Helping Hands

Strategies to improve hand hygiene compliance in hospital care

Anita Huis

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1

Introduction

INTRODUCTION

Improving patient safety has received growing attention over the past two decades. In today's complex health care systems, patients are at risk for injuries or death as a result of care delivered in hospitals.[1] Doctors, nurses and other health care workers (HCWs) have an obligation to provide a safe environment to protect patients from harm in the course of receiving care. Patient safety is the absence of the potential for or occurrence of health care associated injury to patients.[2] Health care associated injury can be the result of health care providers not following the professional standards, shortcomings of the health care system and/or the patient's behaviour.[3] A Dutch report showed that of the 1.3 million patients admitted to Dutch hospitals in the year 2004, 2.3% were the victim of one or more preventable health care associated injuries, resulting in 1,735 potentially avoidable deaths.[4]

One of the essential contributions towards patient safety is the reduction of hospital-acquired infections (HAIs).[5] Since HAIs can often be avoided by taking preventative measures, including proper application of hand hygiene (HH) principles, optimising adherence to HH guidelines is of paramount importance.[6] A systematic stepwise approach, targeting barriers to change with improvement strategies at different levels (professional, team, patient and organisation), is needed to achieve lasting changes in HH routines.[7]

The objective of this thesis is to summarize existing evidence on HH improvement strategies and to provide information on the development, effectiveness, cost -effectiveness and determinants of success of two different strategies for improving HH behaviour in hospital nurses. These strategies are:

1. A literature based state-of-the-art strategy
2. A theory based team and leaders-directed strategy.

The results of this thesis will contribute to the body of knowledge on effective implementation of HH guidelines by evaluating the added value of HH improvement activities based on principles of social influence and leadership.

This chapter describes the impact of HAIs and delineates the HH rationale and HH practices in health care. Subsequently, we concentrate on a model for implementing change and HH improvement strategies. Finally, this chapter presents an introduction to the individual studies that are part of this thesis.

HOSPITAL ACQUIRED INFECTIONS

A hospital-acquired infection (HAI), also known as a nosocomial infection, is an infection in a patient in whom the infection was not present or incubating at the time of admission and whose development is favoured by a hospital environment. This includes infections acquired in the hospital but appearing after discharge, and occupational infections among staff of the facility. Such infections include fungal and bacterial infections and are aggravated by the reduced resistance of individual patients.[8,9]

HAIs are widespread and affect both developed and resource-poor countries.[6] Recent prevalence surveys in Europe have shown that the percentage of patients affected by HAIs on average is 7.1%, ranging from 3.5% to 10.5%.[10] National surveillance in the Netherlands in 2008 has shown a HAI prevalence rate of 7.2%, affecting 100,000 persons each year.[11]

HAIs are burdensome to patients because they add to functional disability and emotional stress of the patient, reducing the quality of life. These infections result in an increased morbidity and a substantial mortality among hospitalised patients.[12] It has been estimated that, in the European Union alone, approximately 37,000 lives are lost to HAIs each year, with an associated monetary cost of roughly 7 billion Euros, which is mainly attributable to increased length of hospital stay.[10]

Due to a growing awareness of the importance of the problem, which is further stressed by the fight against multiple antibiotic-resistant bacteria, the prevention of HAIs has become a top priority on the European public health agenda.[13,14] This is illustrated by the fact that the World Health Organization's World Alliance for Patient Safety designated the substantial reduction of HAIs as one of their first goals. Good HH is considered the most important measure to reach this goal.[6]

HAND HYGIENE AND INFECTION PREVENTION

Micro-organisms on the hands of HCWs contribute to the incidence of infections in patients because hands are the most convenient transport mechanism for micro-organisms.[15,16] During daily practice, HCWs' hands typically touch a continuous sequence of surfaces and substances. In this way, micro-organisms can spread throughout a hospital environment within a few hours.[17,18] Uncertainty remains about the proportion of HAIs that could be prevented by improved HH compliance. However, there is substantial evidence that increased HH compliance is asso-

ciated with reduced HAIs.[6] It is estimated that 15 to 30% of all HAIs can be prevented by avoiding cross-transmission of micro-organisms through the hands of HCWs.[19-24]

HAND HYGIENE PERFORMANCE

HH is operationalized as 'hand washing with either plain soap and water' or 'hand disinfection through the use of an alcohol-based hand rub solution'.[6] The recommended indications –the required moments for HH—have been formulated by the WHO and are displayed in Figure 1.

HH performed with alcohol-based hand rub is microbiologically more effective and faster than hand washing with soap and water.[25,26] Bacteria are rapidly killed by physical contact with an alcohol-based hand rub solution whereas hand washing with soap and water only removes bacteria. Even worse, some studies showed that

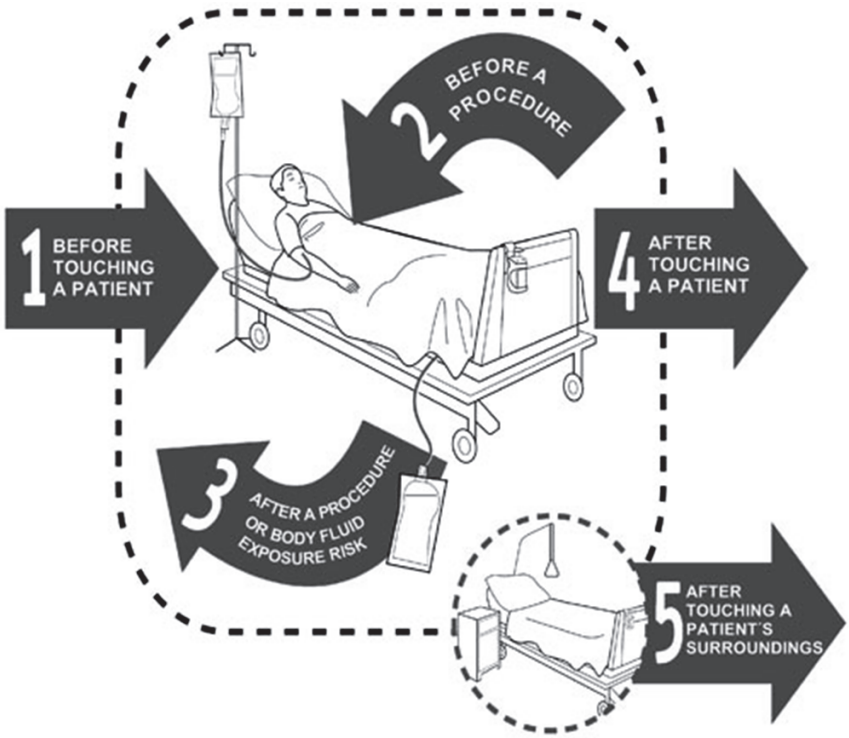

Figure 1. My five moment of hand hygiene *(source: WHO).*

hand washing was associated with considerable skin irritation and dryness which resulted in a paradoxical increase in bacterial counts.[27,28] The effectiveness of an alcohol-based hand rub solution depends on the HH technique used (all areas on the hands must be covered), the applied volume of hand rub (2-3 millilitre) and the adherence to the recommended exposure time (at least 20 seconds).[29,30]

While evidence based guidelines for HH exist, a lack of adherence to these guidelines largely persists, even in the care of patients with diagnosed infections.[31] Compliance with HH recommendations are repeatedly low – representing an overall average of 38.7%.[6,32] Thus, current practice deviates from the goal of providing safe hospital care, aimed at prevention of complications, morbidity and mortality.

IMPLEMENTATION OF CHANGE

Guidelines, best practices or procedures do not usually implement themselves and many efforts are required when introducing guidelines into daily practice.[33,34]

From a general focus on facilitating change in health care practice, Grol and Wensing developed a model for effective implementation (see Figure 2).[34] More than with other models, their stepwise approach takes the user through a series of rational and deliberate steps in order to accomplish practice improvement. The change process begins with the identification of relevant practice issues and matching research findings or guidelines addressing these issues. This match is an essential element in accomplishing change, because without it, implementation might not be justified and members of the target group will likely show strong resistance to change.[33] Then, the implementation model can be applied starting with the description of the innovation that needs to be implemented according to research evidence (step1).

The following two consecutive steps comprise the diagnostic phase. This includes: analysis of current performance (step 2) and identification of factors hindering or stimulating the delivery of optimal care (step 3). These steps are necessary to illuminate what exactly needs to be changed and to provide direction to related improvement activities. The development or selection of strategies (step 4), is facilitated by the previous steps. In this way, the model prevents the selection of standard but inappropriate solutions and facilitates better choices. In the next steps, the developed strategy needs to be tested (step 5) and the cost-effectiveness of the strategy should be examined (step 6). Finally, the results and the process of implementation need to be evaluated in order to understand variation in process

and outcomes and to make adjustments and improvements for the future (step 7). This analytical approach to deliver clear rationale for implementation is an essential feature of the Grol and Wensing model allowing it to be applied in a variety of settings.

CHANGING HAND HYGIENE BEHAVIOUR

To be able to effectively improve compliance with HH recommendations, it is important to use a systematic and stepwise approach that address all relevant barriers.[35] In this thesis, we followed the model of Grol and Wensing to design and test two strategies for improving nurses' adherence to HH guidelines in three Dutch hospitals.[34] The studies described in this thesis refer to step 4 through step 7 of the applied model.

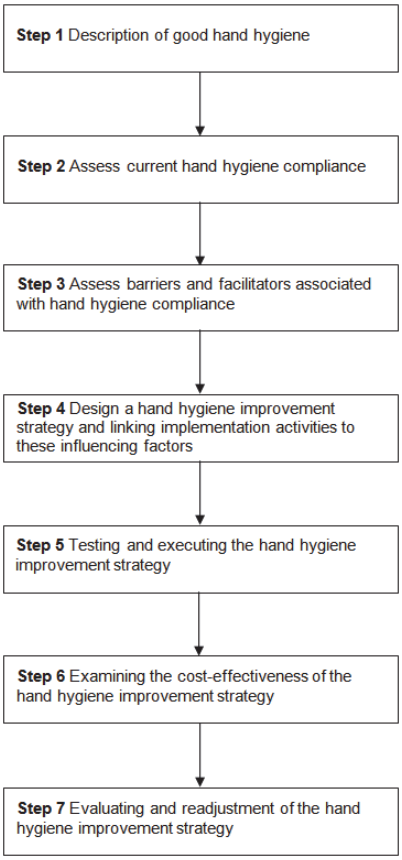

Figure 2. The implementation model.

Step 1: describing good hand hygiene

Good HH is described in the WHO Guideline on Hand Hygiene in Health Care.[6] This guideline provides a comprehensive review of scientific data on HH rationale and practices in health care. The Dutch hand hygiene guideline clearly endorses the WHO procedures with regard to HH.[36] Nonetheless, there are differences in the description of the indications for performing HH between the two guidelines. The WHO guideline requires HH before patient contact under all circumstances, while the Dutch guideline requires HH before patient contact only with a patient in protective isolation. The WHO guideline also clearly describes the need for HH after contact with inanimate objects, while the Dutch guideline requires HH after 'nursing actions'. In our study, we defined the HH moments according to the WHO guidelines excluding the HH indication 'before patient contact' because of its absence in the Dutch guideline.

Step 2: assessing current hand hygiene compliance

By analysing current practice it becomes clear whether current practice deviates from recommended care. Guidelines stipulating when HH is required have been in place for many years, but are often not adhered to. Two thirds of the studies included in a systematic review reported compliance rates below 50%.[37] The adherence to HH guidelines in the Netherlands is even lower. A study conducted in 24 Dutch hospitals showed that the HH guidelines were adhered to in only 19.5% of the observed opportunities.[38]

Step 3: analysing barriers for non-compliance with hand hygiene guidelines

Several factors may affect the implementation of an innovation, positively or negatively. To develop a successful HH strategy, information is needed on the behavioural determinants of HH compliance.[39]

Grol undertook a survey of 120 doctors and nurses in seven hospitals and nursing homes, and identified barriers related to the individual HCW (not convinced of the evidence, working routines); the social context within the team (no mutual accountability and control, no leadership); and the hospital organisation (high workload, insufficient facilities).[7] See Table 1.

Our analysis of published work on HH also identified several factors that may influence HH behaviour. Pittet et al. showed hospital wide predictors of poor adherence to recommended HH measures during routine patient care. Predicting variables included professional category, hospital ward and intensity of patient care (defined as the number of opportunities for HH per hour of patient care).[22] Perceived barriers to adherence with HH guidelines also include skin irritation caused by HH agents, inaccessible HH supplies, interference with HCWs' relationships with patients, patient needs perceived as a priority over HH, wearing of gloves, forgetfulness, lack of knowledge of guidelines, insufficient time for HH, high workload and understaffing, and the lack of scientific information showing that HH prevents cross-infection.[40-48]

Recently, Erasmus confirmed the above findings for the Dutch situation. The study indicated that beliefs about the importance of self-protection are the main reasons for performing HH. They also found that negative role models, poor accessibility of materials and a poor social culture hamper good HH.[49]

Finally, a recent Cochrane review of the effectiveness of 'tailored' strategies gave a foundation to the assumption that strategies for change are more effective if they deliberately address identified barriers.[50]

Table 1. Barriers for non-compliance with hand hygiene guidelines.

Focus of barriers	Difficulties to change	Percentage[1]
Cognition	Seldom see complications	61%
	Lack of hard evidence for some of the prescriptions	43%
Attitude & motivation	Irritation of the hands	81%
	Takes too much time	50%
Routine	Forgetting	65%
Social	Nobody controls	50%
	Management not interested	45%
Organisational	Not feasible in work 61%	61%
	No hospital guideline	49%
Recourses	Lack of facilities	42%

Adapted from Grol and Grimshaw, 2003.[7] [1] Number (%) of people seeing this obstacle as a problem

Step 4: selecting or developing improvement strategies

Literature based state-of-the-art strategy

Following the analyses of step 1 through 3, we faced the crucial step of selecting or developing strategies for improvement. Van Achterberg et al.[33] performed a literature search into the effects of various strategies for improving HH in hospital workers. A total of 33 studies for improving HH were evaluated. Investigators reporting positive effects generally demonstrated an improvement in HH compliance from 45% to 60% of all relevant opportunities. See Table 2 for an overview.

The evidence retrieved indicated that the use of education or reminders as single strategies does not improve compliance with hand-hygiene prescriptions, whereas the single use of either performance feedback, improved products, or improved facilities (e.g., more sinks or dispensers in the ward) probably does. Combined strategies were mostly effective. Often these strategies were education in combination with improved products or facilities, and either reminders or performance feedback. Finally, social influence and patient involvement were positively evaluated, but evidence was too scarce to draw conclusions.

The identified key-elements formed the building blocks of our the state-of-the-art strategy applied in our study (chapter 3).

Theory based team and leaders-directed strategy

The literature search of Van Achterberg et al. revealed that most of the studies did not provide a clear rationale for their choice of strategies.[33] However, barriers relat-

Table 2. Evidence for strategies aimed at improving hand hygiene in health care workers (33 studies).

No. of studies	Mostly effective	No. of studies	Mostly ineffective
7	Performance feedback	7	Education
5	Improved products	3	Reminders
3	Improved facilities		
1	Patient involvement		
1	Social influence		
12	*Combined strategies*		

Adapted from Van Achterberg et.al., 2008.[33]

ed to cognition, motivation, routines, and resources were often addressed. Barriers like negative role models, lack of management involvement and a poor social culture received less attention and specific team-oriented activities were rarely applied within these strategies. Yet team-directed strategies could really be valuable, as HCWs (especially nurses) usually work in teams.

Evidence for the effectiveness of team-directed strategies in other settings exists and could also be valuable in HH improvement strategies.[34,51] We concluded that performing a strategy that also targets the social context of teams and leadership, might considerably contribute to HH improvement.[33,52,53]

Probably the most promising way to build a suitable strategy is to use relevant theories to go from the identification of barriers to the selection of strategies, especially where theories are supported by empirical evidence.[33] Key theories in the area of role models, management involvement and social culture are Social Learning Theory,[54] Social Influence Theory,[55] Theory on team effectiveness,[56,57] and Leadership Theory.[58]

Together, these theories provide a coherent set of methods to target the social context in which HH behaviour takes place. Table 3 provides an overview of our theory selecting process based on identified HH performance barriers including the characteristics and key elements of the behaviour change theories. The identified key elements were used to build our team and leaders-directed strategy as described in Chapter 3.

Determinants of behaviour change in hand hygiene improvement strategies

The literature search of Van Achterberg et al. provided useful information on effective strategies for improving HH in hospital workers. However, only limited conceptual clarity on the nature of the strategies could be obtained. To better un-

derstand *how* these strategies work, application of knowledge from the behavioural and social sciences appears valuable.[52, 53] Alongside the development of our strategies we therefore evaluated frequently used HH improvement strategies from a behavioural viewpoint (Chapter 2).

Step 5: testing hand hygiene improvement strategies

There is an urgent need to undertake methodologically robust evaluation studies to explore the effectiveness of soundly designed and enacted strategies to increase HH compliance. Adequately powered cluster randomised trials or well designed interrupted times series studies are considered the optimal study designs for such studies.[59]

We undertook a cluster randomised trial (HELPING HANDS) in three Dutch hospitals to investigate whether the innovative team and leaders-directed strategy would be more effective in increasing HH compliance rates in nurses compared to a state-of-the-art strategy.

Our study was focused on the important subgroup of nurses, who interact with patients around the clock, and who are often confronted with a large variety of organic materials (Chapter 4).

Table 3. Selected behaviour change theories matching barriers in performing hand hygiene.

Theory	Focus	Key elements
Social learning theory[61]	Behaviour is learned from the environment through the process of observational learning	• Demonstration, role modelling • Encompasses attention, memory, and motivation
Social influence theory[62]	Social norm in a network determines what correct behaviour is	• Norm and target setting • Commitment team members • Use of opinion leaders. • Performance feedback • Team members address each other in case of undesirable behaviour
Theory on team effectiveness[63,64]	Orientation on team climate and willingness to change	• Team Vision: clarity, perceived value, and attainability • Participation Safety: decision-making, information sharing, interaction and safety • Support for Innovation: articulated and enhanced support • Task Orientation: commitment to excellence, appraisal and task orientation
Theories of leadership[65]	Leading, coaching and managing a team	• Active commitment/ participation in performance improvement initiatives • Setting norms and targets/direction/expectations • Encouragement and support/ motivate staff • Monitoring performance and feedback

Step 6: determining the cost-effectiveness of chosen improvement strategy
Individual health care organisations have relatively few resources which implies that a choice has to be made in favour of the strategy that is most cost-effective in terms of strategy related cost consequences and health effects.[60] Unfortunately, well-designed economic evaluations of HH improvement strategies are lacking.[6] Therefore, we also examined the cost-effectiveness of both strategies. The purpose of this analysis was to determine whether the hypothesised additional increase in HH compliance due to a team and leaders-directed strategy justified the additional costs (Chapter 5).

Step 7: continuous evaluating and adapting the improvement strategy
Both our HH improvement strategies were multifaceted and consisted of a number of potentially effective components. All these components might influence effectiveness both independently and inter-dependently. Performing a process evaluation is a way to obtain insight into the contribution of the different components of a multifaceted strategy. While our randomised controlled trial will show to what extent the HH strategies really results in changes in nurses' HH performance, a process evaluation can illuminate the mechanisms and processes responsible for the result. [61]

A strategy for change can only have its theoretical impact if it is performed as intended by its developers.[62] The degree to which strategies are performed as intended by the strategy developers is, in literature, also termed implementation fidelity or programme integrity.[63-65] To draw a valid conclusion about a strategy's effectiveness, research into strategies for change and their effectiveness should therefore always include an evaluation of the degree to which strategies are performed as intended by the strategy developers.[61] Without checking for this, we cannot determine whether a lack of impact results from a poorly conceptualized strategy or from a poorly performed strategy. Therefore, the exposure of the nurses to the different components of the improvement strategies and the changes in HH compliance achieved should be assessed. In this way, insight into the essential components of the strategies that determined success can be obtained (Chapter 6).

Physician compliance with HH guidelines is often found to be lower than that of nurses.[22,66] The application of our team and leaders-directed strategy in a multidisciplinary setting - including nurses as well as physicians - could provide essential knowledge on how physicians could be stimulated to comply with HH guidelines (Chapter 7).

OUTLINE OF THE THESIS

Chapter 2 describes a review on the content and effectiveness of frequently used HH improvement strategies and related determinants of behaviour change that prompt good HH behaviour. The databases of MEDLINE, CINAHL, EMBASE, and Cochrane Database of Systematic Reviews, Database of Abstract of Reviews of Effects were searched for the period 2000 to 2009.

Chapter 3 reports on the selection and development of the state-of-the-art strategy and the team and leaders-directed strategy, as well as the design of the HELPING HANDS study, in which we have tested the effect of both strategies on nurses' compliance with HH guidelines.

In Chapter 4 we tested whether a innovative team and leaders-directed strategy, using additional activities based on social influence and leadership theories, would be more effective in increasing HH compliance rates in nurses compared to a state -of-the-art strategy, which mainly addressed the individual and the organisational level. The primary outcome was the percentage of nurses' actions in line with HH guidelines in case of an opportunity to perform this action.

Chapter 5 describes our economic evaluation. Based on our HH compliance data, we developed a decision model to determine whether the additional increase in HH compliance due to the team and leaders-directed strategy justifies the additional costs.

Chapter 6 expands on the findings of the HELPING HANDS study by integrating process and outcome evaluations. We examined which components of the HH improvement strategies were particularly associated with increased nurses' HH compliance, as well as other possible factors that may have influenced nurses' HH compliance.

In Chapter 7 we applied and tested our team and leaders-directed strategy in a multidisciplinary setting by addressing nurses as well as physicians. This was an observational, prospective, before-and-after study. We measured HH knowledge and HH compliance of the nurses and the physicians before (baseline), directly after (post strategy), and 6 months after (follow-up) the performance of the team and leaders-directed strategy.

In the general discussion in Chapter 8, the results described in this thesis are summarized and our findings are discussed in view of several methodological issues, implications for practice and aims for future research.

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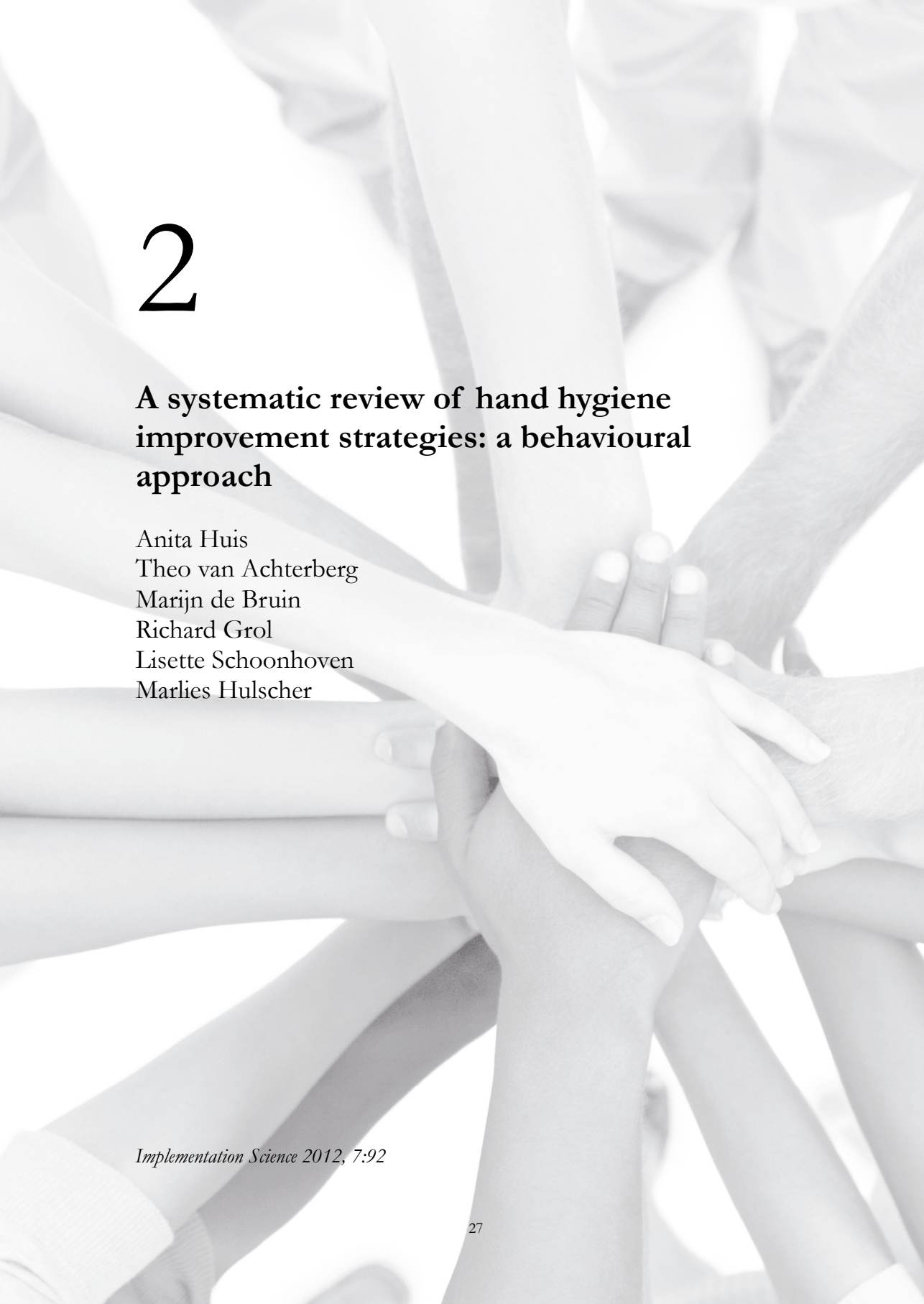

2

A systematic review of hand hygiene improvement strategies: a behavioural approach

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ABSTRACT

Background

Many strategies have been designed and evaluated to address the problem of low hand hygiene (HH) compliance. Which of these strategies are most effective and how they work is still unclear. We describe frequently used improvement strategies and related determinants of behaviour change that prompt good HH behaviour to provide a better overview of the choice and content of such strategies.

Methods

Systematic searches of experimental and quasi-experimental research on HH improvement strategies were conducted in Medline, Embase, CINAHL, and Cochrane databases from January 2000 to November 2009. First, we extracted the study characteristics using the EPOC Data Collection Checklist, including study objectives, setting, study design, target population, outcome measures, description of the intervention, analysis, and results. Second, we used the Taxonomy of Behavioural Change Techniques to identify targeted determinants.

Results

We reviewed 41 studies. The most frequently addressed determinants were knowledge, awareness, action control, and facilitation of behaviour. Fewer studies addressed social influence, attitude, self-efficacy, and intention. Thirteen studies used a controlled design to measure the effects of HH improvement strategies on HH behaviour. The effectiveness of the strategies varied substantially, but most controlled studies showed positive results. The median effect size of these strategies increased from 17.6 (relative difference) addressing one determinant to 49.5 for the studies that addressed five determinants.

Conclusions

By focussing on determinants of behaviour change, we found hidden and valuable components in HH improvement strategies. Addressing only determinants such as knowledge, awareness, action control, and facilitation is not enough to change HH behaviour. Addressing combinations of different determinants showed better results. This indicates that we should be more creative in the application of alternative improvement activities addressing determinants such as social influence, attitude, self-efficacy, or intention.

BACKGROUND

Hospital-acquired infections (HAIs) burden patients, complicate treatment, prolong hospital stay, increase costs and can be life threatening. [1] Recent studies in Europe have shown that HAIs affect 4.6% to 9.3% of the hospitalised patients.[2-8] In Europe, the estimated five million HAIs that occur annually have an assumed attributable mortality of 50,000 to 135,000 at a cost of € 13 to € 24 billion.[9] In the United States, prevalence rates were estimated at 4.5% for 99,000 cases of excess mortality and an economic burden of US $ 6.5 billion in 2004.[10,11]

Adequate hand hygiene (HH) among hospital personnel could prevent an estimated 15% to 30% of the HAIs.[12,13] Numerous studies over the last few decades have shown that HH compliance rates are generally less than 50% of all the opportunities.[14-16] Many strategies have been designed and evaluated to address the problem of low compliance, but most of the effects are small to moderate and often short term.[12-17] This stresses the importance of a clear evidence-based strategy to improve HH routines.[18,19]

In 2001, Naikoba and Hayward systematically reviewed 21 studies, all aimed at improving the HH of healthcare workers (HCWs).[20] The authors concluded that multifaceted strategies are generally more effective than single strategies. Moreover, strategies directed at educating and motivating HCWs, such as written educational materials, reminders, and continuous feedback about performance, were found to be more useful than strategies aimed at offering more facilities such as automated sinks or moisturised soaps. Despite the importance of this review, Naikoba and Hayward's concluded that most of the reviewed studies had multiple design limitations, which made causal inferences about the effects of strategies problematic. Gould *et al.* also recognised methodological weaknesses of HH studies in their systematic review.[21] However, they conducted a Cochrane review with such stringent criteria that only four studies were included, and many possibly relevant non-randomised trials were disregarded. Therefore, the results of their review provide little guidance to policymakers and hospital staff for designing effective programmes to improve HH adherence. Thus, although high methodological quality is important, reviewers should balance this with the urgency of offering guidance/ potential solutions to the field. An update of the literature, balancing methodological quality and the need for evidence, seems warranted. In order to identify effective routes to promoting HH and thereby reduce HAIs, it is important to search the content of improvement strategies that is correlated with improved HH behav-

iour across studies. In implementation research, the most used classification of strategies is captured in the Data Collection Checklist of the Effective Practice Organisation of Care Group (EPOC), which is based on the form of performed improvement activities.[22] A disadvantage of 'just' coding improvement activities as the EPOC describes, is that information about the corresponding triggers that prompt HH behaviour is disregarded. Improving HH compliance implies behaviour change; therefore, application of knowledge from the behavioural and social sciences appears valuable.[23-25]

An alternative way of classifying strategies is on the basis of their determinants of behaviour change (Table 1). These determinants are derived from behaviour and behaviour change theories and describe the way or trigger to arrive at behaviour change.[26-29] This behavioural approach might shed new light on the nature of improvement strategies and elucidating how these strategies work. For example, regularly displaying charts of HH performance on group levels or information about nosocomial infection rates can be considered 'feedback'. Reviewing the individual HH compliance and promoting a comparison of HH compliance among team members can also be categorised as 'feedback'. However, in the first example, the determinant of behaviour change is 'raising awareness', while the determinant in the second example is 'social influence'. Both examples thus target different determinants of behaviour change, but both would be categorised as 'feedback' in the EPOC classification system.

Table 1. Explanation of terms.

Term	Explanation	Examples
Determinants of behaviour change	The determinants targeted by a systematically developed strategy are those that have been identified for altering behaviours. Theoretically, the application of a chosen behaviour change activity as part of the HH improvement strategy will alter a specific behavioural determinant, which in turn will change behaviours	Knowledge Awareness Self-efficacy
Behaviour change technique	Behaviour change techniques refer to the specific methods used to promote behaviour change	Education Feedback Guided practice
Activities	Activities refer to the operationalisation of behaviour change techniques	Lectures Overview of HH compliance rates Teaching skills / specific instruction
Hand hygiene improvement strategy	A strategy consist of a set of one or more techniques (e.g., education, feedback, goal setting), intended to change specific determinants (e.g., education to increase knowledge, feedback to raise awareness, guided practice to enhance self-efficacy) of HH behaviour	

Theoretically, the application of a chosen behaviour change activity as part of the HH improvement strategy (*e.g.*, a meeting to educate staff on the World Health Organization five moments for HH) will alter a specific behavioural determinant (in this case, their knowledge on the five moments for HH), which in turn will change behaviours (in this case, HH behaviour in line with the five moments for HH).

We hypothesise that a HH improvement strategy targeting more different determinants of behaviour change will be more effective in increasing HH compliance than a HH improvement strategy targeting less different determinants of behaviour change.

The purpose of the present study is to offer sufficient conceptual clarity on the nature of HH improvement strategies by classifying their improvement activities on the basis of their determinants of behaviour change. In addition, we used the controlled studies of our review to explore the effectiveness of targeting different determinants of behaviour change.

METHODS

Search strategy

First, we selected the 21 studies that Naikoba and Hayward reviewed.[20] Second, we searched the databases of MEDLINE, CINAHL, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews, Database of Abstract of Reviews of Effects (DARE) from January 2000 up to November 2009, as well as the Current Controlled Trials, ClinicalTrials.gov, National Health Service Centre for Reviews and Dissemination (NHS-CRD): National Health Service Economic Evaluation Database (NHS-EED), and National Health Service Centre for Reviews and Dissemination Health Technology Assessment (NHS-CRD: HTA). The search was limited to studies of human beings, but no language restrictions were imposed. The search terms included the methodological filters of the EPOC combined with selected MeSH terms (handwashing) and free text terms (hand washing and hand hygiene) as used by Naikoba and Hayward.[20] The search strategies used are outlined in Appendix 1.

Selection criteria

Studies had to include at least one outcome comparison with a randomised or non-randomised comparison group, or a comparison with baseline data in the case of a single group before-and-after test design. Other criteria were:

1. Population: HCWs in hospital settings
2. Intervention: strategies aimed at improving HH behaviour
3. Comparison: HH behaviour before the introduction of the programme or strategy, or HH behaviour in a comparison group where another programme or no programme (usual care) was implemented
4. Outcome: all operationalizations of HH behaviour of HCWs.

Selection of articles

Two reviewers (AH and TvA) independently reviewed the titles and abstracts of citations generated by the search to assess their eligibility for further review based on the selection criteria, and chose relevant articles for possible inclusion. Differences in selection were resolved by consensus or consultation with a third reviewer (MH or LS) in cases of doubt. From potentially eligible studies, the full text papers were subjected to the same evaluation strategy.

Quality assessment

Rather than exclude studies deemed *a priori* to be of poor quality, we chose to include such studies and empirically rate the level of quality. We used a rating system adapted from Anderson and Sharpe[30], who evaluated the impact of various types of interventions on behaviour change directed either at patients or HCWs. (see Table 2).

Two reviewers (AH and TvA) independently determined whether studies met the criteria set for methodological quality, and disagreements were again resolved by discussion. Studies with less than three out of seven points were removed. Studies that rated three points but failed to have a positive score for 'instruments used' were removed. Studies that rated three (with a positive score for ' instruments used') to five points were graded as moderate quality, and those with six or seven points were graded as high-quality studies.

Data extraction and synthesis

We used a two-step approach to examine the studies. First, we extracted the study characteristics using the EPOC Data Collection Checklist that includes study objectives, setting, study design, target population, outcome measures, description of the intervention, analysis, and results.[31] Second, to determine which improvement activities could be considered as behavioural change techniques targeting important determinants of adherence behaviours, we used a pre-structured form in-

Table 2. Methodological quality rating.

Design of study or assignment rating	
Experimental: RCT, random allocation; CCT, quasi-random allocation; three data collection points before and after the intervention	1
Quasi-experimental: CBA, comparable control sites	1
Quasi-experimental: nonequivalent control sites	0
Single group before-after tests with baseline measurement	0
Content	
Intervention is clearly described	1
Sample size	
Described and justified. An n per group sufficient to detect a significant effect ($p < 0.05$) with a power of 0.80 or reported calculation of power	1
Validity and reliability of instruments	
Unobtrusive observations, rater procedure described and $r > 0.80$	2
Unobtrusive observations, rater procedure not described or $r < 0.80$	1
Obtrusive observations, rater procedure described and $r > 0.80$	1
Obtrusive observations, rater procedure not described or $r < 0.80$	0
Volume of soap or hand alcohol used	0
Test statistics	
Test statistics are described	1
Significance	
p Value or confidence interval is given	1

CBA = controlled before-and-after study, CCT = controlled clinical trial, ITS = interrupted time series
The quality rating is a modification of Anderson and Sharpe's rating[30]

cluding the taxonomy of behavioural change techniques of De Bruin *et al.*[26] Although the taxonomy has been primarily applied in health promotion research, we consider this taxonomy as a valuable tool for in-depth evaluation of HH improvement strategies because these strategies are also aimed at changing behaviour of HCWs. The taxonomy used is an adapted version of the 26-item taxonomy developed by Abraham and Michie.[27]

Whereas the original taxonomy already provides a list of well-defined techniques for behaviour change, it was further developed and adapted by De Bruin and colleagues who categorised the behaviour change techniques according to the determinants of behaviour they address. The taxonomy thus provides nine categories to distinguish between techniques addressing knowledge, awareness, social influence, attitude, self-efficacy, intention, action control, maintenance, and facilitation. These determinants are derived from an integration of theoretical constructs from prevailing behaviour (change) theories that have been found predictive of a range of different health behaviours.[28] Together, the nine categories of determi-

nants include a total of 38 behaviour change techniques. See Table 3 for a selection of the most relevant techniques with this overview.

All reviewers participated in a four-hour training on identifying and coding behavioural techniques in line with the taxonomy. A coding manual guided the training.[26] This manual contained comprehensive and detailed criteria for assessing the behaviour change techniques and their related determinants. These criteria and any ambiguities were discussed during the training. Then, we performed a pilot using three excluded studies to validate our scoring results. Finally, two pairs of reviewers (AH and TvA or LS and MH) used the taxonomy to independently code the complete range of improvement activities in the included studies into behaviour change techniques. The techniques identified were grouped under their related determinant. The same procedure was also applied to code 'usual' or 'standard' care provided to control groups The reviewers who coded the strategy were blinded for the study results and vice versa. Differences in coding (i.e. <5%) were resolved through discussion. See Appendix 2 for an example of data extraction and coding.

Data analysis

Given the heterogeneity of the studies with regard to target groups, content and delivery of strategies, and opportunities/moments for HH, no formal meta-analysis was done. We describe frequently used strategies at the level of the nine categories of determinants within the classification of the Taxonomy of Behavioural Change Techniques by reporting the frequency with which the determinants were addressed across all studies included in this review.

We analysed the effectiveness at the level of the nine categories of determinants and compared studies addressing one or more determinants. To obtain methodological soundness, we only make inferences about effectiveness using data of the controlled studies (i.e., randomised controlled trials, controlled before-and-after studies, and studies with a cross-over design).

The overall effect size was determined by calculating the relative difference between the intervention and control groups in each controlled study. This relative difference represents the ratio of difference (in percentages) between the interventional and control groups. We obtained the value by dividing the difference between the post-intervention performance scores from the interventional and control groups by the post-performance test scores of the control group, multiplied by 100 (see Appendix 3). To combine findings across studies, we computed the median effect size and the range, representing the results of strategies related to deter-

Table 3. Selection* of the most relevant techniques and their determinant with this overview.

Determinant	Behaviour change technique	Description of the activity in studies
Knowledge	Provide general information	Educational sessions or educational materials
	Increase memory or understanding of information	Group discussion, answering questions, clarification
Awareness	Risk communication	Information about risks of non adherence or inadequate hand hygiene (infection rates, costs)
	Delayed feedback of behaviour	Overview of recorded hand hygiene behaviour
	Direct feedback of behaviour	Using a system to make professionals aware of their hand hygiene behaviour soon after planned execution
	Feedback of clinical outcomes	Overview of nosocomial infections
Social influence	Provide information about peer behaviour	Information about peers' opinions of correct hand hygiene
	Provide opportunities for social comparison	Group sessions with peers in which discussion and social comparison of hand hygiene practices can occur
	Mobilise social norm:	Exposing the professional to the social norm of important others (not peers) such as opinion leaders
Attitude	Persuasive communication	Positive consequences of proper hand hygiene
	Reinforcement of behavioural progress	Praise, encouragement, or material rewards
Self-efficacy	Modeling	Use of a role model. Demonstration of proper hand hygiene behaviour in group, class, or team
	Verbal persuasion	Messages designed to strengthen control beliefs about the way of performing correct hand hygiene
	Guided practice	Teaching skills and providing feedback. Specific instruction for correct hand hygiene behaviour
	Plan coping responses	Identification and coping with potential barriers
	Set graded tasks, goal setting:	Desired hand hygiene behaviour is achieved with a stepwise model
Intention	General intention information	Explanation of the goals and targets concerning hand hygiene
	Agree to behavioural contract	Contract or commitment with formulated goals of hand hygiene behaviour
Action control	Use of cues	Reminders
Maintenance	Following behavioural change	Not addressed
Facilitation of behaviour	Provide materials to facilitate behaviour	Supportive materials are provided for the healthcare workers
	Continuous professional support	Involves service provided by infection control team or working group, and/or an additional nurse who attends the implementation

*Only terms and definitions for techniques identified in the studies on promoting hand hygiene in healthcare workers are presented

minants. We decided to report the median because it is less sensitive to extreme scores and provides a better estimate of what the 'average' is. Most of the studies included in this review evaluated short-term effects, so we only report results derived from measurements made directly after the interventions were completed.

RESULTS

Our search of published works from 2000 through 2009 resulted in 1949 hits for all the databases. A total of 119 studies met the inclusion criteria, including the 21 studies that Naikoba and Hayward reviewed. We assessed the full text of 115 studies (the full text of four studies could not be retrieved). Twenty-six studies were excluded, mostly because of the absence of HH compliance outcomes or studies were non-interventional. In the initial review, 89 studies appeared potentially eligible for review and were read in detail. After quality assessment, 41 studies were included for analysis, and 48 studies were excluded due to major quality limitations, including 10 studies previously reviewed by Naikoba and Hayward (Figure 1). See Appendix 4 for characteristics of excluded studies.

