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# Implementation of MRSA Infection Prevention and Control Measures – What Works in Practice?

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## 1. Introduction

There have been increasing numbers of media reports about careless behaviour by healthcare workers, mainly involving insufficient cleaning practices and the absence of hand hygiene measures (Boyce, 2009). Although adherence to infection prevention and control measures has received a lot of attention in the media and in scientific literature, surprisingly little attention has been given to the implementation of the infection prevention and control strategies in healthcare practices. In the medical literature the focus is on the availability of national or regional MRSA surveillance data and guidelines for prevention and control. To date hardly any data has been made available about the kinds of interventions that have been successful in implementing infection prevention and control.

Research has shown that an intensive infection prevention programme could prevent about one-quarter to one-third of all hospital infections (Sengers et al., 2000). An example of such a successful policy is the 'search-and-destroy' strategy that has been introduced in the Netherlands, to prevent the spread and outbreak of infections caused by multi-resistant bacteria such as Methicillin Resistant Staphylococcus Aureus (MRSA). However, adherence to this policy still remains a problem. It is known from prior research (van Gemert et al., 2005; Verhoeven et al., 2009) that healthcare workers are insufficiently aware of infection control measures; they do not understand the rationale behind these measures and think that infection control is not their problem, that it is mainly an issue for hygiene experts.

Research in the social sciences has shown that improving safety in hospitals requires a tailored strategy to persuade people to change their attitudes and behaviours (Fogg, 2003). Furthermore, changing routines and habits in healthcare is not easy: it requires an integral approach, with activities addressing human behaviour, culture, incentives and other managerial reinforcement activities, and of course adequate information about safety regulations (Foy et al., 2001; Van Gemert et al., 2005; Verhoeven et al., 2009). A multifaceted implementation strategy might be a solution (Foy et al., 2001, Pittet et al.,

2000). Such a strategy should include interventions aimed at different levels: the management of healthcare institutions, the behaviour of healthcare workers and the quality of the infection control guidelines. However, what empirical evidence exists for a multi-faceted implementation strategy? And how successful are these strategies? To investigate this, we conducted a systematic literature review. This review will be used to develop an implementation strategy that fits the habits and culture of hospital-based healthcare workers (HCWs) in hospital care settings. In this review, we searched for empirical studies to investigate and identify effective implementation strategies for improving adherence to MRSA prevention and control measures. The following questions guided our review of the literature:

- What implementation strategies are used?
  - What is the foundation of these strategies (theories, experience, etc.)?
- What research designs were used to measure the effects of the implementation strategies?
- What effects are reported?
  - On adherence to the measures?
  - On the reduction of costs?
  - On the reduction of MRSA?

## 2. Method of the systematic review

The York protocol for systematic reviews (Centre for Reviews and Dissemination, 2001) was used to guide the review process. Literature searches were carried out in the online databases Scopus, ISI Web of Knowledge and the Cochrane Library. In addition, we hand-searched the indexes of the *Journal of Hospital Infection* (JHI), the *American Journal of Infection Control* (AJIC) and *Clinical Microbiology and Infection* (CMI) for relevant publications. We searched for studies describing the implementation of MRSA prevention or control measures. The publications were included in the review if they met the inclusion criteria listed in Table 1. Most important was that the publications described an implementation strategy and implementation outcomes. Two independent reviewers (NdJ, JW) applied the inclusion criteria to the publications in a title screening round, followed by an abstract and a full-text screening round. After each round, the reviewers compared their judgments and resolved discrepancies through discussion. The included studies are summarized in a data table, and the study features and results are summarized and compared. Due to the heterogeneity of the data and the limited number of included studies, no meta-analysis was performed.

