



# The State of Handwashing in 2017: Annual Research Summary

## *What We Learned about Handwashing in 2017*

### Introduction

The Global Burden of Disease study 2016 (GBD 2016) found that from 2006-2016, the number of global deaths attributable to unsafe water, sanitation, and hygiene (WASH) decreased by 25%, while lost disability-adjusted life years (DALYs) decreased by more than 35%.<sup>1</sup> Among the top ten leading risks in 1990, rates of unsafe sanitation and unsafe water (in addition to child growth failure) have declined the most over the period of 1990–2016. However, in low socio-demographic index (SDI) countries, unsafe WASH is still the third largest contributor to the global burden of disease at 7.8% of DALYs. It is estimated that inadequate hand hygiene results in nearly 300,000 deaths annually, with the majority of deaths being among children younger than 5 years old.<sup>2</sup>

In this summary, we outline key themes and findings from 117 handwashing-related research papers published in 2017. Findings are summarized in narrative form, with methodology and findings of individual studies summarized in tables.

This summary presents the overarching findings of the literature on handwashing published in 2017, and explores specific data and context. Findings are categorized by six key themes:

- Access and coverage (page 1)
- Benefits of handwashing with soap (page 2)
- Measuring handwashing compliance (page 5)
- Handwashing behavior change (page 8)
- Drivers of handwashing (page 12)
- Measuring the efficacy of handwashing hardware including various types of soaps and rubs (page 16).

### Access and Coverage

Research continues to show disparities in access to water and soap for handwashing at the household level in low and middle-income countries. Studies showed that rural healthcare facilities in Sub-Saharan Africa lacked basic hygiene services, posing a threat to the health of patients and healthcare workers. An analysis from 51 LMICs showed large variations between countries with regard to proportion of households with soap available at the handwashing place (i.e., from <0.1% in Ethiopia to 91.5% in Iraq), but within almost every country, households in higher wealth quintiles were more likely to have soap available than households in the lower wealth quintiles.<sup>3</sup> In a cross-sectional study of 1,318 rural healthcare facilities in 6 Sub-Saharan African countries, fewer than 25% of healthcare facilities in each country reported that water, soap, and hand-drying materials were always available.<sup>4</sup>

Analysis of the most recent data from Demographics and Household Survey (DHS) or Multiple Indicator Surveys (MICS) from 25 Sub-Saharan Africa countries showed that the coverage rate for access to water with collection time of 30 minutes or less, plus access to sanitation and hygiene, was 4%: an estimated 921 million people lacked this basic coverage. Urban areas had greater access than rural areas, where level of access was close to zero in many countries.<sup>5\*</sup>

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\*The global SDG indicator Target 6.2 focuses on access to a handwashing facility with water and soap at home, a proxy for individual hygiene practices. While handwashing was not included in the MDGs, the SDGs aim for full universal access and require the reduction of inequalities. Additionally, WHO and UNICEF have proposed an action plan to achieve universal water, sanitation and hygiene (WASH) coverage in healthcare facilities (HCFs) by 2030.

## Benefits of Handwashing

### Diarrheal Diseases and Acute Respiratory Infections

Handwashing with soap can significantly reduce the prevalence of pneumonia and diarrhea, two leading causes of child morbidity and mortality globally.<sup>3</sup> Effective and appropriate handwashing practice is crucial for prevention of diarrhea, which is the second most common cause of death among school-age children in Sub-Saharan Africa.<sup>6</sup> The global burden of disease associated with poor WASH is concentrated among children, particularly with handwashing-preventable diarrheal diseases. The need for improved hand hygiene is particularly strong among households that are poorer and in rural areas where children may be at greatest risk for preventable mortality, but even in middle-income countries, handwashing disparities and risks persist.<sup>3</sup> A systematic review of handwashing with soap for children under 5 shows that interventions promoting handwashing with soap (HWWS) and hygiene education can lead to a 27% decrease in the risk of diarrhea.<sup>7</sup> Another systematic review concludes that multi-level handwashing interventions for children in developing countries can reduce the incidence of diarrhea, respiratory infections, and in turn, school absenteeism.<sup>6</sup>

### Bacterial Infections

Handwashing with soap with proper technique significantly reduced *E. coli* and total coliform contamination of hands among 173 primary caregivers in Zimbabwe. Researchers collected hand rinse samples before and after handwashing at home and found that cleaning under fingernails, scrubbing the fingertips, using soap, and drying hands through rubbing on clothes or a clean towel reduced *E. coli* contamination of hands, while tap use, scrubbing fingertips, and rubbing hands on clothes to dry significantly reduced total coliform contamination.<sup>8</sup>

### Viral Infections

An experimental study comparing 6 different handwashing protocols showed that soap and water was as efficacious as alcohol-based hand sanitizers, sodium dichloroisocyanurate, hypochlorite, and sodium hypochlorite solutions in removal and inactivation of non-pathogenic model organisms. Chlorine use led to persistent chlorine in rinse water, which added extra benefits.<sup>9</sup> A mixed-method study in Lofa County, Liberia, found that during the West Africa Ebola outbreak, no cases of Ebola virus disease were found in open-defecation-free (ODF) communities that had engaged in Community-Led Total Sanitation (CLTS) and in only one CLTS community that had not reached ODF status. These CLTS ODF communities attributed their avoidance of Ebola to WASH behaviors, especially handwashing with soap and disposal of feces, that they learned from CLTS prior to the epidemic.<sup>10</sup>

### Healthcare Systems and Healthcare-Associated Infections

In lower and middle income countries, healthcare-associated infections (HCAIs) are an acute risk, and high infection rates contribute to poor patient outcomes including mortality.<sup>11</sup> Proper hand hygiene reduces disease transmission and HCAIs,<sup>4, 12</sup> but poor hand hygiene compliance amongst clinicians has been identified as one of the major factors contributing to nosocomial infections.<sup>11</sup> A yearlong multicomponent intervention in a Saudi Arabian hospital was effective in improving HH compliance among hospital staff, thereby decreasing the HCAI rate from 3.37 to 2.59.<sup>12</sup> Improvements to handwashing facilities enable proper hand hygiene practice, which is recognized as the single most effective strategy for preventing healthcare-associated infections.<sup>13</sup> However, a cross-sectional study in Nigeria found inconsistency between self-reported attitude and practice in hand hygiene among healthcare workers, with unavailability of soap (88%) and irregular water supply (51%) cited as the main reasons.<sup>14</sup>

### School Absenteeism

Hygiene is associated with reduced school absenteeism. According to a systematic review of the literature, hand hygiene interventions reduce school absenteeism related to gastrointestinal illness, but inadequate evidence is available for the effect on absenteeism due to respiratory illness.<sup>15</sup> Having adequate unlocked toilets with handwashing stations for girls is crucial to help adolescent girls effectively manage their menstrual hygiene at school instead of staying home during menstruation.<sup>16</sup> Another systematic review of the literature on hand hygiene

intervention strategies showed that hand hygiene could reduce the incidence of diarrhea and respiratory conditions among schoolchildren, with three hand hygiene intervention strategies being training, funding and policy; training and funding were implemented more often than policy.<sup>6</sup> In Indonesia, Cambodia and Lao PDR, integrative WASH interventions (including handwashing) contributed to increased attendance and improved health and educational outcomes.<sup>17</sup>

Table 1.