Study characteristics

Appendix 5 provides an overview of study characteristics in the 41 studies reviewed. Naikoba and Hayward had previously reviewed 11 studies that were published from 1986 through 1999, and the remaining 30 studies were published from 2000 through 2009. Twenty-eight studies had a before-after test design, seven had a controlled before-after design, three were randomised controlled trials, and three had a cross-over design. The study settings were predominantly intensive care units (n = 25), followed by medical or surgical wards (n = 10), emergency wards (n = 4), and 2 studies covered all hospital wards. Multicentre trials were conducted in three studies (two to four hospitals) and the number of participating wards varied from one to three per hospital. In 28 studies, the target population was specified as nurses, physicians, and other HCWs. Six studies targeted only nurses, while seven studies did not specify the type of HCW. The unit of analysis was defined as HH opportunities or moments for HH (n = 33), participants (n = 5), patients (n = 1) and number of dispenser activations (n = 2). Most studies (n = 39) reported HH compliance rates as a primary outcome meas-

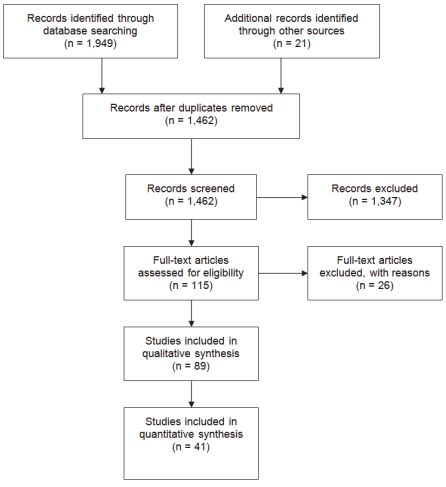

Figure 1. Flow diagram for study selection.

ure. These data were collected by means of unobtrusive observations (n = 30) or by obtrusive observations (n = 9) in HCWs.

One study measured HH performance by volume of soap and hand alcohol used, and one study identified HH episodes by using an electronic counting device. Six studies based their strategy on barriers identified by practice research such as skin irritation, workload, staff personal habits, and priorities. Eleven studies mentioned barriers derived from the literature. The rating of study quality resulted in six high-quality studies. Each of these studies scored six points on our rating scale. Two of the moderate-quality studies scored three points, 28 studies scored four points, and five studies scored five points. Identified quality limitations were: uncontrolled study design (n = 28), absence of sample size justification (n = 33), observations without a description of inter-rater reliability agreement (n = 31), and no description of test statistics (n = 3).

Determinants addressed (n = 41)

We evaluated the HH improvement strategies across the controlled and uncontrolled studies Figure 2 shows the number of studies addressing specific determi-

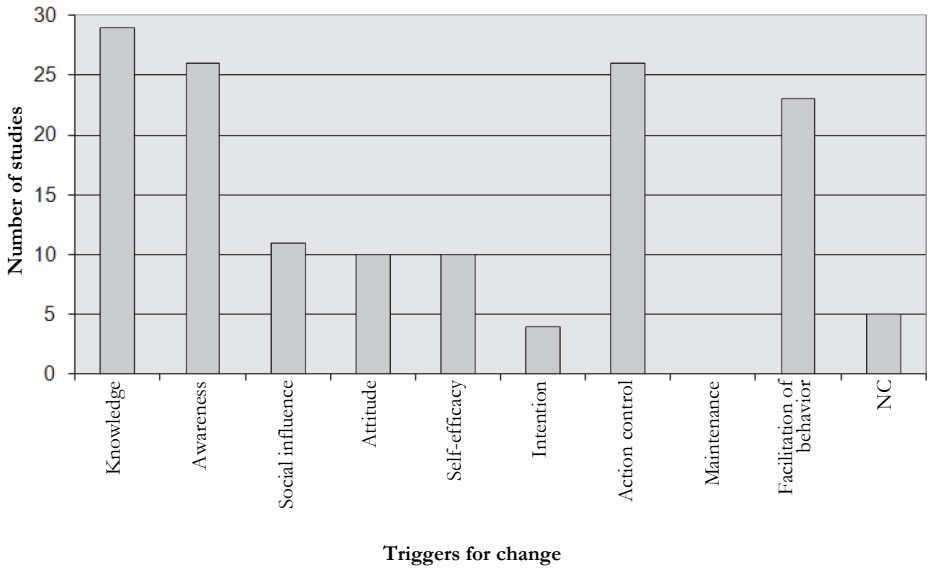

Figure 2. Numbers of studies addressing specific determinants of behaviour change. Knowledge (29), Awareness (26), Social influence (11), Attitude (10), Self-efficacy (10), Intention (4), Action Control (26), Maintenance (0), Facilitation of behaviour (23), NC = no coding possible (5). Total = 144 in 41 studies.

nants. The most frequently addressed determinants were knowledge (n = 29), awareness (n = 26), action control (n = 26), and facilitation of behaviour (n = 23). Fewer studies addressed social influence (n = 11), attitude (n = 10), self-efficacy (n = 10), and intention (n = 4). One determinant directed at behavioural maintenance following behaviour change was not addressed at all. Five studies used techniques focused mainly on gaining senior management support and commitment, and institutional priority for HH.[32-36] These activities could not be coded because they were primarily directed at gaining support for programme implementation rather than serving as a technique to change HH behaviour directly.

The 14 studies that addressed one or two determinants mainly consisted of combinations of knowledge, awareness, action control, and facilitation of behav-

Table 4. Content of strategies related to determinants of behaviour change.

Studies n=41	Determinants of behaviour change (studies)
9	**Studies addressing one determinant (3 controlled and 6 uncontrolled studies)**
2	Action control (38*;39)
2	Awareness (40*;41)
5	Facilities (42;43;44;45*;46)
5	**Studies addressing two determinants (1 controlled and 4 uncontrolled studies)**
2	Knowledge, Action control (47;48)
1	Knowledge, Facilities (49)
1	Awareness, Action control (50)
1	Awareness, Social influence (37*)
8	**Studies addressing three determinants (3 controlled and 5 uncontrolled studies)**
2	Knowledge, Awareness, Action control (51;52)
1	Knowledge, Awareness, Facilities (53*)
1	Knowledge, Awareness, Attitude (54)
1	Knowledge, Awareness, Self-efficacy (55*)
2	Knowledge, Action control, Facilities (56*;57)
1	Knowledge, Action control, Intention (58)
6	**Studies addressing four determinants (2 controlled and 4 uncontrolled studies)**
2	Knowledge, Awareness, Facilities, Action control (59;60)
1	Knowledge, Awareness, Facilities, Social influence (35*)
1	Knowledge, Self-efficacy, Action control, Awareness (61)
1	Knowledge, Self-efficacy, Action control, Facilities (62)
1	Self-efficacy, Intention, Awareness, Social influence (63*)
9	**Studies addressing five determinants (3 controlled and 6 uncontrolled studies)**
2	Knowledge, Awareness, Action control, Social influence, Attitude (64;65)
2	Knowledge, Awareness, Action control, Social influence, Facilities (1*;66)
2	Knowledge, Awareness, Action control, Facilities, Attitude (67*;68)
1	Knowledge, Awareness, Facilities, Attitude, Self-efficacy (69*)
1	Knowledge, Awareness, Facilities, Self-efficacy, Action control (32*)
1	Knowledge, Facilities, Self-efficacy, Action control, Attitude (34)
1	**Studies addressing six determinants (1 uncontrolled study)**
1	Knowledge, Awareness, Social influence, Attitude, Action control, Facilities (33)
3	**Studies addressing seven determinants (1 controlled and 2 uncontrolled studies)**
1	Knowledge, Awareness, Social infl., Self-efficacy, Intention, Action control, Attitude (70*)
1	Knowledge, Awareness, Social infl., Self-efficacy, Intention, Action control, Facilities (71)
1	Knowledge, Awareness, Social infl., Self-efficacy, Action control, Attitude, Facilities (36)

iour (Table 4). Only one study in this group added social influence to its strategy.[37] Moongtui combined social influence with awareness. Colleagues evaluated each other's performance on appropriate hand washing and glove wearing. The investigators also provided feedback at group level by posting compliance scores anonymously on a bulletin board every three days.

Fourteen studies addressed three or four determinants and used combinations as described above, but seven studies also addressed determinants as social influence, attitude, self-efficacy, or intention. For example, Huang focussed on increasing knowledge (educational training programme and written information) and awareness (clarifying risks for blood pathogen exposure), but also enhanced the self-efficacy of nurses with one hour of practical demonstration of hand washing and using gloves.[55] In Marra's study, activities were also aimed at increasing awareness by providing feedback on infection rates. The nurse manager also provided opportunities for social comparison by showing each HCW the total number of times the dispensers were used in each patient room in which the HCW worked compared to the number of times that other HCWs used dispensers. In addition, the nurse manager explained the goals and targets of the HH improvement strategy twice a week, thus strengthening intention and self-efficacy.[63]

All 13 studies addressing five or more determinants consisted of activities addressing multiple different determinants. For example, Trick *et al.* addressed determinants such as knowledge (educational sessions and distribution of educational materials to professionals), awareness (displaying HH adherence), action control (hospital-wide poster campaign), facilities (alcohol-based hand rub), and attitude (pointing out the benefits of using alcohol-based hand rubs).[67]

We found no differences in the extent to which determinants were targeted between the controlled studies and uncontrolled studies (Table 4).

See Appendix 6 for details of improvement activities and results in the 41 studies reviewed.

Effectiveness

Table 5 presents the effectiveness of the controlled studies related to their determinants of behaviour change. Controlled studies addressing one determinant focussed on action control (n = 1), awareness (n = 1) or facilitation of behaviour (n = 1). The median effect for these strategies was a relative difference (improvement) of 17.6 in performance. The effect size from one controlled study addressing two determinants was 25.7. The relative difference increased from 42.3 in the three

studies addressing three determinants to 43.9 for the two studies addressing four determinants. The relative difference was 49.5 for the three studies that addressed five determinants.

No controlled study addressed six determinants. The only controlled study addressing seven determinants showed less impact on short-term effectiveness (relative difference 9.7). However, baseline HH rates in this study were higher in the intervention group than in the control group, probably because administrators were already planning and discussing the strategy during the baseline phase.[70]

The increase in effectiveness correlated closely with the number of determinants (one to five) addressed (Pearson's correlation coefficient = 0.961, p = 0.009). See Figure 3.

DISCUSSION

Improved HH behaviours among hospital personnel could have a considerable impact on HAIs, healthcare costs, and patients' health and quality of life. Yet, re-

Table 5. Effectiveness of controlled studies related to determinants of behaviour change.

Determinants of behaviour change (study)	**Effect size** R = relative difference intervention and control[§]; M = median [range]
All studies	**n = 13 / M: 25.7 [-8.8 to 429]**
Studies addressing one determinant	**n = 3** / M: 17.6 [-8.8 to 61]
Action control (38)	n = 1 / R: -8.8
Awareness (40)	n = 1 / R: 17.6
Facilities (45)	n = 1 / R: 61.0
Studies addressing two determinants	**n = 1 / M: 25.7 [25.7*]**
Awareness, Social influence (37)	n = 1 / R: 25.7
Studies addressing three determinants	**n = 3 / M: 42.3 [19.5 to 82.7]**
Knowledge, Awareness, Facilities (53)	n = 1 / R: 19.5
Knowledge, Awareness, Self-efficacy (55)	n = 1 / R : 42.3
Knowledge, Action control, Facilities (56)	n = 1 / R: 82.7
Studies addressing four determinants	**n = 2 / M: 43.9 [14.8 to 73*]**
Knowledge, Awareness, Facilities, Social influence (35)	n = 1 / R: 73
Self-efficacy, Intention, Awareness, Social influence (63)	n = 1 / R: 14.8
Studies addressing five determinants	**n = 3 / M: 49.5 [-8.6 to 429]**
Knowledge, Awareness, Action control, Facilities, Attitude (67)	n = 1 / R: 49.5
Knowledge, Awareness, Facilities, Attitude, Self-efficacy (69)	n = 1 / R: -8.6
Knowledge, Awareness, Facilities, Self-efficacy, Action control (32)	n = 1 / R: 429
Studies addressing seven determinants	**n = 1 / M: 9.7 [9.7*]**
Knowledge, Awareness, Social influence, Self-efficacy, Intention, Action control, Attitude (70)	n = 1 / R: 9.7

* Median and range calculated over fewer than three studies

§ Relative difference calculated as (the results from the intervention group after the intervention minus the results from the control group after the intervention) divided by the results from the control group after the intervention

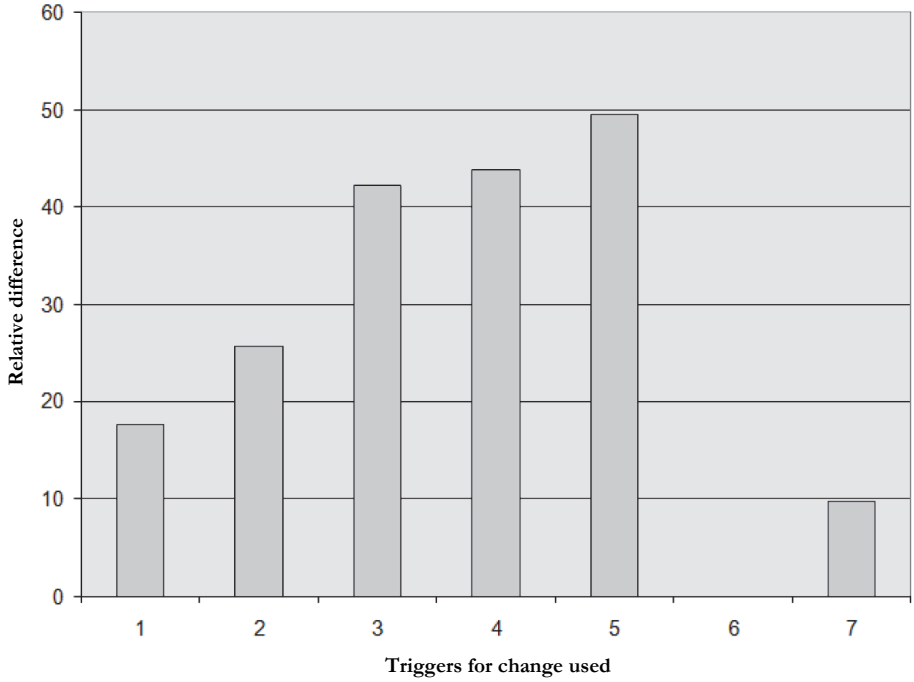

Figure 3. Correlation effectiveness and determinants addressed. Pearson coefficient r = 0.961; p = 0.00.

views with detailed examination of the active content of strategies to promote HH are missing. In the present study, the content and effectiveness of a range of strategies to improve the HH adherence of HCWs were studied. By using a detailed coding taxonomy of behaviour change techniques targeting major behavioural determinants, we were able to obtain a detailed insight into frequently used HH improvement strategies and how they work. Analysing the content of the strategies at the level of determinants that prompt HH behaviour, it was found that those studies focusing on combinations of different determinants gave better results, which indicates that we should be more creative in the application of alternative improvement activities aimed at altering specific behavioural determinants change, such as social influence, attitude, self-efficacy, and intention.

Although the content of the strategies and related determinants varied greatly, most of the studies addressed more than one determinant (mainly knowledge, awareness, action control, and facilitation of behaviour). This is consistent with Naikoba and Hayward's findings and previous systematic reviews of changing professional behaviour in which education (addressing 'knowledge'), feedback

(addressing 'awareness'), reminders (addressing 'action control'), and facilities (addressing 'facilitation of behaviour') were the most frequently used improvement activities.[12,20,21]

Twenty strategies addressed additional determinants that prompt HH behaviour such as social influence, attitude, self-efficacy, or intention. These specific determinants were especially targeted in comprehensive strategies that addressed at least four determinants. This provides new insight into the content of HH improvement strategies: half of the studies used a strategy targeting determinants not mentioned in previous reviews of HH adherence.

Most studies addressed determinants at the individual and institutional levels; specific team-oriented activities were hardly identified. Strategies including team-directed activities could, however, be valuable because HCWs (especially nurses) usually work in teams. Evidence for the effectiveness of team-directed strategies in other settings exists, but these strategies are rarely applied in studies of HH improvement.[72,73] Surprisingly, activities directed at behavioural maintenance following behaviour change were not identified in the studies. Nonetheless, activities aimed at persistence should be part of the strategy for achieving sustainability of improved HH behaviour.

The effectiveness of the strategies varied substantially, but most controlled studies showed positive results. This is in line with previous review findings.[74,75] If determinants such as social influence, attitude, self-efficacy, and intention are targeted within a strategy, the effect is larger than that of strategies consisting solely of a combination of determinants, such as knowledge, awareness, action control, and facilities. Apparently, these specific determinants provide an additional contribution to effectiveness. This finding is confirmed by results of previous studies where social influence, attitude, self-efficacy, and intention are considered relevant to successfully changing behavior.[26-29]

The median effect size increased when more determinants were addressed. In other words, there seems to be a dose response effect. This result deviates from Grimshaw et al.'s finding that there was no dose response relation between the number of improvement activities and the effects of multifaceted strategies.[75] The lack of a rationale in the composition of a multifaceted strategy, such as mentioned by Grimshaw, may be a good explanation for the lack of a relationship between the number of improvement activities and the effect.

An additional explanation for this discrepancy can be found in the framework chosen to classify the strategies for change. Grimshaw used the EPOC classifica-

tion of strategies that is based on the form of performed improvement activities. We used an alternative approach that classed improvement activities on the basis of their determinants of behaviour change. By using the Taxonomy of Behavioural Change Techniques we collected information about triggers that encourage behaviour change rather than describing separate improvement activities. Thus, using multiple activities is not necessarily the same as addressing multiple determinants or vice versa. For example, the combined distribution of educational materials and provision of educational sessions constitute two different improvement activities. We would not label this strategy as multifaceted because both activities apply the same determinant ('knowledge').

Although we found a maximum effect in addressing five determinants, we cannot provide a 'one-size-fits-all' recipe for building a successful strategy. Previous recommendations from the literature have pointed out that an improvement strategy for HH behaviour should address existing problems and barriers[12,73,75] Analyses of barriers and facilitators and linking improvement activities to these influencing factors are important steps in the design of a strategy and may be crucial to success. A multifaceted strategy with many improvement activities that are not precisely tuned to the existing barriers apparently misses the target; part of the components may be redundant or ineffective. For example, if there is no knowledge shortage, educational strategy components probably will not contribute to the effectiveness of the multifaceted strategy. Barriers also exits at other levels than the individual HCW. Barriers like negative role models, a poor social culture, and disinterested management can hamper good HH. Overcoming these barriers requires the use of alternative activities such as social influence, attitude, self-efficacy, or intention.

Of particular interest is the HELPING HANDS study, currently performed in the Netherlands.[76] In this study, improvement activities are directed at gaining active commitment and initiative of ward management; modelling by informal leaders at the ward; and setting norms and targets within the team. This team-directed strategy goes beyond individual and institutional only approaches, but rather addresses determinants at team level by focussing on social influence in groups and strengthening leadership.

In this review, it was not possible to check for this 'appropriateness' of determinants addressed within the studies because context and barrier analysis and the rationale regarding strategy selection were hardly reported. Therefore, for most of the studies, it was unclear how well the strategy fitted the context. In view of the

effectiveness, but also feasibility and costs, we propose selecting appropriate determinants rather than addressing all determinants. We concentrated on determinants within strategies—an alternate view, yet crucial to understanding the working mechanism of strategies to improve HH adherence. We were able to identify less commonly addressed determinants, such as social influence, attitude, self-efficacy, and intention, that considerably contribute to the effectiveness of strategies. Our study findings fit well within the implementation model of Grol and Wensing.[73] for building a successful HH improvement strategy (see Figure 4). The Taxonomy of Behavioural Change Techniques was a valuable tool that led us to convert descriptions of improvement activities into well-defined determinants. We obtained a clear focus on theory-based determinants of behaviour change that were hidden in the improvement strategies. We consider this a crucial step in developing a theoretical understanding of the effectiveness of improvement strategies.

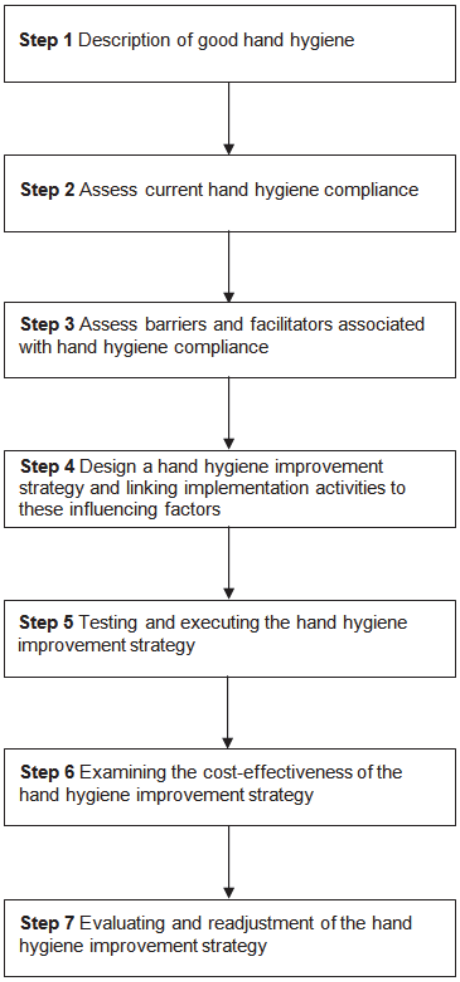

Figure 4. Building a successful hand hygiene improvement strategy.

Methodological discussion

Although we succeeded in achieving substantial insight into the content and effectiveness of HH improvement strategies, some aspects should be considered further. First, the methodological weakness of the studies is still a major concern. Most of the studies were small scale; they lacked a control group comparable to the test group, and made no formal attempt to minimise bias. There is a risk that a positive relationship between the number of determinants targeted and the effect

on HH compliance might be partly explained by an unknown confounder. This holds particularly true for the observational studies where wards were selected to receive an improvement strategy.

In our review, we included studies that clearly described the content of the strategy and were at least of moderate quality. With methodological soundness in mind, we only used results from controlled studies when we reported effectiveness. However, the risk of confounding should be taken into account when interpreting our results. Methodologically robust research is still required to evaluate the effectiveness of interventions intended to improve HH compliance. Adequately powered cluster randomised trials or well-designed ITS studies would provide the optimal study design.

Second, our search included literature up to November 2009. Therefore, we cannot provide information on recently performed HH improvement studies The screening and analysis of the search results as reported in this review served as a starting point for the development of two HH improvement strategies, which were subsequently tested in a randomised controlled trial. The design of this study was published in 2011.[76]

Third, as in any systematic review of the literature, there may be publication bias. Most studies showed positive results; it is possible that studies with negative results have not been published. In our review we were unable to retrieve four articles; it is possible that they contained relevant data.

Fourth, the criteria used to determine when HH should be performed varied over the studies and were not always explicitly stated. This may have implications for the generalizability of the results of the studies.

Fifth, good reliability in coding the improvement activities was observed (>95%), suggesting that our instructions and definitions can be applied reliably after only brief training. Within all steps of the review process, validity was increased by using standardised methods and forms as well as multiple raters. However, once techniques and targeted determinants are well chosen, examining the actual exposure to the improvement activities was problematic. Studies did not or marginally report on how well the improvement strategy was implemented. Designating HH as hospital goal, for example, requires setting specific, realistic, and measurable targets.[77]

However, descriptions of the improvement activities in the studies provide insufficient detail to check for appropriate delivery as well as the actual exposure of the HCWs to this activity. Without sufficient information about implementation

fidelity, it is hard to determine whether the impact of the HH improvement strategy is due to the implementation process or to the composition of the strategy itself, a so-called Type III error.[78]

Finally, most studies did not describe, or only marginally described, the activities of the 'usual' or 'standard' care provided to control groups. Standard care practices may vary from site to site. Therefore, describing standard care is important for the interpretation and comparison of intervention effects. Given the combination of strengths and considerations, this review provides an original and valuable overview of various strategies for improving the HH adherence of HCWs.

CONCLUSIONS AND FUTURE DIRECTIONS

By focussing on determinants of behaviour change, we found hidden and valuable components in HH improvement strategies. Addressing only determinants such as knowledge, awareness, action control, and facilitation is not enough to change HH behaviour. Addressing combinations of different determinants provided better results. This indicates that we should be more creative in the application of alternative activities addressing determinants such as social influence, attitude, self-efficacy, or intention.

A systematically designed strategy that targets various problems and barriers to change, with activities at different levels (professional, team, and organisation), is needed to achieve changes in HH behaviour. Currently, most strategies focus on the individual and the organisation, while group- or team-directed strategies are rarely used. Including team-directed techniques in a strategy is a promising development.

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Appendix 1. Search strategy by database.

Database: Ovid MEDLINE(R) <1950 to November Week 3 2009>
Search Strategy:
---
1 Randomized controlled trial/
2 random$.tw.
3 experiment$.tw.
4 (time adj series).tw.
5 (pre test or pretest or post test or posttest).tw.
6 impact.tw.
7 intervention$.tw.
8 chang$.tw.
9 evaluat$.tw.
10 effect?.tw.
11 compar$.tw.
12 control$.tw.
13 or/1-12
14 Nonhuman
15 13 not 14
16 (hand washing or handwashing or hand hygiene).
17 16 and 15
18 limit 17 to yr="2000 - 2009"

Database: EMBASE <1980 to 2009 Week 48>
Search Strategy:
---
1 Randomized controlled trial/
2 random$.tw.
3 experiment$.tw.
4 (time adj series).tw.
5 (pre test or pretest or post test or posttest).tw.
6 impact.tw.)
7 intervention$.tw.
8 chang$.tw.
9 evaluat$.tw.
10 effect?.tw.
11 compar$.tw.
12 control$.tw.
13 or/1-12
14 Nonhuman/
15 13 not 14
16 (hand washing or handwashing or hand hygiene).
17 16 and 15
18 limit 17 to yr="2000 - 2009"

Database: CINAHL <1980 to November Week 4>
Search Strategy:
---
1 clinical trials/
2 control$.tw.
3 random$.tw.
4 comparative studies/
5 experiment$.tw.
6 (time adj series).tw
7 impact.tw.)
8 intervention$.tw.
9 evaluat$.tw.
10 effect?.tw.
11 exp pretest-posttest design/
12 exp quasi-experimental studies/
13 or/1-12
14 (hand washing or handwashing or hand hygiene).
15 13 and 14
16 limit 15 to yr="2000 - 2009"

Appendix 2. Worked example data abstraction.

Worked example of data extraction and coding improvement activities

Reviewers	
Name reviewer	TvA
Date	30-03-2010

Study	
ID study	55
Title	Controlled trial measuring the effect of a feedback intervention on hand hygiene compliance in a step-down unit
Authors	Blinded
Source + year	2008
Analysed by Naikoba and Hayward	No

Interventions

Description of the intervention

Feedback was provided by the SDU nurse manager who explained the goals and targets for the process measures in the intervention unit twice per week. Feedback was presented to each HCW separately, showing the total number of times the dispensers were used in each patient room in which the HCW worked. These numbers were placed in the medical chart so that the HCWs could review them and improve their performance. They could also review the number of times that other HCWs used dispensers, thus promoting a comparison of hand hygiene compliance among them

Description of usual care

☐ **Not specified**

TvA

Behaviour change techniques used in interventions on hand hygiene compliance

Determinant	#	Method	Description of the activity in article
Knowledge	1	☐ Provide general information	
	2	☐ Increase memory and/or understanding of transferred information	
Awareness	3	☐ Risk Communications	
	4	☐ Self-monitoring of behaviour	
	5	☐ Self-report of behaviour	
	6	☐ Electronic monitoring of behaviour	
	7	☐ Reflective listening: direct feedback of cognitions and emotions	
	8	☐ **Feedback: delayed feedback of behaviour**	Feedback was presented to each HCW separately, showing the total number of times the dispensers were used in each patient room in which the HCW worked
	9	☐ Feedback: direct feedback of behaviour	
	10	☐ **Feedback of clinical outcomes**	Feedback on infection rates
Social influence	11	☐ Provide information about peer behaviour	
	12	☐ **Provide opportunities for social comparison**	review the number of times that other HCWs used dispensers, thus promoting a comparison of hand hygiene compliance among them
	13	☐ Mobilize social norm (important others)	
Attitude	14	☐ Re-evaluation of outcomes, self-evaluation	
	15	☐ Persuasive communication, belief selection	
	16	☐ Reinforcement on behavioural progress, provide contingent rewards	
	17	☐ Reinforcement on motivational progress, provide contingent rewards, affirmation	
Self-efficacy	18	☐ Modeling	
	19	☐ Verbal persuasion	
	20	☐ Practice, guided practice	

TvA

	21	☐ Plan coping responses	
	22	☐ **Set graded tasks, goal setting**	who explained the goals and targets for the process measures in the intervention unit twice per week.
	23	☐ Reattribution training, external attribution	
Intention	24	☐ **General intention information**	who explained the goals and targets for the process measures in the intervention unit twice per week.
	25	☐ Develop medication intake schedule	
	26	☐ Specific goal setting	
	27	☐ Review of general and/or specific goals	
	28	☐ Agree behavioural contract	
	29	☐ Use of social support	
Action control	30	☐ Use of cues	
	31	☐ Self-persuasion	
Maintenance	32	☐ Formulate goals for maintenance of behaviour	
	33	☐ Relapse prevention	
Facilitation of behaviour	34	☐ Provide material to facilitate behaviour	
	35	☐ Continuous professional support	
	36	☐ Individualize regimen	
	37	☐ Cope with side-effects	
	38	☐ Reduce environmental barriers	

TvA

Appendix 3. Calculation of relative difference.

Draft paper

PRESENTATION OF DATA FROM EPOC STUDIES (RCTs and CBAs)

Notation:

	Study	Control
Pre	S_{pre}	C_{pre}
Post	S_{post}	C_{post}
Change	S_{change}	C_{change}

(where $S_{change} = S_{post} - S_{pre}$ and $C_{change} = C_{post} - C_{pre}$)

Data to present:

Pretest mean:	S_{pre} vs C_{pre}
Posttest mean:	S_{post} vs C_{post}
Absolute change (post):	$S_{post} - C_{post}$
Relative percentage change (post):	$\frac{(Spost - Cpost)}{Cpost} x100$
Absolute change from baseline:	S_{change} vs C_{change}
Difference in absolute change from baseline:	$S_{change} - C_{change}$

Example:

	Study	Control
Pre	27%	40%
Post	55%	51%
Change	28%	11%

Pretest mean:	27% vs 40%
Posttest mean:	55% vs 51%
Absolute change (post):	4%
Relative percentage change (post):	7.8%
Absolute change from baseline:	28% vs 11%
Difference in absolute change from baseline:	17%

Appendix 4. Quality assessment. Excluded due to major limitations: *n*=48.

Study (Year)	Design	Design	Content	Sample size	Instruments used	Test statistics	Significance	Level of evidence		Inclusion
	Type	Ranking						low	moderate	high	
Abbot (2006)	UBA	0	1	0	0	1	1		3*		No
Barreau (2003)	UBA	0	1	0	1	1	1		3*		No
Baker (1998)	UBA	0	1	0	1	0	0	2			No
Berhe (2006)	UBA	0	1	0	0	1	1		3*		No
Bhojani (2008)	UBA	0	0	0	1	0	0	1			No
Bischoff (2000)	UBA	0	1	0	0	1	1		3*		No
Bittner (2002)	UBA	0	1	0	0	1	1		3*		No
Coignard (1998)	UBA	0	1	0	0	1	1		3*		No
Colombo (2002)	UBA	1	1	0	0	0	0	2			No
Connoly (1998)	UBA	0	0	0	0	0	0	0			No
Conrad (2001)	UBA	0	0	0	0	1	1	2			No
Coopersmith (2004)	UBA	0	1	0	0	1	1		3*		No
Cromer (2007)	UBA	0	0	0	1	0	0	1			No
Danchaivijitr (2005-1)	UBA	0	1	0	0	1	1		3*		No
Danchaivijitr (2005-2)	UBA	0	0	0	0	1	1	2			No
Das-Neves (2006)	UBA	0	1	0	0	0	0	1			No
Donowitz (1986)	UBA	0	1	0	1	0	0	2			No
Dubbert (1990)	UBA	0	1	0	0	0	0	1			No
Ebnother (2007)	UBA	0	1	0	0	0	0	1			No
Gill (2009)	UBA	0	1	0	0	1	1	3-			No
Girard (2001)	UBA	0	1	0	0	1	1		3*		No
Graham (1990)	UBA	0	1	0	0	1	1		3*		No
Grayson (2008)	UBA	0	1	0	0	0	1	2			No
Higuera (2005)	UBA	0	1	0	0	1	1		3*		No
Johnson (2005)	UBA	0	1	0	0	1	1		3*		No
Lankfort (2003)	UBA	0	1	0	0	1	1		3*		No
Lederer (2009)	ITS	1	1	0	0	0	0	2			No
Maury (2000)	UBA	0	1	0	0	1	1		3*		No
McGuckin (1999)	UBA	0	1	0	0	1	1		3*		No
McGuckin (2001)	UBA	0	1	0	0	1	1		3*		No
McGuckin (2004)	UBA	0	1	0	0	1	1		3*		No
McGuckin (2004)	UBA	0	1	0	0	0	1	2			No
Ozyazicioglu (2008)	UBA	0	0	0	0	1	1	2			No
Panhotra (2004)	UBA	0	1	0	0	0	1		3*		No
Pessoa-Silva (2007)	UBA	0	1	0	0	1	1	3-			No
Rosenthal (2004)	UBA	0	1	0	0	1	1		3*		No
Rosenthal (2005)	UBA	0	1	0	0	1	1		3*		No
Salemi (2002)	UBA	0	1	0	1	0	0	2			No
Sanchez (2007)	UBA	0	1	0	0	0	1		3-		No
Shaw (2003)	UBA	0	1	0	0	0	0	1			No
Sud (2007)	UBA	0	1	0	0	0	0	1			No
Swoboda (2004)	UBA	0	1	0	0	1	1		3*		No
Swoboda (2007)	UBA	0	1	0	0	1	1		3-		No
Thomas (2005)	UBA	0	1	0	0	0	0	1			No
Tibbals (1996)	UBA	0	1	0	1	0	0	2			No
Tolentino (2007)	UBA	0	1	0	0	0	1	2			No
Venkatesh (2008)	UBA	0	1	0	0	1	1		3-		No
Whitby (2008)	UBA	0	1	0	0	1	1		3-		No

Appendix 5. Overview of strategies and methods in the 41 studies reviewed.

Study	**Strategy**	**Methods**				**Quality assessment**
(Year)	Determinants addressed	Design	Setting (n)	Target population	Unit of analysis(n)[$]	Ranking and limitations
Berg (1995)	Knowledge, Awareness, Self-efficacy, Action control	UBA	Medical/surgical ICU (1)	NS	HH Opportunities (677) Before (251) After (426)	4: Moderate Uncontrolled design, rater procedure not described, test statistics not described
Brock (2002)	Awareness	RCT	Study: Emergency care (1) Control: ICU (1)	Nurses Technical staff	Participants (90) Study (45 nurses) Control (45 nurses)	5: Moderate Obtrusive observations, rater procedure not described
Brown (2003)	Knowledge, Awareness, Social influence, Self-efficacy, Intention, Action control, Facilities	UBA	NICU (1)	Nurses Physicians Other HCWs	HH Opportunities (606) Before (283) After (323)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Conly (1989)	Knowledge, Awareness, Social influence, Attitude, Action control	UBA	Medical ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (211) Before (122) After period (99)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Creedon (2006)	Knowledge, Awareness, Action control, Facilities	UBA	Medical/surgical ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (314) Before (152) After (162)	4: Moderate Uncontrolled design, obtrusive observations, rater procedure not described
Dorsey (1996)	Knowledge, Action control	UBA	Emergency department (1)	Nurses Physicians Other HCWs	HH Opportunities (252) Before (132) After (120)	4: Moderate Uncontrolled design, sample size described but not justified/rater procedure not described
Duerink (2006)	Knowledge, Awareness, Self-efficacy, Action control, Facilities	CBA	Study: Medical internal ward (1) Paediatric ward (1) Control: Gynaecology ward (1)	NS	HH Opportunities (7160) Study (5005) Control (2155)	5: Moderate Sample size not described, rater procedure not described
Earl (2001)	Facilitation of behaviour	UBA	Medical ICU (1) Surgical ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (2181) Before (1090) After (1091)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Eldridge (2006)	Knowledge, Awareness, Social influence, Action control, Facilities	UBA	3 Medical centres ICU (4)	Nurses Physicians Other HCWs	HH Opportunities (4103) Before (2338) After (1762)	4: Moderate Uncontrolled design, obtrusive observations, rater procedure not described

Appendix 5. Overview of strategies and methods in the 41 studies reviewed—continued.

Study	Strategy	Methods				Quality assessment
(Year)	Determinants addressed	Design	Setting (n)	Target population	Unit of analysis(n)$	Ranking and limitations
Gian-nitsioti (2009)	Facilitation of behaviour	UBA	Medical ward (1)	Nurses Physicians Other HCWs	HH Opportunities (299) Before (207) After (92)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Gola (2006)	Action control	Cross-over	Medical ICU (1) Surgical ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (1619) Medical ICU (998) Surgical ICU (621)	6: high Rater procedure not described
Gould (1997)	Knowledge, Awareness, Attitude, Self-efficacy, Facilities	CBA	Study: Surgical wards (2) Control: Surgical wards (2)	Nurses	Participants Study (16) Control (15)	4: Moderate Sample size described but not justified, obtrusive observations, rater procedure not described
Haas (2008)	Facilitation of behaviour	UBA	Emergency department (1)	Nurses Physicians Other HCWs	HH Opportunities (757) Before NS After NS	4: Moderate Uncontrolled design, obtrusive observations, rater procedure not described
Harbart (2002)	Knowledge, Awareness, Social influence, Attitude, Action control, Facilities	UBA	General PICU (1), Cardiac ICU (1), NICU (1)	Nurses Physicians Other HCWs	HH Opportunities (12,216)	5: Moderate Uncontrolled design, sample size described but not justified
Howard (2009)	Knowledge, Awareness, Action control	UBA	Surgical ward (4) Emergency department (1)	Nurses Physicians Other HCWs	Patients Before (85 patients) After (74 patients)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Huang (2002)	Knowledge, Awareness, Self-efficacy	RCT	All hospital departments	Nurses	Participants (98) Study (49 nurses) Control (49 nurses)	4:Moderate Sample size described but not justified, obtrusive observations, rater procedure not described
Khatib (1999)	Action control	UBA	ICU (1)	NS	HH Opportunities (1080) Before (537) After (543)	3: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described, test statistics not described
Lam (2004)	Knowledge, Attitude, Self-efficacy, Action control, Facilities	UBA	NICU (1)	Nurses Physicians Other HCWs	HH Opportunities (983) Before (666) After (317)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described

Larson (1991)	Knowledge, Facilities	UBA	NICU*(1) Recovery unit (1)	Nurses Physicians Other HCWs	HH Opportunities (1610) Automatic sink (615) Manual sink (995)	4: Moderate Uncontrolled design, sample size described but not justified, obtrusive observations but rater procedure described
Larson (1997)	Knowledge, Awareness, Social influence, Facilities	CBA	Study: Neurosurgical ICU (1) Control: Surgical ICU (1)	Nurses	HH Opportunities (1983) Study (991) Control (992)	6: High Sample size described but not justified
Larson (2000)	Knowledge, Awareness, Social influence, Attitude, Self-efficacy, Intention, Action control	CBA	Study: 1 hospital Medical ICU (1) NICU (1) Control: 1 hospital Medical ICU (1) NICU (1)	NS	Number of dispenser activations (860,567) Study (477,680) Control (382,887)	4: Moderate Sample size described but not justified, adherence measured by used volume of soap or hand alcohol
Larson (2005)	Facilitation of behaviour	Cross-over	Paediatric emergency dep. (1) PICU (1)	NS	HH Opportunities (5568)	6: High Obtrusive observations but rater procedure described
Marra (2008)	Awareness, Social influence, Self-efficacy, Intention	CBA	Study: step-down unit (1) Control: step-down unit (1)	HCWs (NS)	HH episodes by electronic counting device (228,297) study (117,579) Control (110,718)	4: Moderate Sample size described but not justified, adherence measured by electronic counting device
Mayer (1986)	Knowledge, Awareness, Facilities	CBA	Study: ICU (1) Control: ICU (1)	Nurses	HH opportunities (834) Study (610) Control (224)	6: High Sample size described but not justified
Moongtui (2000)	Awareness, Social influence	RCT	Emergency department (1) Randomisation of nurses	Nurses Other HCWs	Participants (91) Study (36) Control (55)	6: High Rater procedure not described
Muto (2000)	Knowledge, Self-efficacy, Action control, Facilities	UBA	Medical ward (1) Medical ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (239) Before (126) After (113)	3: Moderate Uncontrolled design, rater procedure not described, test statistics not described
Picheansathian (2008)	Knowledge, Awareness, Action control, Facilities	UBA	PICU (1)	Nurses	HH Opportunities (1245) Before (320) After (925)	4: Moderate Uncontrolled design, sample size described but not justified, obtrusive observations, rater procedure described

Appendix 5. Overview of strategies and methods in the 41 studies reviewed—continued.