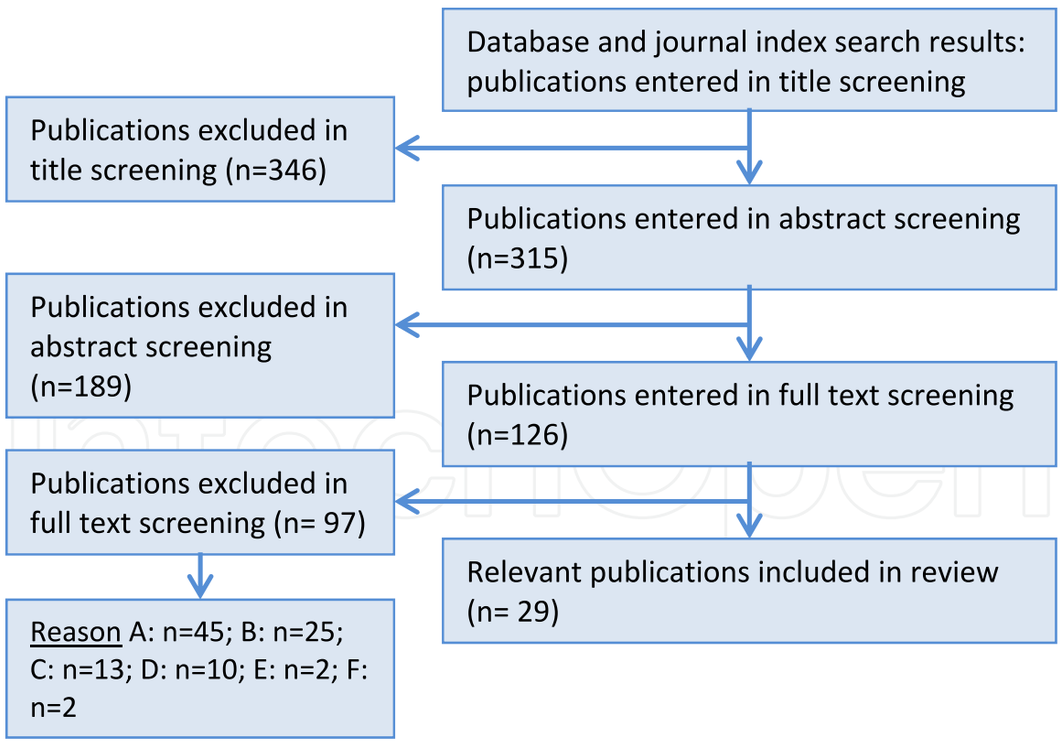
## 3. Results of the systematic review

### 3.1 Article screening

The search strategy resulted in 661 potentially relevant publications (after duplicates were removed). The screening process and outcomes are shown in Figure 1; 29 publications were included in the review. The characteristics of these publications are summarized in Table 2. The characteristics and outcomes of the included studies are discussed in the following sections. The numbers we cite correspond to the publications summarized in Table 2.

| Inclusion Criteria |
|---|
| *Publication Type* |
| (Scientific) Journal article, published between 2005-2010 |
| *Scope of Studies* |
| Implementation of an evidence-based MRSA prevention or control measure. The implementation strategy must be described. |
| *Study Settings* |
| Primary-/secondary-care facilities, long-term care facilities, nursing homes |
| *Outcome measure* |
| Implementation outcomes (mostly behavioural) must be given.<br>• Behavioural (e.g. adherence to implemented measure, knowledge)<br>• Clinical (e.g. prevalence rates, infection rates, deaths)<br>• Organizational (e.g. changes in Length of Stay (LoS), expenditures, costs) |

Table 1. Inclusion Criteria




A: Insufficient implementation strategy information. B: No Compliance rates; no implementation results described. C: Article is a Viewpoint/Review. D: Article was not written in English. E: Article is a report of Conference Proceedings. F: Other.

