REVIEW

Interventions to improve hand hygiene compliance in patient care

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KEYWORDS
Hand hygiene; Healthcare-associated infection; Research design

Summary Healthcare-associated infection is a major cause of morbidity and mortality. Hand hygiene is regarded as the most effective method of prevention but is poorly performed by health workers. We report a systematic review identifying studies which investigated the effectiveness of interventions to increase hand hygiene compliance short and longer term and to determine their success in terms of hand hygiene compliance and subsequent effect on rates of healthcare-associated infection. We employed the inclusion criteria employed by the Cochrane Effective Practice and Organisation of Care Group. Forty-eight studies and one thesis were identified. Only two met the stringent inclusion criteria. Overall studies remain small scale, poorly controlled and follow-up data collection is abandoned too soon to establish impact longer term. Furthermore, designs are insufficiently robust to attribute any observed changes to the intervention. Studies lack theoretical focus and seldom describe the intervention in sufficient detail, the change management process or contextual information about the organisation in the depth necessary to explain success or lack of it. The review concludes that interrupted time-series studies may offer the most rigorous approach to assessing the impact of interventions to increase hand hygiene compliance. In such study designs the number of new cases of healthcare-associated infection should be taken as an outcome measure, with data collection points at least 12 months before intervention and afterwards to allow for seasonal trends. Contextual factors at national and at local level should be carefully documented to take into consideration the influence of secular trends.

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Introduction

Healthcare-associated infection (HAI) is a major problem globally. Ten percent of inpatients in the UK develop HAI, causing 5000 deaths and costing £930 million annually. Figures are similar in other developed countries. Although hand hygiene has been intensively promoted as the most important means of preventing HAI, numerous studies have demonstrated that compliance with hand hygiene recommendations is poor and interventions to improve it lack sustainability.

In 2001 Naikoba and Hayward systematically reviewed 21 studies published before 2000. They classified 17 as uncontrolled trials. Fifteen took place in critical care units (CCUs). Numerous different interventions and combinations of interventions to improve hand hygiene were described. The reviewers concluded that multifaceted approaches promoted hand hygiene compliance more effectively than single interventions, in line with accepted opinion at that time. They suggested that education combining written material with reminders and continuous feedback on performance was more useful than interventions involving novel equipment (e.g. automated sinks, moisturised soaps). Multiple limitations were noted with these studies, including small sample sizes, short duration of follow-up; lack of or inappropriate control groups, and lack of generalisability from the CCU to other clinical settings. In most studies frequency of hand hygiene was taken as the outcome measure rather than microbiological data. However, this review included studies employing research designs that are too weak to justify causal inferences about the effects of interventions.

The number of studies exploring the effectiveness of interventions intended to increase hand hygiene compliance and/or use of alcohol hand rubs short term (less than six months) and longer term (six months or more) and to determine their success in terms of hand hygiene compliance and subsequent effect on rates of HAI.

Methods

The aim of the review was to identify all studies investigating the effectiveness of interventions intended to increase hand hygiene compliance and/or use of alcohol hand rubs short term (less than six months) and longer term (six months or more) and to determine their success in terms of hand hygiene compliance and subsequent effect on rates of HAI.

Search strategy

We employed the rigorous inclusion criteria employed by the Cochrane Effective Practice and Organisation of Care (EPOC) Group which is available on their website. We searched the Cochrane Central Register of Controlled Trials (CENTRAL) and the EPOC specialised register of trials, MEDLINE, PubMed, EMBASE, CINAHL and the BNI. All databases were searched to July 2006; MEDLINE was searched from 1980, CINAHL from its inception, and the remainder from 1990 until July 2006. The following search terms were used: 'hand hygiene' or 'hand hygiene' alone and combined with the following terms: 'education'; 'knowledge'; 'health promotion'; 'audit'; 'compliance'; 'product availability'; 'cross-infection'; nosocomial infection'; hospital-acquired infection' and 'health care-associated infection'. Additional search strategies included: hand searching key journals from 1985 onwards (British Medical Journal, Journal of Hospital Infection, American Journal of Infection Control, Infection Control and Hospital Epidemiology). Conference proceedings from the UK Hospital Infection Society and the Infection Control Nurses’ Association were hand searched. Contact was established with the Hand Hygiene Liaison Group in the UK to discuss progress with their current study funded by the Department of Health. Conference proceedings from the Society of Hospital Epidemiologists of America, and the Community and Hospital Infection Control Association of Canada were hand searched. Colleagues from these organisations were contacted.
for information about relevant unpublished work. Information was sought from pharmaceutical companies manufacturing hand hygiene products.