Study	**Strategy**	**Methods**				**Quality assessment**
(Year)	Determinants addressed	Design	Setting (n)	Target population	Unit of analysis(n)$	Ranking and limitations
Pittet (2000)	Knowledge, Awareness, Social influence, Action control, Facilities	UBA	All hospital wards	Nurses Physicians Other HCWs	HH Opportunities (5403) Before (2834 After (2569)	5: Moderate Uncontrolled design, sample size described but not justified
Raju (1991)	Knowledge, Awareness, Attitude	UBA	NICU (1)	Nurses Physicians Other HCWs	HH Opportunities (412) Before (257) After (155)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Raskind (2007)	Knowledge, Intention, Action control	UBA	PICU (1)	Nurses Physicians Other HCWs Administrative personnel, Family and visitors	HH Opportunities (401) Before (189) After (212)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Rupp (2007)	Knowledge, Action control, Facilities	Cross-over	ICU A/B	Nurses physicians other HCWs	HH Opportunities (3678)	5: Moderate Sample size described but not justified, rater procedure not described
Santana (2007)[63]	Knowledge, Action control, Facilities	UBA	ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (3476) Before (2032) After (1444)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Sharek (2002)	Knowledge, Awareness, Action control	UBA	NICU (1)	Nurses Physicians Other HCWs	Participants (46)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Simmons (1990)	Knowledge, Awareness, Social influence, Attitude, Action control	UBA	Surgical ICU (1) Medical ICU (1)	Nurses Physicians Other HCWs	HH Opportunities (485) Before (257) After (155)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Slota (2001)	Knowledge, Action control	UBA	PICU (1)	NS	HH Opportunities (350) Before and after numbers NS	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described

Trick (2006)	Knowledge, Awareness, Attitude, Action control, Facilities	CBA	Multicentre (4) study: 3 hospitals Medical ward (2) Surgical ward (1) ICU/PICU (5) Skilled care (1) Control: 3 hosp. ICU/PICU (2) Rehab. ward (1)	Nurses Physicians Other HCWs	HH Opportunities (6948) Study (5206) Control (1742)	6: High Sample size described but not justified
v/d Mortel (1995)	Awareness, Action control	UBA	NICU (1) High care (1)	Nurses Physicians Other HCWs	HH Opportunities (893) Before (303) After (590)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
v/d Mortel (2000)	Awareness	UBA	ICU (1) High care (1)	Nurses Physicians Other HCWs	HH Opportunities (542) Before (143) After (399)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Whitby (2004)	Facilitation of behaviour	UBA	Internal med.w. (1) PICU (1) Infectious diseases ward (1) Urology ward (1)	Nurses	HH Opportunities (8146) Before (4001) After (4145)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described
Won (2004)	Knowledge, Awareness, Attitude, Action control, Facilities	UBA	NICU (1)	Nurses Physicians Other HCWs	HH Opportunities NS (312 observation periods) Before NS After NS	4: Moderate Uncontrolled design, sample size not described, rater procedure not described
Zerr (2005)	Knowledge, Awareness, Social influence, Attitude, Self-efficacy, Action control, Facilities	UBA	Paediatric ward (1) Surgical ward (1)	Nurses Physicians Other HCWs	HH Opportunities (1526) Before (958) After (568)	4: Moderate Uncontrolled design, sample size described but not justified, rater procedure not described

CBA = Controlled before-and-after study, HH = hand hygiene, HCWs = healthcare workers, ICU = intensive care unit, NICU = neonatal intensive care unit, NS = , PICU = paediatric intensive care unit, UBA = uncontrolled before-and-after study.

[$]Numbers are calculated from baseline data and data derived directly

Appendix 6. Details of study characteristics, improvement activities and results in the 41 studies reviewed.

Study (Year)	Region	Theory based*	Analysis of barriers†	Description of improvement activities	Results on HH compliance‡
Berg (1995)	Central America			A non-targeted intervention in conjunction with on-going structured education. Placing signs at patient's bedside in case of a present pathogen. Lectures, demonstration of HH technique, positive and negative feedback. Managers of the wards encouraged HH practice.	Before: 5% (13/251) After: 63% (268/426) Absolute difference: 58%
Brock (2002)	USA	Social cognitive theory	Yes	Performance feedback was given to the intervention group on a personal confidential card, which identified the individual's rate of HW and HW technique.	After intervention vs control: 80·1 (47 nurses) - 68·1 (45 nurses) = 12/68·1*100 Relative difference: 17·6
Brown (2003)	Russia			Personalised instruction from infection control nurse, more personalised instruction from a role model. Identification and training of opinion leader (spoke with individual staff members). Display of colonisation rates. Corrected HCWs with poor HH and nosocomial infections. Demonstration of colony forming on fingers. Alcohol-based hand rub provided. Dispensers at each bed. Working group formed. All nursing staff required to sign a statement outlining requirements for HH.	Before: 44% (125/283) After: 48% (155/323) Absolute difference: 4%
Conly (1989)	Canada			Policies and procedures reviewed and modified. Infection control staff emphasised importance of HH. Deficiencies emphasised in service rounds. Feedback data about poor practice. Results of previous surveys presented. Memoranda sent to staff and department. Posters emphasising procedures placed in the MICU.	Before: 21% (26/122) After: 49% (44/89) Absolute difference: 28%
Creedon (2006)	Europe	Precede model		A multifaceted HH programme: provision of knowledge (an educational hand-out and poster campaign), enabled by provision of an alcohol rub; and HH behaviour was reinforced by feedback of baseline observations on posters. Rationale of HH, Nosocomial infection rates and costs, HH technique, knowledge transmitters and behavioural prompts. Feedback on results of HH behaviour (baseline) in poster format. New alcohol hand rub.	Before: 51% (78/152) After: 83% (134/162) Absolute difference: 32%
Dorsey (1996)	USA			Distribution of a HW-related publication to all staff. Brightly coloured fluorescent signs with CDC HW recommendations were posted al all sinks.	Before: 52% (69/133) After: 61% (71/116) Absolute difference: 9%
Duerink (2006)	Asia			The intervention consisted of the development of a protocol for standard precautions, installation of washstands, educational activities and performance feedback. Summary of a protocol for each attendant. Brightly coloured posters depicting the procedures in nurses' rooms. Lecture on standard precaution. Practical sessions in small groups. Charts and oral feedback. Distribution of pocket calculator with statements on infection control as small gift. Installation of washstands. Individual bottles of hand alcohol. Hand alcohol in all rooms of the ward.	After intervention vs control: 90 (unclear) - 17 (unclear) = 73/17*100 Relative difference: 429

Earl (2001)	USA			Introduction of an new alcohol-based hand rub.	Before: 39·6% (432/1090) After: 52·6% (574/1091) Absolute difference: 13%
Eldridge (2006)	USA	Six sigma model	Yes	Alcohol-based hand rubs for each bed, pocket-sized alcohol hand rubs, hand lotion, soap. Posters, brochure or sign to promote alcohol-based hand rubs. One-page summary document of CDC guidelines. An 8-min video about HH. Annual compliance measurement. Posters and buttons for patients and visitors: 'It's OK to ask health care providers if they cleaned their hands.'	Before: 47% (1099/2338) After: 80% (1410/1762) Absolute difference: 33%
Gian-nitsioti (2009)	Europe			Installation of a alcohol-based hand rub antiseptic bed rail system.	Before: 36% (207) After: 36% (92) Absolute difference: 0%
Golan (2006)	USA			The intervention consisted of eliminating the gown-use requirement from the contact precautions protocol for patients infected or colonised with vancomycin-resistant enterococcus or methicillin-resistant *Staphylococcus aureus*.	After: intervention vs control: 1619 observations in total 37 (unclear) - 34 (unclear) = -3 Relative difference: -8·8
Gould (1997)	Europe			Educational sessions included theory and practical demonstrations of HW. Information about and importance of transmission and decontamination. Demonstration of ideal technique. Risk in relation to blood and body fluid contact. Reinforcement of technique and practice with feedback.	After: intervention vs control: 58·6 (16 nurses) - 64·1 (15 nurses) = -5·5/64·1*100 Relative difference: -8·6
Haas (2008)	USA		Yes	Introduction of hand gel to personnel.	Before: 43% (total 757) After: 51% Difference: 8%
Harbarth (2002)	USA			Introduction of an alcohol-based hand gel; multifaceted quality improvement interventions (educational programme, opinion leaders, performance feedback). Hand-out toolkit with educational materials and key journal papers for opinion leaders, educational sessions about the importance of HH and misconceptions about alcohol-based HH, personal reminders from opinion leaders. Performance feedback of HH compliance data in graphic form. Double page-size coloured posters. Multidisciplinary meetings.	12,216 observations in total Before: 28·2% (unclear) After: 37·2% (unclear) Absolute difference: 9%
Howard (2009)	Europe			Distribution of a 'clean practice protocol' poster to raise awareness of key infection-control activities, as advised by the latest international guidelines. Clean practice protocol poster used for education at the multidisciplinary team meetings and on surgical wards to remind staff of clean practice requirements. Results of audits were presented to staff.	Before: 28% (85) After: 87% (74) Absolute difference: 59%

Appendix 6. Details of study characteristics, improvement activities and results in the 41 studies reviewed—cont.

Study (Year)	Region	Theory based*	Analysis of barriers†	Description of improvement activities	Results on HH compliance‡
Huang (2002)	Asia			Educational training programme involving 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.	After intervention vs control: 88·8 (49 nurses) 62·4 (49 nurses)= 26·4/62·4*100 Relative difference: 42·3
Khatib (1999)	Asia			Permanently placed warning labels on mechanical ventilators to remind staff of HW and the use of surgical gloves by respiratory care practitioners in the ICU.	Before: 64·5% (346/537) After: 92% (500/543) Absolute difference: 27·5%
Lam (2004)	Asia			The intervention consisted of problem-based and task-oriented HH education, enhancement of minimal handling protocol and clustering of nursing care, liberal provision of alcohol-based hand antiseptic, improvement in HH facilities. A HH protocol was incorporated as part of the orientation programme for all new staff, emphasising the importance and the correct steps of HW. Step-by-step protocols for common nursing procedures were developed and implemented by face-to-face training and return demonstration that were conducted at regular intervals. Pictures on steps of correct HW procedures were posted at each HW basin. Antiseptic alcohol-based hand rub was made readily available. Water taps of wash basins modified to allow hands-free operation by fitting an infrared automatic sensor.	Before: 39·5% (263/666) After: 56% (178/317) Absolute difference: 16·5%
Larson (1991)	USA			Introduction of an automated sink.	Before: 61·8% (995/1610) After: 38·2% (615/1610) Absolute difference: -23·6%
Larson (1997)	USA	Precede model		A multifaceted intervention including focus group sessions, installation of automated sinks, and feedback to staff on HW frequency. Sessions to reinforce learning. Focus group sessions with staff about HW practices and beliefs. Suggestions for new methods were reviewed. Contradictions were examined, and group process was used to develop a unit-based plan to improve HW. Feedback on HW frequencies (posted bar charts weekly). Installation of automatic sinks; full sequence mode in phase 4. Active and visible involvement and support of the units' administration.	After intervention vs control: 83 (190/229) - 48 (75/157) = 35/48*100 Relative difference: 73

Larson (2000)	USA		Programme consisted of education, feedback, reaction to outbreaks, HH products for home use, role modelling, management commitment, involvement and support, allocation of rewards. HW fact sheet developed and distributed. Educational programme about HH procedures. Unit-specific feedback data about infection rates weekly. Outbreaks and high infection rates used to review and reinforce HH compliance expectations. Article describing correct procedure published in two hospital publications. Sample of HH products for use at home. All personnel in supervisory role encouraged to role model HH and to point out poor HH in others. Selection of individuals for formal recognition (allocation of rewards. All new ones signed a copy of the HH sheet. Letter from chief executive officer and medical director stating their commitment.	After intervention vs control: (number of soap dispensing/patient care days): 42 (148,562/3458) – 39·2 (132,944/3389) = 3·8/39·2*100 Relative difference: 9·7
Larson (2005)	USA		Introduction of manual and touch-free dispensers of alcohol sanitizer.	After: intervention vs control : (number of uses per dispenser per day/ mean) 41·2 - 25·6 = 15·6/26·6*100 Relative difference: 61
Marra (2008)	South America		Feedback was provided by the nurse manager of the step-down units who explained the goals and targets for the process measures in the intervention unit twice per week. Feedback was presented to each HCW separately, showing the total number of times the dispensers were used and promoting a comparison of HH compliance among HCWs.	After intervention vs control (rate of use, number of HH episodes) 41·1 - 35·8 = 5·3/35·8*100 Relative difference: 14·8
Mayer (1986)	USA	Yes	The introduction of a moisturised soap and feedback in the form of daily memos to individual staff about the previous day's HW. Written description of the three behaviour categories en critical procedures that should be followed. Feedback on HW frequency from previous day. Changing HH agent in emollient HW product.	After intervention vs control: 92 (157) - 77 (53) = 15/77*100 Relative difference: 19·5
Moongtui (2000)	Asia		Peer feedback programme. Open observations of HH practice by peers. Posted feedback of compliance at group level every 3 days.	After: intervention vs control: 82·7 (36 nurses) - 65·8 (55 nurses) = 16·9/65·8*100 Relative difference: 25·7
Muto (2000)	USA		Introduction of alcohol-based hand antiseptics accompanied with an educational campaign with 4 weekly visits to these floors to remind and reinstruct staff about the use of the alcohol dispensers and to address questions. Meeting with staffs. Placement of signs in common area. Messages inserted in the wards' communication books to remind staff about new dispensers. Placement of signs in common area. Alcohol dispensers were mounted next to every door. Educational and motivational campaign. Three weekly visits to motivate and reinstruct staff and address any questions and comments about HH and dispensers.	Before: 60% (76/126) After: 52% (59/113) Absolute difference: -8%

Appendix 6. Details of study characteristics, improvement activities and results in the 41 studies reviewed—cont.

Study (Year)	Region	Theory based*	Analysis of barriers†	Description of improvement activities	Results on HH compliance‡
Picheansathian (2008)	Asia			The intervention was a HH promotion programme including a training session, regular performance feedback and reminder poster displays. Provision of bedside alcohol-based solution, distribution of individual bottles of alcohol-based hand rub.	Before: 6·3% (320) After: 81·2% (925) Absolute difference: 75%
Pittet (2000)	Europe		Yes	A hospital-wide programme with special emphasis on bedside, alcohol-based hand disinfection, reminders (posters), feedback and encouragement from senior staff. Involvement and support of hospital management. Participation in regular meetings of project team. Performance feedback twice a year. Visual display of double-page-size colour posters that emphasise the importance of HH. Individual bottles of alcohol hand rub. Custom-made holders were mounted on all beds. Promotional material (talking walls).	Before: 48% (1360/2834) After: 66% (1696/2569) Absolute difference: 18%
Raju (1991)	USA		Yes	The programme included four interventions, namely, five educational sessions (importance of HH related to nosocomial infections, methods of prevention, rationale for HH prophylaxis), in-service training during ward rounds, distribution of literature about HW and feedback of monitoring results from compliance and bacterial cultures.	Before: 28·4% (73/257) After: 62·6% (97/155) Absolute difference: 34·2%
Raskind (2007)	USA			An educational programme that used a range of educational materials, including illustrations and a written description of proper HH techniques specific to the NICU. The educational materials reinforced the importance, frequency and included illustrations and a written description of proper HH techniques specific to the NICU. These materials were disseminated by means of an e-mailed brochure. Prominently displayed bulletins and posters that described proper required HH in the NICU.6Verbal reminders.	Before: 89% (168/189) After: 100% (212/212) Absolute difference: 11%
Rupp (2007)	USA			An educational programme regarding HH in both units, consisting of face-to-face meetings with nursing staff (and mandatory videotaped viewing for the night shift), a questionnaire with hand-outs, and posting of reminder signs. Dispensers for alcohol-based hand gel.	After intervention vs control: (3768 observations in total) 68·5 – 37·5 = 31/37·5*100 Relative difference: 82·7
Santana (2007)	South America			Eight dispensers containing alcohol-based hand gel were introduced (1 dispenser for every 2 beds). Five page-sized colour posters were placed strategically around the unit to emphasise the importance of HH. A sticker was placed on each alcohol dispenser instructions for use and to encourage HH. Ten educational sessions lasting approximately 15 min.	Before: 18·3% (372/2032) After: 20·8% (300/1444) Difference: 2·5%

Simmons (1990)	USA	The interventions included compulsory attendance of in-service training, distribution of educational material, distribution of buttons encouraging HCWs to wash their hands, feedback, and on-the-spot critique of HW for all staff. Delivery of two key publications. In-service rounds by physician about importance of HH and HH indications. Open observations and direct feedback (deficiencies specially pointed out). Control staff wore and handed out buttons to encourage HCWs to proper HH.	Before: 22% (39/177) After: 29·9% (92/308) Absolute difference: 7·9%
Sharek (2002)	USA	An evidence-based HW policy, supported by an intensive education programme, reminders, and feedback. Educational notices and educational sessions. Feedback on compliance data and infection rates. Stickers and posters.	Before: 47·4% (n = 19) After: 85·4% (n = 48) Absolute difference: 38%
Slota (2001)	USA	Strict HW and protective gown and glove use. In-service training. One-to one education with each administered patient to study. Large free-standing signs with direction placed in front of each patient's bed.	Before: 22% (not clear) After: 76% (350) Absolute difference: 54%
Trick (2006)	USA	45-min educational sessions for personnel during their annual mandatory infection control education programmes. Components of the presentation included review of the CDC's Healthcare Infection Control Practices 45-min educational sessions. Data on hospital-specific HH adherence. Pocket-sized bottles of alcohol-based hand rub. An HH fact sheet. Alcohol-based hand rub was readily available in all inpatient care areas. Hospital-wide poster campaigns at the intervention hospitals. The campaign featured humorous posters of high-profile hospital administrative and clinical staff using and encouraging HCWs to use alcohol-based hand rubs.	After: intervention vs control: (6948 observations in total) 46·3 - 31 = 15·3/31*100 Relative difference: 49·5
v/d Mortel (1995)	Australia	Six weekly feedback in the form of charts of non-personalised HW performance. Charts of revised HW performance were displayed about the sinks at 6 weeks intervals.	Before: 63% (191/303) After: 63% (772/590) Absolute difference: 0%
v/d Mortel (2000)	Australia	Feedback about compliance rates.	Before: 61% (87/143) After: 83% (331/399) Absolute difference: 22%
Whitby (2004)	Australia	Sinks positioned at the bedside as well at the entrance to patients room.	Before: 49% (1960/4001) After: 35% (1451/4145) Absolute difference: -14%
Won (2004)	Asia	The HH campaign. Hibiscrub and Better-Iodine were the antimicrobial soaps used for soap -and-water HW during the study period. A special educational programme with formal lectures about the appropriate use of each hand-cleansing agent. Cartoons showing correct HH technique posted above sinks. Folders of written instructions. Formal lectures (appropriate use of agents, correct HH techniques, importance of HH). Feedback about compliance rates monthly. Errors were privately discussed with individual HCWs. Labels with slogan in visible sites. Financial incentives and penalties. Public praise from head nurse.	Before: 43% (unclear) After: 74% (unclear) Absolute difference: 31%

Appendix 6. Details of study characteristics, improvement activities and results in the 41 studies reviewed—cont.

Study (Year)	Region	Theory based*	Analysis of barriers†	Description of improvement activities	Results on HH compliance‡
Zerr (2005)	USA	Social cognitive theory		A hospital-supported, house-wide campaign. Intervention 1 was initiated after period 1 and consisted of education targeting nurses and parents of patients. The goal of intervention 2 was to change HH behaviour through intensive education. Written information for parents, technique, and objective HH. Posters. Temporary tattoos for children. Education about alcohol hand gel. Conferences (hospital grand rounds). Employee newspaper. Dissemination of small bottles of hand alcohol. Placement of hand gel dispensers. Feedback during hospital grand rounds about hospital's own data about HAI and HH over time. Mailings and signs. Written materials invited parents to remind staff to clean their hands. Formulation of multidisciplinary team and use of role models.	Before: 62% (958) After: 74% (568) Absolute difference: 12%

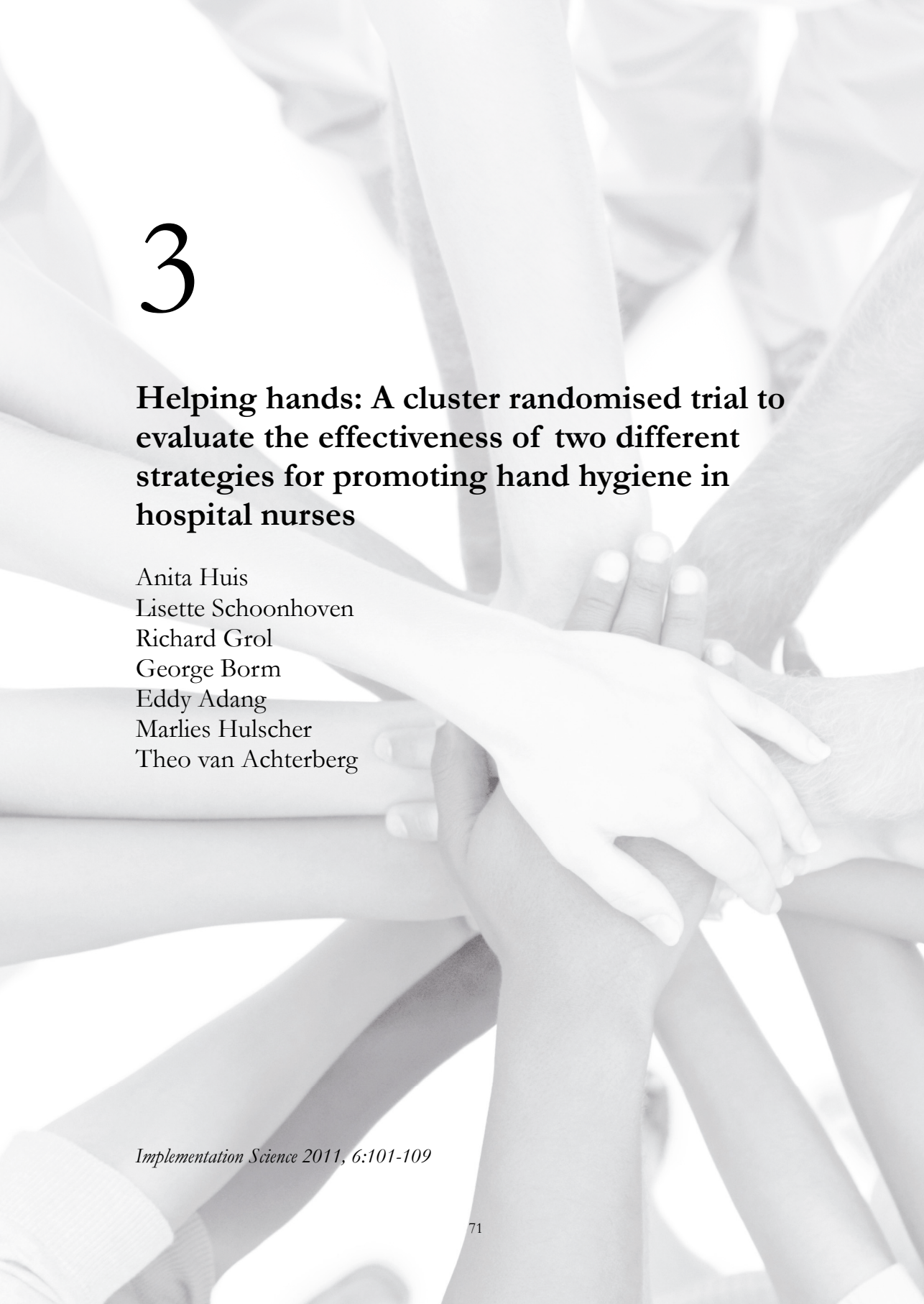
CDC = Centres for Disease Control, HH = hand hygiene, HAI = hospital-acquired infection, HCW = healthcare worker, HW = hand washing, ICU = intensive care unit, MICU = mobile intensive care unit, NICU = neonatal intensive care unit

* Strategy is theory based

† Strategy based on analysis of barriers by practice research

‡ Absolute difference = % After - % Before

Relative difference = 100 * (Intervention – Control)/Control



3

Helping hands: A cluster randomised trial to evaluate the effectiveness of two different strategies for promoting hand hygiene in hospital nurses

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ABSTRACT

Background: Hand hygiene prescriptions are the most important measure in the prevention of hospital-acquired infections. Yet, compliance rates are generally below 50% of all opportunities for hand hygiene. This study aims at evaluating the short- and long-term effects of two different strategies for promoting hand hygiene in hospital nurses.

Methods/design: This study is a cluster randomised controlled trial with inpatient wards as the unit of randomisation. Guidelines for hand hygiene will be implemented in this study. Two strategies will be used to improve the adherence to guidelines for hand hygiene. The state-of-the-art strategy is derived from the literature and includes education, reminders, feedback, and targeting adequate products and facilities. The extended strategy also contains activities aimed at influencing social influence in groups and enhancing leadership. The unique contribution of the extended strategy is built upon relevant behavioural science theories. The extended strategy includes all elements of the state-of-the-art strategy supplemented with gaining active commitment and initiative of ward management, modelling by informal leaders at the ward, and setting norms and targets within the team. Data will be collected at four points in time, with six-month intervals. An average of 3,000 opportunities for hand hygiene in approximately 900 nurses will be observed at each time point.

Discussion: Performing and evaluating an implementation strategy that also targets the social context of teams may considerably add to the general body of knowledge in this field. Results from our study will allow us to draw conclusions on the effects of different strategies for the implementation of hand hygiene guidelines, and based on these results we will be able to define a preferred implementation strategy for hospital based nursing.

BACKGROUND

Hospital-acquired infections (HAIs) are a serious and persistent problem throughout the world. They are burdensome to patients, complicate treatment, prolong hospital stay, increase costs, and can be life threatening.[1,2]

Micro-organisms on the hands of healthcare workers contribute to the incidence of infections in patients.[3,4] Therefore, hand hygiene prescriptions are widely accepted as the most important measure in the prevention of HAIs.[5-11] Unfortunately, numerous studies over the past few decades have demonstrated that healthcare workers still perform hand hygiene on average less than 50 per cent of the times required.[12-14] Thus, current practices deviate from the goal of providing safe hospital care aimed at prevention of adverse events, morbidity, and mortality.

In their review on approaches for transferring evidence to practice, Grol and Grimshaw[15] used a case study looking at strategies to improve hand hygiene in hospital settings. They concluded that plans for improvement of current performance should be based on barriers and facilitators for change. Regarding hand hygiene, they concluded that changing behaviour is possible, but this change generally requires 'a comprehensive plan with strategies at different levels (professional, team, patient, and organisation) to achieve lasting changes in hand hygiene routines.'

Traditionally, implementation strategies have focussed on professionals—the individual level—or addressed structural work context—the organisational level. Team-directed strategies are hardly studied.[15-16] Yet, team-directed strategies could be valuable as healthcare workers (especially nurses) usually work in teams. Performing and evaluating an implementation strategy that also targets the social context of teams may considerably add to the general body of knowledge in this field.

AIMS AND OBJECTIVES

The aim of this study is to test two implementation strategies in inpatient wards to improve nurses' compliance with hand hygiene prescriptions and to compare the short-term and sustained effects of these innovative strategies. The objectives of this project are threefold: to improve compliance with guidelines for hand hygiene in nurses; to assess the cost effectiveness of both strategies; and to gain insight into determinants of success or failure of the strategies.

Scientific hypothesis

Our hypothesis is that an extended strategy, using additional implementation activities based on social influence and leadership, will be more effective in increasing hand hygiene compliance rates compared to a state-of-the-art strategy, mainly addressing the individual and organisational level.

METHODS

Quality improvement strategies

The state-of-the-art strategy is based on current evidence from literature on hand hygiene compliance.[1,15] Short-term effectiveness of this strategy is well-established in several studies and settings.[16,17] The strategy includes: education for improving relevant knowledge and skills; reminders for supporting the transfer from a positive intention to the actual performance of hand hygiene; feedback as a means to provide insight into current hand hygiene behaviour and to reinforce improved behaviour; and screening for adequate hand hygiene products and adequate facilities. The extended strategy also contains activities based on social influence in groups and leadership.

This strategy largely draws from relevant theories and general evidence to support these theories.[18-26] The extended strategy includes all of the elements of the state-of-the-art strategy as well as: gaining active commitment and initiative of ward management; modelling by informal leaders at the ward; and setting norms and targets within the team. Table 1 shows the operationalization of both strategies.

Study design

The study will have a stratified cluster randomised trial design. In a cluster randomised trial, groups of individuals rather than individuals are randomised.[27] Cluster randomisation using wards as the unit of allocation reduces contamination between groups.[28] In our study, the quality improvement strategies involved the entire team of nurses and not individual nurses on nursing wards. Therefore, nurses within the same ward were considered to be a cluster.

Data will be collected for a six-month reference period - no strategy for promoting hand hygiene - prior to the trial (T1 and T2). After data collection for this reference period, randomisation to either the state-of-the-art strategy or the extended strategy will take place. Strategies will be delivered during a second period

of six months. Follow-up measurements will take place directly after strategy delivery (T3) and at six months after the end of strategy delivery (T4). Because the extended strategy consists of the state-of-the-art strategy supplemented with team-directed social influence approaches, randomisation of wards to each of the strategies is feasible. Our study design is illustrated in Figure 1.

Setting and participants

The study will be performed in three hospitals: one university medical centre and two general hospitals. In a fourth (non participating) hospital, we will test the instruments and observer variability. Within the hospitals, all inpatient wards (n = 60), will participate in the study.

Table 1. Description implementation strategies.

State-of-the-art strategy	Extended strategy
Education Distribution of educational material/ written information (leaflet) about hand hygiene • The importance of hand hygiene • Misconceptions about alcohol-based hand disinfection • Theory and practical indications for the use of hand hygiene • Website www.gewoonhandenschoon.nl • Educational material/ written information about hand hygiene • Knowledge quiz • Reward for the nursing ward with the most visitors to the website • Educational sessions on prevention of hospital acquired infections • Launching hospital wide campaign with practical demonstrations of hand hygiene **Reminders** • Distribution of posters that emphasized the importance of hand hygiene, particularly alcohol-based hand disinfection • Interviews and messages in newsletters or hospital magazines • General reminders by opinion leaders/ward management **Feedback** • Bar charts of hand hygiene rates of every nursing ward will be sent to the ward manager twice • Comparison ward performance and hospital performance **Facilities and products** • Screening and if necessary adapt products and appropriate facilities	**All elements of the state-of-the-art strategy** • Education, reminders, feedback, facilities and products **Setting norms and targets within the team** • Three interactive team sessions that includes goal setting in hand hygiene performance at group level • Analysis of barriers and facilitators to determine how they could best adapt their behaviour in order to reach their goal • Nurses address each other in case of undesirable hand hygiene behaviour **Gaining active commitment and initiative of ward management** • Ward manager designates hand hygiene as a priority • Ward manager actively supports team members and informal leaders • Ward manager discusses hand hygiene compliance rates with team members **Modeling by informal leaders at the ward** • Informal leaders demonstrate good hand hygiene behaviour • Informal leaders models social skills in addressing behaviour of colleagues • Informal leaders instruct and stimulate their colleagues in providing good hand hygiene behaviour

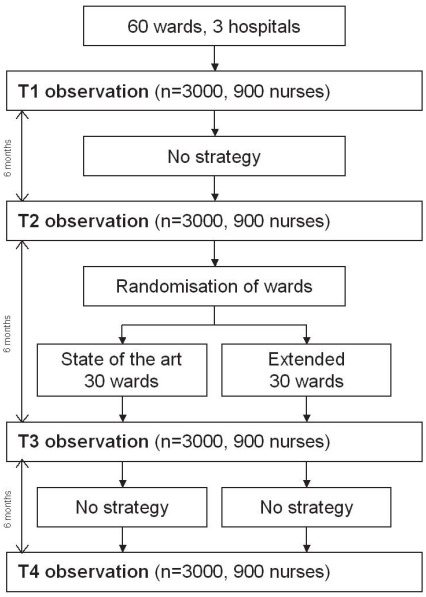

Figure 1. Study design.

After completing baseline measurements of the reference period, wards will be randomly assigned to either the state-of-the-art strategy group (n = 30), or the extended strategy group (n = 30). The randomisation of the wards will be stratified for type of ward to minimize differences in ward characteristics over the strategies. We will randomise surgical wards, internal medicine wards, intensive care units, and paediatric wards.

Parameters, instruments, and analysis

To evaluate the effectiveness and efficiency of the strategies, we will use effect parameters and process parameters. First, we describe the evaluation of hand hygiene compliance and team climate. Second, the economic evaluation regarding costs and health effects. Finally, we describe the assessment of the actual implementation of the strategies and the evaluation of barriers and ward structure.

Effect evaluation: hand hygiene compliance

Table 2 presents the effect parameters and instruments. The primary effect parameter for this study is the percentage of opportunities at which hand hygiene is performed by the nurses according to the National Guideline 'Handhygiene' of the Working group Infection Prevention (WIP) and the WHO Guidelines on Hand Hygiene in Healthcare.[29,30]

The indications that create an opportunity—a required moment—for hand hygiene are listed in Table 3. Hand hygiene is operationalized as 'hand washing with either plain soap and water' or 'hand disinfection through the use of an alcohol-based hand rub solution.'

Other effect parameters are the presence of jewellery (ring, watch, or other jewellery) and whether the nurses wear long-sleeved clothes under their short-sleeved uniforms. We will observe compliance by using a Hand Hygiene Monitoring Tool adapted from the WHO (Appendix 1). The observer will register each opportunity

in a corresponding column block, note all of the applicable indications and whether hand hygiene is performed by hand disinfection or hand washing or is missed.

Data collection

At each point in time, an average of 3,000 opportunities for hand hygiene in approximately 900 nurses will be observed. We will use direct, but unobtrusive observation because this is considered the gold standard and the most reliable method for assessing compliance rates.[1,31-33]

At the beginning of each observation period, nurses will be informed that the observers are conducting research on medication errors and other patient safety issues, but not that hand hygiene will be monitored. Observers will conduct their observations at times with a high density of care, mostly during the morning shifts.

Table 2. Parameters and instruments.

Effect parameter	**Description**	**Instruments**
Hand hygiene compliance	The percentage of opportunities at which hand hygiene was performed according to the National Guideline 'Handhygiene' of the Working group Infection Prevention (WIP) and the WHO Guidelines on Hand Hygiene in Healthcare	Hand hygiene monitoring tool
Other parameters	The percentage of presence of jewelry and long-sleeved clothes	
Team Climate	Dimensions 'participation safety,' 'task orientation,' support for innovation,' and 'interaction.'	Team Climate Inventory
Costs and health effects	Comparing resource consumption and HAIs rate between the two implementation strategies	Activity-based costing; Decision analysis
Process parameter	**Description**	**Instruments**
Performance of the strategies	*State-of-the-art strategy* - Knowledge - number of nurses that completed the knowledge quiz, presence of instruction leaflets. - Reminders - check of presence of posters. - Performance feedback - actual delivery of performance feedback to team members. *Extended strategy* - Coaching of ward management- number of coaching sessions, total time spent on coaching, topics dealt with, managers evaluations of coaching. - Coaching of informal leaders - number of coaching sessions, total time spent on coaching, topics dealt with, informal leaders evaluations of coaching. - Team discussions for norm- and target setting - number of nurses attending per ward, time investment per ward, actual norms and targets decided on, nurses' evaluations of team discussions	Survey, direct observations; systematic registration of time and meeting minutes
Barriers to change	Including determinants like awareness, knowledge, reinforcement, control, social norms, leadership, and facilities	Barrier questionnaire
Barrier questionnaire	Information about existing structures and resources like actual presence of facilities, workload, nurse-bed ratio -under-staffing and support from the management	Ward structure questionnaire

Observers will be blinded for the strategies delivered to the wards under observation.

Observer variability

For each observation period, we will train 10 student nurses, all completing their nursing education and experienced in patient care, as well in collecting data. All student nurses will participate in a two-day training course on understanding the indications for hand hygiene during patient care. They will also learn to apply the observation method and to use the data collection form. Before conducting the observation sessions, the observations by the student nurses will be validated. Visual examples of patient care episodes will be presented, and the students will score related hand hygiene opportunities. Then, we will compare the results of the students and discus discordant notifications. Subsequently, we will undertake parallel monitoring sessions in a non-participating hospital. Every student nurse will perform twenty observations jointly with an experienced observer. We will use a three -step approach to compare the concordance between the observer and the experienced observer. First, we will calculate the concordance between 'the number of recorded hand hygiene opportunities' of the student nurse and the experienced observer. Then, we will calculate the concordance between 'the number of recorded hand hygiene indications' of both observers. Finally, we calculate the concordance between 'the number of recorded actions.' The Wilcoxon rank test will be used to detect differences between the student nurses and experienced observer.

Statistical analysis

The effects of the two strategies will be evaluated on an intention-to-treat basis by comparing the hand hygiene compliance rates in the two study groups after performing the strategies with the compliance rates at the end of the reference period. The differences between the two strategies will be evaluated by comparing the hand hygiene compliance rates of both groups after performing the strategies. Multilevel analysis will be applied to compensate for the clustered nature of the data (compliance is clustered within healthcare workers who are clustered within units) using mixed linear modelling techniques, including the following covariates: ward (random effect), HCW (random effect, nested within ward), institution and the baseline results of the wards. The relevance of nurses' gender, ward specialism, and type of hand hygiene opportunity will also be explored by performing sub group analyses.

Sample size

The state-of-the-art implementation strategy should be able to improve hand hygiene compliance with 15% in the short term.[1] We assume an added effect of 10% from the team-directed approach. This means that the extended strategy would be clinically relevant if it would result in an improvement of compliance with 25% of all occasions for hand hygiene. Calculating from 80% power, two-sided alpha =

Table 3. Observed indications for hand hygiene.

Indication for hand hygiene	When	Transmission risk	Major targeted negative infectious outcome	Examples
Before an aseptic task	Directly before performing an aseptic task	Hand transmission of micro-organisms from any surface (including the patient skin) to a site that would facilitate invasion and infection	Endogenous or exogenous infection of the patient	Giving an injection. Insertion and care of intravenous catheters. Blood draws. Administering intravenous medication. Endotracheal suction
From contaminated body site to another body site	Directly after completing task (whether gloved or ungloved)	Hand exposure to patient's contaminated body sites and fluids potentially containing blood-borne or other pathogens	Infection of the HCW by patient blood borne pathogens	Drawing blood and then adjusting the infusion drop count. Handle wound, mucous membrane, and body fluids. After oral care
After touching the patient	Directly after leaving the patient when the patient was touched	Hand transmission of micro-organisms from the patient flora to other surfaces in the healthcare setting	Dissemination of patient flora to the rest of the healthcare environment and infection of other patients or HCWs	After skin contact with the patient. Bathing, change position or lifting a patient. Taking a pulse or blood pressure. Shaking hands
After taking care of an infected/ colonized patient	Directly after leaving the patient's room	Hand transmission of micro-organisms from the patient flora to other surfaces in the healthcare setting	Dissemination of patient flora to the rest of the healthcare environment and infection of other patients or HCWs	Contact with any patient know to be infectious/ isolated (e.g. MRSA)
After use of gloves	Directly after removing gloves	Hand transmission of micro-organisms from the skin of the HCW 's to other surfaces in the healthcare setting	Dissemination of patient flora to the rest of the health-care environment and infection of other patients or HCWs	Wearing gloves high-risk contacts
After contact with patient surroundings	After completing the task and before contacting another patient	Hand transmission of micro-organisms from the patient flora to other surfaces in the healthcare setting	Dissemination of patient flora to the rest of the health-care environment and infection of other patient or HCWs	Touching the patient's environment like bed, table, blanket, clothes. After contact with medical equipment in the immediate vicinity of the patient

0.05, a ward-ICC of 0.05 and a nurse-ICC of 0.6, in each of the 60 wards in the study an average of 50 observations of occasions for hand hygiene compliance are needed at each point in time, involving 15 nurses per ward.

Effect evaluation: team climate

As the extended strategy will target social interaction in teams of nurses, it is assumed that team climate will be affected in wards receiving this strategy, and not in wards receiving the state-of-the-art strategy.

Team climate will be assessed at T2 and T3, in half of the nurses from each ward. For this purpose, the Team Climate Inventory (TCI) will be used. [34] The TCI includes 44 items on the dimensions 'participation safety', 'task orientation', 'support for innovation' and 'interaction'.

Economic evaluation: costs and health effects

Costs of infections are high, and hand hygiene is a proven effective measure in reducing infections. Therefore, strategies that focus on and result in increasing compliance to hand hygiene guidelines are likely to be cost-effective.

The economic evaluation will compare the two implementation strategies as described earlier in this paper both in terms of implementation costs and health effects. The aim of this evaluation is to detect which of the implementation strategies is the most cost-effective strategy for improving hand hygiene compliance and reducing HAIs. This results in two incremental cost-effectiveness ratios — cost per percentage gained compliance and cost per percentage HAI prevented.

Data collection

The resources consumed by the implementation strategies will be assessed by collecting data on personnel (hours for the strategy delivery team, hours for the nurses attending the strategy related activities, extra time for hand hygiene), and materials (posters, improved products and facilities, use of hand-rub solution). These volumes will be multiplied by their unit prices (market prices, guideline prices or self-determined prices based on costing methods, *i.e.,* full costing.[35]. The cost estimate for a hospital acquired infection and additional healthcare costs will be based on previous estimates of € 4386 per infection.[36]

Statistical analysis

The implementation process and consequent costs will be estimated by an Activity

Based Costing (ABC) approach. The ABC model focuses on identifying all the underlying activities (personnel, material and overhead costs) associated with the state-of-the-art strategy and the extended strategy.

The health effects of the implementation strategies for reducing hospital-acquired infections will be analysed using decision analysis. We assume a baseline prevalence of infection of 6.6%, based on the data from The PREZIES national network for the surveillance of HAIs in The Netherlands.[37] With regard to the association between infection rates and hand hygiene compliance rates, a pooled (if possible) estimation will be applied. For this purpose, we will perform a review of the literature, using systematic review methodology, to identify studies that report of the impact of hand hygiene on HAIs.

