Global implementation of WHO’s multimodal strategy for improvement of hand hygiene: a quasi-experimental study

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Summary

Background Health-care-associated infections are a major threat to patient safety worldwide. Transmission is mainly via the hands of health-care workers, but compliance with recommendations is usually low and effective improvement strategies are needed. We assessed the effect of WHO’s strategy for improvement of hand hygiene in five countries.

Methods We did a quasi-experimental study between December, 2006, and December, 2008, at six pilot sites (55 departments in 43 hospitals) in Costa Rica, Italy, Mali, Pakistan, and Saudi Arabia. A step-wise approach in four 3–6 month phases was used to implement WHO’s strategy and we assessed the hand-hygiene compliance of health-care workers and their knowledge, by questionnaire, of microbial transmission and hand-hygiene principles. We expressed compliance as the proportion of predefined opportunities met by hand-hygiene actions (ie, handwashing or hand rubbing). We assessed long-term sustainability of core strategy activities in April, 2010.

Findings We noted 21 884 hand-hygiene opportunities during 1423 sessions before the intervention and 23 746 opportunities during 1784 sessions after. Overall compliance increased from 51·0% before the intervention (95% CI 45·1–56·9) to 67·2% after (61·8–72·2). Compliance was independently associated with gross national income per head, with a greater effect of the intervention in low-income and middle-income countries (odds ratio [OR] 4·67, 95% CI 3·16–6·89; p<0·0001) than in high-income countries (2·19, 2·03–2·37; p<0·0001). Implementation had a major effect on compliance of health-care workers across all sites after adjustment for main confounders (OR 2·15, 1·99–2·32). Health-care-workers’ knowledge improved at all sites with an increase in the average score from 18·7 (95% CI 17·8–19·7) to 24·7 (23·7–25·6) after educational sessions. 2 years after the intervention, all sites reported ongoing hand-hygiene activities with sustained or further improvement, including national scale-up.

Interpretation Implementation of WHO’s hand-hygiene strategy is feasible and sustainable across a range of settings in different countries and leads to significant compliance and knowledge improvement in health-care workers, supporting recommendation for use worldwide.

Funding WHO, University of Geneva Hospitals, the Swiss National Science Foundation, Swiss Society of Public Health Administration and Hospital Pharmacists.

Introduction Health-care-associated infection is one of the most frequent issues of patient safety worldwide.1 According to WHO estimates, hundreds of millions of patients are affected each year, leading to substantial morbidity, mortality, and financial losses for health systems.2 On average, health-care-associated infection affects at least 7% of patients admitted to hospital in high-income countries3 and about 15% of those in low-income and middle-income countries.4 More than 4 million patients are affected every year in Europe, and 370000 deaths occur because of this infection.5 According to the US Centers for Disease Control and Prevention, in 2002, at least 1·7 million episodes of health-care-associated infection arose in patients admitted to hospital in the USA, leading to almost 100000 deaths.6 Annual costs were estimated to be as high as €7 billion in Europe and US$6.8 billion in the USA.7

Hand hygiene is the most effective measure to prevent pathogen transmission during health-care delivery.4 Compliance of health-care workers with best practices varies between settings and countries, but is usually low and insufficient to ensure patient safety;8 WHO issued draft guidelines in 2006 to provide evidence and recommendations for improvement of hand hygiene.9 These guidelines were based on successful experiences showing a consequent reduction in health-care-associated infection at institutional and regional levels.6,10 Because dissemination of guidelines alone is not enough to change practices,9 WHO developed a multimodal implementation strategy and accompanying methods for hand hygiene,11 which were pilot tested in hospitals worldwide. We assessed the effect of implementation of WHO’s hand-hygiene strategy on a range of indicators, including strategy feasibility and adaptability to the local context and available resources.

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Study design We did a quasi-experimental study between December, 2006, and December, 2008, at six pilot sites (55 departments in 43 hospitals) in Costa Rica, Italy, Mali, Pakistan, and Saudi Arabia (table I). We implemented WHO’s strategy via the hands of health-care workers, but compliance with recommendations is usually low and effective improvement strategies are needed. We assessed the effect of WHO’s strategy for improvement of hand hygiene in five countries.