Fig. 1. Results of the screening process

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 1: Baldwin, et al., 2010, Ireland | Educational meetings<br>Local opinion leaders<br>Audit and feedback<br>Technology supported<br>*Implementation foundation*<br>Theoretical: absence of IC research in nursing home setting<br>*Infection control measure*<br>Hand hygiene<br>Environmental hygiene<br>Personal protective equipment<br>*Design*<br>RCT | **Behavioural**<br>*In-person observations*<br>Mean audit score was higher in the intervention than in the c 12 months.<br>**Clinical**<br>MRSA positive screenings were similar in intervention and c 12 months.<br>MRSA prevalence rates among staff were similar in interven months and 12 months. |
| 2: Bassetti, et al., 2009, Italy | Audit and feedback<br>AB permission<br>Formulary restrictions<br>Clinical multidisciplinary teams<br>*Infection control measure*<br>Medication<br>*Design*<br>Time series design | **Behavioural**<br>Significant reduction in cephalosporins use.<br>Significant increase in ciprofoxacin use.<br>**Clinical**<br>Significant reduction in MRSA due to intervention.<br>An increase in susceptibility to piperacillin/ tazobactam obs in P. aeruginosa isolates ceased after the change in antibiotic<br>Increase in susceptibility to ciprofloxacin in K. pneumoniae i although an abrupt change in the percentage of susceptible i intervention.<br>Decrease in susceptibility to piperacillin/tazobactam and im an increase in susceptibility to ciprofloxacin in P. aerugionos surveillance period, with no significant changes due to interv |
| 3: Burkitt, et al., 2010, United States | Educational meetings<br>Reminders<br>Mass media<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: lack of measurement of actual changes in knowledge due to education<br>*Infection control measure*<br>Hand hygiene<br>Personal protective equipment<br>Patient screening<br>Patient isolation<br>*Design*<br>Before and after design | **Behavioural**<br>*Questionnaires*<br>Significant increase in proportion of respondents who report than soap and water to clean their hands.<br>Significant increase in mean number of knowledge questions<br>Significant increase in proportion of respondents who agree problem in their unit.<br>Significant increase in proportion of respondents who report staff about proper hand hygiene and contact precautions.<br>Significant decrease in job satisfaction. Significant increase in reported using prevention practices.<br>Significant increase in proportion of respondents reporting a hygiene, primarily because they feared that hand rubs or soa forgot to perform hand hygiene. |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 4: Camins & Fraser, 2005, United States | Distribution of educational materials<br>Educational meetings<br>Local opinion leaders<br>Audit and feedback<br>Reminders<br>Rewards<br>*Implementation foundation*<br>Theoretical: CDC Hand Hygiene Task Force recommendations<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design | **Behavioural**<br>*Observations in person*<br>Hand hygiene compliance increased from 1st to 4th quarter o observed compliance not given). |
| 5: Carboneau, et al., 2010, United States | Distribution of educational materials<br>Educational meetings<br>Local opinion leaders<br>Audit and feedback<br>Reminders<br>Mass media<br>Changes in physical structure, facilities and equipment<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: prior research solutions, including scientific articles and at other hospital<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design | **Behavioural**<br>*Observations in person*<br>Hand hygiene compliance increased from 17-months pre-int<br>**Clinical**<br>Decrease in MRSA-positive cases from 17 months pre-interv decrease in invasive MRSA cases.<br>**Financial**<br>Net dollar savings due to MRSA infection prevention of US $ 2006 to September 30, 2007)<br>41 MRSA infections were prevented during study period, the in a savings of $354,276, a net hard-dollar savings of $276,500<br>Increased hand sanitizer costs of $40,000 per year. |
| 6: Cheng et al., 2009, China | Educational meetings<br>Educational outreach<br>Audit and feedback (trained auditors)<br>Reminders<br>Mass media<br>Clinical multidisciplinary teams<br>Changes in physical structure, facilities and equipment<br>*Infection control measure*<br>Hand hygiene<br>Patient isolation<br>*Design*<br>Before and after design Time series design | **Behavioural**<br>*Observations in person*<br>Increased hand hygiene adherence.<br>Increased use of alcohol-based hand rub.<br>**Clinical**<br>Decreased MRSA infection rates<br>Change in ICU onset MRSA infections between phase 1 and and 3 (hand hygiene campaign). |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 7: Davis, 2010, United Kingdom | Reminders<br>Mass media<br>*Duration*<br>6 months<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design | **Behavioural**<br>*Video observations*<br>Significant increase in hand hygiene compliance of HCWs bu<br>no significant increase for patients.<br>**Clinical**<br>Decrease in MRSA incidence (from 2 to 0 cases during 6-mor<br>MRSA incidence (from 0 to 2 cases during 6-month periods). |
| 8: Eveillard, et al., 2006, France | Educational meetings<br>Educational outreach<br>Audit and feedback<br>Reminders<br>Mass media<br>Changes in physical structure, facilities and equipment<br>*Implementation foundation*<br>Empirical: existing programme to limit the spread of MRSA was not effective<br>*Infection control measure*<br>Hand hygiene<br>Patient screening<br>*Design*<br>Before and after design Time series design | **Behavioural**<br>Increase in use of waterless alcohol-based hand disinfectants<br>In 2004, the use of alcohol-based hand disinfectants was twic<br>risk wards.<br>*Questionnaire*<br>46% of 450 employees declared they had attended at least on<br>Number of patients screened on admission or after intra-hos<br>**Clinical**<br>Decrease in the incidence of newly acquired MRSA infection<br>Decrease in the incidence of risk of acquisition.<br>Decrease in proportion of acquired MRSA.<br>Number of MRSA carriage on admission did not increase.<br>Proportion of MRSA/total S. aureus within the first 48 hours |
| 9: Fowler, et al., 2010, England | Audit and feedback<br>Reminders<br>*Implementation foundation*<br>Theoretical: systematic reviews on improving AB prescribing and feedback<br>*Infection control measure*<br>Medication<br>*Design*<br>Time series design | **Behavioural**<br>Significant decrease in targeted ABs: Cephalosporins and Ar<br>Significant increase in the long-term trend of benzyl penicilli<br>Significant increase in level of amoxicillin.<br>Non-significant change in trend (not reversed long-term).<br>Non-significant change in level and trend of trimethoprim.<br>**Clinical**<br>Significant decrease in CDI (clostridium difficile infection) ar<br>Non-significant change in MRSA infections.<br>Non-significant change in crude mortality.<br>**Financial**<br>No change in length of stay throughout study. |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 10: Gagné, et al., 2010, Canada | Distribution of educational materials<br>Educational outreach<br>Patient-mediated interventions<br>Mass media<br>*Implementation foundation*<br>Empirical: own observation that MRSA kept spreading despite staff decontamination<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design | **Behavioural**<br>*Observations in person*<br>Increase in overall staff hand hygiene compliance.<br>**Clinical**<br>Decrease in MRSA infections vs. positive screenings.<br>Decrease in MRSA infections.<br>**Financial**<br>Based on comparative year, 51 cases of infection were preven<br>savings of CAN$688,843. |
| 11: Gillespie, et al., 2007 Australia | Audit and feedback<br>Reminders<br>Mass media<br>Changes in physical structure, facilities and equipment<br>*Infection control measure*<br>Hand hygiene<br>Patient screening<br>*Design*<br>Before and after design | **Behavioural**<br>Exact compliance rate unclear, but all staff/family entering w<br>of non-compliance; compliance is assumed to be close to 100<br>**Clinical**<br>MRSA acquisition rate decreased.<br>Resistance increased, due to a clonal outbreak of rifampicin-r |
| 12: Goodman, et al., 2008, United States | Educational meetings<br>Audit and feedback<br>Changes in physical structure, facilities and equipment<br>*Implementation foundation*<br>Other: development of a novel and nontoxic tracking marker that is visible only under UV lamp<br>*Infection control measure*<br>Environmental hygiene<br>*Design*<br>Before and after design | **Behavioural**<br>*Observations in person*<br>Mark removal was more frequent during the intervention pe<br>Additional predictors of mark removal included type of ICU<br>No difference in the effect of the intervention between surgic<br>**Clinical**<br>Type of ICU was predictive of positive surface-culture result<br>Multivariate models showed significant intervention effect, w<br>VRE contamination when cultures were used as the unit of a<br>room.<br>No direct association between the removal of the mark from<br>the surface culture would yield MRSA or vancomycin-resista<br>Multivariate models assessing the proportion of marks remo<br>positive cultures for every 10% increase in the proportion of |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 13: Grayson, et al., 2008, Australia | Distribution of educational materials<br>Educational meetings<br>Audit and feedback<br>Mass media<br>Technology-supported<br>*Implementation foundation*<br>Empirical: prior success of a single-site HHCCP<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design Time series design | **Behavioural**<br>*Observations in person*<br>Pilot programme: significant increase in hand hygiene comp<br>sites showed some transient declines in compliance (related<br>Pilot programme: alcohol-based hand rubs (ABHRS) increas<br>hygiene compliance.<br>*Observations in person*<br>State-wide: significant increase in hand hygiene compliance<br>*Material use*<br>State-wide: ABHRS increased, but correlated only roughly w<br>**Clinical**<br>Pilot group: significant decrease of patients with MRSA bact<br>number of clinical MRSA cases.<br>State-wide: decrease in patients with MRSA bacteremia.<br>Significant decrease in the number of clinical MRSA isolates,<br>HHCCP. |
