Local production of WHO-recommended alcohol-based handrubs: feasibility, advantages, barriers and costs

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Problem Reduction of health-care-associated infections in low- and middle-income countries is hampered by inadequate supplies of soap and water and the lack or high cost of alcohol-based handrubs (ABHs).

Approach In 2005, the World Health Organization (WHO) developed and tested two formulations for ABHs that were suitable for production in health-care facilities. In 2011, the feasibility, advantages and costs of the local production of the two formulations – and the barriers to such production – were evaluated in an online survey.

Local setting The survey included 34 health-care facilities and 5 private companies in 29 countries.

Relevant changes Local production of one of the WHO formulations was feasible in every participating site. Twenty-one (54%) of the sites had replaced a previously used ABH with one of the WHO formulations. In 32 sites, the WHO formulation that had been produced was well tolerated and accepted by health-care workers. The WHO formulations were found to be less expensive than marketed ABHs. Barriers to local production included difficulty in identifying staff with adequate skills, the need for staff training, and constraints in ingredient and dispenser procurement.

Lessons learnt The WHO formulations can be easily produced locally at low cost. They are well tolerated and accepted by health-care workers. Potential barriers to their local production – such as their smell and problems in the procurement of ingredients and dispensers and in performing quality control – require further investigation.

Abstracts in عربي, 中文, Français, Русский and Español at the end of each article.

Problem

Health-care-associated infections are the most frequent adverse events during the delivery of health-care worldwide.[1–3] Since the hands of health-care workers are the primary source of health-care-associated pathogens,[4] good hand hygiene is an important factor in the reduction of such infections. In most health-care settings, alcohol-based handrubs (ABHs) are currently the preferred method for hand cleansing because they offer a broad antimicrobial spectrum, a rapid antimicrobial effect and good skin tolerance, and can be made available at the point of care.[5] However, problems in market availability, distribution and affordability severely limit the use of such handrubs in low- and middle-income countries.[6,7]

In 2005 – as part of its "Clean Care is Safer Care" programme – the World Health Organization (WHO) developed and tested two ABH formulations that complied with the relevant European norms for hand antisepsis and were suitable for local production in different settings.[5,8] One of these formulations had ethanol – at 80% v/v – as its active component while the other had isopropanol – at 75% v/v. In a randomized cross-over trial, both formulations demonstrated excellent skin tolerability and acceptability among health-care workers.[9] In 2011, we evaluated the feasibility, advantages and costs of the local production of the two formulations – and the barriers to such production – in an online survey. The methods that we used and the results that we obtained are outlined in this paper.

Approach

The survey was based on a questionnaire – on the local production of the WHO formulations – that had already been tested in a pilot study.[5] The questionnaire consisted of 58 open and closed questions. Twenty of the questions were compulsory. The questionnaire was divided into two parts. Part I was designed to collect general information on the survey site and participants while Part II was designed to collect technical information on ABH preparation and storage, ingredient and dispenser procurement, quality control, tolerability, acceptability and promotion. The questionnaire was made available online – in English, Khmer, Mongolian and Spanish – using the SurveyMonkey survey tool (SurveyMonkey, Palo Alto, United States of America).

Through WHO regional focal points, country contacts and stakeholders, 125 potential local producers of either of the two WHO-recommended ABH formulations were identified and invited to complete the questionnaire. The survey was kept open for 9 months and up to four reminders were sent to the nonrespondents.

Results

Local setting

Of the 125 potential survey sites, 100 (80%) responded to our invitation to participate. Of the 100 respondents, 56 stated that they were not currently producing either of the WHO formulations, three did not wish to participate, one could not participate because the respondent could not understand any of the survey's languages, and one was excluded from the final analysis because the data provided were incomplete. Thirty-nine sites from 29 countries were therefore included in the

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final data analysis (Fig. 1). According to the World Bank classification,[10] seven (24%) of the 29 countries included in the final analysis were low-income, 16 (55%) were middle-income and the remaining six (21%) were high-income. The 39 survey sites were health-care facilities ($n = 34$) or private companies ($n = 5$). The five private companies were either selling one of the WHO ABH formulations on the local market ($n = 3$) or were contracted to produce one of the formulations by the national government ($n = 2$).

Human resources

The WHO formulations were produced only by pharmacists in 18 (46%) of the survey sites, jointly by pharmacists and technicians in six (15%) of the sites, only by technicians in four (10%) of the sites and by "other professionals" in the remaining 11 sites (28%). Sixteen (41%) of the survey sites had initial difficulty in identifying staff who had adequate skills for the local production of the WHO formulations, and the respondents representing 29 (74%) of the sites reported that staff had had to be trained in the production of such formulations (Table 1).