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and assessed the hand-hygiene compliance of health-care workers and knowledge of microbial transmission and hand hygiene principles. WHO’s hand-hygiene strategy consists of five main components: (1) ensuring of system change, particularly access of health-care workers to alcohol-based hand rub at the point of patient care to enable recourse to hand rubbing as the preferred method for hand hygiene; (2) training and education of health-care workers; (3) monitoring of practices and provision of feedback about performance; (4) visual reminders in the workplace; and (5) creation of a safety climate within the institution. Inclusion criteria for site selection were no previous hand-hygiene campaign; firm support by senior management and WHO regional and country offices; and balanced country distribution in terms of geographical location, economy level, resources available, and culture. Five sites were single hospitals in which the strategy was implemented either hospital-wide or in specific wards. One site (Italy) comprised a network of 41 intensive-care units (ICUs) in 38 hospitals with a central coordination ensuring consistent implementation between all units. All hospitals followed the study protocol and developed locally adapted techniques and initiatives (table 1).

### Procedures
All sites received instructions about the WHO hand-hygiene strategy and associated methods and followed a

<table>
<thead>
<tr>
<th>City, country; WHO Region</th>
<th>Scope of study implementation</th>
<th>Implementation period</th>
<th>Features of the local intervention in addition to the standard implementation</th>
<th>Local method of preparation or adaptation in addition to WHO standard techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network of 41 ICUs</td>
<td>38 intensive care departments selected according to the following criteria: participating in the national surveillance system for health-care-associated infection, no other major prevention project concurrent to the study implementation, and explicit consent to provide requested data by the agreed timeline</td>
<td>January, 2007, to December, 2008</td>
<td>Coordination and enquiries system through a web platform</td>
<td>Guide to implementation summary, posters, gadgets (badges, stickers)</td>
</tr>
<tr>
<td>Hôpital du Point G</td>
<td>Five departments (nine wards): internal medicine, surgery, emergency, intensive care, and gynaecology and obstetrics</td>
<td>December, 2006, to June, 2008</td>
<td>Local production of WHO-recommended ABHR at the pilot hospital</td>
<td>Leaflet for launch of hand hygiene campaign, promotional t-shirts</td>
</tr>
<tr>
<td>Pakistan Institute of Medical Sciences</td>
<td>One intensive-care department (three medical, surgical, and neonatal ICUs)</td>
<td>October, 2007, to November, 2008</td>
<td>Local production of WHO-recommended ABHR at the pilot hospital</td>
<td>Translation of posters into Urdu</td>
</tr>
<tr>
<td>King Saud Medical Complex</td>
<td>Six departments (12 wards): surgery, emergency, intensive care, gynaecology and obstetrics, paediatrics, and others</td>
<td>September, 2007, to December, 2008</td>
<td>Local production of WHO-recommended ABHR at the hospital</td>
<td>Campaign original logo, posters and banners displayed outside the hospital, gadgets (cup and brooch with the campaign logo); screensaver; promotional video, educational brochures, and pocket leaflets for health-care workers, patients (adults and children), and visitors translated into four different languages (Arabic, English, Rangoli, and Urdu); drawing book for children with cartoons; national hand-hygiene guidelines; summary of hand-hygiene guidelines for health-care workers during the pilgrimage season</td>
</tr>
<tr>
<td>King Abdulaziz Medical City</td>
<td>Two departments (nine intensive-care and surgical wards)</td>
<td>November, 2007, to August, 2008</td>
<td>Gender-specific educational sessions</td>
<td>Banners and posters, brochures for health-care workers, brochures for patients, pocket leaflets for health-care workers, gadgets (badge)</td>
</tr>
</tbody>
</table>


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Table 1: Characteristics of pilot sites
step-wise implementation approach divided into four 3–6 month phases: preparedness, baseline assessment, intervention, and follow-up assessment.24 During phase 1, actions were taken to ensure availability of alcohol-based hand rub at the point of care. At sites where no hand rub was available (Costa Rica and Mali), local production of the hand-rub formulation recommended by WHO was started (table 1).24,25 Two sites (Saudi Arabia King Saud Medical Complex [KSMC] and Pakistan) already used a commercially produced hand rub, but switched to local production because it was less expensive or regarded as better accepted by health-care workers (table 1).24,25 Local multidisciplinary committees appointed a study coordinator to deliver training for health-care workers and to ensure correct implementation of the study protocol.