| 14: Harrington, et al., 2007, Australia | Educational meetings<br>Audit and feedback<br>*Duration*<br>24 months<br>*Infection control measure*<br>Hand hygiene<br>Other (sign put up in case of MRSA)<br>*Design*<br>Time series design | **Behavioural**<br>*Observations in person*<br>Overall rate of usage of the standard of all products increase<br>**Clinical**<br>New patients with MRSA in the ICU decreased.<br>Hospital-wide rate of new patients with MRSA decreased.<br>MRSA central line-associated bloodstream infection (CLABS<br>Decrease in hospital-wide rate of episodes of MRSA bacteren |
| 15: Holder & Zellinger, 2009, United States | Educational meetings<br>Educational outreach<br>Local opinion leaders<br>Audit and feedback<br>*Duration*<br>2 months<br>*Infection control measure*<br>Medication (chlorhexidine baths)<br>*Design*<br>Time series design | **Behavioural**<br>*Patient documentation*<br>Compliance with bathing procedure increased.<br>**Clinical**<br>Bloodstream infection (BSI) rates decreased after implementa<br>procedure.<br>Rate of MRSA/VRE colonization decreased after implementa<br>procedure.<br>**Financial**<br>75% reduction in BSIs over 6 months and increased costs per<br>$1.56 million per year if chlorhexidine baths were used in all |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 16: Huang, et al., 2006, United States | Educational meetings<br>Audit and feedback<br>Reminders<br>Rewards<br>Changes in physical structure, facilities and equipment<br>*Duration*<br>Sterile CVC placement: 10 months. Alcohol-based hand rubs: 1 month. Hand hygiene campaign: 14 months. Routine surveillance: 12 months<br>*Infection control measure*<br>Hand hygiene<br>Personal protective equipment<br>Patient screening<br>Patient isolation<br>*Design*<br>Before and after design Time series design | **Behavioural**<br>*Observations in person*<br>ABHR institution and hand hygiene campaign increased con<br>decreased thereafter.<br>*Lab statistics (PD)*<br>Routine MRSA surveillance caused increase in compliance af<br>for admission and weekly nares cultures.<br>**Clinical**<br>Campaign to promote sterile CVC precautions caused substa<br>associated bacteremia in ICUs.<br>Among the interventions, only routine ICU MRSA surveillan<br>decrease in the incidence density of MRSA bacteremia.<br>After 16 months, routine screening was associated with a dec<br>density in ICUs, in non-ICUs, and hospital-wide.<br>Routine screening was associated with a decrease in hospital<br>non-ICUs, and hospital-wide. All findings were statistically s<br>Routine surveillance caused significant reduction in MRSA a<br>first and last halves of the intervention period, exclusive of th<br>stable MRSA importation rate into ICUs.<br>No significant secular trend and no impact of any infection c<br>methicillin-susceptible S. aureus (MSSA) bacteremia. |
| 17: Johnson, et al., 2005, Australia | Distribution of educational materials<br>Audit and feedback<br>Reminders<br>Mass media<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: scientific articles<br>*Duration*<br>36 months<br>*Infection control measure*<br>Hand hygiene<br>Environmental hygiene<br>Patient screening<br>HCW screening<br>Environmental screening<br>*Design*<br>Time series design | **Behavioural**<br>*Observations in person*<br>Overall hand hygiene compliance improved at 4 months, and<br>months.<br>In individual sentinel areas, compliance rates improved sign<br>months post-intervention in all areas.<br>Use of ABHRS products increased in all sentinel areas.<br>**Clinical**<br>MRSA colonization rates did not change in any of the sentine<br>worker MRSA colonization did not decrease in sentinel areas<br>Environmental contamination did not change significantly d<br>Significant decline in total clinical MRSA infections per 100 p<br>For patient episodes of MRSA bacteremia, the monthly rate c<br>period was static, but fell significantly in the post-interventio<br>monthly rate of MRSA bacteremia had decreased.<br>Total clinical isolates per month of ESBLs increased during th<br>had fallen by more than 90% by the 36th month of OCS. |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 18: Kho, et al., 2008, United States | Reminders<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: low compliance (delay) associated with manual/paper-based information systems; computerized reminders appear promising<br>*Duration*<br>12 months<br>*Infection control measure*<br>Patient isolation<br>*Design*<br>Before and after design | **Behavioural**<br>*Computer logs*<br>Significant increase in proportion of correct contact isolation o<br>Mean time between ward arrival and isolation order decrease<br>Acceptance of the reminder increased.<br>*Questionnaire*<br>19/20 survey respondents reported that the reminder either h<br>saved them time.<br>25/27 agreed with automatic contact isolation, and half of thes<br>surveillance swabs.<br>**Clinical**<br>*Lab statistics*<br>During the intervention period, the number of patients with k<br>reflected an increased ability of the IC service to both identify<br>trend of MRSA/VRE increased during the study (no significa<br>intervention<br>**Financial**<br>Annual isolation gown expenditures increased 23% from the s<br>US$167,000 to US$205,000).<br>No calculations of cost savings in prevented nosocomial infect |
| 19: Kurup, et al., 2010, Singapore | Educational meetings<br>Audit and feedback<br>Reminders<br>Mass media<br>*Duration*<br>12 months<br>*Infection control measure*<br>Hand hygiene<br>Patient screening: Active Surveillance Testing (AST)<br>Patient isolation<br>*Design*<br>Before and after design | **Behavioural**<br>Between groups: compliance in performing all study-related s<br>Surgical ICU (SICU), but the difference between the ICUs was<br>**Clinical**<br>AST detected MRSA in at least 137 of the 653 patients (21.0%).<br>were positive in only 12 patients (1.8%).<br>No significant overall improvement in detection rate when inclu<br>No improvement in detection rate in patients admitted to Me<br>SICU.<br>Inclusion of axilla and groin sites did not affect the MRSA det<br>discharge, both overall and when the ICUs were analysed ind<br>Between groups: the rate of MRSA colonization detected by A<br>discharge was higher in SICU than MICU.<br>No significant difference in MRSA infection rate pre- and post<br>when analysed individually.<br>Less variability in MRSA rates post-intervention; the 95% CI a<br>that at pre-intervention.<br>Septic shock at ICU admission was more common in MRSA-c<br>patients.<br>**Financial**<br>Detection of MRSA at any point was associated with longer pr<br>antibiotic therapy, and longer ICU length of stay. |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 20: Lederer, et al., 2009, United States | Distribution of educational materials<br>Audit and feedback<br>Reminders<br>Mass media<br>Clinical multidisciplinary teams<br>*Implementation foundation*<br>Theoretical and empirical: CDC recommendations and observed low compliance<br>*Duration*<br>10 months<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design Time series design | **Behavioural**<br>Increased hand hygiene compliance with sustained rates gre<br>**Clinical**<br>MRSA healthcare-associated rate decreased, representing a 5<br>compliance. |
| 21: Lee, et al., 2009, Canada | Educational meetings<br>Technology-supported<br>*Implementation foundation*<br>Empirical: SARS outbreak in Toronto in 2003, the Ontario Ministry of Labour mandated an IC education programme for all Mount Sinai Hospital staff<br>*Duration*<br>1 month<br>*Infection control measure*<br>Hand hygiene<br>Personal protective equipment<br>*Design*<br>Before and after design | **Behavioural**<br>Non-significant increase in hand hygiene compliance on inpa<br>Annual volume of ABHRS purchased by the hospital.<br>**Clinical**<br>Significant decrease in nosocomial MRSA acquisition rate pe<br>Significant decrease in nosocomial MRSA acquisition rate pe |
| 22: Liebowitz & Blunt, 2008, United Kingdom | Educational meetings<br>Audit and feedback<br>Clinical multidisciplinary teams<br>*Implementation foundation*<br>Theoretical: prior research, no studies have been published in which the use of both classes of antibiotics has been discouraged. No foundation for content educational activity.<br>*Duration*<br>2 months<br>*Infection control measure*<br>Medication<br>*Design*<br>Time series design | **Behavioural**<br>Hospital-wide decrease in level of dispensing of intervention<br>ICU-specific decrease in level of dispensing of intervention d<br>**Clinical**<br>Decrease in level of MRSA-positive screenings (no statistical<br>MRSA colonization in screening specimens from high-risk pa<br>Decrease in level of MRSA-positive screenings (no statistical |