Benefits of Handwashing	Location
<b>Diarrheal Diseases and Acute Respiratory Infections</b>	
This multi-country study assessed the prevalence ratio of child diarrhea between children with a basic handwashing station and those without. The prevalence ratio of 0.95 suggested a protective effect of having a handwashing station with water and soap. <sup>18</sup>	25 LMICs in SSA
A study in the slums of Addis Ababa found that the most important recommended times for handwashing to prevent acute diarrhea in children under 5 were before preparing food and after defecation. <sup>19</sup>	Ethiopia
Handwashing after contact with domestic animals was associated with a decreased risk of moderate-to-severe diarrhea in children in western Kenya (matched odds ratio = 0.2; 95% CI 0.08–0.7). <sup>20</sup>	Kenya
A health education intervention on handwashing for mothers of children under 5 showed a 10.6% reduction of childhood diarrhea post-intervention. <sup>21</sup>	Nigeria
A systematic review of 8 studies on hand hygiene interventions for schoolchildren in developing countries adds to existing evidence that multi-level hand-washing interventions – those that address at least three different sources of influence, such as individual, organizational, and provider – can reduce the incidence of diarrhea, respiratory infections, and school absenteeism. <sup>6</sup>	Multiple LMICs
Analyses of 6 studies evaluating the effect of handwashing with soap in children under 5 in community settings suggests that handwashing with soap (soap provided with education about handwashing with soap at critical times) leads to a 27% decrease in the risk of diarrhea (pooled RR: 0.73, 95% CI). <sup>7</sup>	South Asia
<b>Bacterial Infections</b>	
Cleaning under fingernails, scrubbing fingertips, using soap, and drying hands through rubbing on clothes or a clean towel statistically significantly reduced <i>E. coli</i> contamination of hands after washing. Tap use, scrubbing fingertips, and rubbing hands on clothes to dry them also significantly reduced total coliform contamination. <sup>8</sup>	Zimbabwe
An RCT of a 1-week handwashing with soap and water treatment intervention, the Cholera-Hospital-Based Intervention-for-7-Days (CHoBI7), showed a significant reduction in symptomatic cholera infections during the intervention period, and there was sustained high uptake of observed handwashing with soap behaviors up to 12 months post-intervention (56% in the intervention vs. 21% in the control arm). <sup>2</sup>	Bangladesh
A study in an academic medical center found that patient hand hygiene can be an important preventative measure against <i>clostridium difficile</i> infections and may be underused. Providing education, reminders and opportunities for patients to wash hands regularly can improve patient hand hygiene. <sup>22</sup>	USA
A study of the efficacy of WHO's recommended structured handwashing technique and a modified WHO structured technique (WHO shortened-repeated) showed that a structured technique was more effective than an unstructured technique to remove <i>C. difficile</i> from hands. <sup>23</sup>	N/A
A review demonstrated that the amount of bacterial flora released from wet hands is more than 10 times as much as is released by dry hands. Some evidence suggests that females transfer fewer bacteria between environment and patients than males. <sup>24</sup>	Iran
A study of rural girls and women and WASH had unexpected findings: reproductive tract infection symptoms for women over their life course were more common for women bathing daily with soap (OR = 6.55, CI = 3.60, 11.94) and for women washing their hands after defecation with soap (OR = 10.27; CI = 5.53, 19.08) or ash/soil/mud (OR = 6.02; CI = 3.07, 11.77) versus water only or no handwashing. Researchers concluded that causality and mechanisms of effect could not be inferred from this study. <sup>25</sup>	India

<b>Viral Infections</b>	
Improved hygiene practices, especially hand washing with soap and the safe disposal of feces and bodily fluids (including from dead bodies), appear to reduce the incidence of new cases of EVD. <sup>10</sup>	Liberia
A randomized comparison of 6 different handwashing protocols, including soap, hand sanitizer, and various 0.05% chlorine solutions, found them to be similarly efficacious for cleaning hands (Phi6 was used as a BSL-1/safe surrogate for the Ebola virus). All chlorine-based solutions were better than other protocols at reducing the persistence of E. coli in rinse water. <sup>9</sup>	N/A
<b>Helminthic Infections</b>	
Food handlers in food establishments who were trained in food hygiene and safety were 66% less likely to have an intestinal parasitic infection than those who were not trained. <sup>26</sup>	Ethiopia
<b>Healthcare-Associated Infections</b>	
Increased PHH compliance can influence hospital-acquired infection rates in an adult cardiothoracic step-down unit, generating significantly reduced infection rates (e.g., in MRSA and VRE). Increased PHH compliance may be attributed to the implementation of patient education and the greater accessibility and use of hand sanitizer. <sup>27</sup>	USA
In a study of 78,344 cases of HCAI in a hospital, utilization of various hand hygiene products (including hand sanitizer, soap and paper towel) was found to be negatively associated with the incidence of HCAs. <sup>28</sup>	China
A yearlong multicomponent intervention in a hospital was effective in improving HH compliance among hospital staff, and in decreasing the HCAI rate from 3.37 to 2.59 (P<0.05). <sup>12</sup>	Saudi Arabia
<b>Childhood Health, Nutrition, Stunting and Wasting</b>	
Children of caregivers/mothers who did not practice handwashing after latrine use were found to be 6.7 times as likely to be underweight as their counterparts whose caregivers did wash their hands. <sup>29</sup>	Ethiopia
A cohort study of children with access to improved sanitation but not improved water found that these children are at lower risk of stunting compared to children without access to improved sanitation or water. <sup>30</sup>	Ethiopia, Peru, India, Vietnam
In a study of the contamination of formula milk, of 92 randomly selected households with children <2, a total of 88% of the formula feeds were contaminated with total coliforms at a level >10 MPN/ml, and 45% contained E. coli, making them 'unfit for human consumption.' Only 2 mothers washed their hands with soap prior to formula preparation, and their prepared bottles contained no E. coli. <sup>31</sup>	Indonesia
In a study of domestic hygiene in 608 rural households with children <2 years, 58% of stored complementary food was contaminated by E. coli, 12% with high levels; the latter was associated with lack of water in food preparation areas and uncovered food storage, suggesting that interventions ensuring water availability for hand hygiene in food preparation areas could reduce fecal contamination. <sup>32</sup>	Bangladesh
A systematic review of evidence-based approaches to address childhood stunting found that nutrition education and counseling, immunization, and WASH were among the programs most often included in the intervention packages analyzed. They appeared most successful where multi-sectoral collaboration between governments, NGOs, and organizations exist and where service delivery had strong community engagement components; nutritional programs alone are unlikely to reduce stunting. <sup>33</sup>	LMICs
A study of over 10,000 children showed that approximately 60% of the association between socio-economic status and wasting (low weight for height) is mediated through WASH factors, including handwashing. <sup>34</sup>	Bangladesh
Compared to baseline, a significantly higher percentage of pregnant women who participated in an intervention to increase maternal health service use and household hygiene were able to demonstrate proper handwashing post-intervention. <sup>35</sup>	Kenya
<b>School Absenteeism</b>	
Risk factors for school absence for girls ages 11 to 17 included insufficient and inadequate WASH facilities at school. 54% of schools did not have an improved, unlocked toilet that students could access, and only 9% of schools had a toilet with soap and water inside. <sup>16</sup>	Bangladesh
28 schools were provided with handwashing and drinking water stations, bleach for water treatment, soap for HW, and educational materials. 4 months post-intervention, 49% of teachers	Kenya

observed decreased absenteeism due to illness in pupils. They reported fewer stomachaches among pupils (85%), less diarrhea among pupils (80%), and increased awareness about diarrheal illnesses among pupils (75%), and fewer respiratory infections (37%). <sup>36</sup>	
Evidence from a systematic review of studies published between 1996 and 2014 suggest that HH interventions may have an effect on acute gastrointestinal illness-associated school absence, but not on respiratory illness-associated absence. <sup>15</sup>	LMICs