Key intervention activities were started in phase 3 of the implementation approach (table 1). A formal launch was done at all sites with an official ceremony attended by health-care workers and health authorities, ranging from the minister of health to ministerial representatives and senior hospital managers. After the launch, alcohol-based hand rub was distributed at sites where it was not previously available and actions were taken where it was already in use to increase the number of dispensers and to optimise their location at the point of care. Hand-hygiene posters were displayed in all pilot wards. In the following weeks, all health-care workers on these wards attended intensive education sessions based on WHO methods,13 and hand rubbing was promoted as the gold standard for hand hygiene according to the so-called my five moments for hand hygiene concept.16 Survey results were presented to staff during educational and follow-up assessment sessions to motivate workers and administrators to understand the local situation, appreciate deficiencies, and secure support for sustainability.

In April, 2010, at least 2 years after the intervention, we assessed the status of implementation of core strategies of hand-hygiene activities with a qualitative assessment done through semi-structured telephone interviews with site coordinators using a pre-defined questionnaire.29

**Outcomes**

We assessed the main outcome of interest—health workers’ hand-hygiene compliance—in phases 2–4 with a validated procedure using the WHO method28,29 for direct observation adapted from previous methods.3 In brief, two to three unobtrusive observers openly watched staff during 20 min sessions and recorded opportunities and actions for hand hygiene. We defined an opportunity as the occurrence of any indication during the observed care sequences.28,30 We recorded actions, either handwashing or hand rubbing, according to five indications: before patient contact, before an aseptic task, after risk of exposure to body fluid, after patient contact, and after contact with patient surroundings.28,30 All health professionals having direct contact with patients or their surroundings were observed randomly at pre-defined times on weekdays. Health-care workers were not identified during observation sessions for confidentiality reasons. We expressed hand-hygiene compliance as the proportion of predefined opportunities met by hand-hygiene actions.3,14,21 As recommended,21 each site collected at least 200 opportunities per ward in phases 2 and 4. Because health-care workers contributed more than one hand hygiene opportunity, observations were not independent.

The secondary outcome was the knowledge of health-care workers about microbial transmission during health-care delivery, and key principles for best practices in hand hygiene. A questionnaire developed by WHO (available in several languages), which was partly based on a previously validated version,22 was administered anonymously to health-care workers before and after training sessions.7,23 We calculated knowledge questionnaire scores with methods described elsewhere.3 The maximum score was 37. All data were collected on paper forms and entered into pre-programmed templates with incorporated automated consistency and completeness checks (Epi Info, version 3.4.3).14

We defined intervention feasibility as the capability of each site to implement all five main components of the WHO strategy for hand-hygiene improvement,31

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**Table 2:** Effect of the WHO intervention strategy on hand-hygiene compliance improvement by pilot site and patient population