| Author, Year, Country | Implementation strategy | Reported Findings (behavioural, clinical, fin |
|---|---|---|
| 23: Madaras-Kelly, et al., 2006, United States | Reminders<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: The Society for Healthcare Epidemiology of America (SHEA) recommendations<br>*Duration*<br>12 months<br>*Infection control measure*<br>Medication<br>*Design*<br>Time series design | **Behavioural**<br>Non-significant decrease of overall AB use.<br>Significant decreases in the use of several antibiotics.<br>Significant differences between non-antibiotic variables: purcha increased; the number of ventilator days, purchase of alcohol fo Total fluoroquinolone and levofloxacin use decreased signifi<br>**Clinical**<br>Decrease in nosocomial MRSA infections (not statistically tes |
| 24: Miyachi, et al., 2007, Japan | Local opinion leaders<br>Audit and feedback<br>Mass media<br>*Implementation foundation*<br>Theoretical: prior research on link nurses in large hospitals<br>*Duration*<br>76 months<br>*Infection control measure*<br>Hand hygiene<br>Other, non-specified<br>*Design*<br>Before and after design | **Behavioural**<br>Significant increase in arithmetic mean of monthly consump<br>**Clinical**<br>Percentage of MRSA in Staphylococcus Aureus increased.<br>Monthly counts of new MRSA cases dropped in 15 of 25 war<br>Significant decrease in the monthly number of inpatient adm |
| 25: Nicastri, et al., 2008, Italy | Educational outreach<br>Clinical multidisciplinary teams<br>*Infection control measure*<br>Medication<br>*Design*<br>Time series design | **Behavioural**<br>Significant reduction of defined daily doses (DDD) of cephal<br>A clinical audit 12 months after introduction of Antibiotic St showed >90% adherence by the physicians (no statistical test<br>**Clinical**<br>Significant decrease of MRSA isolations.<br>Significant correlation between MRSA monthly prevalence r third-generation cephalosporins.<br>Significant reduction of isolation of MRSA from surgical site in (BSI). Significant decrease in MRSA prevalence among Staphy<br>Significant reduction of MRSA prevalence both in Staphyloco respiratory specimens of patients affected by ventilator-associa |
| 26: O'Brien, et al., 2008, United States | Educational meetings<br>Reminders<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: SHEA recommendations<br>*Duration*<br>12 months<br>*Infection control measure*<br>Patient screening<br>*Design*<br>Before and after design | **Behavioural**<br>Post-IT admission culture rate in the telemetry unit was >91<br>Intermediate Care unit.<br>Employee satisfaction with the MRSA surveillance protocol was of the respondents were "fully satisfied", the remaining 12% we<br>Increased efficiency of staff time use.<br>**Clinical**<br>Overall decrease in the rate of MRSA acquisition in the pre-I period was statistically significant.<br>Significant decrease in 2 of 3 unit specific comparisons before |