## Handwashing Compliance

The evidence clearly shows that handwashing compliance remains a challenge across settings. Studies reveal a gap between knowledge about handwashing with soap and optimal handwashing behavior by staff and patients in healthcare settings, by students in schools, and by mothers and other caregivers of children at the home and in the community. Measuring hand hygiene accurately remains a challenge, and variations in indicators and definitions (e.g., of ‘sustained adoption’) make it difficult to compare studies and thus develop best practices. Self-reported behaviors and standard observation methods, especially when subjects are aware of monitoring, are often inaccurate compared to actual practice.

### Handwashing in Schools

Overall HW compliance for public school students in Jordan was quite high, and the majority of students reported always washing their hands after using the toilet (86.7%).<sup>37</sup> In contrast, rates of handwashing after critical times such as after defecation and urination were quite low in a school-based study in Ethiopia (50% and 19% respectively), but these students reported better practice before eating and when their hands were visibly dirty.<sup>38</sup> At times, inadequate WASH infrastructure posed barriers for handwashing compliance for pupils.<sup>39</sup>

### Handwashing in the Community and Among Caregivers of Children under 5

Hand hygiene knowledge and practice of caregivers of children under 5 varied considerably between studies, but frequently moderate or even high levels of knowledge (and positive attitudes, when assessed) exhibited by mothers and other caregivers exceeded the levels of proper hand hygiene practices.<sup>40, 41</sup> For example, amongst community women in a study in Mauritius, levels of awareness of hand hygiene greatly exceeded practice.<sup>42</sup> Interventions described in this review had varying levels of success in handwashing behavior.

### Hand Hygiene in Healthcare Settings

More than 30 articles in this summary examined handwashing compliance within healthcare facilities and teaching hospitals, including in healthcare workers, medical students, patients and visitors. Although proper hand hygiene is the single most effective measure to control HCAs, and it is a key measure to circumvent the transmission of pathogens, the handwashing compliance of healthcare workers is still poor worldwide. Many of the studies described below illustrate and compare hand hygiene rates for various types of staff, physicians, medical students, and nurses.

#### Nurses

Several articles specifically focused on hand hygiene compliance of nurses, as they are often the healthcare workers who have the most contact with patients. In a systematic review including 10 studies that measured hand hygiene knowledge, it was found that nursing students from Slovakia, Jordan, India, Singapore, Nepal, and Saudi Arabia had moderate or insufficient knowledge of hand hygiene. Likewise, in an Indian study, the overall score on nurses’ hand hygiene practices was moderate (58%), revealing gaps in execution of their high overall level of knowledge (91%); authors recommended periodic refresher training on hand hygiene.<sup>43</sup>

Using video demonstration, a handwashing intervention for nurses in neonatal and pediatric intensive care units and nurseries in Nepal increased compliance in all steps of handwashing to 69% post-intervention from 9% at baseline.<sup>44</sup> In Iranian hospitals, direct observation showed low compliance (40%), contradicting the nurses’ high

level of self-reported proper hand hygiene. Some reluctance was due to religious concerns: 16% believed that using alcohol-based hand rubs would make their hands impure and unclean according to religious principle, while 24% had reservations about either alcohol inhalation or absorption. However, most nurses indicated personal beliefs for non-use of alcohol-based hand rubs, such as the belief that rubs caused skin damage or dryness (86.4%) and being too busy to use the rubs (70%).<sup>45</sup>

Table 2.

Handwashing Compliance	Location
<b>Methodology and Measurement Issues</b>	
Authors conducted a mixed-method field test to evaluate methods for monitoring sustainable development goals targets on water, sanitation and hygiene, and found that about 88% of respondents agreed to a water test, 75% of surveyed households were able to provide an answer to the question on emptying pit latrines and septic tanks, and questions on menstrual hygiene were acceptable but required some clarification and probing. <sup>46</sup>	Belize
Of 3 types of studies reviewed (handwashing, household water treatment, and sanitation), handwashing studies utilized the most diverse range of measurements, including self-report via survey or pocket voting, demonstration of behavior technique or spot checks for the presence of supplies; 2 of 7 employed all three measurements, while 5 used both self-report and demonstration to assess HW practice. <sup>47</sup>	LMICs
A descriptive study evaluated the accuracy of hand hygiene observation by healthcare units' routine observers (compared to trained nurses using the same methods), and found that hand hygiene compliance reported by routine observers was significantly higher than that reported by trained nurses (89% vs. 55%). <sup>48</sup>	Qatar
Video surveillance of HH with real-time feedback was found to be an effective tool for measuring HH and improving compliance. During the first 4 weeks, the overall compliance was 14.6%, though the rate of compliance increased to 80.7% during the 12-week post-feedback period. <sup>49</sup>	Pakistan
<b>Handwashing among Primary Caregivers of Children under the Age of 5</b>	
The average prevalence of hand washing with soap at the WHO's five recommended times was 19.8%. One quarter (24.8%) of caregivers washed their hands with soap before feeding a child, 23.8% before preparing food, and 17.1% after defecation. <sup>19</sup>	Ethiopia
In a study of the contamination of formula milk in 92 randomly selected households with children under 2 years of age, only 2 mothers washed their hands with soap prior to formula preparation according to video observations, and none complied with all five WHO-recommended measures of hygienic formula feed preparation. <sup>31</sup>	Indonesia
A cross-sectional study of handwashing knowledge, attitude, and practice showed that mothers of children under five years of age had moderate levels of knowledge of handwashing during critical times, but handwashing attitude and practices during critical times, especially child feeding, were low. Only 8.5% of mothers washed their hands with soap and water before breastfeeding. <sup>41</sup>	Ethiopia
An exploratory, cross-sectional study on disposal of feces of children under five showed that despite the fact that the majority of caregivers had above-average scores in knowledge and attitude, only 20% (during the day) and 69% (at night) of caregivers practiced safe disposal of feces passed by children. Handwashing was associated with household toilet access, wealth, and under-five child defecation preferences during the day and at night. <sup>40</sup>	Nigeria
<b>Handwashing in Schools</b>	
In a study of 30 schools, 16 (53%) reported having a designated handwashing time before serving food, but only one school (3.3%) had a handwashing area away from the latrines and with piped water. <sup>38</sup>	Ethiopia
Of 596 primary school children, handwashing at various times was reported by the following proportions of students: after defecation by 50%, after urination by 19%, before eating by 88%, and when hands were visibly dirty by 78%. <sup>38</sup>	
The vast majority of public school students (grades 1-12) in the study said that in the past month they washed their hands with water (97.5%), while nearly 70% said they used soap and water, and 20% reported using disinfectant. <sup>37</sup>	Jordan