Formulation

Twenty-one (54%) of the survey sites had been using a different ABH before they had started producing one of the WHO formulations. At the time of the survey, 30 (77%) of the survey sites were using the formulation based on ethanol. The ethanol (96% v/v) being used came either from the chemical industry (16 sites) or had been produced – from sugar cane, maize, manioc, mahogany or walnut – by agro-industry (14 sites). The remaining nine sites (23%) used the WHO formulation based on isopropanol. The isopropanol (99.8% v/v) came from the chemical industry (eight sites) or from agro-industry (one site). The alcohol used was procured locally in 28 (72%) of the survey sites (Table 1). Glycerol and hydrogen peroxide (H_2O_2) were procured locally by 55% and 49% of the sites that used these chemicals, respectively. Difficulty in procuring ingredients of adequate quality for the ABHs was reported by 51% of the respondents – and attributed to local shortages and price fluctuations (Table 1).

Nine of the survey sites reported using handrubs based on slight modifications of the WHO-recommended formulations. These modifications comprised: the exclusion of H_2O_2 ($n = 3$); the exclusion of glycerol ($n = 1$) or a reduction in its concentration ($n = 1$) to increase the moisturizing qualities of the final product; an increase in the concentration of glycerol ($n = 1$) to reduce the stickiness of the final product; or the addition of perfume ($n = 3$).

Equipment and dispensers

Respondents representing 24 of the survey sites reported information on the equipment that had been required for the local production of one of the WHO-recommended ABHs. Of the 24 sites, 11 (46%) had purchased equipment specifically for the production of ABHs; 10 (42%) of the sites – six in Cambodia and one each in Kenya, Mali, Saudi Arabia and Senegal – had had the necessary equipment donated; and three (12%) of the sites – in Malawi, Mongolia and the Philippines – already had adequate equipment.

Information on the source of handrub dispensers was available for 36 of the survey sites. Dispensers were only sourced locally by 20 sites, only imported by nine sites and both sourced locally and imported by three sites. The necessary dispensers were donated to three of the survey sites in Cambodia, while one survey site in Mongolia reused shampoo and soap bottles. Just over half of all respondents reported problems with the procurement of dispensers that were both affordable and of adequate quality (Table 1). In Kenya, ABH dispensers had often been stolen until they were wall-mounted and made too large to be easily portable. Of the 39 survey sites included in the final analysis, 26 (67%) – in Belgium, Brazil, Ethiopia, Indonesia, Jordan, Kenya, Malawi, Mali, Mongolia, Nigeria, Oman, the Philippines, Saudi Arabia, Senegal, Sudan, Thailand and Uganda – reused dispenser bottles and 27 (69%) reused the caps. One site in Nigeria bought dispensers in bulk, to reduce costs. Three sites reported that reused dispensers often developed problems as the result of pump or cap damage. Of the 24 health-care facilities that reused dispensers, 11 simply washed the empty dispensers; one thermally disinfected dispensers by submerging them in boiling water before air drying them and storing them with their caps tightly fitted; three only subjected them to chemical disinfection and the rest used various combinations of these three procedures (Table 1).