Studies should at least include outcome comparison with a (randomized or non randomized) comparison group, or a comparison with baseline data in case of a single group pre-test post-test design. Studies will be further selected if they satisfy the following conditions:

1. Population: healthcare workers in hospital settings.
2. Intervention: strategies or programmes aimed at improving hand hygiene behaviour.
3. Comparison: hand hygiene behaviour and infection rates.
   a. Hand hygiene behaviour prior to the introduction of the programme or strategy.
   b. Infection rates in health-care settings prior to the introduction of the programme or strategy.
4. Outcome: hand hygiene behaviour and infection rates.
   a. All operationalizations of hand hygiene behaviour in healthcare workers.
   b. Infection rates in healthcare setting.

Systematic evaluation of implementation fidelity

In trials on the effects of implementation strategies, a process evaluation can shed light on the target group members' actual exposure to the strategy.[38] In this manner, insight is gained into potential determinants of success or failure of the strategies.

This step also will aid in replicating the strategy in future research. For this purpose, process data will be gathered for each of the activities within the state-of-the-art strategy and the extended strategy.

State-of-the-art strategy

Participation in education will be assessed by measuring the number of nurses that completed the knowledge quiz and by monitoring the presence of instruction leaflets on the ward. Use of reminders will be checked by measuring the presence of reminders (posters) at random moments during the strategy delivery period. Whether performance feedback was provided will be assessed by measuring the extent to which the ward manager provided feedback to the nurses. In addition, the extent to which products and facilities were available will be checked by measuring the presence of products and facilities in each ward.

Extended strategy

The use of coaching of either ward management or informal leaders will be assessed by measuring the number of coaching sessions, the total time spent on coaching, and the topics covered during the session. The use of organised team discussions for norm and target setting will be checked by measuring the number of team discussions performed, the number of nurses attending per ward, the time investment per ward, and the actual norms and targets decided on. Process evaluation data will be collected using a combination of data-collection methods, including questionnaires, direct observations, and systematic registration of time and meeting minutes.

For each of the elements of the strategies 'actual exposure' to the strategy element at the level of wards will be coded as 'low', 'moderate' or 'high' based on the process indicator data collection. Relations between strategy exposure and hand hygiene compliance after the delivery of the strategies will be explored.

Evaluation of barriers and ward structure

Previous recommendations from literature have pointed out that an improvement strategy for hand hygiene behaviour should address existing problems and barriers.[21,39,40] Grol and Grimshaw studied the failing implementation of evidence on hand hygiene in the healthcare setting and identified a variety of barriers to change, including a lack of awareness, knowledge, reinforcement, control, social norms, leadership, and facilities.[15] In our study, these identified barriers to change will be targeted by either the state-of-the-art strategy or the extended strategy. The presence of barriers will be investigated twice - before and after strategy delivery - using a questionnaire in one-half of the nurses from each ward. The barrier questionnaire contains 47 different propositions concerning 21 barriers.

To collect information about existing structures and resources, such as actual presence of facilities, workload, nurse-bed ratio, understaffing, and support from the management, a questionnaire on ward structure will be administered twice to every ward manager.

Ethical and legal aspects

The Medical Ethics Committee of district Arnhem-Nijmegen assessed the study and concluded that our study was deemed exempt from their approval because it did not include collection of data at the level of patients.

The Hawthorne effect is probably the most important bias in hand hygiene observations.[1,30,33,41] Persons who know they are being observed change their behaviour and are significantly more likely to wash or disinfect their hands. Unobtrusive observation diminishes the Hawthorne effect, but raises ethical questions regarding privacy of the observed participants. Therefore, we consulted the ethical committee. They concluded that unobtrusive observation will be permitted under the following conditions: the observation topic, hand hygiene, will be covered by using general patient safety issues as subject of the observation; the observations on the nurses should be collected and processed anonymously; and prior to the observation, the patient has given verbal permission to observe.

DISCUSSION

Changes in healthcare can target individual professionals, teams and units, or healthcare organisations.[15] Traditionally, implementation strategies are directed at individual professionals (individual level) or address structural work context (organisational level), whereas team-directed strategies are rarely studied. The unique contribution of the extended strategy was built upon social learning theory, Social influence theory[23],, theory on team effectiveness[20,25,26] and leadership theory.[24] Together, these theories provide a coherent set of methods to target the social context in which hand hygiene behaviour takes place. Because targeting social context is not often employed in implementation strategies, the results of our project will considerably add to the general body of knowledge by evaluation of the added value of the extended strategy as compared to the state-of-the-art strategy.

Results from our study will allow us to draw conclusions on the effects of different strategies for the implementation of hand hygiene guidelines, and based on these results we will be able to define a preferred implementation strategy for hos-

pital-based nursing. Our evaluation of the state-of-the-art strategy will validate the effectiveness of this strategy in Dutch hospital care. The evaluation will further provide a longer term follow-up effect estimate, whereas commonly only effects during or directly after strategy delivery are evaluated.[15,16]

We believe our study has methodological strengths because of the large numbers of observations and participating wards, the randomisation of wards either to the state-of-the-art strategy or the extended strategy, and the use of unobtrusive observations.

We anticipate several challenges in conducting this study. First, in an ideal world, one would choose randomisation of wards or teams to three groups: a state-of-the-art strategy group, an extended strategy group, and a no strategy group. However, as the state-of-the-art strategy includes hospital-wide campaign elements (*e.g.*, posters on doors, instruction leaflets, and short articles in hospital magazines), three-group randomisation at the level of wards would certainly introduce contamination of the no strategy group. This implies that three-group randomisation in the same hospital is not a feasible option. We will collect baseline data twice, with a six month interval, in order to create a reference period with no strategy. Second, timely and accurate data collection for this study is also challenging. To ensure that comprehensive data collection is feasible in all participating hospitals, we will partner with an established Faculty of Health and Social Studies in recruiting, training, and assessing the students who will perform the observations.

Third, in this study we will not measure nosocomial infections. Measuring nosocomial infections on ward level and correcting for all possible interference from other factors would be labour intensive and costly. Given the fact that the relationship between hand hygiene and the occurrence of infections already is well established, and given practical difficulties in achieving comparable patient groups with regard to risk factor and scoring patients who transfer between wards, we decided to use a model-based estimate of HAIs.

Finally, we will not measure compliance in physicians or other healthcare workers. The main reason for not including physicians is the difference in team structure and teamwork between nurses and physicians. Whereas hospital nurses typically work and interact in ward-based teams, physicians more often work independently and on various locations. Targeting physician-directed social influence would ask for strategies other than targeting nurse-directed social influence. Nevertheless, the state-of-the-art strategy is visible to all hospital staff, and may affect physicians' hand hygiene as well.

We believe that by performing this study, we will improve hand hygiene behaviour and contribute to the body of knowledge on effective strategies for implementing hand hygiene guidelines in healthcare settings. We will specifically add knowledge to the social influence based implementation activities.

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Appendix 1. Hand Hygiene Monitoring Tool: Score form Hand Hygiene opportunities.

Afdeling: _____ (bv. C44) Observatorcode: ___

Datum: __-__-20__

Verpleegkundige: ____ ☐ M ☐ V

Hand/pols sieraden: ☐ Ja ☐ Nee

Lange mouwen: ☐ Ja ☐ Nee

Begintijd: __:__ uur

☐ Verpleegkundige: ____ ☐ M ☐ V

☐ Andere professional: _____

Hand/pols sieraden: ☐ Ja ☐ Nee

Lange mouwen: ☐ Ja ☐ Nee

Begintijd: __:__ uur

G	Indicatie	Actie
1.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

G	Indicatie	Actie
1.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

G	Indicatie	Actie
2.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

G	Indicatie	Actie
2.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

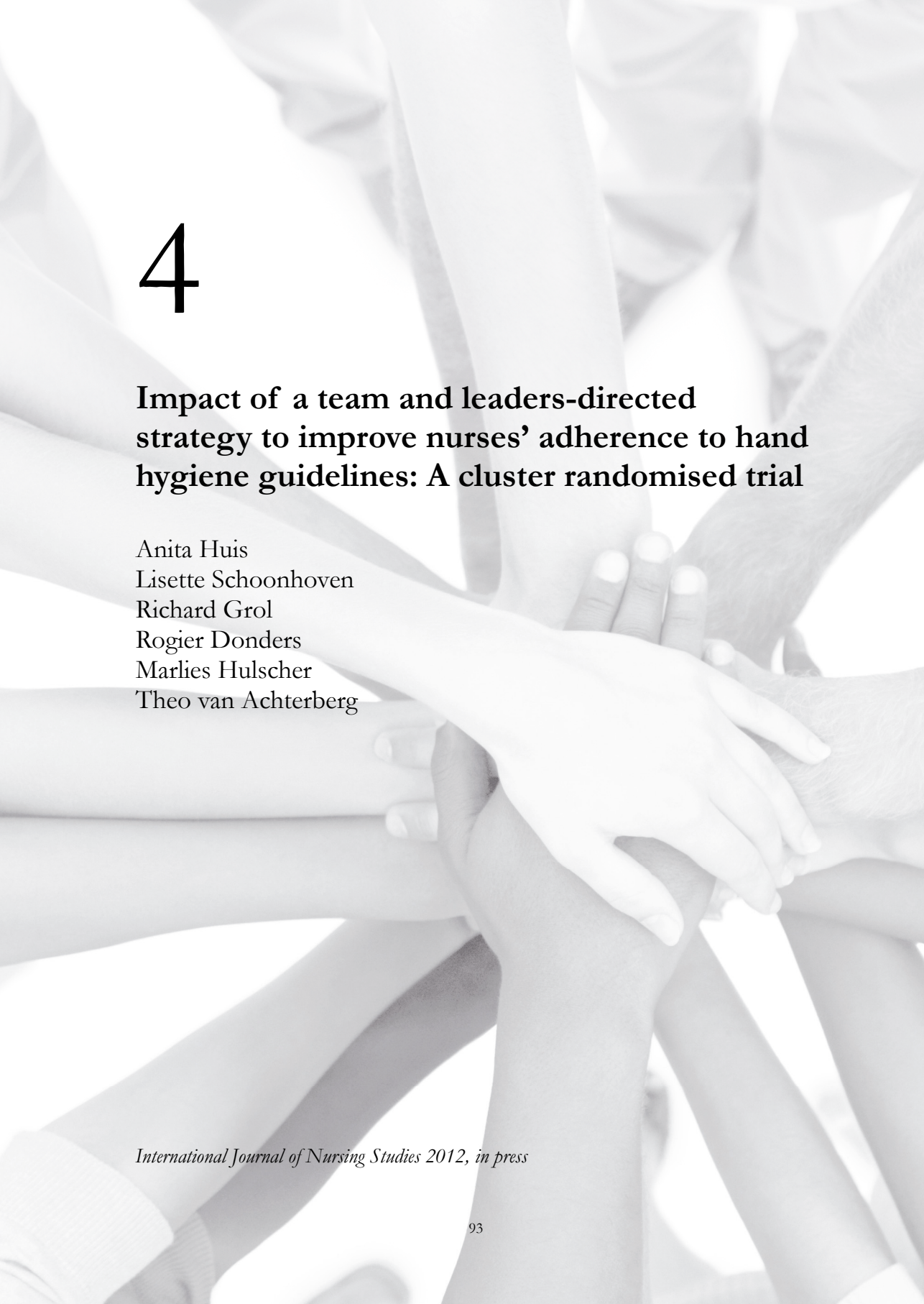
G	Indicatie	Actie
3.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

G	Indicatie	Actie
3.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

G	Indicatie	Actie
4.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

G	Indicatie	Actie
4.	☐ voor - invasief	☐ wassen
	☐ vuil -> schoon	☐ desinfectie
	☐ na - direct contact	☐ geen actie
	☐ na - contact isolatie	
	☐ na - handschoenen	
	☐ na - verplk. handelen	

Kwazo 114, AB



4

Impact of a team and leaders-directed strategy to improve nurses' adherence to hand hygiene guidelines: A cluster randomised trial

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ABSTRACT

Background

Improving hand hygiene compliance is still a major challenge for most hospitals. Innovative approaches are needed.

Objective

We tested whether an innovative, theory based, team and leaders-directed strategy would be more effective in increasing hand hygiene compliance rates in nurses than a literature based state-of-the-art strategy.

Design and setting

A cluster randomised controlled trial called HELPING HANDS was conducted in 67 nursing wards of three hospitals in the Netherlands. Participants: All affiliated nurses of the nursing wards. Wards were randomly assigned to either the team and leaders-directed strategy (30 wards) or the state-of-the-art strategy (37 wards).

Methods

The control arm received a state-of-the-art strategy including education, reminders, feedback and targeting adequate products and facilities. The experimental group received all elements of the state-of-the-art strategy supplemented with interventions based on social influence and leadership, comprising specific team and leaders-directed activities. Strategies were delivered during a period of six months. We monitored nurses' HH compliance during routine patient care before and directly after strategy delivery, as well as six months later. Secondary outcomes were compliance with each type of hand hygiene opportunity, the presence of jewellery and whether the nurses wore long-sleeved clothes. The effects were evaluated on an intention-to-treat basis by comparing the post-strategy hand hygiene compliance rates with the baseline rates. Multilevel analysis was applied to compensate for the clustered nature of the data using mixed linear modelling techniques.

Results

During the study, we observed 10,785 opportunities for appropriate hand hygiene in 2733 nurses. The compliance in the state-of-the-art group increased from 23% to 42% in the short term and to 46% in the long run. The hand hygiene compliance in the team and leaders-directed group improved from 20% to 53% in the

short term and remained 53% in the long run. The difference between both strategies showed an Odds Ratio of 1.64 (95% CI 1.33–2.02) in favour of the team and leaders-directed strategy.

Conclusions

Our results support the added value of social influence and enhanced leadership in hand hygiene improvement strategies. The methodology of the latter also seems promising for improving team performance with other patient safety issues.

INTRODUCTION

Hospital acquired infections (HAIs) are the most common complications in hospital care, and a major threat to patient safety. [1,2] Recent prevalence surveys in Europe have shown that the percentage of patients affected by HAIs on average is 7.1%, ranging from 3.5% to 10.5%.[3] National surveillance in the Netherlands has shown a prevalence rate of HAIs of 6.6%, affecting 100,000 persons each year.[4] Hand hygiene is considered the most important measure in the prevention of HAIs[2], although uncertainty remains about the proportion of HAI's that could be prevented by improved hand hygiene compliance. Especially ethical concerns make it difficult to perform a randomised controlled trial to examine the causal relationship between hand hygiene and the prevention of HAIs. Nevertheless, there is substantial evidence that increased hand hygiene compliance is associated with reduced HAI rates.[5-8] Unfortunately, compliance with hand hygiene recommendations are repeatedly low—representing an overall average of 38.7%.[2] Thus, current practice deviates from the goal of providing safe hospital care, aimed at prevention of complications, morbidity and mortality.

In their review on approaches for transferring evidence to practice, Grol and Grimshaw used a case study looking at strategies to improve hand hygiene in hospital settings.[9] They concluded that plans for the improvement of current performance should be based on barriers and facilitators for change. Given the many barriers on different levels (professional, team, patient, and organisation), hand hygiene behaviour change requires a comprehensive plan with strategies targeting these specific barriers to achieve lasting changes in hand hygiene routines.

Traditionally, hand hygiene improvement strategies have been concentrated on the health care professional (individual level) or focused on the introduction of new products and facilities (organisational level).[9,10] Specific team-oriented activities are rarely applied within these strategies, which is why barriers like negative role models, lack of management involvement and a poor social culture are hardly addressed.

Yet team-directed strategies could really be valuable, as healthcare workers (especially nurses) usually work in teams. Evidence for the effectiveness of team-directed strategies in other settings exists and could also be valuable in hand hygiene improvement strategies.[11] Using insights from the behavioural sciences and performing a strategy that also targets the social context of teams and leadership, may considerably add to the general body of knowledge.[12-14]

We undertook a cluster randomised trial (HELPING HANDS) in three Dutch hospitals to compare a state-of-the-art approach with an innovative team-based approach to improve nurses' compliance with hand hygiene guidelines, and to evaluate the effectiveness of these strategies. This study focuses on the important subgroup of nurses, who usually work in teams, who interact with patients around the clock, and who are often confronted with a large variety of organic materials (all body tissues, urine, defecation etc.).

Our hypothesis was that the innovative team and leaders-directed strategy, using additional implementation activities based on social influence and leadership theories, would be more effective in increasing hand hygiene compliance rates in nurses compared to a state-of-the-art strategy, which mainly addresses the individual and the organisational level.

METHODS

Study design

A cluster randomised trial (HELPING HANDS) was conducted between September 2008 and November 2009. In a cluster randomised trial, groups of individuals rather than individuals are randomised.[15] A randomised design with the in-patient nursing ward as the unit of randomisation was chosen to prevent contamination between individuals.[16] In our study the quality improvement strategies involved the entire team of nurses and not just individual nurses on nursing wards. Therefore nurses within the same ward were considered to be a cluster.

Baseline data were collected just before implementing the improvement strategies (T1). After the collection of baseline data, randomisation to either the state-of-the-art strategy or the team and leaders-directed strategy took place. Strategies were delivered during a period of six months. Follow-up measurements took place directly after strategy delivery (T2) and at six months after the end of strategy delivery (T3). The trial profile of the study has been illustrated in Figure 1.

Setting and participants

We included three hospitals in the Netherlands: one university medical centre and two general hospitals. In a fourth (non-participating) hospital we tested the instruments and observer variability. Within the hospitals, all in-patient nursing wards (n = 67) and all affiliated qualified nurses and nurse students participated in the study (Figure 1). For ethical and privacy reasons we excluded delivery wards and psychi-

atric wards. After completing the base-line measurement (T2), wards were randomly assigned to either the control arm that received the state-of-the-art strategy (n = 37) or the experimental arm that received the team and leaders-directed strategy (n = 30) (see Figure. 1). Prior to the study, we expected to include sixty wards in total. However, sixty-seven in-patient nursing wards proved to be available. We decided to include these extra wards, but for logistic and financial reasons we could not allocate more than the originally planned thirty wards to the experimental group receiving the team and leaders-directed strategy.

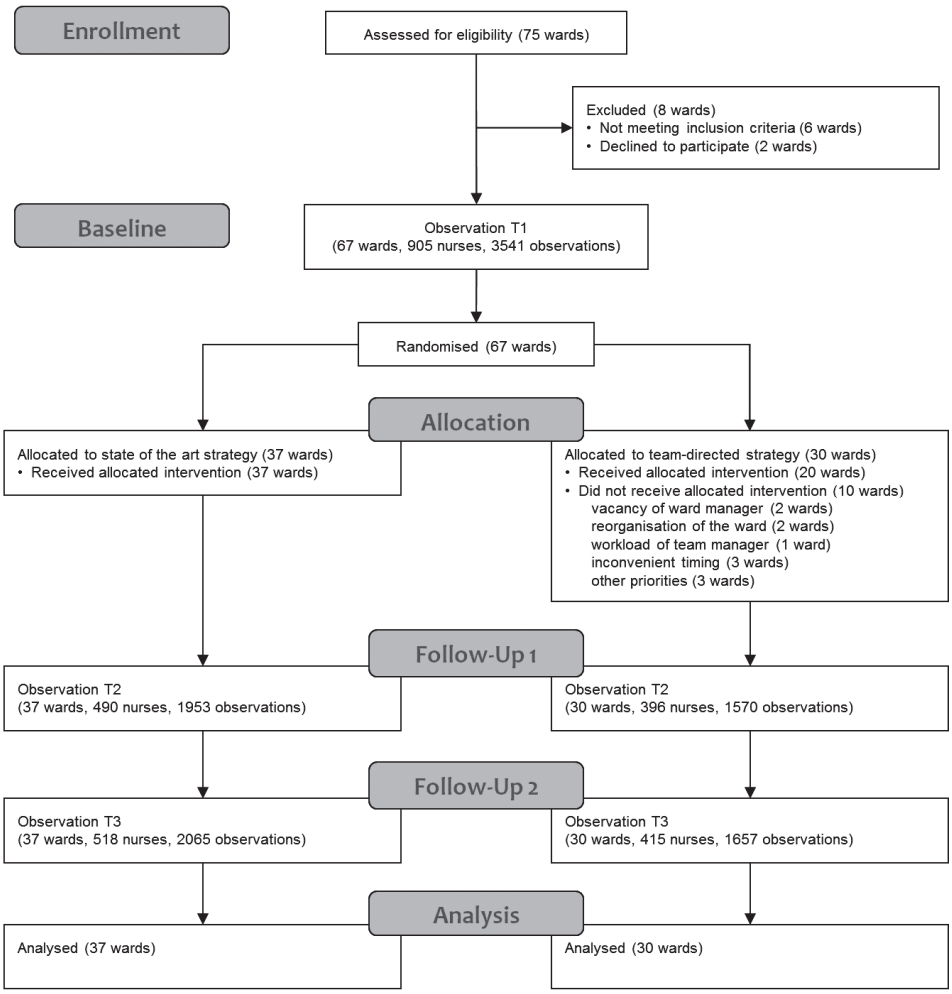

Figure 1. Trial profile.

Randomisation and masking

The randomisation of the wards was stratified for type of ward to minimise differences in ward characteristics over the groups. We randomised surgical wards (n = 21), internal medicine wards (n = 24), intensive care units (n = 13) and paediatric wards (n = 9). The allocation ratio used was 0.55:0.45 for the control group and experimental group respectively. A computer generated random procedure allocated the wards either to the control group or to the experimental group.

During the data collection periods, nurses in all of the participating wards were observed unobtrusively regarding hand hygiene compliance in connection with patient care. Observers were not involved in strategy delivery within this project. Indeed, observers were masked to cluster allocation; those analysing data were not.

Quality improvement strategies

The state-of-the-art strategy was based on current evidence from literature on hand hygiene compliance.[1,2,9,10] The evidence retrieved from the literature pointed out that a hand hygiene improvement strategy should be multi-faceted targeting existing barriers. We identified key-elements on different levels which formed the building blocks of the state-of-the-art strategy. Firstly, the strategy targeted the level of individual professionals and included (a) education for improving relevant knowledge and skills, (b) reminders for supporting the actual performance of hand hygiene and (c) feedback as a means to provide insight into current behaviour and to reinforce improved behaviour. Secondly, the strategy targeted factors related to structural organisational context and included screening and providing for (d) adequate products and facilities.

The team and leaders-directed strategy was also aimed at addressing barriers at team level by focussing on social influence in groups and strengthening leadership. The unique contribution of this strategy was built upon the social learning theory [17], social influence theory[18], theory on team effectiveness[19,20] and leadership theory.[21] The team and leaders-directed strategy included all elements of the state-of-the-art strategy (a–d) supplemented with (e) gaining active commitment and initiative of ward management (f) modelling by informal leaders at the ward, and (g) setting norms and targets within the team.

Every experimental ward started with a 1-h team session to discuss present team performance on hand hygiene. Team members explored their hand hygiene behaviour, analysed barriers and facilitators and formulated improvement activities. Next, team members developed a clear set of behaviour and communication ex-

pectations to address each other in case of inappropriate hand hygiene. The meeting ended with commitment of all team members to achieve a substantial increase in hand hygiene compliance.

During the second session, the ward manager presented the hand hygiene compliance rates of the previous period. Team members discussed questions like: did we achieve our goal? What improvements have been implemented? How can we maintain our improved behaviour? What went wrong and what are we going to do about it? At the third session, team members also discussed the previous period. The content of this meeting was focused at maintenance of the achieved results. Topics discussed were: regularly monitoring hand hygiene compliance, recurrent training and education, modelling social skills in addressing hand hygiene behaviour of colleagues, and the process of introducing new employees to the policy of the ward. All team sessions were guided by the team manager and an external coach.

The coaches organised two support meetings for ward managers and informal leaders to share experiences and to discuss difficulties. During the study period, informal leaders demonstrated good hand hygiene behaviour and stimulated their colleagues in providing good hand hygiene behaviour. Table 1 shows the operationalization of both strategies.

Managers from the assigned wards were invited to participate in a programme to improve patient care by using a team and leaders-directed strategy. We did not mention the topic hand hygiene as the subject of improvement until the start of the intervention.

Before the start of the intervention, all managers participating in the team-directed strategy received a 4-h training in accompanying and motivating the nurses.

Primary and secondary outcomes

The primary outcome was the percentage of nurses' actions in line with hand hygiene guidelines in case of an opportunity to perform this action[2,22], i.e. the number of times that hand hygiene was performed divided by the number of observed hand hygiene moments, whereby the results were multiplied by 100. The recommended indications—the required moments for hand hygiene—have been listed in Appendix 1. Hand hygiene was operationalized as 'hand washing with either plain soap and water' or 'hand disinfection through the use of an alcohol-based hand rub solution'. Secondary out-comes were the presence of jewellery (ring, watch, or

Table 1. Description implementation strategies with the activities.

State-of-the-art strategy
Education
Distribution of educational material/ written information (leaflet) about hand hygiene
• The importance of hand hygiene
• Misconceptions about alcohol-based hand disinfection
• Theory and practical indications for the use of hand hygiene
• Website www.gewoonhandenschoon.nl
• Educational material/ written information about hand hygiene
• Knowledge quiz
• Reward for the nursing ward with the most visitors to the website
• Educational sessions on prevention of hospital acquired infections
• Launching hospital wide campaign with practical demonstrations of hand hygiene
Reminders
• Distribution of posters that emphasized the importance of hand hygiene, particularly alcohol-based hand disinfection
• Interviews and messages in newsletters or hospital magazines
• General reminders by opinion leaders/ward management
Feedback
• Bar charts of hand hygiene rates of every nursing ward will be sent to the ward manager twice
• Comparison ward performance and hospital performance
Facilities and products
• Screening and if necessary adapt products and appropriate facilities
Extended strategy
All elements of the state-of-the-art strategy
• Education, reminders, feedback, facilities and products
Setting norms and targets within the team
• Three interactive team sessions that includes goal setting in hand hygiene performance at group level
• Analysis of barriers and facilitators to determine how they could best adapt their behaviour in order to reach their goal
• Nurses address each other in case of undesirable hand hygiene behaviour
Gaining active commitment and initiative of ward management
• Ward manager designates hand hygiene as a priority
• Ward manager actively supports team members and informal leaders
• Ward manager discusses hand hygiene compliance rates with team members
Modeling by informal leaders at the ward
• Informal leaders demonstrate good hand hygiene behaviour
• Informal leaders models social skills in addressing behaviour of colleagues
• Informal leaders instruct and stimulate their colleagues in providing

other jewellery), whether the nurses wore long-sleeved clothes under their short-sleeved uniforms, and compliance with specific type of hand hygiene opportunity (representing the required moments for hand hygiene).

We observed all outcomes by using a hand hygiene monitoring tool adapted from the WHO (see Appendix 2). The observer registered each opportunity in a corresponding column block, noted all of the applicable indications and whether hand hygiene was performed by hand disinfection or hand washing or was not performed.

Data collection

We used direct, but unobtrusive observation as this is considered the gold standard and the most reliable method for assessing compliance rates.[1,23,24] Direct observation makes it possible to examine and quantify the required moments for hand hygiene and assess the quality of practice. The observations were performed unobtrusively to diminish the Hawthorne effect—the possibility that nurses modify their hand hygiene behaviour in response to the fact that they know they are being studied.

Observers conducted their observations at times with a high density of care—mainly during the morning shifts—to gather a greater number of opportunities and to obtain a representative mix of observations. Per ward we observed 1 nurse per 2.5 beds. The target nurse for observation was randomly selected. Each observer followed just one nurse at the same time until at least four required moments for hand hygiene were scored within a maximum period of 20 min.

To reduce selection bias, every nurse was observed only once during a data collection period. At the beginning of each observation period, nurses were informed that the observers were conducting research on medication and other patient safety errors, but they were not specifically informed that hand hygiene was monitored as well. Observations took place only if the patient and the nurse had given permission.

Observer variability

For each observation period we trained 10 student nurses, all completing their nursing education and experienced in patient care, in collecting data. All student nurses participated in a two-day training course on understanding the indications for hand hygiene during patient care. They also learned to apply the observation method and to use the data collection form. Before conducting the observation sessions, we first validated the observations of the student nurses.

We undertook parallel monitoring sessions in a non-participating hospital. Every student nurse performed at least twenty observations jointly with an experienced observer. Concordance between the observers was determined by comparing the results of each student with the results of the experienced observer, who was considered to be the gold standard.

The Wilcoxon rank test showed that none of the student results differed significantly (alpha 0.05) from the results of the gold standard observer (z scores of every student between -1.96 and 1.96).

Ethical considerations

The Hawthorne effect is probably the most important bias in hand hygiene observations.[1,23,24] When people are aware that they are being observed, they change their behaviour and are significantly more likely to wash or disinfect their hands. Unobtrusive observation diminishes the Hawthorne effect but raises ethical questions regarding privacy of the observed participants. Therefore, we consulted the ethical committee, who concluded that unobtrusive observation was permitted under the following conditions:

- The observation topic, hand hygiene, should be covered by using general patient safety issues as subject of the observation;
- Observations on the nurses should be collected and processed anonymously;
- Prior to the observation, the patient had to give his or her verbal permission to be observed.

All observations took place in compliance with these conditions.

Statistical methods

Our sample size estimates have been described in detail previously.[25,26] Briefly, we expected that the state-of-the-art strategy should be able to increase hand hygiene compliance with 15% in the short term. We assumed an added effect of 10% from the team-directed approach. This means that the team and leaders-directed strategy would result in an improvement of compliance with 25% of all occasions for hand hygiene. Calculating from 80% power, two-sided alpha = 0.05, a ward-ICC of 0.05, a nurse-ICC of 0.6, at least 60 wards in this study and a average of 50 observations of occasions for hand hygiene compliance would be needed at each point in time, involving 15 nurses per ward.

Descriptive statistics included frequencies, percentages, and standard deviations of hand hygiene behaviour. Analyses were completed on an intention-to-treat basis (i.e. analysis included the 30 wards randomly assigned to the team and leaders-directed strategy and 37 wards randomly assigned to the state-of-the-art strategy). In order to assess the effectiveness of the strategies, we performed a multilevel logistic analysis, with hand hygiene compliance versus non-compliance on the two-post strategy measurement periods as the primary outcome variables. This analysis was adjusted for clustering of data (i.e. compliance is clustered within nurses, who are clustered within wards). A series of generalised linear mixed models was fit by the

Laplace approximation with R statistical software, using the lme4 package.[27] The basic model included fixed effects for strategy (the intervention group that received the team-directed strategy vs. the control group that received the state-of-the-art strategy), timing of measurement (post-intervention T2, vs. follow-up T3), institution (hospital 1, 2 or 3) and compliance rate of each ward at baseline (T1). Furthermore, the basic model included a random intercept for nurse and for nursing ward, and a random intercept for timing of measurement effect (also allowing a correlation between these two random effects). The next model also included the interaction between strategy and timing of measurement to test whether the effect of the strategies would change over time. The adjusted estimates and associated standard errors were converted to Odds Ratios (ORs) with 95% CIs. The relevance of type of hand hygiene opportunity was explored by performing a subgroup analysis. The results have been reported according to CONSORT.[15]

RESULTS

General

Figure 1 shows the trial profile. Initially 67 wards were included, 30 to the team and leaders-directed strategy and 37 to the state-of-the-art strategy. Ten wards declined to participate in team and leaders-directed strategy because of the following reasons: a vacancy for the position of ward manager (2x), reorganisation of the ward (2x), workload of the ward manager ruled out other activities (1x), convenient timing of the intervention (2x), and other projects were given a higher priority (3x). These 10 wards received only the state-of-the-art strategy but, according to the intention-to-treat principle, were analysed as wards that received the team and leaders-directed strategy.

At each point in time, 3523–3722 opportunities for hand hygiene were observed in 886–933 nurses. During the entire study we obtained data on 10,785 opportunities for hand hygiene in 2733 nurses (Table 2).

Effects on hand hygiene compliance

The total study group showed a substantial increase in observed compliance with hand hygiene practices after completing the implementation of the strategies. Hand hygiene compliance rates improved from 22% (T1 base- line) to 47% (T2 post intervention) and to 48% (T3 follow up). The state-of-the-art group improved from 23% to 42% in the short term and to 46% in the long run. The compliance in the

Table 2. Number of observed hand hygiene opportunities/moments and number of nurses during study period.

	T1 baseline		**T2** post intervention		**T3** follow-up	
	HH moments	nurses	HH moments	nurses	HH moments	nurses
Total	3541	914	3523	886	3722	933
Strategy SAS*	1981	512	1953	490	2065	518
Strategy TDS†	1560	402	1570	396	1657	415

* State-of-the-Art Strategy
† Team and leaders-Directed Strategy

team and leaders-directed group increased from 20% to 53% (short term) and remained 53% on long term (Table 3).

With the random regression analysis we assessed the project impact on both groups. First we tested whether there was an interaction between strategy-effect and time of measurement. No significant interaction ($p = 0.186$) between strategy-effect and time of measurement could be demonstrated. Subsequently, we repeated the analysis, but now with measurement (T2 and T3) as the independent fixed factor. This analysis showed an Odds Ratio of 1.64 (95% CI 1.33–2.02; $p < 0.001$) in favour of the team and leaders-directed strategy, indicating that the difference in improvement between the team and leaders-directed strategy and the state-of-the-art strategy was statistically significant.

Effects on secondary outcomes

Table 4 shows the compliance with jewellery and long sleeves prescriptions during the study period. The presence of long sleeves in both study groups was very low, and declined only slightly after the intervention period. During the study period,

Table 3. Compliance with hand hygiene prescriptions (and participating wards) in the three participating hospitals.

	T1 baseline	**T2** post intervention	**T3** follow-up
Strategy SAS*	23% (37 wards)	42% (37 wards)	46% (37 wards)
Strategy TDS†	20% (30 wards)	53% (30 wards)	53% (30 wards)
Groups compared TDS vs SAS		Odds ratio 1.64 95% CI [1.33-2.02] $p<0.001$	

Compliance with hand hygiene prescriptions expressed as a percentage of all relevant opportunities based on the average compliance per ward. ORs were adjusted for clustering of data in a multilevel analysis.
* State-of-the-Art Strategy
† Team and leaders-Directed Strategy

Table 4. Non-compliance with jewellery/long sleeves prescriptions during study period.

	T1 baseline		**T2** post intervention		**T3** follow-up	
	% non-compliance	nurses	% non-compliance	nurses	% non-compliance	nurses
Strategy SAS*						
• Jewellery	15	77/512	11	54/490	6	31/518
• Long sleeves	1.6	8/512	0.4	2/490	1.5	8/518
Strategy TDS†						
• Jewellery	15	62/402	5	21/396	3	12/415
• Long sleeves	1.2	5/402	0.3	1/396	0.2	1/415
Jewellery: groups compared TDS vs SAS				Odds ratio 2.56 95% CI [1.80-3.65] $p<0.01$		

A multi-level regression analysis was performed on the outcome measure 'presence of jewellery'.
* State-of-the-Art Strategy
† Team and leaders-Directed Strategy

the number of nurses wearing jewellery decreased in both groups. The largest decline in wearing jewellery was seen in the wards that had received the team and leaders-directed strategy, from 15% (T1) to 5% (T2) and to 3% at T3. Wearing jewellery in the state-of-the-art group decreased from 15% (T1) to 11% (T2) and then to 6% at T3. The multi-level regression analysis showed an Odds Ratio of 2.56 (95% CI 1.80–3.65; $p < 0.01$) in favour of the team and leaders-directed strategy.

Compliance rates differed for the hand hygiene indications. Nurses were most compliant with hand hygiene indication 'after direct contact with the patient', and 'after leaving the room of a patient in contact isolation'. The compliance was consistently lowest 'before an aseptic task' and from a 'dirty to a clean part of the body'. The largest increase in compliance after implementation of both strategies was seen 'after contact with patient surroundings'.

DISCUSSION

Our study tested the hypothesis that an approach focussing on improved team functioning and supportive leadership is more effective in increasing hand hygiene compliance rates than the programme mostly used now around the world, which mainly addresses barriers either at the individual or organisational level. The Odds Ratio of 1.64 in favour of the team and leaders-directed strategy illustrates that organising a strategy at the level of the professional, teams, leaders, and the organisation has been the most effective approach for improving hand hygiene so far.

This finding expands previous research experience on attempts to modify hand hygiene behaviour. Our results are in line with theories from the behavioural sciences where social influence[18], team effectiveness[19,20], role modeling[17] and leadership[21] are considered relevant to successfully changing behaviour. An important advantage of our team and leaders-directed strategy was that the participating ward managers believed that the methodology could also be useful to improve team performance on other patient safety issues. This might well have contributed to the success of the strategy.

The sustained effect of hand hygiene compliance in the state-of-the-art strategy was an unexpected finding because this type of implementation strategy often shows only a short-term effect.[9] There are several possible explanations for these results. First, there was an increased focus on hand hygiene in the Dutch media due to the impending arrival of the H1N1 influenza virus during the follow-up period. A positive impact for both study groups cannot be ruled out. A second possible explanation is that cross-fertilization took place between teams. In one hospital, a number of ICU and paediatric teams entered into partnerships with regard to infection prevention during the follow-up period. As a consequence, some teams from the state-of-the-art study group might have benefited from the experiences of the teams in the team and leaders-directed strategy.

Compliance rates differed for specific hand hygiene indications. The compliance was consistently lowest 'before an aseptic task' and from a 'dirty to a clean part of the body'. As observed by others, some indications are harder to follow than others.[1,28] Educational activities (e.g. instruction leaflets, hand hygiene quiz) and attention to specific hand hygiene indications during the team sessions in the team and leaders-directed study group specifically targeted this aspect. Just before implementing the strategies, compliance for the indication 'after contact with patient surroundings' was only 13%. After strategy delivery, compliance with this indication increased to over 50%.

Although adherence of health care workers to hand hygiene guidelines is repeatedly low – representing an overall average of 38.7% [24]—we were surprised by the low baseline compliance rate of 21% in our study. We would however like to point out that multiple definitions are used for determining adherence, and many studies did not include the same strict criteria for proper hand hygiene as applied in our study. By using these strict criteria, our results may have been lower. For example, only recently more studies have appeared that also evaluated hand hygiene compliance after contact with the patient environment.[24] Nevertheless, our

baseline findings are consistent with recent (unpublished) research by Erasmus on hand hygiene compliance in the Netherlands.

We believe our study has methodological strengths because of the large numbers of observations and participating wards, the randomisation of wards either to the state-of-the-art strategy or the team and leaders-directed strategy, and the use of unobtrusive observations.

However, we also anticipated several challenges in this study. First, timely and accurate data collection for this study was an important issue. Therefore, we collaborated with an established Faculty of Health and Social Studies in recruiting, training and assessing the students who performed the observations. Interrater reliability was established by parallel monitoring sessions in a non-participating hospital and showed no significant differences between the observers.

Second, in this study we did not measure nosocomial infections. Given the fact that the relationship between hand hygiene and the occurrence of infections is well established already.[5-8] We decided against measuring nosocomial infections. Third, we did not measure compliance in physicians or other health care workers. The main reason for not including physicians is the difference in team structure and team work between nurses and physicians. Targeting physician-directed social influence demands other strategies than targeting nurse-directed social influence. Finally, our observations were performed unobtrusively, yet a possible Hawthorne effect cannot be ruled out. However, a systematic bias is unlikely. We compared the compliance rates of the official—unobtrusive—observation periods with the compliance rates of two—obtrusive—periods. The compliance during these obtrusive observation periods was on average 15% higher than the compliance during the unobtrusive observation periods.

In conclusion, our results support the added value of social influence and enhanced leadership in hand hygiene improvement strategies. Currently, most strategies focus on the individual and the organisation. Including team and leaders-directed activities could be a promising development. The methodology of our innovative strategy can probably be used to improve team performance on other patient safety issues as well.

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Appendix 1. Observed indications for hand hygiene.

Indication for hand hygiene	When	Transmission risk	Major targeted negative infectious outcome	Examples
Before an aseptic task	Directly before performing an aseptic task	Hand transmission of microorganisms from any surface (including the patient skin) to a site that would facilitate invasion and infection	Endogenous or exogenous infection of the patient	Giving an injection. Insertion and care of intravenous catheters. Blood draws. Administering intravenous medication. Endotracheal suction
From contaminated body site to another body site	Directly after completing task (whether gloved or ungloved)	Hand exposure to patient's contaminated body sites and fluids potentially containing blood-borne or other pathogens	Infection of the HCW by patient blood-borne Pathogens	Drawing blood and then adjusting the infusion drop count. Handle wound, mucous membrane, and body fluids. After oral care
After touching the patient	Directly after leaving the patient when the patient was touched	Hand transmission of microorganisms from the patient flora to other surfaces in the health care setting	Dissemination of patient flora to the rest of the health care environment and infection of other patients or HCWs	After skin contact with the patient. Bathing, changing position or lifting a patient. Taking a pulse or blood pressure. Shaking hands
After taking care of an infected/colonised patient	Directly after leaving the patient's room	Hand transmission of microorganisms from the patient flora to other surfaces in the health care setting	Dissemination of patient flora to the rest of the health care environment and infection of other patients or HCWs	Contact with any patient known to be infectious/isolated (e.g. MRSA)
After use of gloves	Directly after removing gloves	Hand transmission of microorganisms from the skin of the HCW 's to other surfaces in the health care setting	Dissemination of patient flora to the rest of the health care environment and infection of other patients or HCWs	Wearing gloves with high-risk contacts
After contact with patient surroundings	After completing the task and before contacting another patient	Hand transmission of microorganisms from the patient flora to other surfaces in the health care setting	Dissemination of patient flora to the rest of the health care environment and infection of other patients or HCWs	Touching the patient's environment like bed, table, blanket, clothes. After contact with medical equipment in the immediate vicinity of the patient

Appendix 2. Hand Hygiene Monitoring Tool: Score form Hand Hygiene opportunities.