The majority of students reported always washing their hands after using the toilet (86.7%) and after touching rubbish (84.4%). <sup>37</sup>	
<b>Handwashing in the Community</b>	
In a random sample of community women, the level of HH awareness was generally satisfactory (68.8% attaining highest possible score), but the compliance of handwashing practice and resulting contamination, especially among elders, was not. <sup>42</sup>	Mauritius
Self-reports of handwashing for food handlers at food and drink establishments reported that 77.5% always washed their hands with soap and water before food preparation and 73.8% after visiting the toilet; observations also supported that HH was practiced by most of the food handlers. <sup>26</sup>	Ethiopia
Although food handlers working at a university had moderate levels of food safety knowledge (61.7%) and good attitudes (51.9/60), the good self-reported practices (53.2/60) were not reflected in the microbiological assessment of food handlers' hands: 65% of the handlers examined had a total aerobic count $\geq 20$ CFU/cm <sup>2</sup> and Salmonella was detected on 48% of the food handlers' hands. <sup>50</sup>	Malaysia
<b>Handwashing in Healthcare Facilities</b>	
Poor hand hygiene compliance amongst clinicians has been identified as one of the major factors contributing to nosocomial infections in different clinical contexts <sup>11</sup>	Sri Lanka
Hand hygiene compliance was between 20-45% among health professionals; it was comparatively high among nurses, while very low among ECG technicians. Female HCWs seemed to comply better than males. <sup>11</sup>	
In a study of the WHO-recommended 5 Moments of Hand Hygiene in an overcrowded HCF single patient zone, hand hygiene compliance was highest among auxiliary staff, then nurses, allied health staff (therapists and technicians), and doctors (42.9%, 41.7%, 22.2% and 10%). ABHS was strategically placed and available in the ER, yet hand hygiene compliance was suboptimal. <sup>51</sup>	N/A
In a longitudinal study on the sustainability of a hand hygiene intervention in a rural hospital setting, the hand hygiene compliance rate decreased by 32% between 2015 and 2016. Healthcare workers appeared to substitute patient protection with glove use. Factors associated with the decrease included a high rate of physician turnover, as well as issues with recruiting and retention of key personnel. <sup>52</sup>	Rwanda
A mixed method study with video recordings and follow-up interviews on hand hygiene compliance among healthcare workers showed that putting gloves on before entering a patient's room was one typical breach of hand hygiene protocol. Housekeepers, assistant nurses, and nurses were prone to wearing gloves in most care situations, including when it was not recommended. HCWs also reported keeping gloves on when leaving the room, which may cause contamination of the door handle (claiming that their colleagues had already done the same) and spreading of contamination. <sup>53</sup>	France
A longitudinal quantitative study of compliance to WHO's 5 recommended moments for handwashing among healthcare workers at an emergency department showed that the overall compliance was 54%, and compliance among nurses (67%) was higher than among physicians (41%) <sup>54</sup>	Brazil
The web-based Targeted Solutions Tool for improving hand hygiene was used to identify contributing factors to handwashing non-compliance in a hospital. The top factors identified were: improper use of gloves, hands full of supplies or medications, and frequent entry or exit in isolation areas. <sup>55</sup>	Saudi Arabia
A multimodal hand hygiene improvement strategy launched by the World Health Organization (WHO) was implemented in a traditional Chinese medicine hospital, and found to improve HH compliance and correctness among HCWs. The rate of compliance and correctness with HH improved from 66.27% and 47.75% at baseline to 80.53% and 88.35% post-intervention. <sup>56</sup>	China
A cross-sectional study with direct observation showed that overall hand hygiene compliance among healthcare workers was 22%, and that compliance with measures that protected healthcare workers themselves from infection was higher than compliance with measures that protected patients from infection. <sup>13</sup>	Ethiopia
Despite the presence of HW materials and HH training for HCWs, the prevalence of nosocomial infections in a neonatal unit of a hospital in Cotonou, the HCAI rate was estimated at 8% in 2016. Only 15% of the medical staff followed all of the HH rules. 76.6% of HCWs did not wash their hands before entering the unit; 32% washed their hands before each care session; 95.7% washed their	Benin

hands after each care session; and 85% did not comply with the HW steps. Only 85% of HCWs adhered to the ban on mobile phone use within the treatment room. <sup>57</sup>	
HH compliance for prevention of HCAs was poor among HCWs overall: 39.6% reported complying sometimes and 27.7% said they complied rarely; 32.7% surveyed said they always complied. <sup>58</sup>	Nigeria
HCWs had adequate knowledge of HH to prevent HCAs, but due to poor monitoring, that did not translate into HH compliance. Years of work experience was not significantly associated with increased compliance, but educational level was. <sup>58</sup>	
Physician and medical student respondents stated that they performed HH in the following situations: 74.4% of respondents before an aseptic task; 60.8% before patient contact; 57.0% after patient contact; 11.5% after body fluid exposure risk, and only two respondents (1.1%) after contact with patient surroundings. The overall level of HH knowledge and skills was found to be insufficient. <sup>59</sup>	Poland
Overall HH adherence of HCWs was low, at 13.75 %; there was a significant difference in adherence in the surgical versus 3 other departments, with the highest rate in surgery (27.92%). <sup>60</sup>	India
<b>Among Patients and Visitors to HCFs</b>	
Patient empowerment programs in hand hygiene were implemented in 2 hospitals. Infection control nurses approached 223 patients, of whom 167 patients (75%) agreed to participate. 75 of the patient participants (45%) reminded health care workers to clean their hands, and of those, 70 (93%) received positive response from health care workers. <sup>61</sup>	Hong Kong

## Handwashing Behavior Change

Behaviors are determined by a wide range of factors, but knowledge about the benefits and practice of proper hand hygiene alone does not necessarily translate to uptake. Psychological factors are found to mediate the effect of water, sanitation and hygiene interventions on health behaviors. George et al. assessed the mechanism underlying the change in observed handwashing with soap in the CHoBI7 soap and water treatment intervention for family members of cholera patients and found that the intervention's effect was mediated by response efficacy, disgust, convenience, and awareness about cholera.<sup>2</sup> Several studies suggest that interventions using emotional drivers (such as nurture, disgust, affiliation, and social status) may be more effective than those that teach about health benefits.<sup>62</sup>

The integrated behavioral model for water, sanitation, and hygiene (IBM-WASH) continued to be used as a key theoretical construct that guides and influences WASH interventions. A mixed method review stated that 10 articles discussed IBM-WASH's effect in various and complex social and environmental settings, while the Risks, Attitudes, Norms, Abilities, and Self-regulation (RANAS) approach to systematic behavior change emerges as another model applicable across multiple WASH practices and interventions.<sup>63</sup> Social cognition theories suggest that positive behavior changes occur primarily when individuals are motivated, while the theory of planned behavior suggests that individuals' intentions and perceived control are major predictors of behavioral change.<sup>64</sup>

An extensive Campbell Systematic Review using mixed methods was undertaken by De Buck and colleagues to explore which promotional approaches are most effective in changing handwashing and sanitation behavior, and which implementation factors affect the success or failure of such interventions.<sup>63</sup> The review summarizes evidence from 42 impact evaluations and from 28 qualitative studies from LMICs, particularly in South Asia and Sub-Saharan Africa, and classified the studies into 4 categories of promotional approaches or elements: community-based approaches, social marketing approaches, sanitation & hygiene messaging, and elements of psychosocial theory. The Campbell review's main findings on these approaches are summarized below.