Table 2. Characteristics of the studies included in the systematic review

| Author, Year, Country | Implementation strategy | Reported Finding (behavioural, clinical, fi |
|---|---|---|
| 27: Peterson, et al., 2010, United States | Distribution of educational materials<br>Educational meetings<br>Educational outreach<br>Local opinion leaders<br>Audit and feedback<br>Reminders<br>Changes in physical structure, facilities and equipment<br>Technology-supported<br>*Implementation foundation*<br>Theoretical: Institute for Healthcare Improvement's (IHI) five components to MRSA control<br>*Duration*<br>24 months<br>*Infection control measure*<br>Patient screening<br>*Design*<br>Before and after design | **Behavioural**<br>Screening compliance increased to >90%, and sustained >9<br>**Clinical**<br>Decrease in MRSA transmission (from colonization to infec<br>Decrease in overall MRSA BSIs by the end of the first year.<br>**Financial**<br>Programme cost represented a net expense of $15-$16 per a<br>a reduction of nearly $1,200,000 in medical expenditures, w |
| 28: Robert, et al., 2006, France | Distribution of educational materials<br>Reminders<br>Mass media<br>*Implementation foundation*<br>Theoretical: observational studies indicated that isolation precautions were poorly implemented outside ICUs<br>*Duration*<br>3 months<br>*Infection control measure*<br>Patient isolation (Flagging records)<br>*Design*<br>Before and after design | **Behavioural**<br>Within groups: medical and nursing staff reported that they<br>87% of cases in the control period, and in 96% of cases in th<br>Medical and nursing records were flagged significantly mo<br>the control period.<br>The set of four organizational measures was implemented r<br>than in the control period. The same observation was made<br>separately.<br>When considering only ICUs and rehabilitation units, i.e. w<br>significant increase in the implementation of isolation preca<br>often, use of gowns increased, use of dedicated materials in<br>increased, and proportion of MRSA patients in private roor<br>There was no significant increase in the proportion of healt<br>status of patients or in the proportion of flagged records. |
| 29: Thomas, et al., 2005, United States | Reminders<br>Mass media<br>*Implementation foundation*<br>Theoretical: research on hand hygiene posters<br>*Duration*<br>12 months<br>*Infection control measure*<br>Hand hygiene<br>*Design*<br>Before and after design | **Behavioural**<br>Increase in hand hygiene compliance over all units.<br>Participants agreed that, overall, posters had a positive influe<br>units. More so when poster displayed 'human qualities' or p |

### 3.2 Study design

Among the included studies, there was one randomized controlled trial (RCT) (1). In eight studies, a time series design was used (2, 9, 14, 15, 17, 22, 23, 25), and in fourteen studies a before and after design was used (3, 4, 5, 7, 10-12, 18, 19, 21, 26-29). Five studies applied a combination of time series and before and after design (6, 8, 13, 16, 20).

### 3.3 MRSA prevention and control measures

Different measures were implemented to prevent or control MRSA. In some studies a single MRSA prevention or control measure was implemented, in others a bundle of measures was implemented. *Hand hygiene* was implemented as a stand-alone measure in seven studies (4, 5, 7, 10, 13, 20, 29) and as part of a bundle of measures in eleven studies (1, 3, 6, 8, 11, 14, 16, 17, 19, 21, 24). *Environmental hygiene* was implemented as a stand-alone measure in one study (12) and as part of a bundle of measures in two studies (1, 17). The use of *personal protective equipment* such as gloves or gowns was implemented as part of a bundle of measures in four studies (1, 3, 16, 21); it was implemented as a stand-alone measure in none of the studies. *Medication*, or the correct use of antibiotics, was implemented as a stand-alone measure in six studies (2, 9, 15, 22, 23, 25); in none of the included studies was it part of a bundle of measures. In two studies (26, 27), *patient screening* was implemented as a stand-alone measure, and in six studies (3, 8, 11, 16, 17, 19) it formed part of a bundle of measures that was implemented. *HCW screening* was implemented only as part of a bundle of measures, in one study (17). *Patient isolation* was implemented as stand-alone measure in one study (28), and was part of a bundle of measures in five studies (3, 6, 16, 18, 19).

### 3.4 Implementation strategies and their foundation

Various strategies were used to implement the MRSA prevention and control measures. Most implementation strategies are set up because of the empirical observation of non-adherence to clinical guidelines, thus creating an impediment to successful MRSA control. The theoretical foundation of the chosen strategies is often unclear, or not specified.

Most studies, 24 out of 29, combined different elements (1-17, 19, 20, 22, 24, 25, 26, 27). In five studies the implementation strategy consisted of one component (18, 21, 23, 28, 29). The strategies used are summarized below:

- *Audit and feedback* was performed and given by trained nurses or auditors, infection control specialists, or multidisciplinary teams (nineteen studies: 1, 2, 4-6, 8, 9, 11-17, 19, 20, 22, 24, 27).
- *Reminders* were used in eighteen studies (3-9, 11, 16-20, 23, 26, 27, 28, 29), for example pop-ups, fluorescent tape drawing attention to hand-cleaning facilities, posters or messages clipped to patient charts.
- *Educational meetings* were held, for example to inform HCWs about the measure or to demonstrate new working methods or hygienic practices (seventeen studies: 1, 3-6, 8, 12-16, 19, 21, 22, 26, 27).
- *Mass media* were used in fourteen studies (3, 5-8, 10, 11, 13, 17, 19, 20, 24, 28, 29); posters, and to a lesser extent brochures or flyers, were used to remind or instruct HCWs about the implemented measures. Role models (hospital management or

leaders) were sometimes depicted, or HCWs were involved in the creation of the poster (11, 17, 29).