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of opportunities</th>
<th>Overall compliance with hand hygiene (%)*</th>
<th>Odds ratio (95% CI)**</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>After</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All sites</td>
<td>44 334</td>
<td>51·0 (45·1–56·9)</td>
<td>67·2 (61·8–72·2)</td>
<td>2·15 (1·99–2·32)</td>
</tr>
<tr>
<td>Costa Rica†</td>
<td>2100</td>
<td>39·7 (36·9–42·4)</td>
<td>64·4 (63·6–69·0)</td>
<td>5·82 (5·28–6·30)</td>
</tr>
<tr>
<td>Italy†</td>
<td>18,906</td>
<td>55·2 (54·7–56·5)</td>
<td>68·5 (67·7–69·5)</td>
<td>2·27 (2·00–2·57)</td>
</tr>
<tr>
<td>Mali‡</td>
<td>3546</td>
<td>8·0 (6·8–9·3)</td>
<td>21·9 (20·9–24·0)</td>
<td>2·40 (1·62–3·55)</td>
</tr>
<tr>
<td>Pakistan§</td>
<td>1332</td>
<td>38·2 (35·8–41·6)</td>
<td>58·6 (54·8–62·2)</td>
<td>2·48 (1·75–3·53)</td>
</tr>
<tr>
<td>Saudi Arabia KAMCi</td>
<td>2829</td>
<td>41·7 (37·8–44·7)</td>
<td>61·3 (59·0–63·5)</td>
<td>2·54 (2·00–3·21)</td>
</tr>
<tr>
<td>Saudi Arabia KSMC‡</td>
<td>15,521</td>
<td>53·3 (53·0–53·5)</td>
<td>60·9 (59·9–61·9)</td>
<td>1·83 (1·84–2·89)</td>
</tr>
<tr>
<td>Intensive-care units</td>
<td>28,096</td>
<td>51·7 (46·2–57·2)</td>
<td>66·1 (61·6–68·4)</td>
<td>2·09 (1·90–2·30)</td>
</tr>
<tr>
<td>Surgery wards</td>
<td>7383</td>
<td>35·8 (33·0–38·5)</td>
<td>71·4 (68·1–74·4)</td>
<td>2·88 (2·34–3·54)</td>
</tr>
<tr>
<td>Emergency wards</td>
<td>2034</td>
<td>26·7 (27·7–31·3)</td>
<td>48·1 (41·3–55·5)</td>
<td>0·99 (0·72–1·36)</td>
</tr>
<tr>
<td>Internal medicine wards</td>
<td>1815</td>
<td>10·9 (10·7–11·7)</td>
<td>85·2 (77·8–90·8)</td>
<td>7·31 (4·10–13·02)</td>
</tr>
<tr>
<td>Paediatric wards</td>
<td>1664</td>
<td>49·8 (43·4–56·5)</td>
<td>79·4 (73·3–84·4)</td>
<td>3·99 (2·74–5·81)</td>
</tr>
<tr>
<td>Others</td>
<td>3342</td>
<td>71·5 (67·2–75·4)</td>
<td>47·9 (41·3–54·6)</td>
<td>0·70 (0·51–0·98)</td>
</tr>
</tbody>
</table>

Data in parentheses are 95% CIs. Number of opportunities differ to those in the text because of missing data for some of the covariate-adjusted models. KAMC=King Abdullah Medical City. KSMC=King Saud Medical Complex. *Odds ratio for before the intervention was used as the reference. †Generalised linear mixed model with three nested clusters: session, inside intensive-care units, inside hospitals. §Generalised linear mixed model with two nested clusters: session inside departments. ¶Generalised linear mixed model with one cluster: session. Generalised linear mixed model with two nested clusters: session, inside hospitals, except for others related to only one hospital where the cluster was the session only.
irrespective of their level of resources and expertise. We assessed adaptability by considering the range of activities done to implement the strategy in the local context according to cultural and religious aspects and resources available, including the modification of WHO methods or creation of new methods.

**Statistical analysis**

We analysed hand-hygiene opportunities and actions, compliance by professional category and type of indication, and knowledge scores overall and separately for each pilot site. We estimated the 95% CI for the compliance rate with the exact binomial method. We assessed the global effect of the intervention on hand-hygiene compliance and on knowledge of health-care workers for all sites. For compliance, we used a generalised linear mixed-effects model with a logit link function. We used three nested levels of clustering (from the smallest to the largest) to take into account the correlation of data within three distinct levels: observation session, department, and hospital.

First, we applied the model for hand-hygiene compliance to all merged data from the six pilot sites, then used the model with two or three nested cluster levels (site dependent) for each site. We adjusted the effect of the main predictor for several confounders: professional category, hand-hygiene indications, country income level according to the 2008 World Bank classification, availability of alcohol-based hand rub before the study intervention, and day of the week (taking into account religious factors affecting the establishment of weekend days). In this first model, we assessed interactions between the study period (after vs before intervention) and the following variables: hand-hygiene indications, professional categories, country income level, compliance rate (<60% or ≥60%) before the intervention, and percentage-point improvement in compliance after the intervention (<10%, 10–20%, and >20%). We presented the model with statistically significant interaction terms (ie, between study period and country income level and between study period and hand-hygiene indications). Finally, we calculated the compliance rate estimated by the generalised linear mixed-effects model and its 95% CI by study period alone, by study period and professional categories, and by study period and hand-hygiene indications.