Community-based approaches to promote handwashing and sanitation efforts appeared to work better than the other 3 types of approaches. Programs that combine hygiene and sanitation measures have synergistic effects, tending to show a greater impact than either one alone. Studies using a community-based approach which include



sanitation were shown to increase HWWS at key times, as well as use of latrines and safe disposal of feces, and reduction of open defecation.

Social marketing appeared less effective, mainly showing an effect on sanitation when interventions combined both handwashing and sanitation elements. Interventions with sanitation and hygiene messaging that focused on HWWS had an effect at intervention's end, but did not appear to be sustainable in the long term. Using elements of psychosocial theory seemed promising in small-scale handwashing promotion interventions, or when adding theory-based components to interventions – such as infrastructure promotion or public commitment to an existing promotional approach. However, none of the approaches have consistent effects on behavioral factors such as knowledge, attitudes, and skills. Using a combination of different promotional elements is likely the most effective strategy.

Overall, factors that were observed to affect implementation were: visit frequency; intervention length; using short communication messages; having access to training materials; an implementer's social status, accessibility and qualities such as kindness and respect; and recipient awareness about costs and benefits and their access to social capital and WASH infrastructure.

A key takeaway for future research is that there is a major need for a more uniform method of measurement (type of outcomes, assessment methods, and timing of assessment) and reporting on handwashing and other WASH outcomes.<sup>63</sup> This will facilitate making conclusions on the effects of different approaches to promoting handwashing in the future.

#### Hand Hygiene Behavior Change in Healthcare Facilities

Behavioral nudges, a user-centered designed approach, and a teaching module emphasizing timing and duration could improve hand hygiene and health outcome in hospitals for patients and their family members.

A systematic review of hand hygiene knowledge and compliance among student nurses showed that the levels were sub-optimal, although there was a lack of studies that examined individual and organizational factors for hand hygiene.<sup>65</sup> Another systematic review found that education-feedback and multimodal interventions could improve hand hygiene practices among nurses, but there was a need for more methodologically robust studies to define the most effective and sustainable interventions.<sup>64</sup>

A systematic review of 38 intervention studies to improve hand hygiene in ICUs showed that the studies were of poor quality, and over 90% of the studies implemented bundled interventions. The strategies most frequently used were education (80%), enablement (71%), training (68%), environmental restructuring (66%), and persuasion (66%). The mean relative percentage change was 94.7% (range, 4.3% to 1115.4%) from pre to post intervention.<sup>66</sup>

#### Behavior Change in Schools

Self-efficacy and enhancement of behavioral cues could bridge the intention-behavior gap for handwashing in schools. Peer-led educational campaigns are a promising strategy for improving self efficacy, while cues to action, including posters and stickers, can trigger proper hand hygiene practices.<sup>67</sup>

#### Handwashing Behavior Change in Communities and Among Caretakers of Children Under 5

Elements that facilitated intervention implementation in community settings included: involvement of the community at different stages (including design), enthusiasm of community leaders, having a sense of ownership, the implementer being part of the community, gender of the implementer, trust, income generating activities, clear communication and developing a culture of cooperation.<sup>63</sup> Other effective elements of behavior promotion include social marketing elements such as determining user-centered needs, and consumer preferences and desires. Behavioral antecedents for handwashing in rural Bangladesh may be broader than those reported in the literature. A mixed-method qualitative study showed that in addition to staining with feces and dirt on hands, hand

contact with oil and grease, reminders, behavioral cues, reminders from son and daughter, observing others wash hands, and observing the sunset were also antecedents of handwashing behavior.<sup>68</sup>

Caregivers can be encouraged to build their own handwashing stations in the absence of large-scale provision of handwashing stations. An intervention trial to improve handwashing among caregivers by either providing caregivers with handwashing stations or encouraging caregivers to build handwashing stations showed that nearly all households developed their own handwashing station (bucket, mug, bar soap/soapy water), but households that received handwashing stations from investigators had higher prevalence of observed handwashing with soap than those that were encouraged to build their own handwashing stations.<sup>69</sup>

Table 3.

Behavior Change	Location
<b>Psychosocial and Other Theory-Based Interventions</b>	
Using a theory-driven, systematic approach – Behavior-Centered Design, underpinned by an Evo-Eco theory of change – along with employing emotional motivators and modifying behavior settings substantially improved multiple food hygiene behaviors in Nepal, including handwashing with soap before feeding. The positive emotional reward of each behavior was emphasized, and emotional motivators that may have motivated the key behaviors included nurture, disgust, affiliation, and social status. <sup>62</sup>	Nepal
Developing a theory of change, and involving stakeholders in its development, was found to be a valuable way to understand the context in which promotional programs are implemented in LMICs and to create buy-in from stakeholders on handwashing and sanitation behavior change. <sup>70</sup>	LMICs
Qualitative findings on a handwashing intervention to promote soapy water highlighted several dimensions affecting use that were derived from the IBM-WASH theoretical model: contextual (shared courtyard), psychosocial (perceived value), and technology dimensions (ease of use, convenience). Soapy water may increase habitual handwashing by addressing barriers of cost and availability of handwashing agents near water sources. Delivering the intervention on a larger scale would require effective alternatives to free hardware delivery and specifically promoter-led behavior change strategies. <sup>71</sup>	Bangladesh
A case study identified behavioral determinants of effective handwashing by observing handwashing techniques of 434 primary caregivers in high-density suburbs of Harare and assigning an 8-point sum score, and used regression analyses to find associations between contextual-psychosocial determinants and observed handwashing technique. Significant determinants included knowledge of effective handwashing, availability of handwashing place, self-reported frequency, perceived vulnerability and action planning. The models explained 39% of the variance in overall handwashing techniques. <sup>72</sup>	Zimbabwe
Psychosocial factors were assessed using a structured questionnaire among 170 intervention and 174 control household members enrolled in the CHoBI7 trial based on a handwashing with soap intervention. Response efficacy was found to mediate the intervention’s effect on habit formation for handwashing with soap at the 1-week follow-up, and disgust, convenience, and cholera awareness were mediators of habit maintenance at the 6- to 12-month follow-up. A significant reduction in symptomatic cholera infections was observed during the 1-week intervention period compared to the control arm, and there was sustained high uptake at 12 months. <sup>2</sup>	Bangladesh
<b>Hand Hygiene Behavior Change in Healthcare Facilities</b>	
Behavioral nudges were developed and tested in healthcare workers based on a systematic review of cognitive bias. Nudges, defined as a ‘friendly push to encourage desired behavior’, were displayed as posters and were found to be an easy, inexpensive way to increase the use of alcohol-based rub (as measured by electronic sensors). <sup>73</sup>	The Netherlands
A study evaluated the effect of a hand hygiene teaching module on hand hygiene knowledge and attitudes among medical students. The module significantly improved attitudes toward hand hygiene, knowledge about the use of hand hygiene materials, the ‘Five Moments for hand hygiene’, and duration and indications for hand hygiene. <sup>74</sup>	Australia
A user centered design approach was employed to design a mobile application to promote behavior change for improved hand hygiene. Preliminary insights show this approach led to strong and	Sri Lanka