Quality control

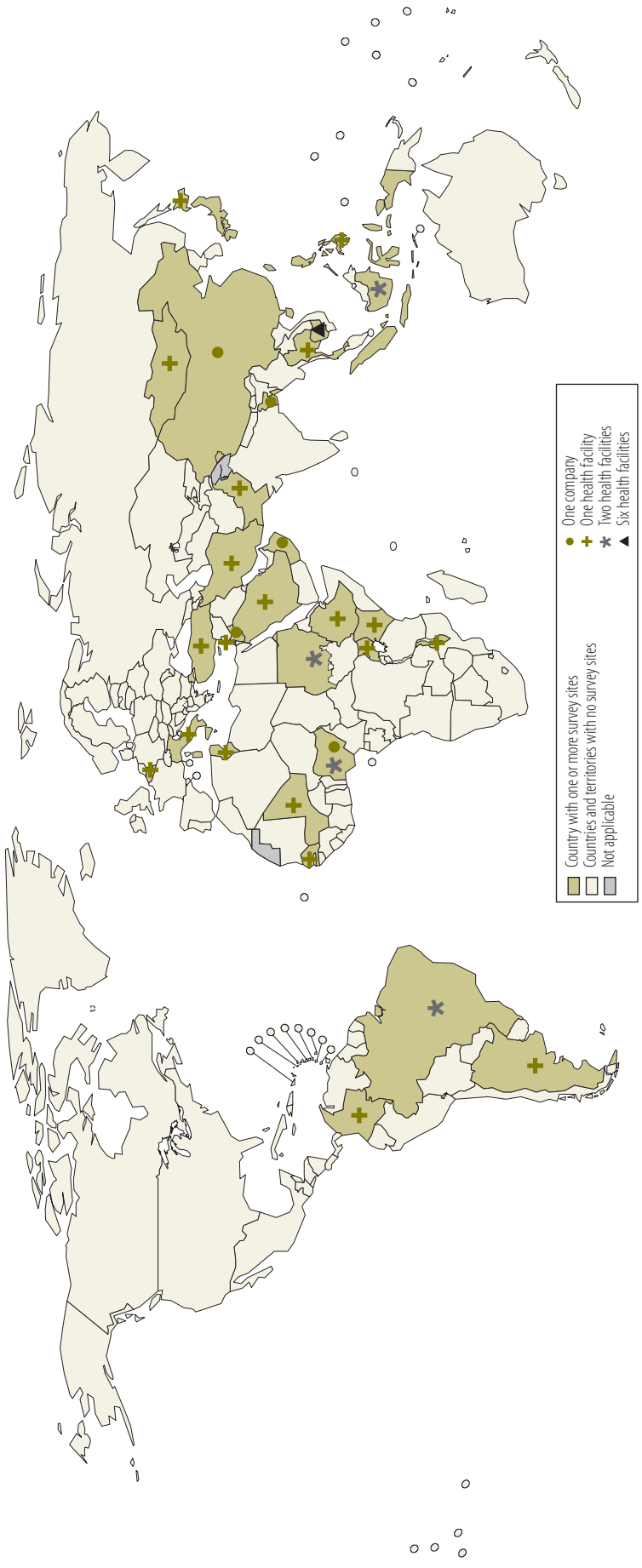
The ABHs produced by 33 (87%) of the survey sites were subjected to quality control. Quality was assessed at the survey site (24 sites), elsewhere in the same country (5 sites), in both the survey site and elsewhere in the same country (2 sites) or only in another country (2 sites). The only type of quality control followed at 17 sites was the evaluation of alcohol concentration – using an alcoholmeter. Four sites only used filtration – to check for microbial contamination[5] – and two only used gas chromatography. Various combinations of alcoholmetry, gas chromatography, filtration and H_2O_2 titrimetry were used in another seven sites. Lack of equipment at the survey sites hampered attempts at quality control in Cambodia, Ethiopia, the Islamic Republic of Iran and Pakistan. However, in Pakistan this barrier was overcome by sending samples of ABHs abroad for testing. Donation of testing equipment to five of the survey sites in Cambodia enabled the quality of the ABHs produced at these sites to be checked at the same sites.

Acceptability and promotion

Data on the acceptability of the WHO formulations were available for 38 of the survey sites. Of these 38 sites, 31 (82%) reported that their ABH was well tolerated by their health-care workers. Workers at the other seven sites complained about one or more of the following: the smell or the stickiness of the handrub and skin damage or soreness resulting from its use (Table 1). Acceptability studies were performed in 20 of the survey sites – mostly by following the relevant WHO protocol (16 sites).[11]

ABH distribution was accompanied by training sessions in 31 (94%) of the health-care facilities included in the final data analysis. Use of the handrubs was promoted using WHO posters (33 health-care facilities) and locally produced educational materials (25 health-care facilities). A multimodal approach to the improvement of hand hygiene among health-care workers – including the promotion of ABH – was reportedly being implemented in 30 (88%) of the 34 health-care facilities included in the final data analysis. One of the private companies included in the survey also offered training in hand hygiene and locally-produced posters on the same topic.

Fig. 1. **Map showing the locations of sites that responded to survey on the local production of the WHO-recommended alcohol-based handrub formulations, 2011**



Note: There was one site each in Argentina, Bangladesh, Belgium, China (Province of Taiwan), Colombia, Ethiopia, Islamic Republic of Iran, Italy, Japan, Jordan, Kenya, Lebanon, Malawi, Mali, Mongolia, Oman, Pakistan, Philippines, Saudi Arabia, Senegal, Thailand, Tunisia, Turkey and Uganda; two sites each in Brazil, Indonesia and Sudan; three in Nigeria; and six in Cambodia.
Source: Public Health Information and Geographic Information Systems, World Health Organization.