We used a linear multilevel model with a two-nested clustering effect (department inside hospital level) to assess the intervention effect on the knowledge score of health-care workers and applied to merged data from the six pilot sites. We adjusted the model for respondents’ sociodemographic variables (ie, sex, age group), professional category, and country income level. We tested the interaction between the study period and professional categories and hand-hygiene indications. We estimated the mean knowledge score and its 95% CI before and after the intervention in each pilot site with use of the coefficients obtained from the linear

**Figure 1**: Overall hand-hygiene compliance in pilot sites worldwide before and after implementation of WHO’s improvement strategy by category of health professional (A) and hand-hygiene indication (B)

Error bars show 95% CIs around the mean compliance. Observation periods before and after implementation lasted 3–4 months each. Moment 1 was before patient contact, 2 was before an aseptic task, 3 was after risk of exposure to body fluid, 4 was after patient contact, and 5 was after contact with patient surroundings. MD=medical doctor. NS=nursing student. MS=medical student.
multilevel model. p values were two-sided. We did statistical analyses with Stata (version IC 12).

Role of the funding source
The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results
For all six pilot sites we recorded 21 884 hand-hygiene opportunities during 1423 sessions before the intervention and 23 746 opportunities during 1784 sessions after. Overall, we noted an increase in hand-hygiene compliance (table 2). This improvement was significant for each pilot site (table 2; appendix). Importantly, compliance improved significantly for all categories of health professional and for all hand-hygiene indications (all p<0·0001; figure 1).

In high-income countries, compliance averaged 54·3% (95% CI 48·7–59·7) before intervention and 68·5% (63·5–73·1) after (p<0·0001). In low-income and middle-income countries, compliance averaged 22·4% (12·2–37·3) before intervention and 46·1% (29·3–63·9) after (p<0·0001). Hand-hygiene compliance was independently associated with gross national income per head and the effect of the intervention was greater in low-income and middle-income countries (odds ratio [OR] 4·67, 95% CI 3·16–6·89; p<0·0001) than in high-income countries (2·19, 2·03–2·37; p<0·0001) after adjustment for confounders. We recorded a significant increase in recourse to hand rubbing and this method became the preferred one for hand hygiene after intervention at all sites (figure 2), apart from one site in Saudi Arabia where handwashing with soap and water remained slightly more frequent (figure 2). Implementation of the WHO strategy had a major effect on measured compliance of health-care workers at all sites after adjustment for the main confounders (table 2). The effect of the intervention was significant in internal medicine, paediatric, and surgery wards, and in intensive-care units (table 2). The effect was also significant for compliance with all hand-hygiene indications (p=0·02). The effect of the intervention on hand-hygiene compliance did not differ significantly among different categories of health professional (p=0·22).

Health-care workers completed the knowledge survey before (n=1743) and after (n=1282) educational sessions at all sites. The average knowledge score improved substantially from 18·7 (95% CI 17·8–19·7) to 24·7 (23·7–25·6) after these sessions at all sites (p<0·0001). We noted significant improvements in knowledge score at all sites, except Costa Rica (figure 3). After adjustment for main confounders, the mean knowledge score significantly increased by 6·1 percentage points (95% CI 5·8–6·5; p<0·0001) after education. The score was independently associated with age groups and professional categories (table 3). After the intervention, knowledge increased significantly in nurses, nursing
auxiliaries, and doctors (all p<0.001) compared with other professions (p=0.35). After adjustment for main confounders, score improvement was more important in nurses and nursing auxiliaries than in doctors (table 3). Neither gross national income nor sex significantly affected knowledge improvement (table 3).

In 2010, 2 years after the intervention, hand-hygiene promotion was ongoing at all sites (table 4) and had even extended to other wards (data not shown). Key activities were regularly repeated at most sites (table 4). Improvement in compliance of hand hygiene was sustained or had progressed even further where monitored (data not shown). Successful pilot test results stimulated strategy implementation in other hospitals or the launch or sustainment of nationwide hand-hygiene campaigns in all countries, apart from Pakistan (table 4).