sustained adoption and usage of the app and shed light on how of how peer assisted monitoring can be used in instilling behavioral change. <sup>11</sup>	
<b>Handwashing Behavior Change among Mothers/Caregivers of Children under 5</b>	
A community-oriented participatory health promotion intervention for caregivers of children under 5 improved caregiver and parental health knowledge and literacy substantially. Because caregivers have a direct link with children and their environment, they can promote health and bring about behavioral change within the child care environment; it is thus recommended that day care centers have relevant health promotion policies and educational programs in place. <sup>75</sup>	South Africa
An intervention study evaluated provision versus promotion to develop handwashing stations, with 40 households receiving a free of cost handwashing station and another 40 households being motivated to place their own soap/soapy-water and water vessel near food prep and child feeding areas. By trial end, 39/40 of the latter developed their own stations, and HH was improved. Encouraging households to develop their own HW station with soap was feasible over the short term, and integrating HW into the nutrition intervention was also found to be feasible and acceptable. <sup>69</sup>	Bangladesh
In the 3 months preceding a health education and handwashing intervention for rural mothers of children under 5, 41.9% of children had diarrheal episodes; this reduced by 10.6% post intervention. A significant association between diarrheal episodes and mother's level of education was also seen. <sup>21</sup>	Nigeria
In an intensive perinatal handwashing promotion intervention, behavior change communicators provided soap and HW stations, and used a participatory approach to motivate maternal handwashing with soap with didactic sessions, role plays, and field pilots. Intervention households were between 5.7 and 15.2 times as likely as control households to have soap and water present at the HW station in the baby's sleeping area, but there was only a modest improvement in handwashing with soap for intervention mothers, and HWWS at recommended times was infrequent in both intervention (9%) and control (2%) groups. <sup>76</sup>	Bangladesh
This intervention with multiple dimensions, including visual prompts like cue cards with times for handwashing, and verbal reminders, did not lead to a substantial increase in the frequency of handwashing. <sup>76</sup>	
<b>Behavior Change in Schools</b>	
A systematic review on targeting children with hygiene promotion messages reported that the evidence base for child-focused handwashing promotion in LMICs is extremely scarce; only 8 relevant studies were found. None of the studies were deemed to be of high quality and most were found to be at high risk of bias. <sup>77</sup>	LMICs
Hygiene education appears to be the most common type of school-based intervention for preventing infectious disease in LMICs. A framework underpinned by formalized psychosocial theories bridging knowledge and behavioral gaps could enhance the design of educational interventions in schools. Such interventions should consider enhancing variables such as behavioral capacity, attitudes and subjective norms (normative beliefs and motivation to comply). <sup>67</sup>	LMICs
Researchers successfully used a grassroots participatory science education model to engage high school pastoralist students and the wider community in the development of empowering and culturally-contextually relevant strategies to improve sanitation and hygiene and reduce diarrheal disease. Key activities included teacher workshops, school-based lessons, extra-curricular activities, community events and a One Health sanitation science fair. <sup>78</sup>	Tanzania
The intervention was followed by key improvements in outcomes, including a decrease in unhygienic behaviors, and increases in the perceived importance of handwashing, and communication in the social network about the importance of improved WASH practices. Strong leadership emerged from youth and enthusiasm from teachers and students. <sup>78</sup>	
A pilot study for school-based intervention showed that grassroots participatory science education and social entrepreneurship model showed promise as an innovative capacity building approach and as an engagement and empowerment strategy for pastoralist youth and communities to develop locally sustainable strategies to improve sanitation and hygiene. <sup>78</sup>	
Schools as health-promoting settings can only be effective in achieving better hygiene behavior, and in providing preventive health or WASH services, if they are able to manage, monitor and finance such services sustainably and consistently. <sup>17</sup>	Cambodia, Indonesia, Lao PDR
Future program evaluation research should include relevant intermediary health outcomes – such as hygiene behavior change including habit formation -- rather than solely measuring conventional	

health indicators, such as weight status (one of the indicators used in the evaluation of Fit for School, a school WASH program). <sup>17</sup>	
<b>Handwashing Behavior Change in Communities</b>	
A systematic review of WASH and handwashing interventions concluded that more consideration needs to be given to developing behavior change models that stress factors related to sustained adoption, and how they differ from those related to initial adoption. Definitions and indicators for ‘sustained adoption’ are not standardized and often inadequate for measuring longer-term behavioral change. Studies should take measurements at multiple time points and use diversified measurement methods. <sup>47</sup>	LMICs
Researchers classified behavioral factors according to the widely used IBM-WASH model: psychosocial, contextual, and technological. Technologies promoted or assessed in the 55 handwashing-focused studies include bar soap (18), ash (7), handwashing stations (7), soapy water (6), and dedicated place for handwashing(6). <sup>47</sup>	
The most common behavior change strategies to promote handwashing in the 55 handwashing studies were: community health workers or promoters (23), women’s groups (14), mass media or social marketing campaigns (13), youth or school clubs or teachers (7), and facility-based HCWs (6). <sup>47</sup>	
A cross-sectional study on the impact of a 4-year intervention to improve access to water, sanitation and hygiene and reduce waterborne diseases showed that the percentage of households with handwashing facilities at the latrine increased from 0% to 13%, but the incidence of diarrhea among children age under five years also increased almost 3-fold over the intervention period. <sup>79</sup>	Tanzania
A community-based hygiene promotion program demonstrated improvements in knowledge of key times for handwashing and water container hygiene. Recommendations for future studies were to use local community participatory approaches, in-depth formative behavioral assessments and to consider environmental barriers to behavior change, in addition to applying a hygiene cluster framework for intervention planning and evaluation. <sup>80</sup>	El Salvador
An intervention was aimed at promoting behavioral change by increasing awareness of the importance of handwashing and providing technical assistance in building HW stations called “tippy taps.” It also included intensive social marketing components and face-to-face interactions. Households in handwashing promotion-only wards showed only marginal improvements in HW behavior related to food preparation but not at other critical junctures. <sup>81</sup>	Tanzania
One successful intervention gave household members a 30-minute intensive handwashing education on influenza infection and its potential impacts, for example, school and work absenteeism. <sup>63</sup>	LMICs
A cluster RCT of 400,000+ low-income persons in Dhaka examined the impact of cholera vaccination plus a handwashing behavior change intervention and found that neither demonstrably reduced the incidence of diarrhea-associated hospitalization. <sup>82</sup>	Bangladesh

## Drivers of Handwashing

Successful handwashing behavior change requires both the availability of functioning facilities (i.e., a handwashing station with soap, a source of clean water, and materials for drying hands) and adoption of good handwashing habits. Insufficient and inaccessible handwashing infrastructure and hardware was a barrier described in many of the studies summarized below, especially in healthcare facilities, and in schools and households. Education and training often helped improve handwashing, although these behaviors were not always sustained. Various environmental, psychosocial and organizational factors, as well as personal motivation, structural barriers, and levels of education and literacy were some of the determinants described below.

### Healthcare Facilities and Healthcare Workers

In a systematic review of 19 studies of HH among nursing students<sup>65</sup>, determinants that predicted better hand hygiene included: knowledge of hand hygiene as a preventative measure against HCAs; technique of using hand rubs; exposure to situations that require hand hygiene; perceptions of being reprimanded for not complying with hand hygiene guidelines; numbers of clinical placement sites; having a respectable hand hygiene mentor; positive attitudes toward hand hygiene; and attendance at hand hygiene trainings. Conversely, being busy; forgetfulness; and the fear of having skin damaged by alcohol-based hand rubs were negatively associated with hand hygiene

compliance in nursing students. Studies from Sri Lanka, India, Italy, and Greece found that nursing students tended to have better hand hygiene knowledge and practice than medical students, perhaps because of the greater emphasis placed on hand hygiene education in nursing programs and more frequent hand hygiene assessments.