Inclusion and exclusion criteria

Two authors reviewed each paper independently. We considered randomised controlled trials, controlled clinical trials, controlled before-and-after studies and interrupted time-series analyses meeting explicit inclusion and quality criteria used by the EPOC Group. Study designs were analysed by annotating the points at which data collection took place in relation to intervention. Appendix 1 shows how annotation and analysis were performed. To be eligible for review, interrupted time-series studies had to include at least three data collection points before and after the intervention to take into account the influence of secular trends and the autocorrelation among measurements repeatedly taken over time. Seasonal variations (e.g. changes in humidity) might influence outcome measures in studies which examine HAI rates. Hand hygiene compliance is likely to be influenced by changes in staffing levels and replacement of usual personnel by temporary employees during national holidays and sickness. Studies reporting proxy indicators of hand hygiene compliance (e.g. increased use of soap or alcohol hand rub) were considered. We reviewed studies where the participants or target groups were nurses, doctors and other allied health professionals (except operating theatre staff because specific hand hygiene techniques are used in this setting). We also considered studies in any hospital or community setting, in any country that involved any type of intervention intended to improve hand hygiene compliance using aqueous solutions and/or alcohol products (e.g. education; audit with performance feedback; health promotion; and variations in availability and types of hand hygiene products). Studies to promote compliance with universal precautions were included providing data relating specifically to hand hygiene were presented separately.

Results

We identified 49 papers and one thesis published from 1980 onwards through electronic searching. No additional papers were identified by hand searching or communication with any organisations contacted. Only two studies met the minimum inclusion criteria for a Cochrane EPOC review. This paper describes included and excluded studies to highlight key issues for investigators, editors and referees.

Included studies

Although meeting the criteria for review, both included studies were poorly designed (see Tables I and II). One had been included in the earlier systematic review. The other has been published since. Gould and Chamberlain reported a controlled before-and-after study conducted in four matched surgical wards in the same hospital. Two wards were randomly selected to serve as intervention wards. Two further matched wards were controls. Sixteen nurses in the intervention wards and 15 nurses in the controls were recruited randomly into the study. Each nurse was observed continuously for 2 h by the same observer, blinded to group allocation. The outcome measure was number of hand washes performed after activities judged to offer significant risk of cross-infection (‘essential’ hand hygiene episodes). The unit of analysis was the individual nurse. Baseline data were similar in control and intervention wards. Three months post-intervention the number of essential hand hygiene episodes was similar for both groups.

In their randomised controlled trial Huang et al. recruited 100 nurses randomised into experimental and control groups. Data were collected from 98 nurses by direct observation by three researchers for 30 min each before the intervention and four months afterwards. Data were presented on the proportion of nurses who washed hands, but there was no information to explain how the proportion was calculated. The unit of analysis was the individual nurse. Four months post-intervention, hand hygiene compliance was significantly improved \( (P < 0.001) \) for the nurses in the experimental group but not the control.

In both studies the outcome measure was the number of times hand hygiene was performed before and after specific types of patient contact collected by direct observation during day shifts. Microbiologically defined outcome measures were not used. The criteria used to determine when hand hygiene should be performed were explicitly stated, with reference to official guidelines from the USA or derived from them. Details of observers’ training were disclosed by Huang et al. but details of inter-rater reliability testing for the three data collectors were not supplied. The ‘Hawthorne effect’ (increased productivity, i.e. more hand hygiene episodes resulting from the presence of observers) was not discussed by Huang et al.
They argued that hand hygiene is such an ingrained activity that it would be impossible for health workers to maintain changes in usual practice throughout the period of observation. This may have been true when their study was conducted as hand hygiene was not attracting its current level of interest, but would no longer be the case.