Discussion

Our findings show that implementation of WHO's multimodal promotion strategy was associated with a significant increase in hand-hygiene compliance and knowledge for all health-care workers across facilities in a range of countries worldwide. Despite different cultural and educational backgrounds, levels of progress and resources, health-care system, and patient population, WHO's recommendations for hand hygiene in health care were successfully translated into practice, as shown by the significant improvement in the primary and secondary outcomes assessed (panel).7 Because these results were obtained mainly with use of local resources and expertise, and with support of WHO guidance documents and techniques, our study shows the feasibility of the WHO strategy in various health-care settings in different countries. The range of creative and successful activities and adaptation or development of instruments used during the strategy implementation shows its adaptability to the local context according to habits, culture, and resources available. These elements support the implementation of the strategy and techniques in more than 15700 health-care settings in 168 countries worldwide between May, 2009, and April, 2013.26

Our data show that health-care workers did not undertake hand-hygiene actions in roughly one of every two opportunities before the intervention, which supports previous evidence.7,27,28 Compliance levels varied greatly between hospitals and were lowest in low-income and middle-income countries. The highest rates were with the key indications that protect health-care workers from microbial contamination and infection—ie, after exposure risk with body fluids and after patient contact. By contrast, compliance with indications specifically protecting the patient was significantly lower before the intervention—ie, before patient contact and before clean and aseptic tasks. This instinctive tendency towards privileging of oneself rather than towards patient protection has been identified repeatedly.7,27,28,30

Compliance with the recommendation to undertake hand hygiene after contact with surfaces and objects in the patient surroundings was poorly understood by health-care workers and neglected before the intervention. Interventions to induce behavioural change should take into account these compliance aspects. This strategic approach was implemented at all sites through crucial evaluation of local performance data and interpretative feedback to health-care workers. The success of our intervention shows that real-life observations of practices are fundamental to confront health-care workers with their actual behaviour and responsibilities and to call for accountability with regard to patient safety.

Hand-hygiene promotion was associated with significant improvement across all specific indications and professional categories. Similar to other reports,27,31
nurses had the highest compliance across all pilot sites before the intervention and doctors the lowest, apart from in Costa Rica and Mali. During the intervention, strong feedback was given to staff on the basis of local data, with an emphasis on differences between professional categories. After the intervention, compliance remained higher in nurses than in doctors across all test sites, apart from Mali. We attributed the initial better performance of doctors than nurses in Costa Rica and Mali to more appropriate education and a stronger perception of their professional role and responsibilities in the local social and cultural context.15

The effect of the intervention on hand-hygiene compliance was higher in low-income and middle-income countries than in high-income countries. Overall compliance before the intervention was significantly lower in low-income and middle-income countries than in high-income countries. As expected, achievement of a greater improvement in low-income and middle-income countries than in high-income countries might have been easier when starting from very low levels of compliance. In settings where basic knowledge and resources enabling hand hygiene are scarce, the contribution of innovation to bridge the gaps could lead to immediate and substantial progress. Such findings are very encouraging for settings with restricted resources and many other competing priorities in health care because they show a return on investment through application of a fairly simple multimodal intervention addressing real needs.

Knowledge of health-care workers significantly improved after the intervention in nurses, nursing auxiliaries, and doctors across all sites. Feedback of local data for defective behaviour, and the inappropriate perception of high hand-hygiene compliance (self-estimated at about 80% on average), were essential to evoke interest in acquisition of improved knowledge and to induce behavioural change. Clear explanations of the ultimate aims of specific hand-hygiene indications within the transmission dynamics, as emphasised in educational sessions and supported by scientific evidence, were also very influential.13,24 The findings suggest that improvement of the knowledge of health-care workers about health-care-associated infections and hand-hygiene principles contributes to achievement of best practices.

System change, represented by the preferred recourse to alcohol-based hand rubs after implementation of the WHO strategy, was a key determinant of practice improvement. Facilities can achieve system change either by commercial procurement of these hand rubs, according to key selection criteria,23 or by local production, according to WHO guidance instructions.25 In four sites (Costa Rica, Mali, Pakistan, and Saudi Arabia KSMC), WHO-recommended alcohol-based hand rubs were produced locally to either overcome serious infrastructure deficiencies or to replace previously available, but more expensive, commercial products. A separate survey done at these sites and other settings worldwide26 showed that local production was easy to do, low cost, did not need specific expertise, and had good quality-control results.