Another systematic review found that hand hygiene compliance education, feedback and support from a team leader, accessibility, and visual reminders are all components that appear to increase hand hygiene in nurses.<sup>64</sup> Additionally, a mixed methods study in Zanzibar, Tanzania, showed that only 49% of health facilities had the infrastructure and 46% had the knowledge required to enable hand hygiene; constant running water was particularly lacking.<sup>83</sup>

#### Among Caregivers, Children and In Schools

Among mothers, caregivers and school children, the availability of handwashing facilities with a reliable water source and soap influences handwashing practice. Even when caregivers have sufficient knowledge and positive attitudes regarding handwashing, these structural inadequacies can be insurmountable barriers to proper hand hygiene.<sup>84</sup> In South African schools, combined improvements in the social and structural environments were found to motivate routine handwashing habits, while social interventions alone (e.g., education) did not.<sup>85</sup> In Burundi and Zimbabwe, programs targeting social norms (which represent perceived social pressure towards a behavior) and self-efficacy appeared to be effective for increasing handwashing practices in school children. In Burundi, the program should also include increasing perceived severity of consequences of diarrhea, while in Zimbabwe, the program should also include increasing children's health knowledge and addressing depression as an underlying factor.<sup>86</sup> In Zimbabwe, knowledge of effective handwashing, availability of a handwashing station with functioning water tap, self-reported frequency of handwashing, perceived vulnerability, and action planning were determinants of effective handwashing techniques among caregivers of under-five children.<sup>72</sup>

Table 4.

Drivers of Handwashing	Location
<b>Healthcare Facilities</b>	
Reasons given by doctors for not practicing hand hygiene were non-accessibility of sinks or alcohol-based hand rubs at points of care and lack of hand drying materials; among nurses it was the belief that their hands are not dirty or hand hygiene is not so important for every patient. When asked why they practice hand hygiene, only 8% reported being motivated by their colleagues. <sup>87</sup>	India
A total of 342 HH opportunities were observed and overall hand hygiene compliance was found to be 14.6% at a tertiary care hospital. Compliance was higher in ICUs (28%) compared to in wards (8.5%). The highest compliance rate was observed in the nephrology (44.4%) and oncology (27.3%) wards. Patients admitted in these departments are more immuno-compromised compared to other patients, which may drive higher compliance rates, as most HCWs in these departments (68%) self-reported practicing hand hygiene because they were concerned about the safety of patients. <sup>87</sup>	
A comparison of psychosocial and organizational factors associated with hand hygiene compliance and perceived need for improvement revealed that factors influencing hand hygiene practices differed between physicians, nurses, and allied health professionals. Interventions to prevent HAIs should therefore be specifically targeted to different groups. <sup>88</sup>	Singapore
Physicians were forgetful but appreciated reminders, while nurses were intrinsically motivated for hand hygiene. Having positive knowledge-attitudes-behaviors (OR 1.44), personal motivators-enablers (OR 1.60) and emotional motivators (1.62, all at 95% CI) were positively related to good compliance. <sup>88</sup>	
Cultural determinants of hand hygiene compliance were observed in a study conducted with Polish medical students and physicians. Medical students are socialized in medical school in a way that prevents them from questioning negative behaviors or reminding others to perform hand hygiene in required situations. Students have respect for medical personnel with extensive experience and knowledge, and tend not to speak out if someone does not follow the rules. The authors felt this dynamic was related to the national culture and a trend toward building hierarchical structures based on large power distances. <sup>59</sup>	Poland

Physicians and interns surveyed felt that the most important preventive action against HCAs was hand hygiene, but students thought it was the use of disposable gloves. <sup>59</sup>	
HCWs had adequate knowledge of hand hygiene to prevent HCAs, but due to poor monitoring, that did not translate into compliance. Years of work experience was not significantly associated with increased compliance, but educational level was. <sup>58</sup>	Nigeria
All 37 HCFs with maternity units in Zanzibar were assessed to determine enabling factors for hand hygiene according to the WHO 'cleans' framework on infection prevention and control (IPC), focusing on key practices (e.g., having clean hands) for prevention of newborn and maternal sepsis. The 4 enabling factors investigated were: knowledge and training, infrastructure (including equipment), staffing levels, and policies (see below). Composite indices were constructed for each enabling factor. <sup>83</sup>	Zanzibar
Complete coverage of knowledge and training around clean hands was 38%, though 70% of HCFs reported having some kind of hand hygiene training. <sup>83</sup>	
Infrastructure conditions for handwashing were met by only 49% of HCFs; lack of running water was seen as a major problem, with the alternative being to use stored water, samples of which had high levels of bacterial contamination. <sup>83</sup>	
Staffing shortages and high caseloads were often cited as reasons for poor IPC. <sup>83</sup>	
Policies or posters about handwashing were available in 51% of HCFs, and only 3 of 7 wards observed in the walkthrough had a poster on hand hygiene displayed in the maternity area. <sup>83</sup>	
Across nearly all indices, HCFs with an operating theatre performed better, in terms of all 4 enabling factors, compared with smaller facilities providing basic obstetric care. Overall facilities' performance across all enabling factors was poor, with nearly all indices being met by no more than half of HCFs. <sup>83</sup>	
Although 97% of healthcare workers reported observing hand hygiene practices, only 70% did so consistently. The main barriers to consistent hand hygiene practices were unavailability of soap (88%) and irregular water supply (51%). <sup>14</sup>	Nigeria
In cases of overcrowding, which can be common in resource-poor settings, the patient-zone-based 5 Moments for Hand Hygiene approach may not optimize the prevention of healthcare-associated infections. HCWs are faced with a dilemma in the performance of hand hygiene, and adapting the 5MHH approach for the care of patients in overcrowded settings could help maximize HCAI prevention. <sup>51</sup>	LMICs
An evaluation of the effect of listening to music on surgical hand disinfection showed that the duration of surgical hand disinfection exceeded 2 minutes in both the intervention and control groups; background music did not achieve an increase in the time spent scrubbing. Listening to music did reduce the proportion of very short scrub times (<90 seconds) from 17% to 9%. <sup>89</sup>	Switzerland
Factors which were positively linked to increased mean scrub time were female sex, lower staff seniority, washing hands in groups, and stop watch usage. <sup>89</sup>	
An evaluation of three different educational programs on improving hand hygiene practice (1: role model training for pediatrics; 2: active presentation for surgery; 3: combination of 1 and 2 for internal medicine; 4: control group - obstetrics-gynecology) showed that hand hygiene compliance rate improved significantly in pediatrics (24% to 44%), internal medicine (5% to 19%), and obstetrics-gynecology (10% to 21%), but nurses' incorrect use of hand rub while wearing gloves also increased. <sup>90</sup>	Indonesia
The "strong smell of hand alcohol" as a reason for non-compliance increased significantly in the departments that received the hand hygiene intervention. <sup>90</sup>	
<b>Caregivers of Children under the Age of 5</b>	
Effective handwashing technique, thorough handscrubbing, and soap use were negatively associated with participants' perception that they showed a good example to children when washing hands in the recommended way. Researchers hypothesized that participants may believe it was a waste of soap if children used soap, as they might just play with it. This hypothesis is supported by findings from the qualitative pre-test of the survey, in which participants voiced concern that children might waste soap. Since this suggests reverse causality, interventions targeting this factor are not recommended. <sup>72</sup>	Zimbabwe
Knowledge and attitude of caregivers towards handwashing were identified as significant factors associated with the practice of effective handwashing. However, the majority of those with a "good" attitude were still not practicing effective handwashing. Barriers described included not having a reliable water supply in the household and respondents lacking soap. <sup>84</sup>	Nigeria