Afdeling: ☐☐☐☐☐ (bv. C44) Observatorcode: ☐☐☐

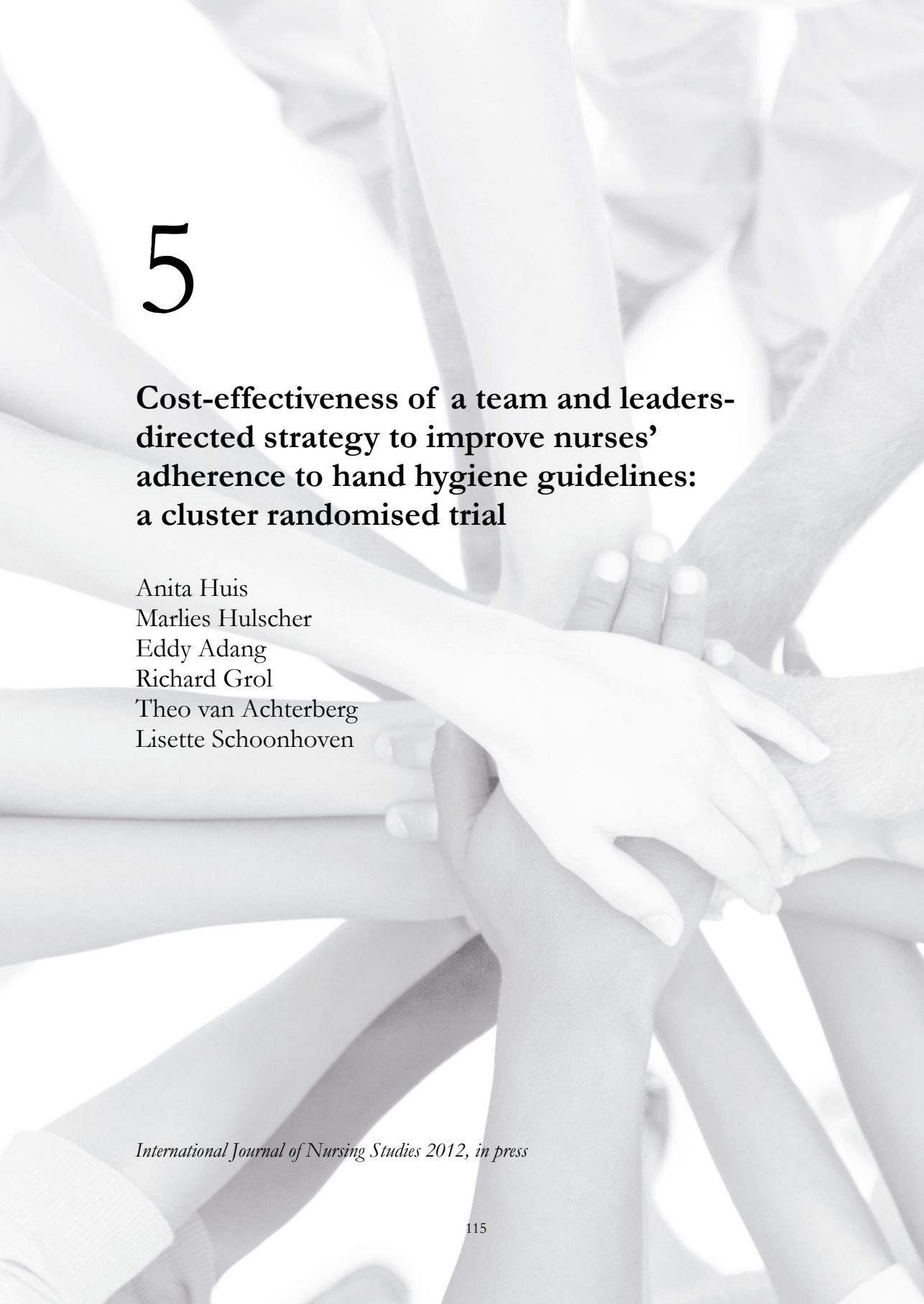
Datum: ☐☐-☐☐-20☐☐

Verpleegkundige: ☐☐☐☐ ☐M ☐V Hand/pols sieraden: ☐Ja ☐Nee Lange mouwen: ☐Ja ☐Nee Begintijd: ☐☐-☐☐ uur	☐Verpleegkundige: ☐☐☐☐ ☐M ☐V ☐Andere professional: _____ Hand/pols sieraden: ☐Ja ☐Nee Lange mouwen: ☐Ja ☐Nee Begintijd: ☐☐-☐☐ uur

G	Indicatie	Actie
1.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie
2.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie
3.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie
4.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie

G	Indicatie	Actie
1.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie
2.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie
3.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie
4.	☐voor - invasief ☐vuil -> schoon ☐na - direct contact ☐na - contact isolatie ☐na - handschoenen ☐na - verplk. handelen	☐wassen ☐desinfectie ☐geen actie

Kwazo 114, AB



5

Cost-effectiveness of a team and leaders-directed strategy to improve nurses' adherence to hand hygiene guidelines: a cluster randomised trial

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ABSTRACT

Background

Many strategies have been designed and evaluated to address poor hand hygiene compliance. Unfortunately, well-designed economic evaluations of hand hygiene improvement strategies are lacking.

Objective

To compare the cost-effectiveness of two successful implementation strategies for improving nurses' hand hygiene compliance and reducing hospital acquired infections (HAI's). Design and setting: A cost-effectiveness analysis alongside a cluster randomised controlled trial was conducted in 67 nursing wards of three hospitals in the Netherlands. The evaluation used a hospital perspective.

Participants

All affiliated nurses of the nursing wards. Wards were randomly assigned to either the control group (n=30) or the experimental group (n=37).

Methods

The control group received a state-of-the-art strategy including education, reminders feedback and optimising materials and facilities. The experimental group received a team and leaders-directed strategy which included all elements of the state -of-the-art strategy supplemented with interventions aimed at the social context of teams and enhancing leadership. The most efficient implementation strategy was determined by the incremental cost-effectiveness ratio per extra percentage of hand hygiene compliance gained and the incremental cost-effectiveness ratio per additional percentage reduction in the HAI rate. Bootstrap methods were used to determine confidence intervals for these incremental cost-effectiveness ratio's. Two scenarios of 15 and 30% were used to express the association between increased hand hygiene compliance and the reduction in HAIs.

Results

The team and leaders-directed strategy was significantly more effective in improving hand hygiene compliance. The mean difference effect was 8.91% (95% CI, 0.75 – 17.06). This extra increase was achieved at an average cost of € 5497 per ward. The incremental cost per extra percentage of hand hygiene gained on ward level

was € 622. The incremental cost per additional percentage reduction in the HAI rate on ward level was € 2074 (30% scenario) and € 4125 (15% scenario). Within the 30% scenario, there is a probability of 90% that the team and leaders-directed strategy is cost-effective and within the 15% scenario, there is a probability of 70% that the team and leaders-directed strategy is cost-effective.

Conclusions

Optimizing hand hygiene compliance through a team and leaders-directed strategy is cost-effective as compared to a state-of-the-art strategy.

INTRODUCTION

Hospital acquired infections (HAIs) are burdensome to patients, complicate treatment, prolong hospital stay and cause high healthcare costs.[1,2] Prevalence surveys in Europe have shown that the percentage of patients affected by HAIs is 7.1 % on average, ranging from 3.5 % to 10.5 %.[3] National surveillance in the Netherlands in 2008 has shown a HAI prevalence rate of 7.2%, affecting 100,000 persons each year.[4] The cost of prolonged hospital stay for patients with HAIs is estimated at 337 million Euros per year in the Netherlands. This corresponds to 1.7% of the total hospital costs.[4]

Although substantial evidence shows that good hand hygiene can decrease the risk of HAIs, empirical data show that compliance with hand hygiene guidelines is inadequate.[5-7]

To improve hand hygiene compliance, it is important to use a hand hygiene improvement strategy with demonstrated value. Previous studies point towards a clear profile of a state-of-the-art strategy aimed at the individual health care worker or the organisational setting.[8,9] However, often experienced barriers like negative role models, lack of management involvement and a poor social culture are not addressed by such a state-of-the-art strategy. Performing a strategy that also targets the social context of teams and leadership, may considerably contribute to hand hygiene improvement.[10-12]

We undertook a cluster randomised trial to compare the effectiveness of a state -of-the-art strategy with a innovative team and leaders-directed strategy for improving nurses' compliance with hand hygiene guidelines. Both strategies successfully improved hand hygiene compliance. The difference between the two strategies showed an Odds Ratio of 1.64 (95% CI 1.33–2.02; $p<0.001$) in favour of the team and leadership-based approach.[13]

However, when resources are limited, a choice has to be made in favour of the strategy that is most cost-effective in terms of strategy related cost consequences and health effects. Unfortunately, well-designed economic evaluations of hand hygiene improvement strategies are lacking.[2,14] Therefore, we also examined the cost-effectiveness of both strategies.

The purpose of the analysis reported in this paper is to determine whether the additional increase in hand hygiene compliance due to a team and leaders-directed strategy justifies the additional costs.

METHODS

Study design, setting, participants and procedures

We evaluated the cost-effectiveness of both strategies alongside a cluster randomised trial (HELPING HANDS) of which the design and the impact were previously published.[13,15] We included three hospitals in the Netherlands: one university medical centre and two general hospitals. Within the hospitals, all in-patient nursing wards (n=67) and all affiliated nurses (n=2167) participated in the study. We focused on the important subgroup of nurses, who usually work in teams, who interact with patients around the clock, and who are often confronted with a large variety of organic materials (all body tissues, urine, defecation etc.).

Strategies were delivered during a period of six months. Baseline data were collected just before implementing the strategies (T1). Follow-up measurements took place directly after strategy delivery (T2) and at six months after the end of strategy delivery (T3). Our primary outcome measure was the observed hand hygiene compliance in nurses. The compliance rate was operationalized as the number of hand hygiene practices divided by the number of opportunities for hand hygiene according to national and international guidelines.[2,16] During the data collection periods, nurses in all of the participating wards were observed unobtrusively by trained student nurses. All these final year students had ample experience in direct patient care resulting from their clinical education.

Implementation strategies

The state-of-the-art strategy was based on current evidence from literature on hand hygiene compliance.[1,2,9] This strategy included

1. education for improving relevant knowledge and skills,
2. reminders for supporting the actual performance of hand hygiene,
3. feedback as a means to provide insight into current hand hygiene behaviour,
4. screening for adequate products and facilities.

The theory based team and leaders-directed strategy included all elements of the state-of-the-art strategy (1 through 4) supplemented with

5. gaining active commitment and initiative of ward management
6. model behaviour by informal leaders at the ward, and
7. setting norms and targets within the team.[17-21]

Before the start of the intervention, all ward managers and informal leaders participating in the team and leaders-directed strategy received a four-hour training in coaching and motivating the nurses.

Nurses of the included wards attended three team sessions, focusing on specific aspects of hand hygiene behaviour, discussing hand hygiene performance, analysing barriers and facilitators, formulating improvement activities, showing model hand hygiene behaviour, and addressing each other in case of undesirable hand hygiene behaviour.

An experienced coach assisted the ward manager during the team meetings. Also, two group sessions were organised to support the ward managers and to discuss progress and difficulties. The operationalization of both strategies is reported in an separate paper.[13]

Type of evaluation and main outcomes

We carried out a cost effectiveness analysis using ward level data collected within the HELPING HANDS study. The analysis was performed according to the intention-to-treat principle. The impact of the implementation strategies was determined by the level of adherence to hand hygiene guidelines, measured by direct unobtrusive observation before and after the implementation of the strategies. Based on these hand hygiene compliance data, a decision model was developed to determine whether the additional increase in hand hygiene compliance due to the team and leaders-directed strategy justifies the additional costs. The impact of the implementation strategies for reducing HAIs was predicted using decision analysis. Within this model, the increase of hand hygiene compliance was translated in a subsequent reduction in the HAI rate. This resulted in two incremental cost-effectiveness ratios:

1. The incremental cost-effectiveness ratio per extra percentage of hand hygiene compliance gained
2. The incremental cost-effectiveness ratio per additional percentage reduction in the HAI rate.

We chose a hospital perspective as both the strategies and the results are of particular interest to hospital management, The time horizon for the analysis was twelve months after the start of the intervention, and consequently we used 2009 as the year of pricing.

The association between hand hygiene compliance and HAI rates

Uncertainty remains about the proportion of HAI's that can be prevented by improved hand hygiene compliance. However, there is substantial evidence that increased hand hygiene compliance is associated with reduced HAI's.[2] It is estimated that 15 to 30% of all HAI's can be prevented by avoiding cross-transmission of micro-organisms on the hands of health care workers.[1,5,7,22-24] The study of Pittet et al. showed an initial HAI rate of 16.9 and a hand hygiene compliance rate of 45%. After implementation of a hand hygiene improvement program the hand hygiene compliance rate increased from 48% to 66% and the HAI rate decreased by approximately 40% to 9.9%.[1] On the basis of this range of available evidence, we used scenarios with 15% or 30% reduction in the HAI rate. We assumed that the HAI rate is a linear function of hand hygiene compliance i.e. 1% increase in hand hygiene compliance is associated with a 0.3% or 0.15% reduction in HAI rates. In our study, the baseline prevalence of hospital acquired infections in the participating hospitals was assumed to be 7.2% in all clinical admissions, based on the 2008 data from The PREZIES national network for the surveillance of HAIs in the Netherlands.[4]

Input data

Inputs for the model calculations were based on the hand hygiene baseline findings in 2008 (T1) and during two follow-up measurements in 2009 (T2, directly after strategy delivery; T3, six months after the end of strategy delivery) for all wards in the intervention and control group. To determine the impact of hand hygiene compliance on the HAI rate, we used the number of clinical admissions from the participating hospitals in 2009. We extracted hand hygiene compliance data from the hand hygiene observation database, data on clinical admissions from the hospital's admission databases, and data of consumed resources from ward structure surveys, project documentation, ward manager's logbooks, and researchers field notes of group meetings.

Cost analysis

Implementation costs

The implementation process and consequent costs were calculated by an Activity Based Costing (ABC) approach. The ABC model was focused on identifying all the underlying activities (personnel, material and overhead costs) associated with the state-of-the-art strategy and the team and leaders-directed strategy. The resources

Table 1. Costs calculated for cost-effectiveness analysis.

	Intervention component	Costs to be calculated	Average costs per ward (€)	Total costs (€)
SAS	Education	Website	35	1301
N=37		Leaflets	27	980
	Reminders	Posters	44	1648
		Newsletters	3	115
		Article in hospital magazines	3	100
	Feedback	Observations baseline	84	3092
		Observations during interventions	30	1104
		Delivery of feedback (2 reports with bar charts)	5	192
		Subtotal	**231**	**8532**
	Hand rub	Costs of alcohol hand rub due to increased use	637	23 573
	Staffing Time	Extra staffing time needed to perform HH	5791	214 263
	Total	**Total costs SAS strategy**	**6659**	**246 368**
TDS	SAS strategy	SAS intervention components	231	6930
N=30	Coaching	Salary costs coach	105	3150
		Staffing costs for managers and role models needed to participate in coaching sessions	497	14 923
	Team discussions	Staffing costs manager needed to prepare and evaluate team discussions	239	7170
		Staffing costs for nurses needed to participate in coaching sessions	1294	38 820
		External guidance by coach	917	27 510
	Hand rub	Costs of alcohol hand rub due to increased use	907	27 205
	Staffing Time	Extra staffing time needed to perform HH	7966	238 960
	Total	**Total costs TDS strategy**	**12 156**	**364 668**

consumed by the implementation strategies were assessed by collecting data on personnel (hours for the strategy delivery team, hours for the nurses attending the strategy related activities, extra time for hand hygiene), and materials (posters, feedback charts and use of hand rub solution). These volumes were multiplied by their unit prices in euros (market prices, guideline prices or self-determined prices based on costing methods, i.e. full costing.[25] In this study, no cost for monitoring hand hygiene compliance was calculated because the student nurses performed the observations during their research education, which is part of the nursing curriculum in the Netherlands. Table 1 gives an overview of the unit costs and the sources from which they were derived.

Costs of hand rub solution

The estimated increase in the use of hand rub solution per ward was adapted from the WHO Alcohol-based hand rub production planning and costing tool.[26] We calculated the volume of hand rub solution needed per year using the following formula: [((nurse ratio per 24 hours * number of hand hygiene opportunities per hour * 5

hours of patient contact * 365 days per year * 0.002 L hand rub per hand hygiene action) + 10% hand rub wastage)) * hand hygiene compliance / 100]. The maximum number of opportunities for hand hygiene can range from 8 per hour per nurse in general wards to approximately 22 per hour per nurse in critical care units.[27]

In our study we assumed 8 hand hygiene opportunities for general wards, 12 opportunities for paediatric wards, 15 opportunities for surgical wards and 22 hand hygiene opportunities for critical care units.

The estimated increase in volume of hand rub solution between T1-T3 was derived from the formula mentioned above. We assumed a gradual increase in hand hygiene compliance between T1→T2→T3. According to the trapezium rule[28], we calculated the mean of the maximum volume differences between two measurements points. For instance, the estimated increase in hand rub solution between T1-T3 was calculated by: [(Volume difference of hand rub between (T1 – T2 real compliance) * 0.75) + (Volume difference of hand rub between T2 – T3 real compliance * 0.25)]. The costs of hand rub solution was based on the market price in 2009 multiplied with the estimated increase in hand rub solution used.

Costs of time needed to perform hand hygiene

The calculated time required for hand rubbing is set at 20 seconds per hand hygiene opportunity.[27] However, not every performed hand hygiene action means a 100% loss of productivity.

A subgroup analysis of indications that created a hand hygiene opportunity showed that 36% of the opportunities were formed by the hand hygiene indication 'after direct contact with the patient', and 'after leaving the room of a patient in contact isolation'.

In general it can be assumed that nurses then leave the patient to perform other duties or take care of another patient. Hand rub can partly be performed while moving from one site to another, so little extra time is involved. We calculated the time (in hours per year) needed per ward to perform hand hygiene using the following formula: [(nurse ratio per 24 hours * number of hand hygiene opportunities per hour * 5 hours of patient contact * 20 seconds of hand rubbing * 0,64 actual loss of productivity per hour * 365 days / 3600 seconds) * hand hygiene compliance / 100].

To compute the estimated increase in nursing time spent on hand rub between T1-T3, we applied the same method as for the estimated increase in volume of hand rub solution. The increase in costs for nursing time spent on hand rub were comput-

ed according to the Dutch guidelines for economic health care evaluations.[25] In correspondence with these guidelines we multiplied the nursing costs with a percentage of 39% for employer premiums as social taxes, holidays, and employee facilities.

Costs of HAI's

The cost of a hospital infection consist mainly of extended hospital stay, increased medical and nursing care, operations and consumables, microbiology tests and investigations, and antibiotics and other drugs. The cost estimate for a hospital acquired infection and additional health care costs was set on 5455 euro per infection, based on previous estimates[29,30] and indexed to the price level of 2009, using the Dutch consumer price index figures for health care costs.[31]

Statistical methods

Estimates of expected cost and benefits were reported for the team and leaders-directed strategy versus the state-of-the-art strategy. All empirical results are reported as mean values with 95% confidence intervals. Statistical significance was set at less than 0.05. The analyses were done using SPSS for the original data and excel for bootstrap simulations.

Incremental cost-effectiveness ratio per extra percentage of hand hygiene compliance gained

First, we calculated 95% confidence intervals for the differences in costs and effectiveness of both strategies on the original data using t-test (assuming normality). Next, a bootstrap method was used to determine confidence intervals for the treatment groups' differences. This resulted in a base case incremental cost-effectiveness ratio expressed as cost per extra percentage of hand hygiene compliance gained due to the team and leaders-directed strategy. From the bootstrap simulations (10 000 replications), we constructed a cost-effectiveness plane. This displays the bootstrapped incremental cost and effect pairs and additionally illustrates the uncertainty surrounding the estimates of incremental expected costs and incremental expected effects associated with the team and leaders-directed strategy compared to the state-of-the-art strategy.

Incremental cost-effectiveness ratio per additional percentage reduction in the HAI rate

We used the results of hand hygiene compliance to predict the reduction in HAI rate of the wards from the three participating hospitals over 1 year. Within our model, the increase of hand hygiene compliance was translated in a subsequent

reduction in the HAI rate, assuming that the HAI rate is a linear function of hand hygiene compliance. As described above, we used two scenarios of 15 and 30% reduction in the HAI rate respectively, expressing the incremental cost-effectiveness ratio per additional percentage reduction in the HAI rate. An improvement strategy can be considered cost-effective only if the decision maker is willing to pay for an additional unit of benefit that is equal to or greater than the incremental cost effectiveness ratio. To summarise information on uncertainty surrounding the incremental cost-effectiveness ratio, we used cost-effectiveness acceptability curves, derived from the joint distribution of incremental costs and incremental effects. These cost-effectiveness acceptability curves show the probability that the team and leaders-directed strategy is cost-effective compared to the state-of-the-art strategy, as a function of willingness to pay per additional percentage reduction in the HAI rate.[32] Decision-makers may choose their own willingness-to-pay threshold.

RESULTS

Initially 67 wards were randomised, 30 in the team and leaders-directed strategy and 37 in the state-of-the-art strategy. Ten wards declined to participate in the team and leaders-directed strategy. These ten wards received only the state-of-the-art strategy but, according to the intention-to-treat principle, were analysed as wards that received the team and leaders-directed strategy. At each point in time, 3523 to 3722 opportunities for hand hygiene were observed in 886 to 933 nurses. During the entire study we obtained data on 10,785 opportunities for hand hygiene in 2733 nurses.

Effects on hand hygiene compliance

Compliance in the state-of-the-art strategy group improved from 21.8% to 45.9% whereas the compliance in the team and leaders-directed strategy group increased from 19.1% to 52.1%. The mean difference between the state-of-the-art strategy and the team and leaders-directed strategy was 8.91% (95% CI, 0.75 – 17.06).

Incremental cost-effectiveness ratio per extra percentage of hand hygiene compliance gained

The team and leaders-directed strategy was significantly more effective in improving hand hygiene compliance which comes at a significantly higher cost (Table 2). The total implementation costs were € 246 368 for the state-of-the-art strategy (37 wards; € 6659 per ward) and € 364 668 for the team and leaders-directed strategy

Table 2. Cost and effects of the implementation strategies per ward.

		Mean	Mean difference	Confidence interval difference	
Effects	TDS*	33,07%	-8,91%	-17,06%	-0,75%
	SAS†	24,16%			
Costs	TDS	€12156	-€5497	-€9032	-€1962
	SAS	€6659			

* State-of-the-art strategy
† Team and leaders-directed strategy

(30 wards; € 12156 per ward). In both strategies, the additional time needed to perform hand hygiene came with higher costs; € 238 960 (66%) in the team and leaders-directed strategy and € 214 263 (87%) in the state-of-the-art strategy. Twenty five per cent of the costs in the team and leaders-directed strategy were staffing costs (€ 91 573) due to coaching and participation in team discussions. The mean difference in cost between wards from the state-of-the-art strategy and wards from the team and leaders-directed strategy was € 5497 (95% CI, € 1962 - € 9032). The bootstrap simulations generated an incremental cost-effectiveness ratio of € 622

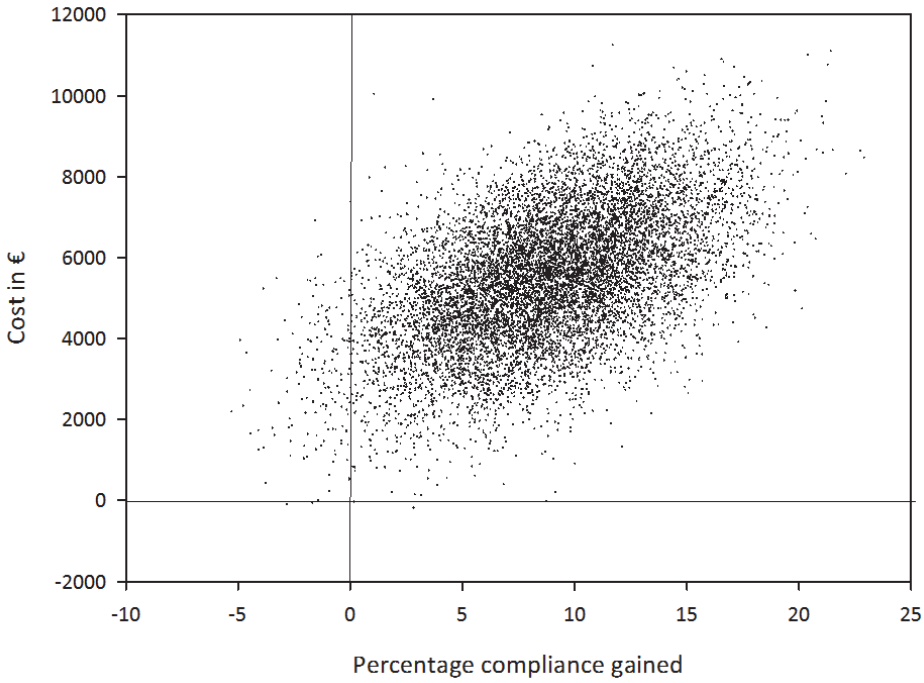

Figure 1. Cost-effectiveness of the team and leaders-directed strategy.

Table 3. Cost and effects of the implementation strategies per ward.

Indicative effects per ward without intervention in 2009					
Infections	Number	87688* x 0.072† / 67‡	94.2		
	Cost per infection		€ 5455		
	Total cost per ward			€ 514 035	
30%-scenario in 2009					
SAS§	Number	94.2 (1 – 0.24‖ x 0.30)	87.4		
	Cost per infection		€ 5455		
	Total cost per ward			€ 477 024	
	Savings per ward				€ 37 011
TDS¶	Number	94.2 (1 – 0.33** x 0.30)	84.9		
	Cost per infection		€ 5455		
	Total cost per ward			€ 463 145	
	Savings per ward				€ 50 889
Savings TDS versus SAS					€ 13 879
15%-scenario in 2009					
SAS§	Number	94.2 (1 – 0.24 x 0.15)	90.8		
	Cost per infection		€ 5455		
	Total cost per ward			€495 530	
	Savings per ward				€ 18 505
TDS¶	Number	94.2 (1 – 0.33 x 0.15)	89.6		
	Cost per infection		€ 5455		
	Total cost per ward			€ 488 590	
	Savings per ward				€ 25 445
Savings TDS versus SAS					€ 6 939

* Clinical admissions
† Infection percentage in 2009
‡ Number of wards
§ State-of-the-art strategy
‖ Absolute increase in hand hygiene compliance in state-of-the-art strategy
¶ Team and leaders-directed strategy
** Absolute increase in hand hygiene compliance in team and leaders-directed strategy

(95% CI € 146 – € 1098) per extra percentage of hand hygiene compliance gained due to the team and leaders-directed strategy. Figure 1 displays the cost-effectiveness plane showing that most of the bootstrapped incremental cost-effectiveness ratios fall in the north east quadrant meaning there is some trade-off between costs and compliance gained.

Incremental cost-effectiveness ratio per additional percentage reduction in the HAI rate

Table 3 presents the indicative effects of the expected reduction in HAIs due to improved hand hygiene for the wards in 2009. The hospitals accounted for 87 688 clinical admissions. We estimated there to be 6313 HAIs (7.2%), distributed across

the 67 wards in the three hospitals; approximately 94 HAIs per ward in 2009. As described above, the initial hospital costs was set on € 5455 per infection. Without any intervention, the estimated cost for HAIs per ward were € 514 035.

Applying the 30% scenario, we assumed that 1% increase in hand hygiene compliance would result in 0.3% reduction of the HAI rate. The state-of-the-art strategy showed a 24% increase in hand hygiene compliance with an expected decrease of 94.2 to 87.4 HAIs per ward. Ward savings with the state-of-the-art strategy would be € 37 011. The team and leaders-directed strategy showed a 33% increase in hand hygiene compliance and an expected decrease of 94.2 to 84.9 HAIs per ward, both within a one year time frame. As a result, ward savings with the team and leaders-directed strategy would be € 50 889. In this model, the difference in ward savings between the two strategies was € 13 879 in favour of the team and leaders-directed strategy, as a result of an additional reduction in the HAI rate by 2.7%.

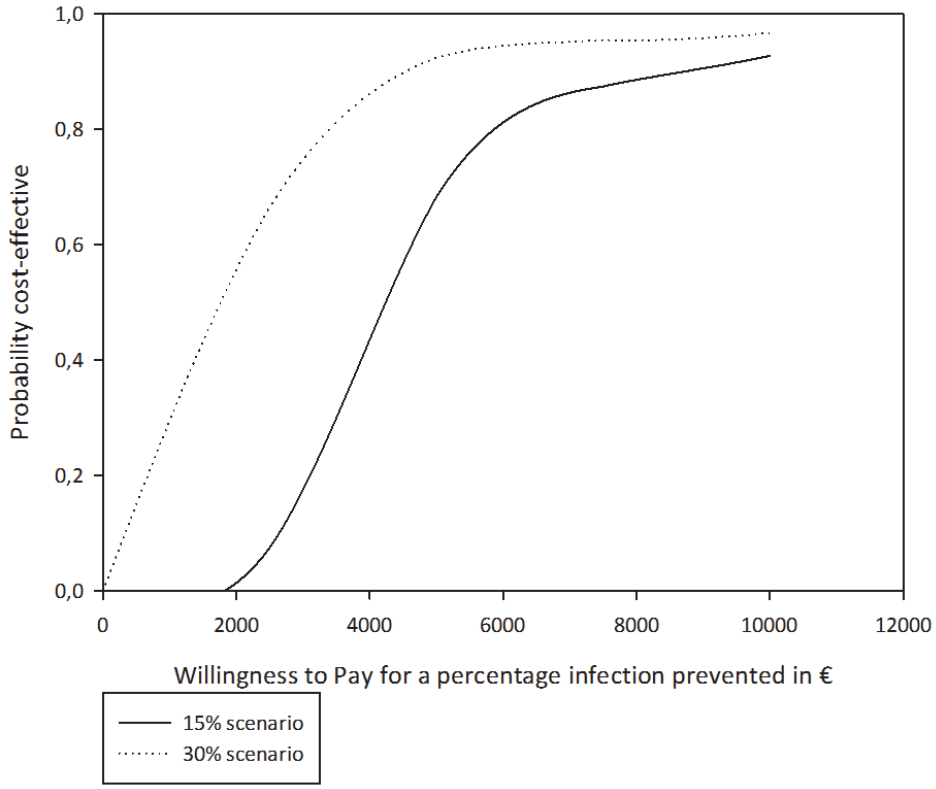

Figure 2. Acceptability curves for the team and leaders-directed strategy.

The results concerning costs per additional percentage reduction in the HAI rate due to the team and leaders-directed strategy are displayed in Figure 2 where two cost-effectiveness acceptability curves are presented. The vertical axis of the cost-effectiveness acceptability curve represents the probability that the team and leaders-directed strategy compared to the state-of-the-art strategy is acceptable for a range of values of the willingness-to-pay per additional percentage reduction in the HAI rate. The bootstrapped incremental cost-effectiveness ratio is € 2074 with a 95% confidence interval ranging from € 487 to € 3661. This means that a ward has to invest € 2074 for an additional percentage reduction in the HAI rate. Including uncertainty ranges this cost-effectiveness acceptability curve can be read as follows: if stakeholders concerned are willing to pay € 5000 for an additional percentage reduction in the HAI rate then there is approximately a 90% probability that the team and leaders-directed strategy is cost-effective.

Applying the 15% scenario, we assumed that 1% increase in hand hygiene compliance would result in 0.15% reduction of the HAI rate. The difference in ward savings would then be € 6939 in favour of the team and leaders-directed strategy, as a result of an additional reduction in the HAI rate by 1.35%. The bootstrapped incremental cost-effectiveness ratio is € 4125 with a 95% confidence interval ranging from € 1016 to € 7234. This cost-effectiveness acceptability curve can be read as follows: if stakeholders concerned are willing to pay € 5000 during one year as an investment for an additional percentage reduction in the HAI rate then there is about a 70% probability that the team and leaders-directed strategy is cost-effective.

DISCUSSION

In this study we compared the cost-effectiveness of a widely applied state-of-the-art strategy with an innovative team and leaders-directed strategy for improving hand hygiene compliance and reducing HAIs. The results show that wards exposed to the team and leaders-directed strategy increased their hand hygiene compliance rates by 33%, while control wards exposed to the state-of-the-art strategy increased their hand hygiene compliance rates by 24%. Thus, the additional implementation activities based on social influence and leadership resulted in 9% more hand hygiene compliance. This extra increase was achieved at an average cost of € 5497 per ward. Assuming that 1% increase in hand hygiene compliance is associated with a 0.3% reduction in HAI rates (the 30% scenario), the difference in ward savings

between the two strategies was € 13 879 in favour of the team and leaders-directed strategy, as a result of an additional reduction in the HAI rate by 2.7%. In this scenario, there is a probability of 90% that the team and leaders-directed strategy is cost-effective.

Within the 15% scenario, the difference in ward savings was € 6939 in favour of the team and leaders-directed strategy, as a result of an additional reduction in the HAI rate by 1.35%. This results in a probability of 70% that the team and leaders-directed strategy is cost-effective.

Comparison of our results with the literature is difficult, because currently no formal prospective studies have assessed the cost-effectiveness of hand hygiene implementation strategies in health-care settings. Available reviews of the literature hint at the possibilities of cost savings, but they also request the development of appropriate economic models for infection control programs.[33,34]

In general, studies have compared the costs of hand hygiene implementation strategies versus the potential cost savings from preventing HAIs. Pittet evaluated the costs associated with a sustained and successful hand hygiene promotion campaign.[35] The total costs for the hand hygiene implementation strategy were Swiss francs (CHF) 131 988. The total cost of HAIs were estimated to be CHF 132.6 million. The authors concluded that the hand hygiene implementation strategy was cost saving if less than 1% of the reduction in HAIs observed over the study period was due to improved hand hygiene practices. MacDonald et al. reported that the rate of new MRSA cases decreased from 1.9% to 0.9% after implementation of a hand hygiene strategy.[36] Correspondingly, the cost of antibiotics used fell from UK £ 35 600 to under £ 22 000. For every £ 1 spent on alcohol-based gel, £ 9-20 were saved on antibiotics expenditure. Despite the positive results of the above-mentioned studies, there is still substantial uncertainty on the cost–effectiveness of various hand hygiene implementation strategies.

The principal strength of our study was the comprehensive cost–effectiveness analysis within the context of a pragmatic randomised controlled trial. Our economic evaluation was well conducted and provides data on incremental costs, incremental cost-effectiveness ratios and cost-effectiveness acceptability curves whereas most articles only provide quantitative estimates of the cost savings from hand hygiene implementation strategies. Although hand disinfection costs less time than hand washing, extra staffing time needed to perform hand hygiene was mostly neglected in previously performed studies. To be as complete as possible we also took these costs into account. Our results demonstrated that a major part of the

total costs consisted of extra staffing time needed to perform hand hygiene, which were 87% of the total costs in the state-of-the-art strategy and 66% of the total costs in the team and leaders-directed strategy.

Limitations should be considered in interpreting the results of our study. We modelled the reduction in the HAI rate based on estimates from the literature and based on the results from the landmark study of Pittet.[1] However, uncertainty remains about the proportion of HAI's that can be prevented by improved hand hygiene compliance. We therefore used two scenario's 15% and 30%. The 15% scenario is very conservative whereas the 30% scenario is more optimistic. Nevertheless, both scenarios remain within the margins of the estimates from the literature.

A second methodological consideration concerns our assumption about the linearity of HAI reduction, which is debatable. However, we could not retrieve evidence from the literature for a non-linear relationship between hand hygiene and HAIs or directions from which a mathematical function could be derived. Further research should focus on a sensitivity analysis in which the assumption of linearity should be varied with a couple of scenarios.

Thirdly, we based our cost estimate of HAIs on quite old data.[29,30] Unfortunately, information on the cost of HAIs remains limited. Although more attempts are made to calculate the cost HAIs, new and valid data are not available yet.[37]

Fourth, hand rubbing is highly promoted and used in the Netherlands. Our calculations are based on the use of hand rub rather than washing hands with soap and water. This might affect the generalizability of our results.

Fifth, our observations were performed unobtrusively, yet a possible Hawthorne effect cannot be ruled out. However, this would affect both study groups equally.

Sixth, we found a sustained effect after six months of strategy delivery but we cannot provide evidence for a sustained effect over several years.

Seventh, in this study we focused on nurses. The main reason for not including other health care workers is the difference in team structure and team work between nurses other health care workers. Activities aimed at social influence to improve HH behaviour of other health care workers, will probably differ from nurse-directed social influence activities.

Finally, as both the strategies and the results are of particular interest to hospital management we used a hospital perspective. This means that we have not taken into account, for example, costs incurred in primary care, costs incurred by pa-

tients and the impact on productivity in the wider economy. Thus, the societal effects and hence the cost-effectiveness of the team and leaders-directed strategy might be more favourable than we report here.

This is the first prospective study that has assessed the cost-effectiveness of two hand hygiene implementation strategies in a health-care setting, demonstrating that our innovative team and leaders-directed strategy has a high probability of being cost-effective. To appreciate our results, it is necessary to consider the potential cost savings that can be achieved by reducing HAIs. Our economic evaluation provides data that allow hospital management to judge the additional health outcomes and the additional resources of the team and leaders-directed strategy compared to the health outcomes and the resources needed for the state-of-the-art strategy. Whether or not the investment of € 5000 during one year for an additional percentage reduction in the HAI rate represents a good deal for ward management depends on the preferences of the decision maker. It is conceivable that decision makers of a medical ward where mainly relatively cheap urinary tract infections occur, choose to use only the state-of-the-art strategy. By contrast, the prevalence of infections on the ICUs in the Netherlands in 2008 was 25.5%, mainly consisting of severe infections such as primary bloodstream.[38] The excess hospital costs associated with this type of HAIs can motivate a decision maker on the ICU to use the team and leaders-directed strategy. In addition to financial savings, the likely patient benefits in terms of lives saved and well-being may also be a consideration for implementing the team and leaders-directed strategy.

In conclusion, optimizing hand hygiene compliance through a team and leaders -directed strategy is cost-effective as compared to a state-of-the-art strategy. These initial results require affirmation by further economic evaluations of hand hygiene improvement strategies.

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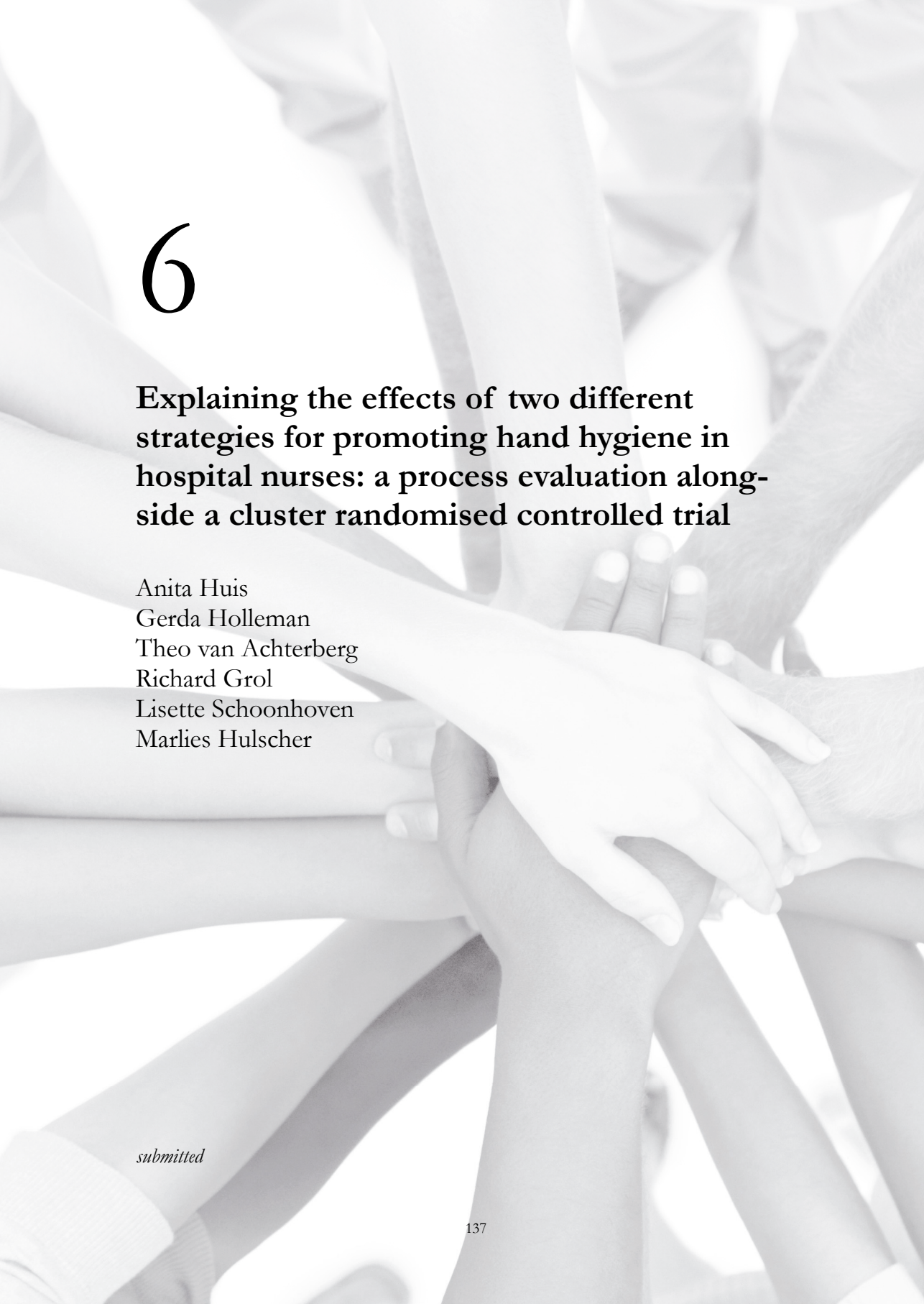

6

Explaining the effects of two different strategies for promoting hand hygiene in hospital nurses: a process evaluation alongside a cluster randomised controlled trial

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submitted

ABSTRACT

Background

There is only limited understanding of why hand hygiene improvement strategies are successful or fail. It is therefore important to look inside the 'black box' of such strategies, to ascertain which components of a strategy work well or less well. This study examined which components of two hand hygiene improvement strategies were associated with increased nurses' hand hygiene compliance.