The originality and uniqueness of our work are shown in the large study population and the participation of countries representing various regions with different cultural backgrounds, economic levels, health systems, and degrees of implementation of infection control. To take this diversity into account, we applied multilevel regression models, including nested clustering levels. This approach accounts for the complexity of datasets with some degree of intracorrelation and intercorrelation, and captures the variance between clusters, while estimating the global effect of WHO’s programme in this heterogeneous study population.

Long-term sustainability of the hand-hygiene promotion strategy was shown by the continuation and reinforcement of core activities over time. The successful results from the test sites have encouraged the spread of the WHO strategy to other facilities, including the launch of nationwide initiatives and large-scale production of the WHO-recommended alcohol-based hand rub at the national level.27 We considered potential unintended consequences of implementation of new strategies and new quality standards in various countries with different

Panel: Research in context

Systematic review

We searched Medline for papers published between Jan 1, 2008, and Dec 31, 2012, with the terms “hand hygiene” [MeSH] OR “hand washing” OR “hand rubbing” OR “alcohol-based handrub” AND “intervention” OR “compliance improvement” OR “promotion” OR “implementation strategy” without language restriction. We used WHO’s guidelines on hand hygiene in health care issued in 2009,2 which include systematic reviews on the topic, as a reference for the time before our search. We also searched the reference lists of identified articles for further relevant papers, and the personal libraries of authors (DP, BA). We selected potentially suitable papers according to the title, reviewed the abstracts, and read the full manuscript when pertinent to the topic. We identified several studies implementing strategies for hand-hygiene improvement and reporting data of compliance improvement. The most recently used multimodal interventions included some of the elements of the WHO strategy, but very few included all five elements. No multicentre, multicountry study, and no paper combining outcome assessment of both hand-hygiene compliance and health-care-workers’ knowledge in more than one hospital were available.

Interpretation

To our knowledge, our study is the first to assess the implementation of WHO’s multimodal strategy for improvement of hand hygiene in a large study population from sites in several countries in different continents. The intervention was associated with a significant improvement of hand-hygiene compliance in all sites, across all professional categories, and for all indications for hand hygiene. Furthermore, after adjustment for main confounders, the knowledge of health-care workers significantly increased after education. Our findings show the feasibility of implementation irrespective of the level of resources and expertise available at the facility. Further research, including assessment of effect on health-care-associated infection and cost-effectiveness aspects, would add value to the available evidence.
systems, resources, and cultural backgrounds. Among these consequences are the risks of resistance to change, scarcity of continuous resources for sustainability, and cultural and religious barriers preventing the adoption, scale-up, and maintenance of the innovation. Findings from previous reports\textsuperscript{11,13,14} and results from this intervention, including sustained activities for promotion of hand hygiene with scale-up in most pilot sites after at least 2 years, strongly suggest the absence of unintended consequences.

Our study has limitations. First, the scope of the intervention varied across pilot sites and was based on local decisions, dependent on feasibility and available resources and expertise. For this reason, we were unable to uniformly include control wards. Second, because the identity of health-care workers was not recorded for confidentiality reasons, we could not include the participant level in the random part of our statistical models, and regarded all hand-hygiene observations and the knowledge score before and after the intervention as independent. Nonetheless, our mixed-effect regression models are conservative and therefore not considering the participant level should not change the direction of the observed effect. Third, we could not measure the effect of the intervention on rates of health-care-associated infection because surveillance was not in place in most pilot sites. Of note, the study was neither designed nor powered to monitor health-care-associated infection and we chose instead to invest available resources in support of the intervention. Finally, we did not include assessment of cost-effectiveness in the study objectives, although such data would have added value to our findings. Previous studies have shown that successful multimodal strategies for improvement of hand hygiene are cost-effective and that the financial investment for a strategy, which is recommended by both the US Centers for Disease Control and Prevention and the European Centre for Disease Prevention and Control, Joint Commission International and accredited bodies, most professional organisations, and many governments worldwide, including 50 national hand-hygiene campaigns.\textsuperscript{15,26}

Our findings represent powerful support for decision and policy makers to enforce implementation of WHO’s strategy, which is recommended by both the US Centers for Disease Control and Prevention and the European Centre for Disease Prevention and Control, Joint Commission International and accredited bodies, most professional organisations, and many governments worldwide, including 50 national hand-hygiene campaigns.\textsuperscript{35}

Contributors
BA and DP designed the study, supervised study implementation, contributed to data analysis, and wrote the paper. AG-A led the data analysis and contributed to the writing of the paper. BA, LB, ND, M-LM, ZM, OU, HR, and JS coordinated project implementation and data collection. MLMcL contributed to data analysis and interpretation. LB, ND, M-LM, ZM, OU, HR, JS, and LD provided crucial revision of the manuscript for important intellectual content.