Both studies featured a single intervention involving education relating to universal precautions as well as hand hygiene. In the study by Gould and Chamberlain teaching was provided by a nurse teacher with particular infection control expertise. The educational package was designed to consist of five different sessions each 30 min long, covering a comprehensive range of topics relating to infection control generally and specifically to universal precautions and hand hygiene. Practical demonstrations were included. Half the teaching sessions were cancelled because the wards were too busy. Thus some nurses failed to receive all the intended input. The teaching was, however, well-evaluated. The intervention employed by Huang et al. involved 2 h of formal teaching about blood-borne pathogens and universal precautions delivered by specially trained nurses, 1 h of practical demonstration, 30 min of discussion, and written information. Details of evaluation and attendance were not disclosed. Neither study employed a theoretical framework to inform the intervention, but Gould and Chamberlain discussed the rationale for delivering work-based teaching with reference to the nursing education literature.

Excluded studies (see Appendix 1)

The thesis and the paper subsequently written from it were discounted because the data related to universal precautions with information pertaining to hand hygiene were not presented separately. A further paper was excluded because it did not contain data. Of the remaining 45 studies, three were excluded because no baseline data

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Characteristics of included studies</th>
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<tbody>
<tr>
<td>Gould and Chamberlain (1997)</td>
<td>Controlled before and after study</td>
</tr>
<tr>
<td>Methods</td>
<td>Done</td>
</tr>
<tr>
<td>Design</td>
<td>Done</td>
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<tr>
<td>Baseline measurements</td>
<td>Done</td>
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<tr>
<td>Appropriate choice of control</td>
<td>Done</td>
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<tr>
<td>Objective measure of performance</td>
<td>Done</td>
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<tr>
<td>Outcome measures</td>
<td>Reliable</td>
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<tr>
<td>Protection against contamination</td>
<td>Not done</td>
</tr>
<tr>
<td>Validated audit tool used</td>
<td>Done</td>
</tr>
<tr>
<td>Inter-rater reliability tested</td>
<td>Not appropriate</td>
</tr>
<tr>
<td>Possibility of Hawthorne effect</td>
<td>Discussed</td>
</tr>
<tr>
<td>Participants</td>
<td>UK nurses on general surgical wards</td>
</tr>
<tr>
<td>Interventions</td>
<td>Single teaching session: hand hygiene, universal precautions</td>
</tr>
<tr>
<td>Outcomes</td>
<td>% frequency of hand washes after high-risk activities</td>
</tr>
<tr>
<td>Notes</td>
<td>Intervention not successful at three months</td>
</tr>
<tr>
<td>Allocation concealment</td>
<td>Not done</td>
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</tbody>
</table>

Huang et al. (2002) | Randomised controlled clinical trial |
| Methods  | Done |
| Design   | Done |
| Baseline measurements | Done |
| Appropriate choice of control | Done |
| Objective measure of performance | Done |
| Outcome measures | Not reliable |
| Protection against contamination | Done |
| Validated audit tool used | Not stated |
| Inter-rater reliability tested | Not done |
| Possibility of Hawthorne effect | Not discussed |
| Participants | People's Republic of China |
| Nurses throughout a hospital | Education, mainly universal precautions |
| Interventions | % of nurses washing hands before and after patient contact |
| Notes | Intervention successful after four months |
were collected or were collected on only a few of the participating wards.17–19 A further 21 studies were excluded because they reported uncontrolled before-and-after study designs.20–39 Three interrupted time-series studies were reported, each with less than three pre- and post-intervention data collection points.40–42

Of the remaining 20 studies, an additional 12 reported complicated before-and-after designs in which two or more sequential interventions took place, but with only one or two episodes of data collection after each new intervention.6,7,44–53 This group included an influential study which is widely quoted as evidence of the ability of hand hygiene campaigns to increase compliance and decrease rates of HAI and a longer follow-up building on the original work.6,7 In this group of studies, a single episode of baseline data collection took place with further data collected over extended periods. These long periods of data collection became interventional, because feedback performance was provided to health workers during each as part of a deliberately engineered Hawthorne effect.