- *Technology* was used in ten studies (1, 3, 5, 13, 17, 18, 21, 23, 26, 27), in the context of education (PowerPoint presentations, training via DVD), electronic order forms, pop-ups assisting medication choice or screening of patients.
- *Changes in physical structure, facilities and equipment* were applied in eight studies (4, 5, 6, 8, 11, 12, 16, 27). These changes included strategically placed hand disinfectant dispensers, equipping HCWs with pocket bottles of hand disinfectant, or new cleaning materials (cloths), the bundling of protective gear and the availability of a test kit for screening.
- *Educational materials* were distributed in eight studies (4, 5, 8, 10, 13, 17, 20, 27). Brochures, newsletters or instructional pocket cards were given to HCWs, often focused on applying correct (hand) hygiene.
- *Local opinion leaders* guided the implementation process in six studies (1, 4, 5, 15, 24, 27), sometimes by reinforcing good infection control, or acting as a link worker between the professions and management.
- *Clinical multidisciplinary teams* were used in five studies (2, 6, 20, 22, 25) to guide the implementation of a MRSA control measure. Via cooperation or consultation these teams supported the measures taken, for example by approving antibiotic prescriptions.
- *Educational outreach* was carried out in five studies (6, 10, 15, 25, 27) to teach HCWs on-site and sometimes on demand how to apply the implemented measure.
- *Rewards* for correctly performing the implemented measures were given in two studies (4, 16), either to individuals directly after observing correct behaviour, or to groups based on periodic adherence results.
- A *patient-mediated intervention* was implemented in one study (10); patients and visitors were actively addressed to perform the desired hand hygiene behaviour and motivate adherence among staff.
- *AB permission/formulary* was applied in one study (2) where permission to use a certain antibiotic was required.

### 3.5 Outcomes

We classified the reported effects into three categories: adherence to the measures, reduction of costs and reduction of MRSA.

In twelve studies (1-3, 7, 9, 12, 13, 17, 18, 24, 28) significant improvements (e.g. fewer prescriptions for antibiotics, more correctly executed hand hygiene, reduced expenditure on materials) in adherence to the MRSA control measures were observed. Similar positive results were observed in fourteen studies (4-6, 8, 10, 14-16, 20, 22, 23, 25, 27, 29), although these results were not statistically tested. In one of the studies (16), negative effects were observed: adherence to the measures increased in the first year but decreased thereafter.

Acquiring a hospital-associated infection (HAI) results in a longer length of stay for the patient and poses many additional *costs*. Therefore, reductions in length of stay are an important outcome associated with decreased MRSA infection rates. Cost savings, or at least cost-neutral intervention effects, were observed in four studies (5, 10, 15, 27). On the other hand, increased isolation and increased expenditure also posed costs, as described in one

study (18). However, in this study, these increased costs were not compared to possible savings due to prevented infections. In another study (19), improved screening led to increased lengths of stay (pre-ICU and ICU), because MRSA detection increased.

In nine studies (8, 12-14, 16, 17, 21, 25, 26), significant clinical improvements were reported, including MRSA prevalence, MRSA infection rates and susceptibility rates. Positive effects were also observed in eleven other studies (2, 5, 7, 10, 11, 15, 20, 22-24, 27), although these results were not statistically tested.

## 4. Conclusion and discussion

The results of our review show that in most cases hygiene experts or an infection control team (nurse, infectologist, microbiologist) are the developers of implementation strategies. These strategies are driven by empirical observations and audits. The theoretical foundation of the chosen strategies is often unclear. No references to theories and models of human behaviour are made. However, some articles indicated that a literature search was carried out.

When looking at the implementation strategies, we can conclude that in most cases a multi-faceted strategy was carried out. This strategy entails a combination of several activities:

- Education or training modules for HCWs, sometimes mandatory, taking various forms (DVDs, PowerPoint presentations, posters, meetings, brochures) to improve hand hygiene and compliance with protocols.
- Inspections of the adherence to the safety programme and of hand washing behaviour via audits, on-site instructions, and observations by hygiene experts or trained auditors. Results were communicated to management and demonstrated via feedback meetings.
- Environmental interventions (red lines at the entrance to high-risk wards, talking walls) to remind HCWs to behave safely in that particular area and to provide antibiotic policy support via guidelines and cards.

The implementation pathway consists of *education-inspection-feedback* rounds; unfortunately it is unclear who is responsible for the management of the intervention strategies and who invests in these activities. No business model seems to underpin the entire implementation strategy.

To answer the research question about the effect of the implementation strategies, we reviewed the research designs that were used to measure their effects. In general, quasi-experimental designs (before and after and time series designs) underpin the research activities. Implementation outcomes are usually measured in a before-and-after design, where they do not concern antibiotic use, and therefore provide little insight into temporal changes in implementation results or adherence. HCWs are the main target group in the research designs. It is unclear who these designs seek to manage (researchers, HCWs, management) in their execution or whether a project manager is responsible for this. Trained nurses or infection control teams are sometimes used. In most cases quantitative instruments are used to measure the effects on knowledge and behaviour (questionnaires, self-reporting of behaviour, material use, and hand hygiene) and on a reduction in MRSA and antibiotic doses (lab statistics). The effects on cost/benefits were sometimes measured, addressing utilizations such as reduced length of stay. In general the outcomes are

promising. However, the extent to which the outcomes are related to the implementation strategies is not clear, except for the routine screenings and reduced MRSA rates. The outcomes on cost-savings are especially hard to analyse. It remains unclear what is measured, how it is measured and to what purpose. Long-term effects are almost never addressed.