Methods

A process evaluation alongside a cluster randomised controlled trial was conducted in 67 nursing wards of three hospitals in the Netherlands. The control group received a state-of-the-art strategy including education, reminders feedback and optimising materials and facilities. The experimental group received a team and leaders-directed strategy which included all elements of the state-of-the-art strategy supplemented with activities aimed at the social and enhancing leadership. The evaluation used four sets of measures: effects on nurses' hand hygiene compliance, adherence to the improvement strategies, contextual factors, and nurses' experiences with strategy components. Analyses of variance and multiple regression analyses were used to explore changes in nurses' hand hygiene compliance and thereby better understand trial effects.

Results

Both strategies were performed with good adherence to protocol. Two contextual factors were associated with changes in hand hygiene compliance: a hospital effect in long term ($p < 0.05$) and high hand hygiene baseline scores were associated with smaller effects ($p < 0.01$). In short term, changes in nurses' hand hygiene compliance were positively correlated with experienced feedback about their hand hygiene performance ($p < 0.05$). In the long run, several items of the components 'social influence' (i.e., addressing each other on undesirable hand hygiene behaviour $p < 0.01$), and 'leadership' (i.e., ward manager holds team members accountable for hand hygiene performance $p < 0.01$) correlated positively with changes in nurses' hand hygiene compliance.

Conclusion

This study illustrates the use of a process evaluation to uncover mechanisms underlying change in hand hygiene improvement strategies. Our study results demonstrate the added value of specific aspects of social influence and leadership in hand hygiene improvement strategies, thus offering an interpretation of the trial effects.

BACKGROUND

Strategies to improve adherence to practice guidelines are often multimodal and consist of a number of potentially effective components and related improvement activities.[1-3] See Table 1. All these components might influence effectiveness both independently and interdependently. This poses challenges for strategy evaluation. A randomised controlled trial (RCT) is the most rigorous way to evaluate the effectiveness of improvement strategies, regardless of their complexity. However, published reports of RCTs mainly focus on the outcomes, answering the question "Does it work?" [4,5] RCTs rarely answer the question why an improvement strategy has been successful or has failed. Despite of the CONSORT guidelines[6], a detailed description of an improvement strategy - reporting on all components and corresponding activities - and how well the strategy was performed is often lacking. This equally applies to information on contextual aspects such as the environment or setting, as well as factors that inhibited or promoted effectiveness.[4,7] Understanding RCT results is also complicated by the limitation of the intention-to-treat analysis.[8] In this, individuals or clusters are analysed according to the group

Table 1. Explanation of terms used in this article.

Term	Explanation
Hand hygiene improvement strategy	A HH improvement strategy is composed of a number of components intended to change HH behaviour. These various components work best together and support each other in targeting potential barriers to appropriate HH
Strategy component	A strategy component refers to the specific method used to address a potential barrier to appropriate HH. Examples: education, reminders, performance feedback, social influence, leadership, setting norms and targets
Improvement activities	Improvement activities refer to the operationalization of strategy components Examples: educational website, bar charts of HH rates, posters, ward manager addresses barriers to enable HH as recommended, provision of alcohol-based hand rub.
Intention-to-treat analysis	The intention to treat analysis in our study was an analysis based on the initial treatment intent. In this, wards were analysed according to the group (experimental or control) to which they were originally allocated, regardless of whether they actually received the improvement strategy and despite the fact that there may be less impact on those who did not receive the intervention
As-received analysis	The as-received analysis in our study is based on the treatment actually received. In this, wards were analysed according to improvement strategy actually received, regardless of their allocation.

(experimental or control) to which they were originally allocated, regardless of whether they actually received the improvement strategy.[9] Therefore, it is necessary to combine the strength of an RCT with that of a well designed process evaluation.[10]

Process evaluations are important because they can clarify to what extent the improvement strategy was performed in a uniform way, whether the target population actually received the planned activities, what factors inhibited or promoted effectiveness, and what the participants' actual experiences with the executed strategy were.[5,11-13] Process evaluations also provide information important to understanding and validating theory-informed strategies. Identifying the mechanisms for how and why these strategies produce successful change (or fail to produce change) is crucial to refining theory and improving strategy effectiveness.[14]

Combined analysis of process and outcome data allows evaluations to explore associations between strategy delivery and receipt, and outcomes on effectiveness.[15] In this way, insight is gained into the mechanisms responsible for the results which could improve the validity of the findings and help understand the potential generalizability of the improvement strategy.[11,12,16].

The case of hand hygiene: the HELPING HANDS study

Hospital acquired infections are the most common complications in hospital care, and a major threat to patient safety.[3,17] Hand hygiene (HH) is considered the most important measure in the prevention of hospital acquired infections.[3,18,19] Unfortunately, compliance with HH recommendations is repeatedly found to be insufficient.[3,18,19]

Many potentially effective strategies for improving HH compliance are described but most of the effects are small to moderate.[2,20,21] Traditionally, strategies have concentrated on the health care professional or focused on the introduction of new products and facilities.[2,21] However, often experienced barriers like negative role models, lack of management involvement and a poor social culture are rarely addressed.[22] Using insights from the behavioural sciences and performing a strategy that also targets social within teams and leadership, could be a valuable addition to HH implementation strategies.[22-24]

We undertook a cluster randomised trial (the HELPING HANDS study) at 67 nursing wards in three Dutch hospitals to compare the effectiveness of a state-of-the-art strategy with a team and leaders-directed strategy for improving nurses' compliance with HH guidelines. The effects were evaluated on an intention-to-

treat basis by comparing the post-strategy HH compliance rates with the baseline rates for the two strategies. The compliance in the state-of-the-art group increased from 23% to 42% in the short term and to 46% in the long run. The HH compliance in the team and leaders-directed group improved from 20% to 53% in the short term and remained 53% in the long run. The difference between the two strategies showed an Odds Ratio of 1.641 (95% CI 1.33–2.02; $p<0.001$) in favour of the team and leaders-directed strategy.[25]

The findings of this study indicated the added value of strategy components aimed at social influence within teams and enhanced leadership of wards managers on nurses' HH behaviour. However, these results provide no insight into the mechanisms of impact. For instance, the extent to which nursing wards improved their HH compliance varied considerably for both strategies, ranging from -2% to 70% improvement in the long run. In addition, the effect size of the team and leaders-directed group was limited by the intention-to-treat analysis, which is the main statistical approach for RCT analyses.

Wards were analysed according to the group - state-of-the-art strategy or team and leaders-directed strategy - to which they were originally allocated. In the HELPING HANDS study, thirty nursing wards were randomly assigned to the team and leaders-directed group but ten wards declined to participate in the team and leaders-directed strategy. Therefore, only twenty wards fully participated in the team and leaders-directed group.

The current article expands on the findings of the HELPING HANDS study by linking process and effectiveness evaluations. The aim of this paper is to ascertain which components of the two HH improvement strategies can be particularly associated with increased nurses' HH compliance, as well as to explore other possible factors that may be associated with changes in nurses' HH compliance. We focused on three specific questions:

1. What impact might variation in adherence to the improvement strategies as planned have on changes in nurses' HH compliance?

2. What impact might specific contextual factors as hospital and ward characteristics have on changes in nurses' HH compliance?

3. What impact might differences in nurses' actual experiences with strategy components have on changes in nurses' HH compliance?

METHODS

The methods of the HELPING HANDS study have been previously described according to the CONSORT statement.[6,25,26]

Setting and participants

The HELPING HANDS study was performed in three hospitals in the Netherlands: two general hospitals and one university medical centre. Within the hospitals, all in-patient nursing wards (n=67) and all affiliated nurses' participated in the study. After the collection of baseline data, wards were randomly assigned to either the team and leaders-directed group (30 wards) or the state-of-the-art group (37 wards). We included surgical wards (n=21), internal medicine wards (n=24), intensive care units (n=13) and paediatric wards (n=9). Strategies were delivered during a period of six months. Follow-up measurements took place directly after strategy delivery (T2) and at six months after the end of strategy delivery (T3).

HH improvement strategies

The state-of-the-art strategy was based on current evidence from literature on HH compliance.[3,17,21] This strategy targeted the individual and organisational level and included the following components: a) education for improving relevant knowledge and skills, b) reminders for supporting the actual performance of HH c) feedback as a means to provide insight into current HH behaviour and to reinforce improved behaviour d) screening for adequate HH products and adequate facilities.

The team and leaders-directed strategy was also aimed at addressing barriers at team level by focussing on social influence within teams and strengthening leadership of the ward manager. The unique contribution of this strategy was built upon the Social learning theory[27], Social influence theory[28], Theory on team effectiveness[29,30] and Leadership Theory.[31] The team and leaders-directed strategy included all components of the state-of-the-art strategy (a through d) supplemented with e) gaining active commitment and initiative of ward management f) modelling by informal leaders at the ward, and g) setting norms and targets within the team. Table 2 provides an overview of our theory selecting process including the characteristics and key elements of the behaviour change theories.

Before the start of the intervention, all managers participating in the team and leaders-directed group received a four-hour training in coaching and motivating

Table 2. Selected behaviour change theories matching barriers in performing hand hygiene.

Theory	Focus	Key elements
Social learning theory[27]	Behaviour is learned from the environment through the process of observational learning	• Demonstration, role modelling • Encompasses attention, memory, and motivation
Social influence theory[28]	Social norm in a network determines what correct behaviour is	• Norm and target setting • Commitment team members • Use of opinion leaders. • Performance feedback • Team members address each other in case of undesirable behaviour
Theory on team effectiveness[29,30]	Orientation on team climate and willingness to change	• Team Vision: clarity, perceived value, and attainability • Participation Safety: decision-making, information sharing, interaction and safety • Support for Innovation: articulated and enhanced support • Task Orientation: commitment to excellence, appraisal and task orientation
Theories of leadership[31]	Leading, coaching and managing a team	• Active commitment/ participation in performance improvement initiatives • Setting norms and targets/direction/expectations • Encouragement and support/ motivate staff • Monitoring performance and feedback

the nurses. During the intervention period, the ward manager was assisted by an experienced coach in three team meetings. Also, two group sessions were organised to support the ward managers and to discuss progress and difficulties. Table 3 presents the content and related activities of both strategies.

Measurements and data collection

Data were collected using a wide range of methods, including: student observations, questionnaires to nurses, a ward structure survey, registration of website visitors, structured logbooks of ward managers and coaches and researchers' field notes of group meetings. Using these data sources, we constructed four sets of measures.

Effect evaluation

Effects on nurses' HH compliance

The primary outcome was the percentage of nurses' actions in line with HH guidelines in case of an opportunity to perform this action.[3,32] We monitored nurses' HH compliance unobtrusively during routine patient care before and directly after strategy delivery, as well as six months later.

Table 1. Description implementation strategies.

State-of-the-art strategy	Extended strategy
Education Distribution of educational material/ written information (leaflet) about hand hygiene • The importance of hand hygiene • Misconceptions about alcohol-based hand disinfection • Theory and practical indications for the use of hand hygiene • Website www.gewoonhandenschoon.nl • Educational material/ written information about hand hygiene • Knowledge quiz • Reward for the nursing ward with the most visitors to the website • Educational sessions on prevention of hospital acquired infections • Launching hospital wide campaign with practical demonstrations of hand hygiene **Reminders** • Distribution of posters that emphasized the importance of hand hygiene, particularly alcohol-based hand disinfection • Interviews and messages in newsletters or hospital magazines • General reminders by opinion leaders/ward management **Feedback** • Bar charts of hand hygiene rates of every nursing ward will be sent to the ward manager twice • Comparison ward performance and hospital performance **Facilities and products** • Screening and if necessary adapt products and appropriate facilities	**All elements of the state-of-the-art strategy** • Education, reminders, feedback, facilities and products **Setting norms and targets within the team** • Three interactive team sessions that includes goal setting in hand hygiene performance at group level • Analysis of barriers and facilitators to determine how they could best adapt their behaviour in order to reach their goal • Nurses address each other in case of undesirable hand hygiene behaviour **Gaining active commitment and initiative of ward management** • Ward manager designates hand hygiene as a priority • Ward manager actively supports team members and informal leaders • Ward manager discusses hand hygiene compliance rates with team members **Modelling by informal leaders at the ward** • Informal leaders demonstrate good hand hygiene behaviour • Informal leaders models social skills in addressing behaviour of colleagues • Informal leaders instruct and stimulate their colleagues in providing good hand hygiene behaviour

Process evaluation

Adherence to the improvement strategies as planned

The measurement of adherence captures the following subcategories: (a) content: whether improvement activities were delivered as planned (yes/no); (b) dosage: whether improvement activities were delivered as often and long as planned (yes/no); (c) coverage: the extent to which the intended target group received the improvement activities.[33]

Education was assessed by monitoring the presence of instruction leaflets on the ward and by measuring the number of nurses who completed the knowledge quiz. The use of reminders was checked by measuring the presence of reminders (posters) at random moments during the strategy delivery period. Feedback was

assessed by checking the distribution of performance feedback reports to ward managers and by a question from the study's survey asking if nurses had received performance feedback from the ward manager. In addition, the extent to which products and facilities were available in each ward was also explored by survey questions to ward managers and nurses. The attendance of ward management and informal leaders to the training sessions and the support sessions was derived from an attendance checklist.

The use of coaching of ward management and informal leaders was assessed by measuring the number of coaching sessions and the total time spent on coaching. The use of organised team discussions for norm- and target setting was checked by measuring the number of team discussions performed, the number of nurses attending per ward, the time investment per ward, and whether norms and targets were established. Leadership was assessed by checking documented agreements on the following points: whether the ward manager had discussed HH compliance rates during the team sessions; whether the ward manager had prioritized good HH as a ward target, and whether the ward manager had formulated specific activities to support the team members and informal leaders. Finally, information whether informal leaders served as role models was derived from group discussion during the support sessions for ward managers and informal leaders.

Contextual factors

We explored the influence of three contextual variables namely: hospital, ward specialism - general ward, surgical ward, paediatric ward or critical care ward- and the HH compliance rate at baseline.

Nurses' experiences with specific components of the improvement strategies

In order to explore the relationship between HH outcomes and nurses' actual experiences with different strategy components, we drew on the findings of a 7-subscale questionnaire consisting of 24 items. Each item was a proposition on a specific component of the improvement strategies. These components were education, reminders, feedback, facilities and products, setting norms and targets, social influence and leadership.

An example of a proposition that explores nurses' actual experiences with leadership is 'my ward manager hold team members accountable for HH performance'. Nurses' scored this proposition on a 4-point Likert scale, ranging from strongly agree (4) to strongly disagree (1). Negatively formulated propositions were recod-

ed. Higher scores indicated more positive experiences with respective components (Appendix 1).

Statistical analyses

In this study our primary research goal is to understand the mechanisms of impact of strategy components on nurses' HH compliance. Therefore, we combined data from the process evaluations with data from the effect evaluation. Inputs for the effect analysis, used in this paper, were based on the HH compliance findings of the previously mentioned HELPING HANDS study. The effectiveness of the HELPING HANDS study was examined using an 'intention-to-treat' analysis. However, ten wards declined to participate in the team and leaders-directed group and did not receive any component of this strategy. We therefore explored whether the inclusion, in our intention-to-treat analysis, of wards who did not receive the team and leaders-directed strategy, might have resulted in different effects in changes in nurses' HH compliance. All data were analysed using SPSS version 19.0 (SPSS, Inc, Chicago, IL) and analyses were performed at ward level.

Effect evaluation

Effects on nurses' HH compliance: intention-to-treat versus as-received analysis

First we compared the outcome data on changes in HH compliance of the intention-to-treat analysis with the results of the as-received analysis. We used descriptive statistics, including the mean and standard deviation, for the change in HH compliance between the measurement points for each of the two strategies. One way ANOVAs were used to test whether there was a statistically significant difference between the group means for both strategies. A *p*-value of 0.05 or less was considered to indicate the statistical significance of the difference between measurements at baseline (T1), directly after strategy delivery (T2) and at six months after the end of strategy delivery (T3).

Next, we compared the HH compliance outcomes of the wards allocated to the team and leaders-directed group but who did not participate in the team and leaders-directed group (thus actually received the state-of-the-art strategy) with the HH compliance outcomes of the wards allocated to the state-of-the-art group. A T- test on the three measurement moments showed no differences between both groups of wards. From this point, all analyses were performed on an as-received basis with 47 wards in the state-of-the-art group and 20 wards in the team and leaders-directed group.

Process evaluations linked to effectiveness evaluations

Analysis of adherence to the improvement strategies and related changes in HH compliance

Frequencies and proportions were used to assess the adherence to the several components of the improvement strategies. One-way ANOVAs were used to test the influence from varying strategy components on HH compliance. If a strategy component was significant, correlations between changes in nurses' HH compliance and the significant term were also examined within each strategy group using the Spearman correlation analysis.

Analysis of contextual factors and related changes in HH compliance

One-way ANOVAs were used to test the influence from the contextual factors hospital, ward specialism and the HH compliance rate at baseline. The correlation between nurses' HH baseline scores and changes in nurses' HH compliance was tested with the Pearson correlation analysis. Next, we applied forced entry multiple regression analyses to assess the impact of several potential explanatory variables on changes in HH compliance. As an estimation for the explained variance of the model, an adjusted R-Squired was determined.

Analysis of nurses' actual experiences with specific components of the improvement strategies and related changes in HH compliance

Descriptive statistics, including the mean and standard deviation, were used to explore differences in nurses' actual experiences with specific strategy components between nurses in the team and leaders-directed group and in the state-of-the-art group. Inclusion criteria for analysis were wards whose respondents returned ≥ 3 questionnaires. One way ANOVAs were used to test whether there was a statistically significant difference between the group means for both strategies. To determine whether differences in nurses' actual experiences with strategy components predicted variation in HH compliance effects, we tested non parametric correlations with Spearman analyses between groups and within groups.

RESULTS

General

Initially 67 wards were included, 30 to the team and leaders-directed group and 37 to the state-of-the-art group. Ten wards declined to participate in the team and leaders-directed group because of a vacancy for the position of ward manager (2x),

reorganisation of the ward (2x), workload of the ward manager ruled out other activities (1x), inconvenient timing relating to the execution of the strategy (2x), or other projects were given a higher priority (3x). Finally, 47 wards received only the state-of-the-art strategy and 20 wards received the team and leaders-directed strategy (Table 4). At each point in time, 3523 to 3722 opportunities for HH were observed in 886 to 933 nurses. During the entire study we obtained data on 10,785 opportunities for HH in 2733 nurses.

Effect evaluation

Effects on nurses' HH compliance: intention-to-treat versus as-received analysis

Table 5 displays the results of changes in nurses' HH compliance derived from the intention-to-treat analysis and the as-received analysis. In both analyses, the team and leaders-directed group demonstrated better results on HH compliance than the state-of-the-art group. The as-received analysis showed higher effect sizes for the team and leaders-directed group than the intention-to-treat analysis. A statistically significant (p=0.002) increase in nurses' HH compliance was observed in the long run (T3) in favour of the team and leaders-directed strategy. The intention-to-treat analysis showed no significant difference in nurses' HH compliance between both strategies at T3.

No differences in HH compliance were found between the wards originally allocated to the team and leaders-directed group but actually receiving the state-of-the-art strategy and the wards a priori allocated to the state-of-the-art group. *P*-values were: 0.322 (T1), 0.650 (T2) and 0.224 (T3). We considered these wards comparable and all subsequent analyses were done as-received with 47 wards in the state-of-the-art group and 20 wards in the team and leaders-directed group.

Table 4. Characteristics of the wards.

Ward characteristics	**SAS†**	*n=47*	**TDS‡**	*n=20*
Hospital	University based hospital	*n=16*	University based hospital	*n=9*
	General teaching hospital A	*n=15*	General teaching hospital A	*n=5*
	General teaching hospital B	*n=16*	General teaching hospital B	*n=6*
Specialism	Surgical ward	*n=14*	Surgical ward	*n=7*
	Medical ward	*n=16*	Medical ward	*n=8*
	Intensive care unit	*n=12*	Intensive care unit	*n=1*
	Paediatric ward	*n=5*	Paediatric ward	*n=4*

† State-of-the-art strategy
‡ Team and leaders-directed strategy

Table 5. Changes in HH compliance in participating hospitals during study period.

Intention-to-treat analysis	**T1** Baseline	**T2** post intervention	**T3** follow-up
Strategy SAS†	21.8% (37 wards)	40.4% (37 wards) Δ T1-T2 18.6%	45.9% (37 wards) Δ T1-T3 24.1%
Strategy TDS‡	19.1% (30 wards)	53.1% (30 wards) Δ T1-T2 34.0%	52.1% (30 wards) Δ T1-T3 33.0%
Groups compared TDS vs. SAS ANOVA	f=0.465 p=0.498	f=19.409 p=0.000**	f=1.781 p=0.187*
As-received analysis	**T1** Baseline	**T2** post intervention	**T3** follow-up
Strategy SAS†	21.5% (47 wards)	40.7% (47 wards) Δ T1-T2 19.2%	44.1% (47 wards) Δ T1-T3 22.6%
Strategy TDS‡	20.7% (20 wards)	58.6% (20 wards) Δ T1-T2 37.9%	59.5% (20 wards) Δ T1-T3 38.8%
Groups compared TDS vs. SAS ANOVA	f=0.001 p=0.978	f=40.304 p=0.000**	f=10.187 p=0.002**
Groups compared SAS groups randomised to TDS (n=10) vs SAS groups randomised to SAS (n=37) T-test	p=0.322	p=0.650	p=0.224

Compliance with HH prescriptions expressed as a percentage of all relevant opportunities based on the average compliance per ward.
† State-of-the-art strategy
‡ Team and leaders-directed strategy
* $p < .05$; ** $p < .01$

Process evaluations linked to effectiveness evaluations

Adherence to the improvement strategies and related changes in HH compliance

Both improvement strategies were carried out with good adherence to protocol. Detailed results on strategy adherence are described in Appendix 2.

Impact of variation in adherence to the components of the state-of-the-art strategy (n=67).

On the adherence subcategory 'content' we found that the main components of the state-of-the-art strategy were generally delivered as planned. The 'HH promotion event' was not delivered in one hospital. The infection control department of this particular hospital had already organised a HH promotion event one year before the start of our study. Despite the variation in delivering the 'HH promotion event', no effect on changes in HH compliance could be demonstrated (p=0.384). The subcategory 'coverage' showed some variation in the extent to which washstands were accessible. The analysis showed that variation within these components had no effect on changes in HH compliance (p=0.348).

The subcategory 'coverage' also demonstrated a significant difference between the numbers of nurses from wards receiving the state-of-the-art strategy and the numbers of nurses from wards receiving the team and leaders-directed strategy in completing the knowledge quiz (13% and 37%; p=0.001). This was positively correlated with changes in HH compliance at both follow-up measurements (T1-T2: p=0.019; T1-T3: p=0.016) However, completing the knowledge quiz did not predict variation in HH compliance within groups of the state-of-the-art strategy (T1-T2: p=0.779; T1-T3: p=0.426) or within groups of the team and leaders-directed strategy (T1-T2: p=0.354; T1-T3: p=0.452).

Impact of variation in adherence to the additional components of the team and leaders-directed strategy (n=20)

On the adherence subcategory 'content' we found that all components of the team and leaders-directed strategy were delivered as planned. Components that differed in adherence across the wards concerned the subcategories 'dose' and 'coverage'. Five wards organised only two team sessions instead of three team sessions. Thus these wards did not receive a full dose. However, this did not affect the course of nurses' HH compliance (T1-T2: p=0.240; T1-T3: p=0.254). Full coverage was also not achieved for attending two sessions in support of the role models and ward managers but everyone took part in at least one session. Variation in adherence within the component 'support sessions' had no effect on changes in HH compliance (ward managers T1-T2: p=0.262; T1-T3: p=0.994; role models T1-T2: p=0.184; T1-T3: p=0.688). There was also some variation in the average number of nurses that attended the team sessions, related to total number of nurses employed. However, variation within this component had no effect on changes in HH compliance (T1-T2: p=0.445; T1-T3: p=0.823). In conclusion, the evaluation of strategy adherence did not provide any explanatory variables associated with changes in nurses' HH compliance.

Contextual factors and related changes in HH compliance

Our next step was to determine the impact of contextual factors on changes in nurses' HH compliance. Two contextual factors were associated with changes in HH compliance: type of hospital and HH performance at baseline. The ANOVA showed a hospital effect on changes in HH compliance in long term (p=0.036). HH compliance decreased in one hospital in long term, while the HH compliance in the other two hospitals remained stable or increased further. At baseline, the

HH scores of all wards from the state-of-the-art strategy and the wards that participated in the team and leaders-directed group were comparable (p=0.978). For both study groups, baseline HH scores were negatively correlated with follow-up scores (r=-0.693, p=0.000). Initially, short-term changes in HH compliance (T1-T2) revealed a specialism effect (p=0.002). In particular, the paediatric wards showed a smaller increase in HH compliance than the wards from other specialisms. However, the baseline HH scores of the paediatric wards were significantly higher than the baseline HH scores of other wards (p=0.000). This alleged specialism effect was, in reality, a baseline effect.

We then tested all significant variables in forced entry multiple regression analyses. Table 6 presents the results from two multiple regression analyses. The basic model included baseline HH compliance (covariate), hospital, specialism, and strategy. The first model analysed changes in HH scores from baseline (T1) to the first follow-up measurement, directly after strategy delivery (T2). Baseline HH scores (p<0.01) and hospital (p<0.05) contributed negatively to short-term changes in HH compliance. The team and leaders directed strategy contributed positively to short-term changes in HH compliance (p<0.01). The second model analysed changes in HH compliance from baseline (T1) to the second follow-up measurement, six months after the end of strategy delivery (T3). Baseline HH scores (p<0.01) and hospital (p<0.01) contributed negatively to long-term changes in HH compliance. The team and leaders directed strategy contributed positively to long-term changes in HH compliance (p<0.01). The adjusted R^2 was 0.702 for the first model and 0.510 for the second model. This suggests that 70% and 51% of the variation in HH change scores could be explained by the regression model.

Nurses' experiences with the improvement strategies and related changes in HH compliance

In this section we explored differences in nurses' actual experiences with strategy components and how these differences affected changes in nurses' HH compliance. Five hundred and twenty-eight questionnaires out of 1100 (369 questionnaires from the state-of-the-art group and 159 from the team and leaders-directed group) were returned, giving a response rate of 48%. Questionnaires of 515 nurses from 59 wards met the inclusion criteria for analysis. Of these, 42 wards belonged to the state-of-the-art group (360 questionnaires) and 17 wards to the team and leaders-directed group (155 questionnaires).

The ANOVA showed significant differences in actual experiences with several items of the questionnaire between nurses from the state-of-the-art group and

Table 6. Summary of forced entry multiple regression analysis for variables predicting changes in HH compliance in participating hospitals during study period.

	Δ HH compliance T1-T2			**Δ HH compliance T1-T3**		
Variable	B	*SE* B	β	B	*SE* B	β
Constant	27.78	6.32		47.74	7.78	
Baseline T1	-.91	.94	-.80**	-.69	.12	-.64**
Strategy	17.29	2.61	.45**	13.47	3.21	.36**
Hospital	-.3.92	1.66	-.19*	-.12.17	2.03	-.60**
Specialism	.72	1.28	.04	.41	1.60	.03
R^2		.70			.51	
F for change in R^2		39.83**			18.18**	

* p < .05; ** p < .01

nurses from the team and leaders-directed group. Nurses from the team and leaders-directed group, who unlike the nurses from the state-of-the-art group were exposed to the strategy components 'setting norms and targets', 'social influence' and 'leadership', experienced more social support (p=0.005), social influence (p=0.046) and leadership (p=0.011) with respect to HH performance. In addition, these nurses experienced more priority for HH on their ward (p=0.009) and experienced more feedback about their HH performance (p=0.000) than nurses from the state-of-the-art group.

Table 7 displays nurses' experiences with components of both improvement strategies and their impact on changes in HH compliance. First we examined the impact of strategy components in both study groups (n=67). In short term (T1-T2) and in the long run (T1-T3), changes in nurses' HH compliance were positively correlated with experienced feedback about their HH performance (p<0.05 and p<0.01 respectively). In the long run (T1-T3), two items of the component 'social influence' correlated positively with changes in nurses' HH compliance: addressing each other on undesirable HH behaviour (p<0.01) and support from colleagues in performing HH (p<0.01).

Also in the long run, five items of the component 'leadership' correlated positively with changes in nurses' HH compliance: regular attention to the adherence of HH guidelines (p<0.05); designation of HH as ward priority (p< 0.05); addressing barriers to enable HH as recommended (p<0.05); accountability for HH performance (p< 0.01); and encouraging and motivating team members to perform HH (p< 0.01).

Within the state-of-the-art group (n=47), we found a few correlations between nurses' experiences with strategy components and changes in HH compliance. In short-term, experienced knowledge of HH indications showed a negative correlation with HH change scores (p< 0.05). In the long term, positive correlations with changes in HH compliance could be demonstrated for one item of social influence, namely: addressing each other on undesirable HH behaviour (p< 0.05). We also found positive correlations with changes in HH compliance for two leadership items: accountability for HH performance (p< 0.01) and encouraging and motivating team members to perform HH (p< 0.05). We found no significant correlations between scores on specific items and HH change scores within the group of the team and leaders-directed strategy (n=20).

Table 7. Nurses' experiences with strategy components and correlations with changes in HH compliance.

Component **- Proposition**	**Δ T1-T2 S rho (*p*)**	**Δ T1-T3 S rho (*p*)**
Correlation with changes in HH compliance in all study groups		
Performance feedback		
- I do know my wards HH performance	,315 (.015*)	,347 (.007**)
Social influence		
- My colleagues support each other in performing HH		,381 (.003**)
- Our team members address each other in case of undesirable HH behaviour		,414 (.001**)
Leadership		
- My manager pays regular attention to the adherence of HH guidelines		,293 (.025*)
- HH is not a priority at our ward		,261 (.046*)
- My ward manager addresses barriers to enable HH as recommended		,319 (.014*)
- My ward manager holds team members accountable for HH performance		,382 (.003**)
- My ward manager encourages and motivates our team members to perform HH		,352 (.006**)
Correlation with changes in HH compliance within SAS†		
Education		
- I know exactly when to perform HH	-,315 (.042*)	
Leadership		
- My ward manager encourages and motivates our team members to perform HH		.387 (.011*)
- My ward manager holds team members accountable for HH performance		.398 (.009**)
Social influence		
- Our team members address each other in case of undesirable HH behaviour		.347 (.025*)
Correlation with changes in HH compliance within TDS‡		
No significant correlations between scores on specific items and HH change scores		

† State-of-the-art strategy
‡ Team and leaders-directed strategy
* p < .05; ** p < .01

DISCUSSION

In this article, we examined which components of the HH improvement strategies were particularly associated with increased nurses' HH compliance, as well as other possible factors that may have influenced nurses' HH compliance. We therefore linked process and effectiveness evaluations in the analysis of findings from the HELPING HANDS study.[25]

Effect evaluation: Intention-to-treat versus as-received analysis.

In this article we have tried to explain the effects of two different HH improvement strategies on changes in nurses' HH. It is important to recognize that this research goal requires a different view on the treatment effects compared to a evaluation of effectiveness. The outcomes suggests that the overall conclusions about the effectiveness of the team and leaders-directed strategy arising from the original intention-to-treat analysis may have underestimated the impact and strength of this strategy. The as-received analysis showed higher effect sizes for the team and leaders-directed group than the intention-to-treat analysis on both measurements points. In the long run, we now observed a statistically significant (p=0.002) increase in nurses' HH compliance due to the team and leaders-based strategy. This suggests that the team and leaders-directed strategy might have had a more permanent impact on HH outcomes than shown by the intention-to-treat analysis.

This corresponds with the findings of Strange et al.[9] Their as-received analysis showed higher Odds ratios in decreasing risky sexual behaviour than the original intention-to-treat analysis, thereby suggesting that their peer-led sex education programme, if consistently implemented, probably had a greater impact on study outcomes.

Effects of strategy adherence on nurses' HH compliance

The evaluation of strategy adherence did not provide any explanatory variables associated with changes in nurses' HH compliance. Thus, variation in the HH outcomes across the wards could not be explained by a so called 'failure of implementation'.[34] Nevertheless, it is noteworthy that more nurses' from the team and leaders-directed group completed the knowledge quiz compared to nurses' from the state-of-the-art group (37% and 13% respectively, p=0.001). A possible explanation is that the team and leaders-directed strategy positively influenced the adherence to specific components of the state-of-the-art strategy.

Effects of contextual factors on nurses' HH compliance

Hospital culture

The as-received analysis showed a hospital effect which was mainly due to one hospital. Especially in the long run, HH compliance started to decrease in this particular hospital while HH compliance in the other two hospitals remained stable or increased further. Little is known about how hospital cultural factors are associated with the implementation of HH improvement strategies. The WHO[3], Larson et al.[35] and Pittet[24] emphasise the commitment of high-level administrators to create and support a culture of safety and accountability.

Culture manifests itself through the values, beliefs, and assumptions embedded in organisations and is reflected in 'the way things are done around here'.[36] The two hospitals that showed sustainability in HH compliance designated HH as a hospital-wide priority. The third hospital was less explicit and distinct in addressing the goal of HH as an organizational priority. This raises the question whether the observed changes in HH compliance were affected by hospital culture.

Standard care activities

Although the average HH baseline scores of the wards were comparable between wards from both groups, our analysis showed that a high baseline HH compliance was associated with a smaller effect of both HH improvement strategies. High HH compliance at baseline was particularly seen in the paediatric wards. Wagner and Kanouse[37] have pointed out that standard care activities may affect adherence behaviours and thus intervention outcomes. It is possible that certain components of our improvement strategies are already part of daily practice in some wards and therefore leave less room for improvement.

Despite the influence of baseline scores and hospital effect, the team and leaders-directed strategy significantly contributed to an additional increase in nurses' HH compliance, both short- and long term.

Effects of experiences with the improvement strategies on nurses' HH compliance

The exploration of the relation between determinants of success and HH compliance provided empirical evidence for performance feedback, social influence and leadership as important vehicles for changing HH behaviour. It seems likely that the mixture of these strategy components affect the teams' ability to focus on achieving their HH improvement goals.

Our results have strengthened the theoretical underpinning of the composition of our team and leaders-directed strategy by using a team approach for changing individual behaviour. By setting clear norms and targets within the team, individual team members are invited to support each other in achieving this goal.

Speak up

The findings of our study also show that it is important to promote a team culture that empowers team members to speak up when non-adherence is observed. This is of particular interest because 'speak up' is positively correlated with improved HH behaviour.

During the team sessions, we taught the nurses to provide feedback on the HH behaviour of their colleagues in a correct way. At the same time, we learned the nurses to receive this feedback positively.

Active commitment and initiative from ward management

The results of our study show that specific components of leadership are positively correlated with an improvement in nurses' HH compliance. Thus, ward managers should address barriers to enable HH as recommended, designate HH as a ward priority, motivate and encourage team members to perform HH, and hold team members accountable for their HH behaviour.

Credits of our findings are not entirely due to the delivery of the team and leaders-directed strategy. Nurses from the state-of-the-art group were not exposed to social influence and leadership as a result of improvement activities from our study. A possible explanation is that these wards, independent of our study activities, have given priority to HH and were motivated and encouraged by their managers. This explanation is supported by the results of a further analysis within the group of the state-of-the-art strategy.

We found a significant relation between changes in HH compliance and differences in nurses' experiences with social influence and leadership. Compared to the state-of-the-art group, the analysis within the group of the team and leaders-directed strategy showed less variation in changes of nurses' HH compliance. Therefore, an association between changes in HH compliance and differences in nurses' perceptions of strategy components within the team and leaders-directed group could not be demonstrated.

We hypothesize that the lack of variation in this group is due to the consistent implementation of the team and leaders-directed strategy. As already shown by our

evaluation of strategy adherence, all nurses within the group of the team and leaders-directed strategy were equally exposed to the main components of this strategy.

Strengths and limitations

The principal strength of our study was the comprehensive process evaluation within the context of a pragmatic randomised controlled trial. Questions about variations in the adherence to both HH strategies, and about factors contributing to the relationship between the HH improvement strategies and nurses' HH outcomes, would not have been apparent as a result of only analysing the HH outcome data. Process evaluations are, in this sense, part of a more theory-based approach to evaluation, responding to the need to understand which theoretical constructs of an improvement strategy make a difference.[38] By linking data of effectiveness to process data, a theoretical explanatory model can be derived from the process evaluation itself.[9]

Some researchers encourage the simultaneous application of a process evaluation in control groups.[5,39] By doing so, we discovered the impact of specific aspects of social influence and leadership in the state-of-the-art group which served as a control group. This finding has strengthened the theoretical underpinning of the composition of our team and leaders-directed strategy.

In combining process with outcome evaluations, we collected data using a wide range of methods as recommended by several authors.[5,16] We developed a questionnaire, derived from the components of the improvement strategies. We undertook extensive pilot work to ensure that all important components of the strategies were adequately captured in questionnaire measures. We then pre-tested the questionnaire among ninety nursing students.

An important issue concerns the use of 'as-received' analysis as distinct from the conventional 'intention-to-treat' analysis used in the analysis of RCTs. These analyses differ not only in terms of the estimation procedure, but also in terms of the underlying research goal for a specific study. This study is an example of explanatory research and the as-received analysis was therefore appropriate. Our as-received analysis was illuminating but also lost the benefits of the original random assignment, and there is therefore the potential for bias. This should be considered when interpreting our results.[40]

A limitation of our study concerns the low questionnaire response rate of 48%. This may be a potential source of bias. For this reason, our findings from the nurses' experiences analysis need to be interpreted with caution.

Implications

This is the first prospective study that has assessed the working mechanisms of two HH improvement strategies, demonstrating the added value of specific aspects of social influence and leadership. This is an important finding for hospital administrators and ward managers who want to improve nurses' HH behaviour. Currently, most strategies focus on the individual and the organisation. Including activities aimed at social influence and leadership could be a promising development. Our results point to: addressing each other in case of undesirable behaviour, support from colleagues, accountability, goal setting, and active commitment of the ward manager. The methodology of our team and leaders-directed strategy can probably be used to improve team performance on other patient safety issues as well.

Our study points to ways in which the design of process evaluations within randomised controlled trials may be conducted. Our initial results require affirmation by further process evaluations of HH improvement strategies. Further research is also needed to examine the different aspects and impact of social influence and leadership. Finally, future research should explore the influence of hospital culture.

CONCLUSION

In summary, with this study we were able to look inside the 'black box' of two HH improvement strategies, to generate insights into which of the strategy components are effective. Our results support the added value of social influence and enhanced leadership in HH improvement strategies, thus offering an interpretation of the trial effects. Our findings point to: addressing each other in case of undesirable HH behaviour, support from colleagues, accountability, goal setting, and active commitment of the ward manager. These results have strengthened the theoretical underpinning of the composition of our team and leaders-directed strategy. Our study also points to ways in which the design of process evaluations within randomised controlled trials may be conducted.

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Appendix 1. Questionnaire on nurses experiences with strategy components.