Six controlled before-and-after studies were identified. Each employed one intervention and one control unit.54–59 These were excluded because the intervention was completely confounded by the study site. Thus it was difficult to attribute any observed changes to the intervention rather than to other site-specific variables. Additional weaknesses of these studies were the dissimilarities of the control and intervention sites, and, in some studies, imbalances between baseline hand hygiene rates.

In the controlled before-and-after study by Mayer et al., the intervention and control wards were dissimilar.54 One was a medical ICU while the other was a surgical ICU. Wound care places greater demands on health workers to perform hand hygiene. In this study percentage number of hand hygiene episodes was the same (63%) on experimental and control wards, but on the experimental (surgical) unit demand for hand hygiene was more than double the demand on the control ward. Other differences between the wards likely to have influenced the outcome measures included differing admission rates and ratios of (less well qualified) nursing assistants to qualified nurses.

The controlled before-and-after study reported by Larson et al. in 1991 was in two completely dissimilar clinical settings (neonatal intensive care

**Table II** Detailed comparison of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Results</th>
<th>Additional notes</th>
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</thead>
<tbody>
<tr>
<td><strong>Huang et al.</strong> *(2002)*11</td>
<td>Percentage of 49 nurses who used appropriate hand hygiene:</td>
<td>Significant increase in experimental group at post-test for both before patient contact (PL.001) and after patient contact (PL.05) compared to control and baseline No confidence intervals reported</td>
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<td></td>
<td>— Before patient contact</td>
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<td></td>
<td>Experimental group</td>
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<td></td>
<td>Pre-intervention 51%</td>
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<td></td>
<td>Post-intervention 85.7%</td>
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<tr>
<td></td>
<td>Control</td>
<td></td>
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<tr>
<td></td>
<td>Pre-intervention 53.1%</td>
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<tr>
<td></td>
<td>Post-intervention 53.1%</td>
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<td></td>
<td>— After patient contact</td>
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<td>Experimental group</td>
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<td></td>
<td>Pre-intervention 75.5%</td>
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<td></td>
<td>Post-intervention 91.8%</td>
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<tr>
<td></td>
<td>Control</td>
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<td></td>
<td>Pre-intervention 75.5%</td>
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<tr>
<td></td>
<td>Post-intervention 71.4%</td>
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<tr>
<td><strong>Gould and Chamberlain</strong> *(1997)*10</td>
<td>Percentage of essential hand decontamination:</td>
<td>No significant difference between experimental group and control No confidence intervals reported</td>
</tr>
<tr>
<td></td>
<td>Experimental group</td>
<td></td>
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<tr>
<td></td>
<td>Pre-intervention 54.5%</td>
<td></td>
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<tr>
<td></td>
<td>Post-intervention 58.6%</td>
<td></td>
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<tr>
<td></td>
<td>Control</td>
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<tr>
<td></td>
<td>Pre-intervention 54.4%</td>
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<tr>
<td></td>
<td>Post-intervention 64.1%</td>
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and post-anaesthesia recovery). Baseline measures of hand hygiene were not quoted separately.

In the controlled before-and-after study reported by Larson et al. in 1997 a seven-bed neurosurgical ICU served as the experimental unit against a reasonably similar control (a seven-bed surgical ICU). However, provision for hand hygiene was not the same. In the experimental unit, five patients were nursed in a bay area with one sink. Two more beds were in single rooms, each with its own sink. The control unit was better equipped, with individual rooms for all patients, each with its own sink. Baseline observation of hand washing (not use of alcohol) was 151 episodes in the experimental unit compared to 310 episodes in the better-equipped control, although this difference was not statistically significant.

The controlled before-and-after study published by Larson et al. in 2000 was sited in two hospitals. The authors state that the experimental and control hospitals were ‘similar’ in terms of nurse:patient ratios, staffing patterns and patient populations, but without supporting evidence. However, hand hygiene frequency was documented in only two dissimilar sites in these hospitals, adult medical critical care and neonatal intensive care, with no data to describe the characteristics of the two units. Baseline frequency of hand hygiene was greater in the experimental hospital [42.6%; confidence interval (CI): 1.3] than the control (30.3; CI: 1.52).