Table 1. **Advantages of – and potential barriers to – the local production of alcohol-based handrubs, 2011**

Advantages and barriers	No. of sites/total that provided data (%)	Countries (no. of sites)
Advantages		
Less expensive than marketed alcohol-based handrubs	7/9 (78)	Brazil (1), Cambodia (3), Islamic Republic of Iran (1), Mongolia (1), Pakistan (1)
Excellent tolerance and acceptability	31/38 (82)	Argentina (1), Bangladesh (1), Brazil (2), Cambodia (3), China (Province of Taiwan) (1), Colombia (1), Ethiopia (1), Indonesia (2), Italy (1), Japan (1), Jordan (1), Kenya (1), Lebanon (1), Malawi (1), Mali (1), Mongolia (1), Nigeria (3), Oman (1), Pakistan (1), Saudi Arabia (1), Senegal (1), Sudan (1), Thailand (1), Tunisia (1), Turkey (1)
Used in health facility as part of a multimodal approach to improve hand hygiene	30/34 (88)	Argentina (1), Brazil (1), Cambodia (6), Colombia (1), Ethiopia (1), Indonesia (2), Islamic Republic of Iran (1), Italy (1), Japan (1), Kenya (1), Lebanon (1), Malawi (1), Mali (1), Mongolia (1), Nigeria (1), Pakistan (1), Philippines (1), Saudi Arabia (1), Senegal (1), Sudan (2), Tunisia (1), Turkey (1), Uganda (1)
Manufactured from locally-sourced alcohol[a]	28/39 (72)	Argentina (1), Brazil (2), Cambodia (6), China (Province of Taiwan) (1), Colombia (1), Ethiopia (1), Indonesia (2), Italy (1), Japan (1), Kenya (1), Lebanon (1), Malawi (1), Mali (1), Nigeria (2), Philippines (1), Saudi Arabia (1), Sudan (1), Tunisia (1), Turkey (1), Uganda (1)
Barriers		
to production		
Staff needed training on production process	29/39 (74)	Argentina (1), Bangladesh (1), Belgium (1), Brazil (1), Cambodia (6), Colombia (1), Ethiopia (1), Indonesia (1), Islamic Republic of Iran (1), Italy (1), Jordan (1), Kenya (1), Lebanon (1), Malawi (1), Mali (1), Mongolia (1), Nigeria (2), Oman (1), Pakistan (1), Saudi Arabia (1), Sudan (1), Tunisia (1), Turkey (1)
Occasional difficulty in procuring ingredients locally	20/39 (51)	Brazil (1), Cambodia (6), China (Province of Taiwan) (1), Colombia (1), Ethiopia (1), Indonesia (1), Japan (1), Kenya (1), Malawi (1), Mali (1), Mongolia (1), Nigeria (1), Senegal (1), Sudan (1), Turkey (1)
Difficulty in procuring appropriate dispensers	19/37 (51)	Brazil (2), Cambodia (4), Ethiopia (1), Indonesia (1), Kenya (1), Malawi (1), Mali (1), Mongolia (1), Nigeria (2), Pakistan (1), Philippines (1), Saudi Arabia (1), Senegal (1), Uganda (1)
to quality control		
Suboptimal reprocessing of dispensers[b]	11/24 (46)	Brazil (2), Cambodia (4), Colombia (1), Ethiopia (1), Nigeria (1), Saudi Arabia (1), Sudan (1)
Quality control not performed on site (mainly due to lack of equipment)	11/24 (46)	Argentina (1), Ethiopia (1), Islamic Republic of Iran (1), Japan (1), Lebanon (1), Malawi (1), Nigeria (2), Pakistan (1), Sudan (1), Turkey (1)
to acceptability		
Unpleasant smell	4/38 (11)	Belgium (1), Cambodia (1), Philippines (1), Uganda (1)

[a] Alcohol produced from sugar cane, maize, manioc, mahogany or walnut.
[b] The simple washing of used dispensers, with no attempt at disinfection or sterilization.

Costs

Reliable information on the costs of the ingredients in the ABH and the salary costs of producing the handrub was available for 16 of the survey sites. Thirteen of these sites used ethanol-based handrubs; the remainder used the isopropanol-based formulation. The mean costs per 100 ml of the ethanol- and isopropanol-based formulations – including salaries but excluding the costs of dispensers – were 1.4 (range: 0.3–4.5) and 0.8 (range: 0.1–1.3) United States dollars (US$), respectively.