	Agree		Disagree	
When I am wearing gloves, I don't have to perform hand hygiene	O	O	O	O
Sinks are awkwardly placed at my ward	O	O	O	O
My colleagues think that the hand hygiene prescriptions do not always need to be followed	O	O	O	O
At my ward alcohol-based hand rub is in the immediate vicinity (<1 meter) at the point of care	O	O	O	O
Hand hygiene during procedures with low risk of contamination is of less importance	O	O	O	O
Other patient safety issues are more important than hand hygiene	O	O	O	O
It often happens that soap / hand alcohol / towels or disposable gloves are not available	O	O	O	O
My colleagues support each other in performing hand hygiene	O	O	O	O
Not performing hand hygiene could have (severe) implications for the patient	O	O	O	O
My manager pays regular attention to the adherence of hand hygiene guidelines	O	O	O	O
I regularly forget to perform hand hygiene	O	O	O	O
Hand hygiene is not a priority at our ward	O	O	O	O
My ward manager sets norms and targets for HH adherence	O	O	O	O
My ward manager encourages and motivates our team members to perform hand hygiene	O	O	O	O
Our team members address each other in case of undesirable hand hygiene behaviour	O	O	O	O
I know the content of the hand hygiene guidelines	O	O	O	O
I know exactly when to perform hand hygiene	O	O	O	O
It's important to perform hand hygiene during procedures with high risk of contamination	O	O	O	O
I know exactly how to perform hand hygiene	O	O	O	O
Infection prevention is an important topic on my ward	O	O	O	O
I do know my wards hand hygiene performance	O	O	O	O
My ward manager provides resources to enable hand hygiene as recommended	O	O	O	O
My ward manager addresses barriers to enable hand hygiene as recommended	O	O	O	O
My ward manager holds team members accountable for hand hygiene performance	O	O	O	O

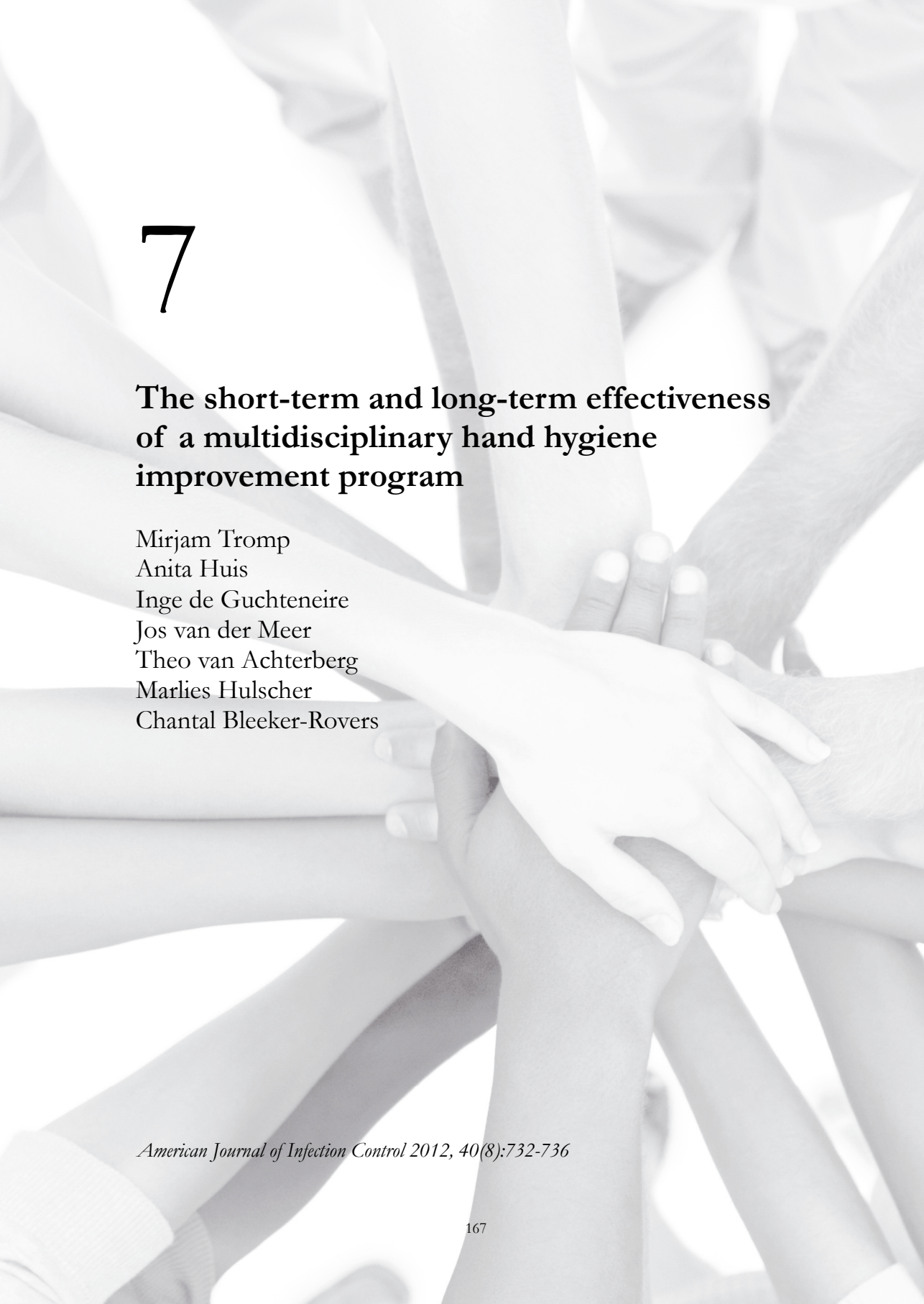
Appendix 2. Adherence of nursing wards to strategy components.

State-of-the-art group *n*=47

Component	Improvement activities	Adherence
Education	Presence educational website and knowledge quiz (*content*)	100%
	Participation in knowledge quiz (*coverage*)	11%
	Presence of leaflets (*content*)	100%
	HH promotion event (*content*)	68%
Reminders	Three newsletters to ward manager (*content*)	100%
	Publication in hospital magazine (*content*)	100%
	Distribution of hand hygiene posters twice (*content*)	100%
	Presence of hand hygiene posters on the wards (*coverage*)	100%
Performance feedback	Distribution performance feedback reports to ward manager twice (*content*)	100%
Facilities and products	Presence of hand hygiene products (*content*)	100%
	Acceptable access to washstands / hand rub (*coverage*)	45%

Team and leaders-directed group *n*=20

Component	Improvement activities	Adherence
Education	Presence educational website and knowledge quiz (*content*)	100%
	Participation in knowledge quiz (*coverage*)	37%
	Presence of leaflets (*content*)	100%
	HH promotion event (*content*)	75%
Reminders	Three newsletters to ward manager (*content*)	100%
	Publication in hospital magazine (*content*)	100%
	Distribution of hand hygiene posters twice (*content*)	100%
	Presence of hand hygiene posters on the wards (*coverage*)	100%
Performance feedback	Distribution performance feedback reports to ward manager twice (*content*)	100%
Facilities and products	Presence of hand hygiene products (*content*)	100%
	Acceptable access to washstands / hand rub (*coverage*)	40%
Setting norms and targets	Team discussion organised (*content*)	100%
	Number of team discussions (*dosage*)	92%
	Nurses' participation in team discussions (*coverage*)	50%
	Time spent on team discussions (*dosage*)	90%
	Topics	100%
	Goal setting in hand hygiene performance (*content*)	
	Analysis of barriers and formulating improvement activities (*content*)	100%
	Norms and targets established (*coverage*)	100%
Social influence	Nurses address each other in case of undesirable hand hygiene behaviour (*content*)	100%
Leadership	Ward manager discusses hand hygiene compliance rates with team members (*content*)	95%
	Ward manager designates hand hygiene as a priority (*content*)	95%
	Ward manager actively supports team members and informal leaders (*content*)	95%
Modelling	Informal leaders model social skills of team members in addressing hand hygiene behaviour of colleagues (*content*)	90%
	Informal leaders demonstrate good hand hygiene behaviour (*content*)	90%
	Informal leaders instructs and stimulates colleagues in providing good hand hygiene behaviour (*content*)	90%



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The short-term and long-term effectiveness of a multidisciplinary hand hygiene improvement program

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ABSTRACT

Background: Although hand hygiene (HH) compliance has been an important issue for years, the compliance rate is still a problem in health care today.

Methods: This was an observational, prospective, before-and-after study. We measured HH knowledge and HH compliance before (baseline), directly after (post-strategy), and 6 months after the performance of HH team strategies (follow-up). The study was composed of employed nurses and physicians working in the department of internal medicine of a university hospital. We performed a multifaceted improvement program including HH education, feedback, reminders, social influence activities including the use of role models, and improvement of HH facilities.

Results: Ninety-two nurses and physicians were included. Compared with baseline, there was a significant improvement in the overall mean HH knowledge score at post-strategy (from 7.4 to 8.4) and follow-up (from 7.4 to 8.3). The overall HH compliance was 27% at baseline, 83% at post-strategy, and 75% at follow-up. At baseline, the compliance rate was 17% in nurses and 43% in physicians and significantly improved to 63% in nurses and 91% in physicians at follow-up.

Conclusion: Our multifaceted HH improvement program resulted in a sustained improvement of HH knowledge and compliance in nurses as well as physicians.

INTRODUCTION

The presence of health care-associated infections (HAIs) is one of the major causes of death and increased morbidity among hospitalized patients.[1,2] The strategies to reduce HAIs are complex.[3] One important strategy for the prevention of HAIs is optimal hand hygiene (HH) compliance in all health care workers.[4-6]

Although HH compliance has been an important issue for years, the compliance rate is still a problem in health care today.[6,7] In many studies, the effectiveness of different HH improvement strategies are described.[8-12] The improvement of HH because of multifaceted strategies seems higher as compared with using a single strategy. Education with written material, reminders, and continued feedback of performance can have an important effect on HH compliance.[8,9] Unfortunately, most of the effects are small to moderate and often short-term.[10]

A recent study on potential determinants of HH compliance in the Dutch hospital setting showed that, besides the perception of the health care workers that there is a lack of evidence that HH is effective in preventing HAIs, a lack of positive role models and social norms may hinder compliance.[13] Health care workers mentioned that creating a stronger social norm and establishing more explicit social control would be important for improving HH compliance. Strategies with specific activities on social influence are rarely applied in previous studies: role models changed health care workers HH behaviour by showing them how to improve HH practices and the best way to perform HH in the unit.[12-14]

Using this information on HH improvement strategies[9-14], we developed a multidisciplinary improvement program, including education, feedback, reminders, and social influence activities including the use of role models, to improve the HH knowledge and compliance in our department of internal medicine. The aim of the current study was to test the short-term and long-term effects of a multifaceted HH improvement program for nurses and physicians, on nurses' and physicians' knowledge of HH guidelines, and their HH compliance.

METHODS

Study design

To improve HH knowledge and HH compliance among nurses and physicians, we performed an observational pilot study in the department of internal medicine of a 953-bed university hospital in the Netherlands. Our study consisted of four study

phases (Table 1), including the performance of a multifaceted HH improvement program (Phase II). HH knowledge tests and HH compliance tests were performed at baseline (Phase I), post-strategy (Phase III), and follow-up (Phase IV).

In view of the observational and anonymous nature of the study, and the performance of non-patient-related strategies, the local medical ethics committee waived the need for written informed consent.

Study setting and population

At the department of internal medicine, 45 nurses and 54 physicians are employed. The nurses work at the 32 bed nursing ward (n=42) and the outpatient clinic (n=3). All physicians (30 staff physicians, 24 residents) alternately work at the nursing ward, the outpatient clinic, emergency department, or are involved in medical scientific research and teaching. The nurses at the outpatient clinic were excluded for this study because of their limited patient contact and their dissimilar activities in contrast to the nurses in the nursing ward. Furthermore, 1 nurse and 3 physicians were excluded because of their involvement in the HH improvement strategies. At the start of the study, each patient room included 1 wall-fixed, alcohol-based liquid hand disinfectant dispenser; 1 wall-fixed unmedicated soap dispenser; and 1 wall-fixed paper towel dispenser.

Hand hygiene improvement strategies

We developed an improvement program from current literature: a 'state of the art strategy', which includes education, feedback, reminders, and targeting adequate

Table 1. Study phases and performed tests during the study.

Study phase and performed test	Date
Phase I: Baseline (test 1)	
Hand hygiene compliance observations nurses	October 2008
Hand hygiene compliance observations physicians	December 2008
Hand hygiene knowledge questionnaire nurses	December 2008
Hand hygiene knowledge questionnaire staff physicians	January 2009
Phase II: The hand hygiene improvement program	January 2009 - May 2009
Phase III: Post-strategy (test 2)	
Hand hygiene compliance observations nurses	May 2009
Hand hygiene compliance observations physicians	May 2009
Hand hygiene knowledge questionnaire nurses	June 2009
Hand hygiene knowledge questionnaire staff physicians	July 2009
Phase IV: Follow-up (test 3)	
Hand hygiene compliance observations: nurses	November 2009
Hand hygiene compliance observations: physicians	December 2009
Hand hygiene knowledge questionnaire: nurses	December 2009
Hand hygiene knowledge questionnaire: staff physicians	January 2010

products and facilities.[8,9] To these, we added strategies with specific activities on social influence. These strategies were built on relevant behavioural science theories and include gaining active commitment and initiative of ward management, modelling by informal role models at the ward, and setting norms and targets within the team.[13-17] All performed strategies are summarized in Table 2 and were aimed at the nurses as well as the physicians.

Measurements

We measured the HH knowledge of the nurses (n=41) and staff physicians (n=27) at baseline, post-strategy, and follow-up. Furthermore, we measured the HH compliance of nurses and physicians (staff physicians and residents, n=51) in the nursing ward as well as the HH compliance of physicians in the outpatient clinic at baseline, post-strategy, and follow-up.

Hand hygiene knowledge

To obtain data about participants' knowledge regarding the indications for HH, an anonymous questionnaire was developed. The questionnaire consisted of 19 questions (yes/no). Each question described a situation in daily patient care and asked whether HH was necessary. The questionnaire was pilot tested by an infectious disease registered nurse and an infectious disease physician. Because of the high turnover of the residents and their absence during several educational trainings, only nurses and staff physicians were included in this part of the study.

Hand hygiene compliance

Based on the five moments for HH[7] and the Dutch national infection prevention guideline, an observation list was developed. In many cases in which professionals go from one patient to another, the 'after patient contact' category is immediately followed by an indication of the 'before' category (generally 'before patient contact') in another patient. Given this overlap, the Dutch guideline on HH in hospital care does not include the HH indication 'hand hygiene before touching a patient'. Furthermore, the HH indications 'after taking care for an infected patient' and 'after removing sterile or non-sterile gloves' are included in the Dutch guideline. The final observation list contained six indications for HH: (1) before clean/aseptic procedure, (2) after body fluid exposure risk, (3) after touching a patient, (4) after touching patient surroundings, (5) after taking care of an infected patient, (6) after removing sterile or non-sterile gloves.

Table 2. Performed hand hygiene improvement strategies during the study.

	Date
Education	January 2009 - May 2009
Hospital wide HH promotion meeting for nurses and physicians	
Educational HH website, including knowledge quiz on indications for HH	
Educational training on prevention of hospital-acquired infections	
Educational training on HH technique	
HH brochure including practical indications about HH	
Daily business meeting for nurses about practical HH cases	
Reminders	January 2009 - May 2009
Poster 1 and 4: The importance of HH	
Poster 2 and 5: Nurses' HH performance and own formulated goals	
Poster 3: Physicians' HH performance and own formulated goals	
Performance feedback	February 2009 - May 2009
Bar chart 1: HH compliance rates at baseline	
Bar chart 2: HH compliance rates at post-strategy	
Examining hands under UV light	
Facilities and products	August 2009 - October 2009
Install clocks in the outpatient clinic to overcome need for watches	
Distribute pin-on watches to nurses and physicians	
Place one electronic alcohol dispenser in the nursing ward	
Place additional alcohol dispensers in the nursing ward	
Appoint role models	January 2009 - January 2010
Demonstrate good HH behaviour	
Models social skills in addressing behaviour of colleagues	
Instruct and stimulate colleagues in providing good HH behaviour	
Active commitment and initiative of ward management	January 2009 - January 2010
Active commitment and involvement during team sessions	
Prioritizes good HH behaviour as specific team goal	
Provides adequate facilities and supports improvement activities	
Supports team members and role models	
Setting norms and targets within the team	February 2009 - May 2009
Team sessions that includes goal setting in HH performance at group level	
Analysis of barriers and facilitators	
Nurses and physicians address each other in cases of undesirable HH behaviour	

HH compliance was defined as hand disinfection using alcohol-based hand rub or washing hands with soap and water following one of the above-mentioned indications. The observers had to mark the applied HH indication(s) and the performed HH action. In addition, the presence of jewellery and whether the nurses and physicians wore long-sleeved clothes under their short-sleeved uniforms or white coats was observed.[7] All observers were trained during three 2-hour meetings on HH indications, HH actions, and observation techniques. Subsequently, the observation technique of the students and the observation list was pilot tested in a nursing ward of a hospital not participating in our study. Every student performed 20 observations jointly with a 'gold standard' observer. Concordance between the observers was determined by comparing the results of each student with the 'gold standard' observer. For that, we used a 3-step approach. First, we calculated the

concordance between the number of recorded HH opportunities of the student nurse and the 'gold standard' observer; next, the concordance between the number of recorded HH indications; and, finally, the concordance between the number of recorded actions. The Wilcoxon rank test showed that neither of the student results differed significantly (α=.05) from the results of the 'gold standard' observer (Z scores of every student on every step between -1.96 and 1.96).

Students from the faculty of health and social studies were responsible for the unobtrusive observations of the nurses. They mentioned the observation of patient safety-related items (such as medication safety and fall prevention) and their own learning experience as explanations for their observations. Two nurse practitioners, one physician assistant, and two staff physicians performed the observations of the physicians in the nursing ward and the outpatient clinic during their daily practice, so the physicians were unaware that their HH was under observation. Because of the closed consulting rooms, in the outpatient clinic only the presence of jewellery and wearing long-sleeved clothes could be observed. All participants were observed for a maximum number of four occasions for the purpose of including as many different nurses and physicians as possible. All observations took place on week days, during day shifts.

Data analysis

All data were analysed using SPSS version 16.0 (SPSS Inc, Chicago, IL, USA). Descriptive statistics included percentages, means, and standard deviations.

All questions about HH knowledge were given an equal weight of 1 point per question, and the sum scores were recalibrated to a 0-10 scale. They were analysed using linear regression, with independent factors period, gender, and nurse/staff physician/resident.

The HH compliance rates were expressed as percentages. To determine the effects of the improvement strategies on the compliance rates, we used a generalized linear model, with linear link function and Bernoulli distribution; such a model evaluates the absolute differences between the percentages in each period, in contrast to a logistic model, which determines odds ratios. The logistic approach was not used because odds ratios overestimate rate ratios when the occurrence of the dependent variable is not rare. Fixed factors included strategy period and gender. To account for the fact that the professionals (nurses and physicians) were observed repeatedly, the random factor 'professional' was included in the model. When the results for all professionals were evaluated, an additional factor that dis-

tinguished among the three types of professionals (nurse/staff physician/resident) was included. In a secondary analysis, we investigated whether the effect of the strategies depended on gender and type of professional by including the interaction factors period, gender and period, and nurse/staff physician/resident in the models. Results with $P<.05$ (2-sided) were considered statistically significant.

RESULTS

Hand hygiene knowledge

At baseline, as well as post-strategy and follow-up, 68 HH knowledge questionnaires were distributed. Forty-four participants (65%) returned the questionnaire at baseline, 41 (60%) at post-strategy, and 39 (57%) at follow-up (Table 3). Compared with baseline, there was a significant improvement in the overall mean HH knowledge score at post-strategy (from 7.4 to 8.4) and follow-up (from 7.4 to 8.3). Overall, the questionnaire score was significantly better in nurses than in staff physicians (0.5 points more; 95% confidence interval [CI]: 0.1-1.0). There was no evidence that this difference varied among the periods. There were no statistically significant differences in the overall score for gender.

Hand hygiene compliance: nursing ward

In the nursing ward, a total of 294 HH opportunities were observed. The most frequently observed indications for HH were 'after touching a patient' (51%) and 'after touching patient surroundings' (34%). For physicians, the most frequently occurring HH indication was 'after touching a patient'; for nurses also, 'after touching patient surroundings' was a frequent indication.

Table 3. Hand hygiene knowledge scores and hand hygiene compliance scores in the nursing ward.

Variable	Baseline	Post-strategy	Follow-up
Hand hygiene knowledge			
Questionnaire scores (0-10)			
Overall (standard deviation)	7.4 (±1.2)	8.4 (±1.1)	8.3 (±1.2)
Nurses (n)	7.4 (29)	8.5 (28)	8.8 (25)
Staff physicians (n)	7.2 (15)	8.2 (13)	7.5 (14)
Hand hygiene compliance			
Number of opportunities	99	92	103
Number of indications	115	105	138
Compliance scores (%)			
Overall	27	83	75
Nurses (n)	17 (15)	83 (13)	63 (15)
Physicians (n)	43 (11)	83 (11)	91 (11)

The overall HH compliance was 27% at baseline, 83% at post-strategy, and 75% at follow-up (*Table 3*). In the subgroup of nurses, the HH compliance significantly improved with 66% points (95% CI: 47%-86%) to 83% at post-strategy and with 46% points (95% CI: 27%-64%) to 63% at follow-up. In the subgroup of physicians, the HH compliance significantly improved with 41% points (95% CI: 22%-59%) to 83% at post-strategy, and with 48% points (95% CI: 31%-66%) to 91% at follow-up. Overall, the HH compliance of the physicians was significantly better than the nurses' compliance: 16% points (95% CI: 2%-29%) better compliance in residents and 24% points (95% CI: 7%-39%) better compliance in staff physicians. There was no evidence that this difference depended on the period. Overall, there was no significant difference in compliance rate for gender. For both groups, the compliance for 'not wearing jewellery' and 'not wearing long-sleeved clothes' was already high at baseline (≥ 90%) and did not change at post-strategy and follow-up.

Hand hygiene compliance: outpatient clinic

The compliance rate for 'not wearing jewellery' significantly improved from 51% at baseline to 79% at post-strategy and to 91% at follow-up. Overall, women were significantly more compliant to 'not wearing jewellery' than men (20%; 95% CI: 2%-37%). The compliance rate for 'not wearing long-sleeved clothes' improved from 57% at baseline to 85% at post-strategy and to 86% at follow-up. After adjustment for type of professional and gender, the differences were 34% (95% CI: 16%-51%) and 28% (95% CI: 11%-44%), respectively. Overall, men were significantly more compliant to not wearing long-sleeved clothes than women (33%; 95% CI: 17%-49%). There was no evidence that the differences between men and women's compliance rates depended on the period. Overall, no statistically significant differences in compliance rates for 'not wearing jewellery' and 'not wearing long-sleeved clothes' between staff physicians and residents were found.

DISCUSSION

Our study showed that overall as well as in the subgroups of nurses and physicians, a considerable increase in the HH knowledge (about 1 point increase at post-strategy and at follow-up) and in HH compliance (about 50% increase at post-strategy and at follow-up) was achieved.

In line with Naikoba and Hayward's conclusion,[8] we developed a multifaceted strategy. It is impossible to conclude which components were—to what degree—

responsible for our achieved improvement. However, there was only a relatively small increase in HH knowledge—knowledge was already rather high at baseline (>7), relative to the low initial compliance and the large increase in compliance. Based on this information, one might conclude that only providing education on the indications for HH would have been insufficient.

Our study showed that our strategies were highly effective for the nurses as well as the physicians. In contrast to other studies,[4,18] the overall compliance in our study was significantly higher in physicians than in nurses. Possibly differences in observed HH indications have influenced the HH compliance results among the subgroups.

Although the HH improvement program in our study was mostly focusing on the nurses and staff physicians, and not on the residents, there was no significant difference between the staff physicians' and residents' compliances. Probably, the staff physicians functioned as role models for the residents.[19,20]

For measuring the HH compliance, we used unobtrusive observations: the gold standard as defined by the World Health Organization.[7] By mentioning the observation of patient safety-related items and their own learning experience as explanations for their observations and by performing observations during the researchers' daily practice, the nurses and physicians were unaware of the true reason for the observations. Nevertheless, observation bias and the Hawthorne effect cannot be excluded.

Some possible limitations of our study must be considered. Sixty-eight nurses and staff physicians anonymously received the HH questionnaire. Approximately 60% of the distributed HH questionnaires were completed and compared; there could be a matter of selection bias. Moreover, the HH compliance was anonymously observed. Although all participants were equally likely to have been selected for observation during the study periods, selection bias cannot be ruled out.

The effectiveness of HH on the prevention of HAIs depends not only on compliance but also on the HH technique.[21] Although HH technique training was part of the program, it was not evaluated in this study.

Finally, the physicians' HH compliance in the outpatient clinic was not observed. Sladek et al. concluded in their study that the observational setting had an effect on HH compliance: HH was significantly more likely during ward rounds than during clinics.[22] Therefore, we highlighted during our improvement program that HH is important with inpatients just as with outpatients. However, the effect on the HH compliance in the outpatient clinic remains unclear.

In conclusion, our HH improvement program for nurses and physicians had large positive effects on the HH knowledge and HH compliance, and these positive effects sustained after 6 months follow-up. This multifaceted HH improvement program will be tested in a multicentre controlled trial.

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8

Discussion

DISCUSSION

Research evidence is not always used in daily practice and as a result many patients do not receive optimal care. This is also true in the field of infection prevention. Since a substantive portion of hospital-acquired infections (HAIs) can be prevented by performing adequate hand hygiene (HH), optimising adherence to HH guidelines is of paramount importance. A systematic stepwise approach, targeting barriers to change with improvement strategies at different levels (professional, team, and organisation), is needed to achieve lasting changes in HH routines.

In this thesis, we developed and tested the effectiveness and cost-effectiveness of two different strategies for improving HH behaviour in hospital nurses. We also explored the and determinants of success of both strategies and the applicability in a multidisciplinary setting.

In this final chapter we summarize and discuss our main findings. Subsequently, we review relevant methodological issues. We end this general discussion with implications for practice and future research.

MAIN RESEARCH FINDINGS

Evidence for the content and effectiveness of HH improvement strategies

Strategies to improve adherence to HH guidelines are often multifaceted and consist of a number of potentially effective components and related improvement activities that target determinants of behaviour change. The most frequently targeted determinants are knowledge, awareness, action control (*e.g.* use of cues to prompt HH performance) , and facilitation of behaviour. Fewer strategies are directed at social influence, attitude, self-efficacy (*e.g.* guided practice to master skills and build successful experiences) and intention (Chapter 2).

The effectiveness of strategies to improve adherence to HH guidelines varies substantially, but most controlled studies show positive results. Addressing combinations of different determinants of behaviour change provides better results. The median effect size increases when more determinants were addressed (Chapter 2).

Effectiveness of two HH improvement strategies

Both the state-of-the-art strategy—including education, reminders, feedback and targeting adequate products and facilities—and the team and leaders-directed strategy—including all elements of the state-of-the-art strategy supplemented with spe-

cific team and leaders-directed activities—are capable of achieving improvements in nurses' HH behaviour. In our study, nurses' HH compliance in the state-of-the-art group improved from 23% to 42% in the short term and to 46% in the long run. The HH compliance in the team and leaders-directed group increased from 20% to 53% (short term) and remained 53% on long term. The results indicate the added value of the team and leaders-directed activities. The combined post-strategy analysis on the difference in effectiveness between the two strategies showed an Odds Ratio of 1.64 (95% CI 1.33–2.02) in favour of the team and leaders-directed strategy (Chapter 4).

Costs and cost-effectiveness of two different HH improvement strategies

Costs

The performance of a HH improvement strategy represents substantial investments of time, effort and funding in the health care delivery system. In our study, the total implementation costs were € 246 368 for the state-of-the-art strategy (37 wards; € 6659 per ward) and € 364 668 for the team and leaders-directed strategy (30 wards; € 12 156 per ward). In both strategies, the additional time needed to perform hand hygiene came with high costs: € 214 263 in the state-of-the-art strategy and € 238 960 in the team and leaders-directed strategy. The cost of alcohol-based hand rub due to increased use were € 23 573 in the state-of-the-art strategy and € 27 205 in the team and leaders-directed strategy. Twenty five per cent of the costs in the team and leaders-directed strategy were staffing costs (€ 91 573) due to coaching and participation in team discussions (Chapter 5).

Cost-effectiveness

The findings of our study show that wards exposed to the team and leaders-directed strategy increased their HH compliance rates by 33%, while control wards exposed to only the state-of-the-art strategy increased their HH compliance rates by 24%. Thus, the additional improvement activities of the team and leaders-directed strategy resulted in 9% more HH compliance. This extra increase was achieved at an average cost of € 5497 per ward. Assuming that 1% increase in hand hygiene compliance is associated with a 0.3% reduction in HAI rates, the difference in ward savings over one year between the two strategies was € 13 879 in favour of the team and leaders-directed strategy.

Assuming that 1% increase in HH compliance is associated with a 0.15% reduction in HAIs, the difference in ward savings over one year was € 6939 in fa-

vour of the team and leaders-directed strategy. In both cases, optimizing HH compliance through a team and leaders-directed strategy is cost-effective as compared to a state-of-the-art strategy (Chapter 5).

Explaining the effects of two different HH improvement strategies

Effects of strategy adherence

The findings of the HELPING HANDS study (Chapter 4) showed that the extent to which nursing wards improved their HH compliance varied considerably, ranging from -2% to 70% improvement per ward in the long run. Ten wards assigned to the team and leaders-directed group showed negligible strategy adherence and received the state-of-the-art strategy. By moving from an original intention-to-treat analysis (30 wards in the team and leaders-directed group) to the as-received analysis (20 wards in the team and leaders-directed group), the impact of the team and leaders-directed strategy on HH compliance was significantly larger. This indicates a strong overall effect of strategy adherence. The as-received analysis of strategy adherence of both the state-of-the-art group (47 wards) and the team and leaders-directed group (20 wards) did not provide any explanatory variables associated with changes in nurses' HH compliance. Thus, variation in the HH improvement outcomes across the wards could not be explained by a so called 'failure of implementation' (Chapter 6).

Effects of contextual factors on nurses' HH compliance

Besides a strategy effect, we identified two contextual factors associated with changes in HH compliance improvement. Our analysis demonstrated that high HH baseline scores were associated with smaller improvement effects ($p < 0.01$). We also found a hospital effect on changes in HH compliance in long term ($p=0.036$). The overall HH compliance decreased in one hospital in long term, while it remained stable or increased further in the other two hospitals (Chapter 6).

Effects of experiences with the improvement strategies

In short term, changes in nurses' HH compliance were positively correlated with experienced feedback about their HH performance ($p < 0.05$). In the long term, experienced items of the components 'social influence' (i.e., addressing each other on undesirable HH behaviour $p < 0.01$), and 'leadership' (i.e., ward manager holds team members accountable for HH performance $p < 0.01$) correlated positively with changes in nurses' HH compliance (Chapter 6).

The team and leaders-directed strategy in a multidisciplinary setting

Alongside the HELPING HANDS study, we pilot tested the team and leaders-directed strategy in a multidisciplinary setting aimed at nurses as well as physicians. This pilot study demonstrated that overall as well as in the subgroups of nurses and physicians, a considerable increase in HH knowledge (about 1 point increase at post-strategy and at follow-up) and in HH compliance (about 50% increase at post -strategy and at follow-up) was achieved. Overall, HH compliance of physicians was significantly better than the compliance of nurses (Chapter 7).

DISCUSSION OF THE MAIN RESEARCH FINDINGS

Evidence for the content and effectiveness of HH improvement strategies

We encountered several challenges in our quest to identify the content and effectiveness of HH improvement strategies (Chapter 2).

Study rigour

The evidence base underlying HH improvement strategies is just emerging. Over the past two decades, many strategies have been designed and evaluated, but the majority of the studies suffer from a number of methodological problems. The lack of rigorous methodology to study the impact of HH improvement strategies is illustrated by a recent Cochrane review.

In this review almost all the published evidence about effective strategies work was rejected on the grounds of methodological weakness.[1] Therefore, the results of this Cochrane review provide little guidance to policymakers and hospital staff for designing effective strategies to improve HH adherence. HH improvement strategies aim to change behaviour in complex socio-cultural environments, which makes their effect evaluation more complicated as compared to studies that evaluate a single intervention under highly controlled circumstances.[2]

It is increasingly recognised that the impact of multifaceted strategies and their generalizability, should be reviewed considering the context in which they have been performed.

This also applies to the fact that less robust studies contain potentially valuable information and provide a rich source for those designing further research or quality improvement initiatives.[3-5,6] Thus, although high methodological quality is important, reviewers should balance this with the urgency of offering guidance / potential solutions to the field.

Classification of HH improvement strategies

Another challenge was selecting a framework to classify the HH improvement strategies. At present, the EPOC classification of strategies—which is based on concrete improvement activities—is the most used classification in implementation research.[6] It is therefore also the most used method to assign and test multifaceted strategies for effectiveness. Nevertheless, the EPOC classification is debatable. Some activities in the EPOC classification are labelled as single strategies, while in fact they cover various activities. For example, 'outreach visits' are classed as a single strategy while they combine multiple activities, such as instruction, feedback, practical help, reminders, and organisational change.[7] Another disadvantage of 'just' coding improvement activities as the EPOC describes, is that information about the corresponding triggers that prompt behaviour change is disregarded. We therefore moved to an alternative approach that classed HH improvement activities on the basis of their determinants of behaviour change. By using the Taxonomy of Behavioural Change Techniques[8,9] we were able to collect information about triggers that encourage behaviour change rather than describing separate improvement activities. This approach provided new insights: half of the studies addressed determinants not mentioned in previous reviews of HH adherence such as social influence (*e.g.* mobilising a social norm), attitude (*e.g.* reinforcement of behavioural progress), self-efficacy (*e.g.* demonstration of good HH) and intention (*e.g.* explanation of the goals and targets concerning HH). We consider this finding an important contribution to the body of knowledge on effective strategies for changing HH behaviour and we encourage the application of the Taxonomy of Behavioural Change Techniques in the evaluation of strategies for change.

Rationale regarding strategy composition

The combinations of determinants addressed in the studies of our review differed greatly. Literature on the effectiveness and efficiency of implementation strategies underscores that a unique combination of strategies was chosen for almost every study.[10,11] The huge variation in the composition of strategies makes the comparison of these strategies a challenging task.

Ideally, strategies are chosen and enacted that correspond as closely as possible to the problems in changing practice. In our review, it was not possible to check for this 'appropriateness' of determinants addressed within the studies because context and barrier analysis and the rationale regarding strategy selection were hardly reported. This is consistent with findings from previously performed re-

views, in which it is concluded that the explicit rationale for the choice of the strategy for change was often difficult to deduce: reported details of contextual factors were poor and there was little description of the potential barriers and facilitators to practice.[10,12] As a result, it was unclear whether researchers had an a priori rationale for the choice of their specific combination of strategy components.

A clear understanding of why HCWs do or do not change their individual behaviour is essential in order to guide strategy design. Several authors have proposed rationales for choosing different interventions in the presence of different types of barriers and facilitators.[10,13-15] A recent Cochrane review of the effectiveness of tailored improvement strategies also gave a foundation to the assumption that multifaceted strategies for change are more effective if they deliberately address identified barriers.[16]

The same authors who developed the Taxonomy of Behavioural Change Techniques to classify the content of behaviour change strategies[8], developed a framework to explore barriers and facilitators related to behaviour change. This framework, developed by Michie et al. (2005) describes possible domains that can facilitate or hinder successful performance of improvement strategies: knowledge, skills, social/professional role and identity, beliefs about capabilities, beliefs about consequences, motivation and goals, memory and attention and decision processes, environmental context and resources, social influences, emotion, behavioural regulation, and nature of the behaviours.[17] The knowledge generated from their work provides a structured approach to (1) exploring barriers and facilitators related to HH behaviour change and (2) studying the evidence on HH improvement strategies. Ultimately, this approach leads to a better understanding of how to change HH behaviour and guides the selection and combination of potentially effective strategy components.

Designing and testing two HH improvement strategies

Even though less rigorous studies can still offer valuable insights, there is an urgent need for methodologically robust evaluation studies that explore the effectiveness of soundly designed improvement strategies to increase HH compliance in hospital care. The HELPING HANDS study meets this challenge because of the systematic development of the HH improvement strategies (Chapter 3), the chosen study design to test the effectiveness of these strategies, and the large numbers of (unobtrusive) observations and participating wards (Chapter 4). Nevertheless, some important topics need to be discussed.

Patient involvement to improve HH practices

The improvement strategies of the HELPING HANDS study did not include patient oriented activities. Involving patients in HH improvement in health care has been the subject of much debate. Only a few studies have assessed the efficacy of patient involvement to increase HH, and these studies appear to be based on the work of a single research team. In these studies, patient involvement consisted of patients reminding health care workers to wash their hands before patient contact.[18-20] Asking patients to remind staff about performing HH has been criticized for several reasons.[21,22] First, performing HH is a fundamental ethical responsibility of all health care workers. Second, patients vary in their capacities to remind staff about performing HH and those who are socially disadvantaged will probably find it harder. Even well-educated people familiar with health care quality issues will encounter difficulties in reminding staff when they are seriously ill in a hospital. Third, some health care workers may not be receptive to being reminded by patients to perform HH. As a result, patients may be treated disrespectfully. It is important to realise that involving patients is not the same as relying on patients to change health care workers behaviour. Increasing patients' contributions to improve HH practices requires a research based understanding of patients' perspectives and an appropriate translation to patient oriented activities. Rigorous research on patient involvement is lacking and further research on this topic is necessary.

Empirical findings from the HELPING HANDS study versus review findings

The results of the empirical study performed in this thesis (Chapter 4) support our review conclusion that addressing combinations of different determinants of behaviour change provide better results. Especially our suggestion that we should be more creative in the application of alternative activities that address determinants such as social influence, attitude, self-efficacy, or intention (Chapter 2) seems to be confirmed by the study results of our cluster randomised controlled trial.

Converting our study results to the relative difference used for comparing the studies in our review, the effect size of the team and leaders-directed strategy corresponds with the findings of our review. The relative difference represents the ratio of difference (in percentages) between the intervention and control groups. Our team and leaders-directed strategy addressed four additional determinants compared to the state-of-the-art strategy. The analysis on the difference in effectiveness between the two strategies showed a relative difference of 44% in favour of the team and leaders-directed strategy. In our review we found a median effect

size of 43.9% for studies that addressed four determinants of behaviour change. However, the controlled before-after studies in our review were mainly small scale studies examining the effects of the improvement strategy in just one or two wards. The strength of our study was that we performed a large scale study with a representative number of wards in both the intervention group and the control group.

Acceptable level of compliance with HH guidelines?

Although we achieved a considerable improvement in HH compliance due to our improvement strategies, one might criticize our results because we have failed to reach 100% HH compliance. First, the compliance rate is greatly influenced by what indications are chosen for measurement. We measured nearly all WHO indications for HH whereas others measure more narrowly—for example, only whether HH was performed before and after patient care. Second, as described by Voss and Widmer[23], up to 40 opportunities to perform HH occur per hour of patient care.

In critical situations, HH prescriptions might conflict with other patient safety regulations. Thus, it may be unrealistic to expect hospitals to achieve adherence rates of 90% to 100%. Furthermore, it is unclear up to which point HH promotion is still effective. Perhaps a HH compliance level of *e.g.* 70% is sufficient to prevent the large majority of HAIs. Nevertheless, hospitals should be able to demonstrate significant improvements in HH compliance over time.

Generalizability of the team and leaders-directed strategy

Numerous examples from daily nursing practice show how the implementation of evidence in practice is often not accomplished. For example, De Laat reported that nurses do not use effective measures for pressure-ulcer prevention.[24] Another example is the study of Segaar who demonstrated that effective, nurse-delivered smoking-cessation interventions were not adequately applied.[25] An important advantage of our team and leaders-directed strategy was that the participating ward managers believed that the methodology could also be useful to improve team performance on other patient safety issues. Therefore, it is not unreasonable to assume that the team and leaders-directed strategy can also be effective in improving nurses' adherence to guidelines that are focused on other topics instead of only HH. Future research should explore the feasibility and effectiveness of the team and leaders-directed strategy to other relevant guidelines.

Explaining the effects of two different HH improvement strategies

Chapter 6 reports on the first prospective evaluation of determinants of success of HH improvement strategies. The conducted study is in line with a new move towards embedding detailed process evaluations in the design of RCTs.[26,27] Our study reflects the ambition of understanding the working mechanisms of HH improvement strategies embedded in the relationship between strategy performance and nurses' HH compliance. In this sense, our process evaluation was part of a more theory-based approach, responding to the need to understand which components of an improvement strategy make a difference.[27,28] By linking data of effectiveness to process data, we have been able to extend the outcome analysis of the HELPING HANDS study (Chapter 4).

Hospital's safety culture

Our process evaluation showed a hospital effect which was mainly due to one hospital. Especially in the long run, HH compliance started to decrease in this particular hospital while HH compliance in the other two hospitals remained stable or increased further. The two hospitals that showed sustainability in HH compliance designated HH as a hospital-wide priority. The third hospital was less explicit and distinct in addressing the goal of HH as an organizational priority. This raises the question whether the observed changes in HH compliance were affected by the hospital's safety culture.

Culture manifests itself through the values, beliefs, and assumptions embedded in organisations and is reflected in 'the way things are done around here'.[29] A recent review conducted by the Health Foundation UK (2012) revealed no evidence for a linear or one-way causal relationship between safety culture and patient outcomes.[30] However, 66% of the included studies in the review found a positive link between safety culture and the safety behaviours of staff. The authors suggest that there is a complex interrelationship, with changes to processes and patient outcomes having an impact on the way staff think about safety. Sinkowitz-Cochran et al. (2008) found that perceptions of organizational culture were strongly associated with perceptions of the benefit of hand hygiene and actual HH practices.[31] Larson reported that commitment of high-level administrators and system change is essential to achieving and sustaining reductions in infection rates.[32] Rosenthal et al. (2003) also found that administrative support played an important role in the improvement of HH adherence.[33] Thus, a safety-oriented hospital culture seems supportive in changing HH practices but requires active commitment of high-level

administrators. Further research is needed to explore the link between a hospital's safety culture and HH performance.

Determinants of success: speak up

The findings of our study show that it is important to empower team members to speak up when non-adherence is observed. This is of particular interest because our study shows that 'speak up' is positively correlated with improved HH behaviour (Chapter 6). During the team sessions, we taught the nurses to provide feedback on the HH behaviour of their colleagues in a correct way. However, professional hierarchy may hinder team members to speak up. Thomas et al. examined and compared the attitudes of critical care physicians' and nurses' about teamwork. Only 33% of nurses rated the quality of collaboration and communication with the physicians as 'high or very high'.

In contrast, 73% of physicians rated collaboration and communication with nurses as 'high or very high'. The study also revealed that relative to physicians, nurses reported that it is difficult to speak up.[34] Edmondson identified professional hierarchy as a barrier for 'low-power' team members to speak up. The author concluded that team leaders can facilitate speaking up and that ease of speaking up, in turn, enables successful implementation of new practices.[35] Chapter 7 describes a pilot of our team and leaders-directed strategy in a multidisciplinary setting. The pilot was successful for nurses as well as for physicians. This was partly due to the leadership team—consisting of a nurse and a physician—who encouraged their nurses and physicians to speak up and work together to perform the best possible HH behaviour.

Determinants of success: active commitment and initiative from ward management

The results of our study show that ward leadership is important in improving nurses' HH compliance. The items 'ward managers address barriers to enable HH as recommended', 'designating HH as a ward priority', 'motivating and encouraging team members to perform HH', and 'holding team members accountable for their HH behaviour' were positively correlated with improved HH behaviour (Chapter 6). Our findings are supported by recent research on improving patient safety in Belgian hospitals.[36] They demonstrate that leaders who show a genuine concern for safety can expect their team to show a similar genuine commitment to safety in that they not only adhere to safety protocols but also remain willing to admit safety mistakes. We therefore advocate active involvement and initiative of the ward

manager to the primary care process. This ward manager is visible and approachable for team members, makes sure everything happens as agreed, and sets limits to undesirable behaviour.