The controlled before-and-after study by Bittner et al. was excluded because the experimental unit was a surgical CCU and the control was a medical CCU. The baseline rates of hand hygiene were similar.

The controlled before-and-after study reported by Colombo et al. was excluded because of lack of matching between control and intervention sites. The intervention was conducted on surgical, medical and intensive care units. The control specifically excluded intensive care. This was not considered a valid comparison because of the differences between critical care and general ward patients.

Nine of the excluded studies involved a single intervention featuring education or training related to hand hygiene, usually formal teaching with practical demonstrations. Hand hygiene was often discussed in conjunction with other topics (e.g. universal precautions, epidemiology). Dubbert et al. combined education with audit and feedback, while six studies looked at audit and feedback alone. Seven studies involved single interventions related to the introduction of a new hand hygiene product (e.g. emollient soap, alcohol hand rub). Marena et al. compared plain soap and antimicrobial solution, combined with education. Other single interventions studied were visual feedback of organisms from hand cultures, use of gowns, labelled teddy bears, labels on ventilators, reminders from patients, posters, voice prompts, automated sinks, and relocation to a new hospital. The remaining studies involved multidimensional campaigns featuring different combinations of an educational or training programme, a new product, audit and performance feedback, written information and written reminders such as posters or labels. Theoretical frameworks were clearly articulated in two studies only.

Neither of the studies reviewed or those excluded considered economic outcomes. Apart from Pittet et al. none of the authors mentioned the cost of the resources required to increase hand hygiene compliance. Similarly there was no mention of health service utilisation outcomes such as: readmission rates, changes in levels of health care; length of patient stay; or the effects of any of the interventions on patients’ health.

Discussion

Study designs

There is a dearth of methodologically robust studies to explore the effectiveness of interventions to improve hand hygiene compliance. Studies remain small scale, poorly controlled, abandon follow-up too soon to establish longer-term impact and seldom include microbiological data as outcome measures. We rejected most studies included in the older review because they were uncontrolled before-and-after designs, interrupted time-series studies lacking sufficient data collection points or because they reported controlled before-and-after designs with poor controls and only one control and intervention site, making it impossible to attribute any observed changes to the intervention. Ethically conducted studies (those where data collection was not covert) were inherently weakened through the possibility of a Hawthorne effect. This was also a problem when, as is inevitable with hand hygiene, the intervention was not blind. Cluster-randomised controlled trials may offer a solution. They are recommended when it is not feasible to enroll individuals from the same venue (ward, hospital) because of cross-contamination (e.g. health workers discussing a training programme). For intervention studies to enhance hand hygiene they would be feasible because the intervention is usually applied to groups rather
than individuals. A future study design might involve random sampling wards of the same type. However, this approach has two drawbacks. Cluster-randomised controlled trials require large samples and are thus expensive to undertake as well as challenging in terms of project management. Difficulties matching intervention and control sites mean that for hand hygiene compliance, they suffer from the same disadvantages as controlled before-and-after studies; the many contextual factors have the potential to influence HAI rates and weaken findings.

Well-designed interrupted time-series studies meeting strict criteria might offer a better solution. When applied to studies involving HAI as an outcome measure, data collection would need to take place for ≥12 months before intervention and again afterwards to allow for seasonal trends. Overcoming secular trends in studies lacking controls would never be entirely possible although qualitative data and routinely collected audit data for the extensive range of variables influencing hand hygiene compliance and HAI rates (e.g. policy initiatives, media storms, long-term trends in the epidemiology of HAI and the introduction of new drugs and therapies) could be taken into consideration. Arguably such studies would be better attempted outside the UK, since there have been excessively rapid changes in health policy directed towards reducing HAI, accompanied by increasing media attention.

Interventions

Our review raises questions about the adequacy of interventions intended to achieve improved hand hygiene compliance. This is supported by one of the studies we reviewed, while in the other study failure to improve hand hygiene compliance can be attributed to inability to implement an otherwise well-designed, educationally sound programme.