Additional data on dispenser costs were available from only nine sites. Seven of these sites used ethanol-based handrubs, while the remainder used the isopropanol-based formulation. At these nine sites, the mean total costs of the ethanol- and isopropanol-based formulations – including salaries and dispensers – were US$ 2.2 (range: 0.9–4.8) and US$ 1.6 (range: 0.9–2.3) per 100 ml, respectively.

Lessons learnt

Our survey provided valuable insight on field experience in the local production of WHO-recommended ABH formulations globally and – particularly – in low- and middle-income countries. Local production of these handrubs has been rolled out over a wide range of geographical and economic settings by both health-care facilities and private companies. Ease of production combined with affordable cost and good product acceptability and tolerability appear to be the main advantages of the WHO formulations – despite the frequent, initial challenge of identifying staff with the skills required to produce them (Box 1). More than half of our survey sites reported that they had switched from a commercially marketed ABH to an ABH that they had produced themselves –in accordance with one of the WHO-recommended formulations.

To promote hand hygiene, an overwhelming majority of the health-care facilities that we investigated used a multimodal approach that included training, the display of WHO and locally-adapted posters and other educational approaches. Such multimodal strategies have been found to improve hand hygiene in many regions and

Box 1. **Summary of main lessons learnt**

- Local production of alcohol-based handrubs based on the formulations recommended by the World Health Organization (WHO) is feasible and provides a low-cost alternative to commercially-produced handrubs that may be unavailable or unaffordable – particularly in low- and middle-income countries.
- The handrub formulations recommended by WHO already have good product acceptability and tolerability but improvement of their smell could increase their acceptability even more.
- Quality control issues and difficulties in the local availability of ingredients and dispensers are potential barriers that could be partially overcome by increasing awareness of the optimal methods for dispenser reprocessing and improving the availability of cheaper, single-use dispensers of good quality.

thereby reduce the incidence of health-care-acquired infections.[5,12–14]

Excellent product acceptability and tolerability were reported in most survey sites. The most common complaint about the locally produced ABHs was that they had an unpleasant smell – probably because of the H_2O_2 content. In an attempt to resolve this issue, some survey sites had either stopped adding H_2O_2 to their handrubs or had tried to mask the unpleasant smell with a fragrance. Further studies are needed to assess how the exclusion of H_2O_2 – which is currently not recommended by the international experts who developed the *WHO guidelines on hand hygiene in health care*[5] – affects the risk of handrub contamination.

The mean costs of a commercially-produced ABH – typically US$ 2.5 to 8.5 for a 100-ml dispenser (unpublished data, 2012) – appear higher than the mean costs that we evaluated for ABHs that were locally produced according to the WHO formulations. Similar observations have been made previously.[5,12,13] The costs of the salaries of the heath-care workers who make ABHs are relatively low and many of our study sites were buying relatively cheap alcohol locally – particularly ethanol from agro-industrial sources – but the cost of the dispensers was high. At several sites, reuse of dispensers helped overcome difficulties caused by local shortages and the relatively high costs of new dispensers. Such reuse may, however, lead to handrub contamination, especially when empty dispensers are reprocessed by simple washing before being refilled. Increased awareness of the WHO recommendations for the reprocessing of handrub dispensers[8] and improvements in the availability of appropriately-priced, single-use dispensers of good quality could help avoid such contamination.

Encouragingly, most of our survey sites performed some form of quality control on the ABHs that they produced. The purchase or donation of additional alcoholmeters would facilitate such checks.

Government contracts for the large-scale commercial production of the WHO formulations could make it possible to globally market low-cost ABHs. However, more related research – on market share, competitiveness and product quality, tolerability and acceptability – is needed.

Our survey had limitations. Although sites from all WHO regions participated, the Americas, the Eastern Mediterranean and Europe were underrepresented, perhaps because of language restrictions and because most European countries can afford to use commercially-produced ABH. Limited internet access posed a challenge for several of the low-income countries that were invited to participate in the online survey – although this issue was partially overcome by faxing the questionnaire to and from some potential survey sites.

In summary, the local production of WHO-recommended ABH formulations provides a feasible alternative to the use of relatively expensive, commercially-produced ABH. It appears to be a particularly attractive option for low- and middle-income countries. This survey confirms earlier data that indicated that both WHO formulations are well tolerated and accepted by health-care workers. However, improvements are needed in quality control, the supply of dispensers and the procurement of ABH ingredients. Information on the sourcing of affordable dispensers of good quality and increased awareness of the WHO-recommended methods for the reprocessing of used dispensers are likely to reduce the overall production costs of ABH and the risks of handrub contamination. Large-scale production of the WHO-recommended formulations and the development of production networks and partnerships may both be beneficial. ■

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