Feedback

In short term, changes in nurses' HH compliance were positively correlated with experienced feedback about their HH performance (Chapter 6). Evidence on the best way of providing feedback in the field of infection control is limited. Some researchers recommend combining feedback with other improvement activities such as education, or reminders.[37]

Both the improvement strategies of the HELPING HANDS study combined feedback with at least three other improvement activities which might have contributed to success. A second possible contribution to the success of feedback is that we narrowed the range of feedback *i.e.* ward rather than hospital wide feedback. Finally, we encouraged ward managers to discuss wards' HH performance with team members and to formulate goals for improvement. We believe that monitoring HH compliance at regular intervals and discussing HH compliance rates with team members is needed to keep focused on HH in order to achieve sustained changes in HH compliance.

Cost-effectiveness of two different HH improvement strategies

To the best of our knowledge, our cost–effectiveness analysis within the context of a pragmatic randomised controlled trial is the first to have been performed (Chapter 5).[38,39] Our economic evaluation was well conducted and provides data on incremental costs, incremental cost-effectiveness ratios and cost-effectiveness acceptability curves whereas most articles only provide quantitative estimates of the cost savings from HH implementation strategies. Therefore, our study may serve as an example for other researchers planning to perform a cost-effectiveness analysis on improvement strategies.

Cost-effectiveness analyses and decision making

Administrators who set budgets for the prevention of HAIs must address two questions. First, should current rates of HAIs be reduced, and if so, by how much? Second, which if the improvement strategies are cost-effective to achieve this reduction? [40] The economic rationale for preventing HAIs seems obvious: HAIs take up scarce health sector resources by prolonging patients' hospital stay and in-

creased use of medical interventions.[41] The economic impact of HAIs on the length of stay in the hospital depends on the type of infection but the costs of prevention are likely to be lower than the value of the resources released, even when costs are estimated liberally and the benefits presented conservatively.[40-42]

The application of a HH improvement strategy can be considered an investment that needs to be judged against its cost-effectiveness. Expanding economic data from controlled evaluations like our HELPING HANDS study is needed to help hospital administrators select from potential HH improvement strategies. Our team and leaders-directed strategy required considerable investments of professional time and energy. However, even in the most conservative scenario, ward savings were € 6939 as a result of a reduction in the current HAI rate by 0.15%.

Side effects: extra staffing time

Improving HH compliance means that more time is spent on hand disinfection. Previously conducted studies were mainly focussed on the costs of implementation activities and the increased use of alcohol-based hand rub. We included the extra staffing time—needed to perform HH—in our analysis. Our results demonstrated that a major part of the total costs consisted of extra staffing time needed to perform hand hygiene.

The effects of both strategies resulted in increased hand hygiene compliance which takes more time of health care workers, leaving less time for other activities. This implies that extra staffing time should be taken into account when performing economic evaluations of HH improvement strategies.

Perspective of the cost-effectiveness analysis

As both the strategies and the results are of particular interest to hospital management we used a hospital perspective. Some health economists recommend broadening the perspective.[43-45] In the case of preventing HAIs, a wider range of costs that extend beyond the hospital sector should be included in any infection control decision. Examples include the infection-related costs incurred by community based health services, indirect costs linked to loss of income as the result of illness and death, or intangible costs associated with the physical and emotional pain and suffering. Linking excess illness and death to HAIs is difficult, and accurately valuing these costs is fraught with problems.[44] Nevertheless, the societal effects and hence the cost-effectiveness of the team and leaders-directed strategy might be more favourable than we report here.

METHODOLOGICAL CONSIDERATIONS

Rigorous study designs are required to provide evidence about the effect size of an intervention. A cluster randomised controlled trial (RCT) is considered the 'gold standard' in implementation research.[46,47] In the HELPING HANDS study, we controlled for all possible confounders or influencing factors as described in the checklist for reporting on cluster randomised controlled trials, the so called CONSORT guidelines for cluster randomised controlled trials.[48] However, we also encountered several challenges in this study. In this section, we discuss the most important issues.

Blinding and inter-observer reliability

We could not perform a double blind study because the nurses of the wards knew they received the team and leaders-directed strategy. However, observers were blinded for treatment allocation. Inter-observer reliability was established by parallel monitoring sessions in a non-participating hospital and showed no significant differences between the observers. For these reasons we believe that our results were not significantly affected by observer bias.

The Hawthorne effect

The observations in the HELPING HANDS study were performed unobtrusively to reduce the Hawthorne effect—the possibility that nurses modify their HH behaviour in response to the fact that they know they are being studied. This method is considered the gold standard and the most reliable method for assessing HH compliance rates [49-51], yet a possible Hawthorne effect cannot be ruled out. In our study, a systematic bias is unlikely. We compared the compliance rates of the official—unobtrusive—observation periods with the compliance rates of two—obtrusive—periods. The compliance during these obtrusive observation periods was on average 15% higher than the compliance during the unobtrusive observation periods. To eliminate the Hawthorne effect, there is a move towards measuring the use of alcohol-based hand rub instead of directly observing HH.[1] However, in such studies it is not clear who used the alcohol-based hand rub. It is also impossible to distinguish what specific HH indication provoked a HH action as well as to assess the quality of HH practice. Therefore, we prefer using unobtrusive observations to measure HH compliance instead of monitoring the consumption of alcohol-based hand rub.

Confounders

The sustained effect on nurses' HH compliance in the state-of-the-art group was an unexpected finding because this type of improvement strategies often shows only a short-term effect.[10,52] A possible explanation could be the increased focus on HH in Dutch media due to the impending arrival of the H1N1 influenza virus during the follow-up period. A positive impact for both study groups cannot be ruled out.

The association between HH compliance and HAI rates

Uncertainty remains about the proportion of HAIs that can be prevented by improved HH compliance (Chapter 5). A substantial proportion of HAIs is not avoidable in real-life hospital conditions, because of the underlying illness of the hospitalised patient (*e.g.* immune deficiency), the treatment to which patients sometimes have to be exposed in order to survive (*e.g.* numerous invasive procedures), and the presence of potential pathogens that may cause severe infections if normal host defence mechanisms are breeched.[41] Estimates from the literature hint at a preventable proportion of HAIs of 15% to 30%.[50,53,55] Harbath et al. reviewed 30 studies assessing exogenous cross-infection and found a minimum reduction effect of 10% to a maximum effect of 70%, depending on the setting, study design, baseline infection rates and type of infection.[56] The authors concluded that on average 20–30% of all HAIs occurring under current health care conditions can be prevented. We used two scenarios to estimate the reduction of HAIs. The 15% scenario is very conservative whereas the 30% scenario is more optimistic. Nevertheless, both scenarios remain within the margins of the estimates from the literature.

Linearity versus non-linearity of HAI reduction

A final methodological consideration concerns our assumption about the linearity of HAI reduction, which is debatable. We did try to retrieve evidence from the literature for either a linear or a non-linear correlation between HH compliance and HAIs. Alongside this cost-effectiveness study we performed a literature search to determine a mathematical function between HH compliance and the prevention of HAIs. Eventually, we were able to identify 10 studies with both data on HH compliance and on HAIs. An effort was made to pool the data of these 10 studies. Unfortunately, studies were too heterogeneous and we could not retrieve evidence for either a linear or non-linear relationship between HH compliance and HAIs or directions from which a mathematical function could be derived. Further research should explore different scenarios of linearity in reducing HAIs by improved HH compliance.

IMPLICATIONS FOR PROFESSIONALS AND POLICY MAKERS

The findings of this thesis demonstrate the added value of social influence and enhanced leadership in HH improvement strategies. Our team and leaders-directed strategy proved to be more effective in improving HH compliance compared to the state-of-the-art strategy and had a high probability for being cost-effective, even when implementation costs were taken into account. Based on the results of our studies we formulate the following recommendations to professionals and policy makers:

Selection, developing and performing HH strategies

- Based on our study findings we strongly recommend to include team and leaders-directed activities in HH improvement strategies.
- We recommend that team members analyse current practice, including barriers and facilitators for behaviour change.
- Ward managers should balance their choice of improvement strategy based upon current HH compliance rates, the incidence of HAIs, and type of infections. In addition to financial savings, the likely patient benefits in terms of lives saved and well-being should also be a consideration for implementing a specific HH improvement strategy.

Audit and feedback

- Monitoring HCWs adherence to HH guidelines at regular intervals and provide them with performance feedback should be part of an integrated quality improvement system, aimed at sustained change and embedded in the normal routines.

Goal setting

- We advise hospital administrators for making good HH an institutional priority and provide appropriate leadership, administrative support and financial resources for improving HH compliance.

IMPLICATIONS FOR RESEARCH

The studies in this thesis were among the first to explore improving HH compliance by incorporating team and leaders-directed activities in a HH improvement strategy. A number of implications for future research arise from our findings. The widespread use of HH improvement strategies and the available evidence strengthens the importance of a deeper understanding of the effectiveness, cost-effectiveness and determinants of success of these strategies.

Study rigour

- Methodologically robust research, including assessments of cost-effectiveness and implementation fidelity, is still required to evaluate the effectiveness of interventions intended to improve HH compliance. Adequately powered cluster randomised trials or well-designed ITS studies would provide the optimal study design.

Classification of HH improvement strategies

- Future research is needed to validate the Taxonomy of Behavioural Change Techniques as a preferred framework for classifying the content and effectiveness of strategies for behaviour change and to compare the EPOC classification with the Taxonomy of Behavioural Change Techniques.

Rationale regarding strategy composition

- An important focus for future research should be to design and validate a coherent theoretical framework of health professional behaviour change to inform better the choice of different components of a multifaceted HH improvement strategy.
- Further research is needed to validate the theoretical framework which was used to compose the strategies in our HELPING HANDS study.

Patient involvement to improve HH practices

- There is a need for rigorous research and debate—with both patients and health care workers - to what roles are appropriate for patients to play in improving HH practices and how health care workers should facilitate and support their contributions.

Hospital's safety culture

- Future research is required to explore the link between a hospital's safety culture and HH performance.
-

The association between HH compliance and HAI rates

- Future research is needed to investigate until which point HH promotion is still effective.

Linearity versus non-linearity of HAI reduction

- Further research should explore different scenarios of linearity in reducing HAIs by improved HH compliance. A logical next step is to expand our cost-effectiveness study with a sensitivity analysis with other than linear scenarios.

Generalizability of the team and leaders-directed strategy

- Future research should explore the feasibility and effectiveness of the team and leaders-directed strategy in improving nurses' adherence to other relevant guidelines.

FINAL CONCLUSION

This thesis has added insight into the behavioural determinants addressed in frequently used HH improvement strategies and how specific improvement activities could target these determinants. The research presented in this thesis contributes to the body of knowledge on effective implementation of HH guidelines, because it provides evidence for the added value of improvement activities based on principles of social influence and leadership. Since the HELPING HANDS study is the first which investigates the effectiveness, cost-effectiveness and determinants of success simultaneously, more research is necessary to underline the results of this study.

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Summary

SUMMARY

Doctors, nurses and other healthcare workers have an obligation to provide a safe environment to protect patients from harm in the course of receiving care. One of the essential contributions towards patient safety is the reduction of hospital-acquired infections. Since a portion of hospital-acquired infections (HAIs) can be prevented by performing adequate hand hygiene (HH), optimising adherence to HH guidelines is of paramount importance. A systematic stepwise approach, targeting barriers to change with improvement strategies at different levels (professional, team, patient and organisation) is needed to achieve lasting changes in HH routines.

The objective of this thesis is to summarize existing evidence on HH improvement strategies and to provide information on the development, effectiveness, cost -effectiveness and determinants of success of two different strategies for improving HH behaviour in hospital nurses. These strategies are:

1. A literature based state-of-the-art strategy
2. A theory based team and leaders-directed strategy.

Chapter 1 describes the prevalence, impact and prevention of hospital-acquired infections, followed by the principles for applying HH and a picture of the actual HH practices. Finally, we introduce a model that was used as a framework for designing and testing our two HH improvement strategies. At the end of the chapter, an outline of the thesis is presented.

Chapter 2 contains an overview of studies on the content and effectiveness of HH improvement strategies. The aim of this study was to describe frequently used improvement strategies and related determinants of behaviour change that prompt good HH behaviour to provide a better overview of the choice and content of such strategies. We conducted systematic searches of experimental and quasi-experimental research on HH improvement strategies in Medline, Embase, CINAHL, and Cochrane databases from January 2000 to November 2009. First, we extracted the study characteristics using the EPOC Data Collection Checklist, including study objectives, setting, study design, target population, outcome measures, description of the intervention, analysis, and results. Second, we used the Taxonomy of Behavioural Change Techniques to identify targeted determinants. We reviewed 41 studies. The most frequently addressed determinants were

knowledge, awareness, action control and facilitation of behaviour. Fewer studies addressed social influence, attitude, self-efficacy and intention. Thirteen studies used a controlled design to measure the effects of HH improvement strategies on HH behaviour. The effectiveness of the strategies varied substantially, but most controlled studies showed positive results. The median effect size of these strategies increased from 17.6 (relative difference) addressing one determinant to 49.5 for the studies that addressed five determinants. By focussing on determinants of behaviour change, we found hidden and valuable components in HH improvement strategies. Addressing only determinants such as knowledge, awareness, action control and facilitation is not enough to change HH behaviour. Addressing combinations of different determinants showed better results. This indicates that we should be more creative in the application of alternative improvement activities addressing determinants such as social influence, attitude, self-efficacy and intention.

Chapter 3 explains the study protocol for the entire study including the selection and development of the state-of-the-art strategy and the team and leaders-directed strategy. In addition, we describe the design of the HELPING HANDS study, in which we have tested the effect of both strategies on nurses' compliance with HH guidelines and the cost-effectiveness of both strategies.

Chapter 4 reports on the impact of the team and leaders-directed strategy on nurses' HH compliance rates compared to the state-of-the-art strategy. A cluster randomised controlled trial was conducted in 67 nursing wards of three hospitals in the Netherlands. Wards were randomly assigned to either the team and leaders-directed strategy (30 wards) or the state-of-the-art strategy (37 wards). All affiliated nurses of the nursing wards participated in the study. The control group received the state-of- the-art strategy including education, reminders, feedback and targeting adequate products and facilities. The experimental group received all elements of the state-of-the-art strategy supplemented with interventions based on social influence and leadership, comprising specific team and leaders-directed activities. Strategies were delivered during a period of six months. We monitored nurses' HH compliance during routine patient care before and directly after strategy delivery, as well as six months later. The effects were evaluated on an intention-to-treat basis by comparing the post-strategy HH compliance rates with the baseline rates. During the study we observed 10,785 opportunities for appropriate HH in 2733 nurses. The compliance in the state-of-the-art group increased from 23% to 42% in the short term and to 46% in the long run. The HH compliance in the team and leaders-directed group improved from 20% to 53% in the short term and remained

53% in the long run. A random effect regression analysis was applied for testing the added value of the team and leaders-directed strategy compared to the state-of-the-art strategy. The difference between both strategies showed an Odds Ratio of 1.64 with confidence interval [1.33–2.02] en $p<0.001$ in favour of the team and leaders-directed strategy. This represents a significant added value of the components 'social influence' and 'leadership' on compliance with HH guidelines.

Chapter 5 describes the economic evaluation. Analyses were based on the HH compliance data from the impact study described in chapter 4. The total implementation costs were € 246 368 for the state-of-the-art strategy and € 364 668 for the team and leaders-directed strategy. In both strategies, the additional time needed to perform hand hygiene came with higher costs: € 214 263 in the state-of-the-art strategy and € 238 960 in the team and leaders-directed strategy. The cost of alcohol hand rub due to increased use were € 23 573 in the state-of-the-art strategy and € 27 205 in the team and leaders-directed strategy. Twenty five per cent of the costs in the team and leaders-directed strategy were staffing costs (€ 91 573) due to coaching and participation in team discussions.

The additional improvement activities of the team and leaders-directed strategy resulted in 9% more HH compliance. This extra increase was achieved at an average cost of € 5497 per ward. The probabilistic cost-effectiveness of the team and leaders-directed strategy in relation to the decrease in the percentage of HAIs was modelled on the basis of two expected scenarios. Assuming that 1% increase in hand hygiene compliance is associated with a 0.3% reduction in HAI rates, the difference in ward savings between the two strategies was € 13 879 in favour of the team and leaders-directed strategy. Assuming that 1% increase in HH compliance is associated with a 0.15% reduction in HAIs, the difference in ward savings was € 6939 in favour of the team and leaders-directed strategy. Within the 30% scenario, there is a probability of 90% that the team and leaders-directed strategy is cost-effective and within the 15% scenario, there is a probability of 70% that the team and leaders-directed strategy is cost-effective. Therefore, optimizing HH compliance through a team and leaders-directed strategy is cost-effective as compared to a state-of-the-art strategy.

Chapter 6 expands on the findings of the HELPING HANDS study by integrating process and outcome evaluations. We examined which components of the HH improvement strategies were particularly associated with increased HH compliance, as well as other possible factors that may have influenced nurses' HH compliance. We have used four sets of measures: effects on nurses' HH compli-

ance, adherence to the improvement strategies as planned, contextual factors, and nurses' experiences with strategy components. Analyses of variance and multiple regression analyses were used to explore changes in nurses' HH compliance and thereby better understand trial effects. Both strategies were performed with good adherence to protocol. Two contextual factors were associated with changes in HH compliance: a hospital effect in long term ($p < 0.05$) and high HH baseline scores were associated with smaller effects ($p < 0.01$). In short term, changes in nurses' HH compliance were positively correlated with experienced feedback about their HH performance ($p < 0.05$). In the long run, several items of the components 'social influence' (i.e., addressing each other on undesirable HH behaviour $p < 0.01$), and 'leadership' (i.e., ward manager holds team members accountable for HH performance $p < 0.01$) correlated positively with changes in nurses' HH compliance. This study illustrates the use of a process evaluation to uncover mechanisms underlying change in HH improvement strategies. Our study results demonstrate the added value of specific aspects of social influence and leadership in HH improvement strategies, thus offering an interpretation of the trial effects.

Chapter 7 describes the application of our team and leaders-directed strategy in a multidisciplinary setting. This was an observational, prospective, before-and-after study. The study was composed of employed nurses and physicians working in the department of internal medicine of a university hospital. We measured HH knowledge and HH compliance of the nurses and the physicians before (baseline), directly after (post strategy), and 6 months after (follow-up) the performance of the team and leaders-directed strategy. Ninety-two nurses and physicians were included. Compared with baseline, there was a significant improvement in the overall mean HH knowledge score at post-strategy (from 7.4 to 8.4) and follow-up (from 7.4 to 8.3). The overall HH compliance was 27% at baseline, 83% at post-strategy, and 75% at follow-up. At baseline, the compliance rate was 17% in nurses and 43% in physicians and significantly improved to 63% in nurses and 91% in physicians at follow-up. Our multifaceted HH improvement program resulted in a sustained improvement of HH knowledge and compliance in nurses as well as physicians.

In **Chapter 8**, the results of our studies are discussed and integrated. Furthermore, our findings are discussed in view of several methodological issues and we provide implications for research and practice.

Samenvatting

SAMENVATTING

Artsen, verpleegkundigen en andere werkers in de gezondheidszorg hebben de morele plicht om patiënten een veilige omgeving te bieden. Een belangrijke bijdrage aan patiëntveiligheid is het reduceren van het aantal ziekenhuisinfecties. Een deel van die ziekenhuisinfecties kan voorkomen worden door het uitvoeren van een adequate handhygiëne (HH). Het optimaliseren van de naleving van HH-richtlijnen is dan ook van het grootste belang. De barrières die dat in de weg staan, zullen daar voor aangepakt moeten worden. Dat vergt een systematische en stapsgewijze benadering, waarbij goed gekozen verbeterstrategieën gebruikt moeten worden die hun effectiviteit in de praktijk bewezen hebben. Deze verbeterstrategieën bestaan uit diverse methoden en maatregelen en moeten op meerdere niveaus (professional, team, patiënt en organisatie) ingezet worden om blijvende veranderingen in HH-gedrag te bewerkstelligen.

Het doel van dit proefschrift is het geven van een overzicht van bestaand bewijsmateriaal betreffende de inhoud en effectiviteit van HH-verbeterstrategieën en verslag doen over de ontwikkeling, effectiviteit, kosteneffectiviteit en werkingsmechanismen van twee strategieën voor het verbeteren van het HH-gedrag bij ziekenhuisverpleegkundigen.

Deze strategieën zijn:

1. De literatuur gebaseerde state-of-the-art strategie
2. De theorie gebaseerde team and leaders-directed strategie.

Hoofdstuk 1 beschrijft de prevalentie, de impact en de preventie van ziekenhuisinfecties, gevolgd door de uitgangspunten voor het toepassen van HH en een beeld van de huidige praktijksituatie. Tot slot introduceren we een model dat gebruikt wordt als kader voor het ontwerpen en testen van onze twee verbeteringstrategieën.

Hoofdstuk 2 biedt een systematisch overzicht van studies naar de inhoud en effectiviteit van HH-verbeterstrategieën, met als doel te onderzoeken in welke mate deze strategieën gericht zijn op specifieke gedragsdeterminanten die het toepassen van HH stimuleren. Een dergelijk overzicht kan beleidsmakers helpen bij het kiezen of samenstellen van een HH-verbeterstrategie. Uit de databases van Medline, Embase, CINAHL, Cochrane werden de relevante studies geëxtraheerd uit de periode van januari 2000 tot november 2009. Als eerste hebben we de verkregen

studies ingedeeld met behulp van de EPOC Data Collection Checklist en beoordeeld op doelstelling, context, studieopzet en methode, doelgroep, uitkomstmaten, beschrijving van de interventie, analyse en resultaten. Vervolgens hebben we met de Taxonomy of Behavioural Change Techniques in de studies gezocht naar de determinanten van gedrag die door de gehanteerde verbeterstrategie werden geactiveerd. In totaal zijn 41 studies beoordeeld. De meest geactiveerde determinanten waren: kennis, bewustzijn, actiecontrole, en facilitering van het gedrag. Minder studies activeerden determinanten als sociale invloed, attitude, self-efficacy en intentie. Dertien studies maakten gebruik van een gecontroleerd studiedesign om de effecten van hun verbeterstrategie te meten. De effectiviteit van de strategieën varieerde aanzienlijk, maar de meeste gecontroleerde studies lieten positieve resultaten zien. De mediaan van de relatieve effectgrootte nam toe van 17,6 procent bij studies die één determinant activeerden tot 49,5 procent voor de studies die vijf determinanten activeerden.

Door ons te richten op determinanten van gedragsverandering, ontdekten we verborgen, maar waardevolle componenten in veelvoorkomende HH-strategieën.

Het activeren van een enkele determinant als kennis, bewustzijn, actiecontrole en facilitering van gedrag is niet voldoende om HH-gedrag effectief te verbeteren. HH-verbeterstrategieën die gericht zijn op het activeren van een combinatie van verschillende determinanten lieten grotere verbeteringen in het HH-gedrag zien. Dit betekent dat we meer activiteiten moeten gebruiken die gericht zijn op sociale invloed, attitude, self-efficacy en intentie.

In **Hoofdstuk 3** wordt het studieprotocol voor de HELPING HANDS studie uiteengezet. Dit bestaat uit het ontwikkelen van een state-of-the-art strategie and een team en leaders-directed strategie. Daarnaast wordt in dit hoofdstuk de methode beschreven waarmee we het effect van beide strategieën op het HH-gedrag van verpleegkundigen hebben getest en kijken we naar de kosteneffectiviteit van beide strategieën.

Hoofdstuk 4 doet verslag van de impact van de team en leaders-directed strategie op het HH-gedrag van verpleegkundigen in vergelijking met de state-of-the-art strategie. Op 67 verpleegafdelingen in drie Nederlandse ziekenhuizen werd een cluster gerandomiseerd onderzoek uitgevoerd. Binnen elk ziekenhuis werden de verpleegafdelingen willekeurig toegewezen aan de team en leaders-directed strategie (30 afdelingen) of de state-of-the-art strategie (37 afdelingen). Alle werkzame verpleegkundigen op deze afdelingen maakten onderdeel uit van de studie. De controlegroep onderging de state-of-the-art strategie, bestaande uit educatie, remin-

ders, feedback en de aanwezigheid van adequate producten en faciliteiten. De experimentele groep onderging de team en leaders-directed strategie, bestaande uit alle componenten van de state-of-the-art strategie, uitgebreid met componenten gericht op sociale invloed en leiderschap. De strategieën werden uitgevoerd gedurende een interventieperiode van zes maanden. We observeerden het HH-gedrag van verpleegkundigen vlak voor de start van de interventieperiode, direct na het beëindigen van de interventieperiode en 6 maanden later. Tijdens de metingen werden alleen de handelingen geobserveerd die direct bij of rondom een patiënt plaatsvonden. Om de effecten van beide strategieën te achterhalen, werd een intention-to-treat analyse uitgevoerd waarbij het percentage correct toepast HH-gedrag van de voormeting werd vergeleken met dat van de nametingen. Tijdens het onderzoek hebben we 10.785 gelegenheden voor HH geobserveerd bij 2733 verpleegkundigen. De HH-compliance in de state-of-the-art groep nam op korte termijn toe van 23% naar 42% en steeg op lange termijn verder naar 46%. De HH-compliance in de team en leaders-directed afdelingen verbeterde op korte termijn van 20% naar 53% en liet eenzelfde percentage van 53% zien op de lange termijn. Via een random effect regressieanalyse werd de toegevoegde waarde van de team en leaders-directed strategie ten opzichte van de state-of-the-art strategie getoetst. De odds-ratio in het voordeel van de team en leaders-directed strategie was 1,64 met betrouwbaarheidsinterval [1,333; 2,02] en $p<0,001$. Dit betekent een significant toegevoegde waarde van de componenten 'sociale invloed' en 'leiderschap' op de naleving van HH-voorschriften.

Hoofdstuk 5 beschrijft de economische evaluatie. Analyses waren gebaseerd op de HH-compliancedata uit de effectstudie beschreven in hoofdstuk 4. De totale implementatiekosten bedroegen € 246.368 voor de state-of-the-art strategie en € 364.668 voor de team and leaders-directed strategie. In beide strategieën werd een groot deel van de toegenomen kosten bepaald door de extra tijd die de toegenomen naleving van de HH-voorschriften kost. De kosten van het toegenomen handalcoholgebruik bedroegen € 23.573 (10%) voor de state-of-the-art strategie and € 27.205 (7%) voor de team and leaders-directed strategie. Een kwart van de implementatiekosten in de team and leaders-directed strategie was te wijten aan begeleiding van de teams en deelname aan de teambijeenkomsten.

De team en leaders-directed strategie was significant effectiever in het verbeteren van HH-compliance. Het gemiddelde verschil in effect was 8.91%. Dit extra verschil in HH-compliance als gevolg van de team en leaders-directed strategie kostte gemiddeld € 5497 per afdeling. De probabilistische kosteneffectiviteit van

de team en leaders-directed strategie in relatie tot de afname van het percentage ziekenhuisinfecties werd gemodelleerd op basis van twee verwachtingsscenario's. Bij het 30%-scenario hanteerden we de aanname dat elke procent stijging van HH-compliance gepaard gaat met een daling van 0,3% op het bestaande percentage ziekenhuisinfecties. Het verschil in afdelingsbesparingen tussen de twee strategieën bedroeg € 13.879 in het voordeel van de team en leaders-directed strategie. Bij het 15%-scenario hanteerde we de aanname dat elke procent stijging van HH-compliance gepaard gaat met een daling van 0,15% op het bestaande percentage ziekenhuisinfecties. Het verschil in afdelingsbesparingen tussen de twee strategieën bedroeg daarbij € 6939 in het voordeel van de team en leaders-directed strategie. Binnen het 30%-scenario is de kans dat de team en leaders-directed strategie kosteneffectief is 90%, en binnen het 15%-scenario is de kans op kosteneffectiviteit 70%. Het optimaliseren van HH-compliance met behulp van de team en leaders-directed strategie is dan ook kosteneffectief in vergelijking met de state-of-the-art strategie.

Hoofdstuk 6 gaat dieper in op de bevindingen van de HELPING HANDS studie door het integreren van proces- en effectevaluaties. We onderzochten welke componenten van de HH-verbeterstrategieën geassocieerd waren met een toename van HH-compliance, alsmede mogelijke factoren die het HH-gedrag beïnvloedden. We hebben vier datasets gebruikt: veranderingen in de HH-compliance van verpleegkundigen, het uitvoeren van de verbeterstrategieën zoals gepland, contextfactoren en de ervaringen van verpleegkundigen met specifieke strategiecomponenten. Variantieanalyse en multiple-regressieanalyse werden toegepast om veranderingen in de HH-compliance van verpleegkundigen te exploreren, om van daaruit de onderzoekseffecten beter te kunnen begrijpen. Beide verbeterstrategieën werden vrijwel geheel volgens voorgenomen plan uitgevoerd. Twee contextuele factoren waren geassocieerd met veranderingen in HH-compliance: op de lange termijn was er sprake van een ziekenhuiseffect ($p < 0,05$), en een hoge HH-compliance tijdens de voormeting was geassocieerd met een kleiner effect in de nametingen ($p < 0,01$). Op de korte termijn correleerden veranderingen in HH-compliance positief met de feedback die verpleegkundigen ervaren hadden ($p < 0,05$). Op de lange termijn correleerden meerdere aspecten van sociale invloed (bijvoorbeeld elkaar aanspreken op het niet toepassen van HH, $p < 0,01$) en meerdere aspecten van leiderschap (bijvoorbeeld dat een teamlid door de leidinggevende op zijn/haar verantwoordelijkheid gewezen wordt als blijkt dat diegene de handhygiënerichtlijnen niet naar behoren naleeft, $p < 0,01$) positief met veranderingen in HH-compliance.

Deze studie illustreert de waarde van een procesevaluatie bij het blootleggen van de onderliggende mechanismen van HH-verbeterstrategieën. De bevindingen van deze studie tonen de meerwaarde van specifieke aspecten van de componenten sociale invloed en leiderschap.

Hoofdstuk 7 beschrijft de toepassing van de team en leaders-directed strategie in een multidisciplinaire omgeving. Het betreft een observationele, prospectieve voor-na studie. De studie was gericht op verpleegkundigen en artsen, werkzaam op de afdeling interne geneeskunde van een academisch ziekenhuis in Nederland. HH -compliance en kennis van de HH-richtlijnen werden gemeten vlak voor het invoeren van de strategie (voormeting), direct na het beëindigen van de interventieperiode (nameting) en 6 maanden later (follow-upmeting). In totaal participeerden 92 verpleegkundigen en artsen in de studie. Vergeleken met de voormeting was er een significante verbetering van kennis over de HH-richtlijnen op zowel de nameting (van 7,4 naar 8,4) als de follow-upmeting (van 7,4 naar 8,3). De overall HH-compliance was 27% tijdens de voormeting, 83% tijdens de nameting en 75% tijdens de follow-upmeting. Tijdens de voormeting bedroeg de HH compliance van verpleegkundigen 17% en van artsen 43%. De HH-compliance van de verpleegkundigen steeg significant naar 63% tijdens de follow-upmeting. De HH-compliance van de artsen verbeterde significant naar 91% tijdens de follow-upmeting. De team en leaders-directed strategie had dus niet alleen effect bij verpleegkundigen, maar ook bij artsen.

In **Hoofdstuk 8** - het afsluitende discussiehoofdstuk - worden de resultaten van de studies in dit proefschrift bediscussieerd en geïntegreerd. Bovendien bespreken we in dit hoofdstuk onze bevindingen in het licht van een aantal methodologische kwesties en belichten we de implicaties voor de dagelijkse praktijk en toekomstig onderzoek.

Dankwoord

DANKWOORD

'Werken en feesten vormt schoone geesten'
Johanna Westerdijk – de eerste vrouwelijke hoogleraar van Nederland (1883-1961)

Ik wou dat ik dit levensmotto zelf bedacht had. Zowel werken als feesten vergt de inzet en betrokkenheid van meerdere personen die ik hier wil bedanken bij mijn vorming tot een 'schoone geest'.

(Co) Promotoren

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Theo, jij hebt onbewust de aanzet gegeven tot mijn wetenschappelijke ontwikkeling. Door onze prettige samenwerking tijdens een praktijkonderzoek in het Canisius Wilhelmina Ziekenhuis ontstond bij mij de wens om me verder in de wetenschap te verdiepen en als 'oudere jongere' te starten met de studie Verplegingswetenschap. Heel bewust heb ik destijds gekozen voor een onderzoeksonderwerp waarbij jij mijn eerste begeleider kon zijn. Dit bleek een gelukkige keuze en het feit dat ik mijn weg als 'jongere oudere' mocht vervolgen via een promotietraject vervulde mij met trots. Je bewaakte op deskundige wijze het proces en gaf me tegelijkertijd de ruimte om te pionieren en te groeien in mijn onderzoeksvaardigheden. Ik waardeer daarnaast je ondeugende humor en goedmoedige plagerijen. Met veel plezier kijk ik terug op de gezamenlijke optredens waarin we gevoelige duetten ten gehore hebben gebracht ('omdat ik zoveel van je hoouuwww') of transformeerden naar beroemde musicalsterren ('the amazing sound of Betsie').

Richard, jij volgde mijn vorderingen tijdens het onderzoek op iets grotere afstand. Alhoewel onze contacten misschien wat minder intensief waren, was je feedback altijd constructief en leidde die altijd tot nog betere artikelen. Ik ben erg blij met de huidige samenwerking binnen het NFU-consortium Kwaliteit van Zorg. Ik dank je heel hartelijk voor het vertrouwen in mij.

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ons doorgaans de slappe lach bezorgden. Zelfspot is één van jouw eigenschappen en dat is een verademing in een wereld waar alles soms zo serieus wordt bekeken. Ik vind het een voorrecht dat onze samenwerking wordt gecontinueerd binnen jouw leerstoel 'Kwaliteit van zorg voor infectie- en ontstekingsziekten'.

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Leden van de stuurgroep

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Gerda Holleman verdient een speciaal woord van dank. Gerda, samen met jou zijn de teamactiviteiten tot stand gekomen. Het brainstormen vond plaats op aangename locaties zoals het Arsenaal in Nijmegen. De aangename sfeer wakkerde onze creativiteit aan en kan zeker beschouwd worden als een 'determinant' van succes. Met je collega Marjo van Tol ben je ook actief geweest als trainer van alle teamcoaches en hebben jullie diverse afdelingsteams begeleid tijdens de teambijeenkomsten. Veel waardering was er voor jullie aanpak, enthousiasme en deskundigheid. Dit heeft er mede toe geleid dat alle afdelingen 'binnen boord' bleven. Veel bewondering heb ik voor je doorzettingsvermogen en veerkracht. Succes met de laatste loodjes van je eigen promotietraject!

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daarmee wordt natuurlijk 'ambassadeur' bedoeld. Door jullie gedrevenheid en enthousiasme was het een genoegen met jullie samen te werken.

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Medewerkers en studenten van de Hogeschool van Arnhem en Nijmegen (HAN)

Meer dan veertig studenten Verpleegkunde van de HAN hebben aan dit onderzoek meegewerkt en stonden gedurende een maand voor dag en dauw op om de observaties te verrichten. Vrijwel zonder uitzondering toonden zij zich betrouwbare en consciëntieuze onderzoeksassistenten. Na hun bijdrage aan het onderzoek hebben velen zich ontwikkeld tot ware ambassadeurs voor handhygiëne, dus de toekomst ziet er wat dat betreft rooskleurig uit.

Dat ik kon beschikken over een dergelijke poule aan studenten is de verdienste van Marian Adriaansen. Als toenmalig directeur van de opleiding Verpleegkunde sloten wij een pact: Marian stond garant voor voldoende studenten om de observaties te kunnen uitvoeren en Marlies Hulscher, Lisette Schoonhoven en ik begeleidden de studenten als tegenprestatie bij een kwaliteitsopdracht. Met recht voor beide partijen een bijzonder kosteneffectieve constructie, die ook nog eens mooie kwaliteitsprojecten heeft opgeleverd.

Naast de studenten hebben wij ook een beroep mogen doen op docenten van de HAN. José de Jong, Annegien de Hoop, Marjo Kwast en Ans Rensen hebben als coach een belangrijke inbreng gehad bij de uitvoering van de teamgerichte strategie en zijn dus medeverantwoordelijk voor het succes. Ik ben jullie zeer erkentelijk voor jullie inzet.

(Overige) medeauteurs

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Dr. Mirjam Tromp, beste Mirjam, ik kan inmiddels de s weglaten want je was me net een paar maanden voor. Ik denk dat we een mooi voorbeeld vormen van 1+1=3. In plaats van het project HELPING HANDS met jullie project CLEAN CARE IS SAFER CARE te laten concurreren, hebben we de krachten gebundeld en hebben we

de teamgerichte strategie ook uitgeprobeerd bij de artsen. Extra leuk dat deze studie heeft geresulteerd in een gezamenlijk geschreven artikel dat we allebei hebben kunnen gebruiken voor ons proefschrift.

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Manuscriptcommissie

De leden van manuscriptcommissie: prof. dr. J.G. van der Hoeven, prof. dr. L.A. Kiemeney, en prof. dr. S. de Geest, dank ik voor de snelle en vakkundige beoordeling.

Collega's Scientific Institute for Quality of Healthcare (IQ healthcare)

Een aantal collega's van IQ healthcare heeft mij met raad en daad bijgestaan tijdens het onderzoek. Marjan Knippenberg, wat had ik moeten doen zonder jouw ondersteuning?! Jouw logistieke werkzaamheden, het vormgeven van de vragenlijsten en jouw accuraat datamanagement hebben me veel werk uit handen genomen. Heel veel dank! Annick Bakker-Jacobs dank ik voor de secretariële ondersteuning tijdens het onderzoek en Jolanda van Haren voor de noodzakelijke procedures bij het aanvragen van de promotie.

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Heinen was mijn 'partner in crime' tijdens afdelingsuitjes en feestjes. Ik weet niet of het nu nog gepast is om met opwaaiende zomerjurken op een tandem door de stad te fietsen, maar als keurig alternatief hebben we gelukkig onze bijklets-etentjes.

Vrienden en familie

Ik ben mij er terdege van bewust dat ik de afgelopen jaren minder heb kunnen investeren in mijn sociale leven. Desondanks zijn jullie mij trouw gebleven, hebben jullie welwillend geluisterd naar mijn beslommeringen, maar ook gezorgd voor de broodnodige ontspanning tijdens (aangeboden) etentjes, uitbundige feestjes en tijdens sportieve of muzikale activiteiten. Heel veel dank dat jullie laten merken dat ik er toe doe en dat jullie deze persoonlijke mijlpaal met mij willen meebeleven.

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Curriculum Vitae

CURRICULUM VITAE

Anita Huis werd geboren op 24 november 1961 in Nijmegen. Na haar middelbare schoolopleiding (Atheneum A, Elshof College te Nijmegen) startte zij in 1980 met de Verpleegkundige inservice-A opleiding in het Canisius-Wilhelmina Ziekenhuis (CWZ) te Nijmegen. Vervolgens rondde zij succesvol de opleiding operatie Operatieassistent differentiatie anesthesie af (1984-1986).

Vanaf dat moment werkte zij meer dan 12 jaar als anesthesieassistent op het operatiecomplex van het CWZ. In 1998 ging zij werken als verpleegkundig consulent pijnbehandeling en als medecoördinator van het palliatief consultteam voor de regio Nijmegen. Van 2002 tot 2007 was zij tevens voorzitter van de Verpleegkundig Advies Raad van het CWZ.

Nadat zij in 2003 haar colloquium doctum had behaald, volgde zij een wiskunde opleiding aan het James Boswell instituut van de Universiteit Utrecht. Vervolgens studeerde zij Gezondheidswetenschappen met als afstudeerrichting Verplegingswetenschap aan de Universiteit Utrecht en behaalde in 2007 cum laude haar doctoraaldiploma. Voor haar afstudeerscriptie ontwikkelde en toetste zij een klinisch zorgpad voor volwassenen met een vergevorderd stadium van kanker. Met haar afstudeerscriptie won zij de Talma Eykman-prijs van het Medisch Faculteitsfonds van de Universiteit Utrecht.

In 2007 werd zij aangenomen als promovendus/wetenschappelijk onderzoeker bij het Universitair Medisch Centrum St Radboud, afdeling IQ Healthcare. Haar onderzoek resulteerde uiteindelijk in dit proefschrift getiteld: Improving hand hygiene compliance in hospital nurses: developing, testing and understanding two hand hygiene improvement strategies. Het onderzoek werd begeleid door prof. dr T. van Achterberg, prof. dr. R. Grol, prof. dr. M. Hulscher en dr. L. Schoonhoven. Tijdens haar onderzoeksperiode werd het project HELPING HANDS genomineerd voor de IGZ Zorgveiligprijs 2010.

Anita Huis werkt momenteel bij het NFU-consortium Kwaliteit van Zorg. Het NFU-consortium Kwaliteit van Zorg wil bevorderen dat UMC's hun expertise op het gebied van kwaliteitsverbeteringen in de patiëntenzorg meer met elkaar delen. Als projectleider is zij verantwoordelijk voor de uitvoering van uitwisselingen verbetertrajecten die bedoeld zijn om de kwaliteit van zorg te verbeteren. Daarnaast is zij als postdoc onderzoeker verbonden aan de leerstoel Kwaliteit van zorg voor infectie- en ontstekingsziekten, afdeling IQ Healthcare van het Universitair Medisch Centrum St Radboud.