In future studies the nature and content of the intervention requires consideration in addition to its length. Older change management literature suggested that multifaceted campaigns are most effective, but this view has now been challenged. According to more recent evidence, interventions previously thought to be ineffective such as educational intervention are modestly successful. Audit with performance feedback is less successful than educational intervention. Few existing hand hygiene intervention studies described the intervention adequately. Authors used the terms ‘education’ and ‘training’ interchangeably or were confused about their meanings. The purpose of education is to promote intellectual curiosity, development (personally, professionally and academically) and encourage the aspiration which must underpin service transformation. Training is a narrower endeavour, promoting discipline, but encouraging rigidity and inhibiting development. The interventions described by Gould and Chamberlain and Huang et al. fulfil the criteria of education; however, the Geneva initiative, and others that it has stimulated such as the CleanYourHandsCampaign in England and Wales, represent training because of their heavy reliance on audit with performance feedback as the drivers for behaviour change. Educational initiatives are resource intensive and expensive, but if well-designed and well-implemented, have the potential to effect sustainable change. Training is less expensive but its effects are likely to be short-lived and influenced by staff turnover and shortage, because health workers are coached to undertake a repetitive set of activities rather than problem-solve. Future ventures to increase hand hygiene compliance should state explicitly whether they are employing education or training, with underlying rationale. This would pave the way towards the development of strong theoretical frameworks, which are essential for the external validity, and generalisability of study findings. Descriptions of educational interventions should include: rationale for choice of educational approach and venue; who delivered the education and their preparation; programme content; numbers of health workers attending; evaluation; changes necessary to the planned programme; and their impact. Studies geared towards training that involve audit with performance feedback should indicate the nature of the audit tool and how feedback was provided.

In conclusion, initiatives to enhance hand hygiene compliance lack rigour. Existing study designs are inherently weak. Possible alternatives are insufficiently robust because the many contextual variables likely to influence hand hygiene compliance and HAI rates are not amenable to control. Future studies must combine the expertise of clinical scientists with that of behavioural scientists able to include qualitative analysis of contextual factors into the analysis of findings. Interventions intended to improve compliance are poorly articulated and not grounded in theoretical frameworks necessary for external validity.

Conflict of interest statement
D.J.G. co-authored one of the studies included in this review.

Funding sources
None.
Appendix 1: Analysis of the research design of excluded studies

The studies were summarised by annotating the data collection points as recommended by Cook and Campbell.8

O, data collection point; X, the intervention.

Studies with few/no baseline data

Maury et al.17: X O1
Panhotra et al.18: X O1 O2 O3 O4n
Thomas et al.19: O1 X1 X2 O2 (baseline data were collected in one of the participating units only)

Uncontrolled before-and-after study designs

Baker20: O1 X O2, O3
Berg et al.21: O1 X O2
Brown et al.22: O1 X O2
Coignard et al.23: O1 X O2
Creedon24: O1 X O2
Diekema et al.25: O1 X O2 O3 O4
Dorsey et al.26: O1 X O2
Dubbert et al.27: O1 X O2
Earl et al.28: O1 X O2 O3
Graham29: O1 X O2
Hughes et al.30: O1 X O2
Lam et al.31: O1 X O2
Mareni et al.32: O1 X O2
McGuckin et al.33: O1 X O2
Muto et al.34: O1 X O2
Prieto and Macleod-Clark et al.35: O1 X O2 O3
Salem et al.36: O1 X O2 O3 O4 O5
Shaw and Tanner et al.37: O1 X O2
Van de Mortel and Heyman38: O1 X O2
Van de Mortel et al.39: O1 X O2 O3
Won et al.40: O1 X O2 O3

Interrupted time-series designs (less than three data entry points before/after each intervention)

Conly et al.41: O1 O2 X O3 O4
Donowitz42: O1 O2 X O3 O4
Raju and Kobler43: O1 O2 X O3 O4 O5

Uncontrolled before-and-after study designs with sequential data collection

Pittet et al.6 with Hugonnet et al.7 comprising a unit: O1 X O2 O3 X2 X3 O4 Xn O4

Controlled before-and-after study designs with one intervention and one control site

Mayer et al.54
Larson et al.55
Larson et al.56
Larson et al.57
Bittner et al.58
Colombo et al.59

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