Conflicts of interest
We declare that we have no conflicts of interest.

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References


International implementation of WHO’s hand hygiene strategy

The increase in international interest in the global challenge of antimicrobial resistance1,2 is a stark reminder of the importance of reducing transmission through effective prevention practice and hand hygiene.

In The Lancet Infectious Diseases, Benedetta Allegranzi and colleagues3 report results of a comprehensive effort to change key factors needed to improve hand-hygiene knowledge and compliance in health-care workers. Over 2 years, the investigators implemented WHO’s strategy for improvement of hand hygiene in 43 pilot hospitals in five countries with diverse health-care systems (Costa Rica, Italy, Mali, Pakistan, and Saudi Arabia). They recorded 21 884 hand-hygiene opportunities (so-called moments) in 1423 sessions before the intervention, and 2376 in 2784 sessions after. Refreshingly, in three of the settings the strategy included patients and users in the development of culturally sensitive, local initiatives. Overall hand-hygiene compliance increased from 51·0% (95% CI 45·1–56·9) before the intervention, to 67·2% (61·8–72·2) after, with significant improvements for each pilot hospital, across all categories of health professional and for all hand-hygiene moments. Increases in compliance were greater in low-income and middle-income countries (from 22·4% to 46·1%) than in high-income countries (from 54·3% to 68·5%).

Furthermore, health-care workers’ knowledge of hand-hygiene principles significantly increased in all sites except Costa Rica. 2 years after the pilot phase ended, the strategy seemed to be sustainable and had expanded beyond the initial pilot sites, according to a qualitative follow-up analysis done by Allegranzi and colleagues.

In view of the paper’s findings, readers would conclude that concerted efforts to introduce and support WHO’s strategy should be pursued; however, they should consider some open questions. For example, identification of the best implementation mechanisms has received growing attention4 despite the availability of implementation guidelines5. Additionally, how could the culture of safety mentioned be fostered6, and what drivers would secure political commitment and support, if not present? And in common with other packages of patient safety initiatives, would success require inclusion of all elements proposed in the strategy7.

As emphasised by the investigators, that an assessment of the strategy’s effect on health-care-associated infections was not possible because of resource constraints and limitations of existing surveillance mechanisms (admittedly, the focus of their paper was other) is unfortunate. Such obstacles are not irrelevant, suggesting that for large-scale hand-hygiene initiatives to be successfully introduced, surveillance and reporting systems should be strengthened if necessary. The monitoring of hand-hygiene compliance is a costly and labour-intensive task, with limitations because of its own effect on compliance8. Different electronic monitoring devices have been proposed to overcome these obstacles, but their adoption has been modest9.

Undertaking of a rudimentary economic analysis of the initiative in any of the countries would have been valuable. Although we agree that complex hand-hygiene interventions have shown positive returns on investment10,11 useful economic evidence should be generated for public health practitioners, service commissioners, and government officials who, to implement WHO’s strategy (akin to a vertical programme), might divert resources from other important issues12. Unlike many investigators, Allegranzi and colleagues explored the sustainability of their intervention, with re-examination of the situation in 2010. The situation should be revisited again, in view of the shift in economic priorities and resource allocation in national health and social care systems affected by the financial crisis13. The intervention reported here might have expanded organically, but its continued effect on hand-hygiene compliance could have waned with time. Adhering to the cyclical review process recommended in WHO’s guidelines would identify whether any aspects of the hand-hygiene strategy need refreshing to maintain their effect.

Iatrogenic morbidity and mortality remains a bitter failure in medicine. That we do not protect vulnerable individuals in health-care settings from preventable harm inflicted by treatments or clinical procedures is unacceptable. That so many patients are harmed by health-care-associated infections that are avoidable with adequate hand hygiene14 is a major challenge in the patient safety agenda. Allegranzi and colleagues’ paper is an international step towards addressing this challenge.
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