect* or AB staphylococ* N2 infect*
S3 TI staphylococcus aureus or AB staphylococcus aureus
S2 (MH "Staphylococcus Aureus")
S1 (MH "Staphylococcal Infections+")

WHAT'S NEW

Date	Event	Description
13 November 2013	New citation required but conclusions have not changed	No change to conclusions. Third update.
13 November 2013	New search has been performed	New search, no additional included studies, three studies excluded (Chami 2012; Ho 2012; Horner 2012).

HISTORY

Protocol first published: Issue 1, 2007
Review first published: Issue 1, 2008

Date	Event	Description
6 September 2011	New citation required and conclusions have changed	One additional study included, conclusions updated, new review author joined the team.
6 September 2011	New search has been performed	Second update, new search, one additional study included.
5 November 2009	New search has been performed	New search, no studies identified for inclusion
2 June 2008	Amended	Converted to new review format.
17 October 2007	New citation required and conclusions have changed	Substantive amendment

CONTRIBUTIONS OF AUTHORS

Carmel Hughes initiated the review, conducted some of the searches, reviewed the results of all searches and wrote the protocol, review and updated the review.
Michael Tunney reviewed the results of all searches and commented on all final drafts of the protocol, review and updated review.

Marie Bradley undertook the second review update including data extraction and risk of bias assessment and contributed to the writing of the review update.

Contributions of editorial base:

Nicky Cullum: edited the review, advised on methodology, interpretation and review content. Approved the final review and review update prior to submission.
Sally Bell-Syer: coordinated the editorial process. Advised on methodology, interpretation and content. Edited the review and the updated review.
Ruth Foxlee: designed the search strategy, ran the searches and edited the search methods section for the update.

DECLARATIONS OF INTEREST

Carmel Hughes and Michael Tunney were investigators on the study which was included in the 2011 review and this latest version of the review (Baldwin 2010). Mike Smith (author on the original review and first two updates) independently extracted and checked the data on the included study.

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- Research and Development Office, Northern Ireland, UK.
- NIHR/Department of Health (England), (Cochrane Wounds Group), UK.

INDEX TERMS

Medical Subject Headings (MeSH)

*Homes for the Aged; *Nursing Homes; Cross Infection [*prevention & control] [transmission]; Infection Control [*methods]; Methicillin-Resistant Staphylococcus aureus [*drug effects]; Staphylococcal Infections [*prevention & control] [transmission]

MeSH check words

Aged; Humans