Due to several shortcomings in research designs, the overall impact of the implementation strategies could not be measured sufficiently. Shortcomings in the research designs include, for example, the one-sided focus on HCWs. We know from prior research (Verhoeven et al., 2009) and from behaviour change models that not only is a multifaceted strategy needed to change safety behaviour, but that a multi-perspective stakeholder view (HCWs, infection experts, patients, the safety policy of the management of the organization) is necessary to obtain insight into the cost/benefits of the implementation strategy and to discuss the long-term implications of the strategy for the organization and workflow (Kukafka et al., 2003). This requires a theory or innovation-driven approach that grounds the implementation strategy, enabling an assessment of which activities are successful for whom (patient, HCWs, management) and what the interaction effects of the different components of the strategy are.

Another shortcoming concerns the chosen study designs. Authors of the included studies refer to the difficulties in matching control and intervention groups, the high rates of drop-outs and the low volume of included respondents, and confounding factors that cannot be excluded. These shortcomings are well-known impediments related to RCTs and the self-reported behaviours. In fact, these shortcomings cannot be avoided due to the study of real-time behaviours and contextual factors that influence these behaviours. Therefore, these factors should not be regarded as nuisances, as the authors do; they are the key issues that are important in implementation studies aimed at changing culture and behaviour. For example, some authors reported problems in implementing the activities due to a lack of resources (a result of the economic downturn) to manage the implementation and problems with measuring the effects of each component of the implementation strategy due to financial constraints. A lack of transparent funding models and lack of management support made the participation of different institutes or wards in the research projects problematic, resulting in only small pilot projects being carried out. These financial barriers should not be reported as shortcomings; rather, these factors should be determined by the key stakeholders and considered as critical factors for changing behaviour and the culture of safety in hospitals or other institutions.

In addition, some authors reported a lack of commitment on the part of nursing personnel to participate in the implementation projects. It appeared that some personnel were uncertain about the implications of several measures. For example, they were concerned that patients would not feel as clean after being washed with wipes instead of soap and water. The level of commitment of HCWs and management is one of the main conditions for success in programmes for innovation or change. The impediments indicate that the implementation strategies are expert-driven rather than stakeholder-centred. Changing safety behaviour in hospitals is first and foremost a cultural problem of management and staff, which requires that implementation strategies should address that level.

How to improve the implementation strategies? Given the fact that the implementation strategies influenced the attitude and knowledge of HCWs in a positive way, that intentions to behave safely increased, and that MRSA rates decreased in several studies, the question is

how to boost the impact of the implementation strategies. *Education-inspection-feedback* rounds could be one way to do this.

Based on prior experience in infection management control and on information gathered from other studies of innovation management (Cain & Mittman, 2002; Rogers, 2003), we argue that the participation of staff and management is crucial to the development and implementation of interventions, to increase applicability, accountability and ownership and to create a fit between the proposed activities and the culture of the organization (Van Gemert et al., in press). In addition, both positive and negative incentives are needed to encourage staff to do the right things at the right times. Change agents and demonstration of best practices will improve the incorporation of safety behaviour. To enhance the transparency of the implementation programme and strategies, communication of results or key factors for success should be available to staff. Communication should include insights into results related to infection management (prevalence and incidence rates of MRSA, identification of increasing/decreasing trends), the business model underpinning the programme (resources, investments, additional costs) and benchmarking (how are we doing and what are others doing?). It is also important to demonstrate to the management and staff that the investment costs of the intervention can be less than the costs of not adopting an MRSA-infection control programme.

Another point of attention is the use of media to implement the strategies. Even though evidence of the usefulness and effectiveness of computerized decision support or reminders exists (Grimshaw et al., 2004), it is not often used. We found that in ten studies DVDs, PowerPoint presentations, educational programmes available online or on CD-ROM, and electronic alerts or reminders were used. This is rather remarkable in our Internet-driven world. Web-based communications systems in particular can increase staff knowledge and provide access to accurate, adequate and easy to understand information (Kreps & Neuhauser, 2010). In prior and on-going research projects aimed at cross-border infection control (MRSA-net; EurSafety Health-net) we developed stakeholder-driven, web-based communication systems, based on national infection control standards, to support staff and patient behaviours (see for example Verhoeven et al., 2009). This resulted in fewer errors, time savings and also appropriate behaviour by HCWs.

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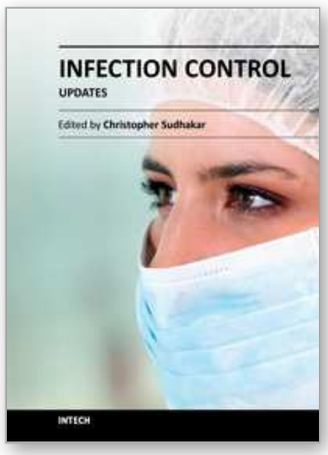


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Health care associated infection is coupled with significant morbidity and mortality. Prevention and control of infection is indispensable part of health care delivery system. Knowledge of Preventing HAI can help health care providers to make informed and therapeutic decisions thereby prevent or reduce these infections. Infection control is continuously evolving science that is constantly being updated and enhanced. The book will be very useful for all health care professionals to combat with health care associated infections.

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