In a cross-sectional study on handwashing practices among 250 mothers of under-five children in urban slums in Coimbatore in Tamil Nadu, Southern India, the age of the mother, literacy status, and joint family system were associated with good handwashing practice. <sup>91</sup>	India
Community health clubs – a model for promoting healthy practices such as handwashing with soap – had no effect on caregiver-reported diarrhea among children younger than 5, casting doubt on the value of implementing this intervention at scale. It is noteworthy that HW stations were almost non-existent among study households. <sup>92</sup>	Rwanda
In an exploratory cross-sectional design on awareness of child feces management systems, safe sanitation practice among caregivers of children age under 5 years was associated with being rich (i.e., of high socioeconomic status), while knowledge of safe sanitation was associated with ownership of household toilet, night feces management chain practice, and disposal of anal cleaning materials. <sup>40</sup>	Nigeria
<b>In Schools and Among Children</b>	
A program targeting social norms and self-efficacy would be most effective for school children in increasing handwashing practices. Researchers found that, in rural Burundi, raising the children's perceived severity of the consequences of contracting diarrhea, and in Zimbabwe, increasing the children's health knowledge should be elements of the interventions. <sup>86</sup>	Burundi & Zimbabwe
Social environment interventions (education and cultural practices) alone, without alterations in the structural environment (improved access to soap and water), did not alter handwashing behaviors. Combined improvements in structural and social environments significantly motivated routine risk reduction behaviors such as handwashing. <sup>85</sup>	South Africa
More than half the children assessed in a study in peri-urban Harare were found to be depressed. Childhood depression exerts a negative influence on handwashing in children; depression-relieving measures should be conducted together with any WASH interventions. <sup>93</sup>	Zimbabwe
Using the RANAS model of behavior change, researchers assessed the behavioral determinants of HW and found that these determinants worked differently, and were significantly lower, in depressed children versus non-depressed children. This was especially true in perceived vulnerability (fear of contracting diarrhea), perceived severity (personal consternation in case of contracting diarrhea), health knowledge, instrumental beliefs (benefits and costs of handwashing), affective beliefs (experiencing pleasure during handwashing), injunctive norm (what others think about handwashing), remembering (forgetting), commitment (importance of handwashing and guilt in case of not washing hands at critical times), and intention to always wash hands with soap. <sup>93</sup>	
Although the majority of 6-18 year-old public school students in the study usually washed their hands, not washing hands was associated with perceptions that there was 'no need' (70.8%) and 'the hand-washing facilities were not clean' (62.3%). <sup>37</sup>	Jordan
While school children's knowledge practice and self-efficacy in proper handwashing were low, significant associations were found between gender (girls higher than boys), academic achievements (positive association) and practices with self-efficacy in proper handwashing. <sup>94</sup>	Malaysia
<b>Education and Training on Handwashing</b>	
Evaluating the effectiveness of HH education, in a random sample of community women, a better HH awareness score was significantly associated with scarce bacterial growth and absence of potential pathogens. <sup>42</sup>	Mauritius
A trial found that nutrition education for adolescent girls increased their handwashing practice and the tendency to use hygienic materials for handwashing. <sup>95</sup>	Bangladesh
In a cross-sectional survey of 523 Indian medical undergraduates, nearly 57% of the respondents had never received any formal training in hand hygiene throughout their course of study, and awareness of proper HH practices was low, with only 12% of respondents possessing a good level of HH knowledge. <sup>96</sup>	India
<b>Other</b>	
In addition to well-recognized antecedents related to fecal contact and dirt on hands, researchers identified other behavioral antecedents for handwashing in a low-income urban setting: cutting greasy fish, having a meal, contact with oil and fat stuck to dishes, oil and lice from hair, sweat, unwashed vegetables, reminders from a son or daughter, observing others wash hands, and seeing the evening sky or coming back from outside at night (e.g., for prayer). <sup>68</sup>	Bangladesh

## Measuring Hardware Access and Soap Efficacy

Access to adequate handwashing hardware and WASH infrastructure, including a reliable supply of water and soap, is paramount for ensuring that daily handwashing can be practiced at recommended times in households, schools, communities, and workplaces. Placement is key in hospitals and other healthcare facilities, as well as in public and household food preparation areas, near toilets and child-changing areas.

### WASH Infrastructure / Handwashing Hardware in Various Settings

Research demonstrates the need to promote and expand access to handwashing materials, including soap, and placement at handwashing locations in one's dwelling,<sup>3,40</sup> and in schools,<sup>6</sup> particularly in poorer, rural areas where children are more vulnerable to handwashing-preventable diseases such as pneumonia and diarrheal diseases.<sup>3</sup>

The WHO recommends that health care facilities have 'a reliable water point, with soap or a suitable alternative, available at all critical points within the health-care setting and in service areas' and 'at least two handwashing sinks in wards with more than 20 beds' – criteria that are often not met, especially in smaller and rural health care facilities, and where overcrowding is the norm.<sup>97</sup> Furthermore, measuring water access may overestimate coverage in health care facilities because the actual functionality of handwashing stations may not be directly observed.<sup>97</sup>

### Measuring Soap Efficacy

Many studies assessed and compared the efficacy of various types of soaps and sanitizers, including bar soaps, both antimicrobial and bland; various chlorine solutions; alcohol-based hand rubs; soapy water solutions, and so on (see results in the table below). Further research is recommended to assess various handwashing protocols and other ways of handwashing, including with the use of iodine-based scrubs, alcohol-based foams and wipes, traditional practices such as using ash or sand, and washing of gloved hands with any of these approaches.<sup>9</sup>

### Alcohol-Based Hand Sanitizers

Mixed results were observed in different studies, but overall most showed ABHS to be efficacious. In some regards, ABHS seemed to be better than soap, e.g., cheaper and quicker,<sup>98</sup> easy to use and no water is required<sup>9</sup> – but ABHS appeared inferior to handwashing with soap in preventing gastrointestinal<sup>99</sup> and *C. difficile* infections.<sup>27</sup>

### Soapy Water

Increasing the availability and promotion of affordable alternatives to bar soap, such as soapy water, may close the gap in access to soap for handwashing in low-income households.<sup>3</sup> Soapy water preparation is easy, low cost, and equivalent to soap in terms of its antimicrobial efficacy, which may facilitate uptake, particularly since materials are less likely to be stolen than bar soap.<sup>71</sup> Soapy water is currently used at a relatively small scale, but should be considered for future interventions.

### Surgical Glove Use

Gloves, combined with proper hand hygiene, can be helpful in preventing the spread of pathogens, but improper usage may be common,<sup>53,55</sup> and dispensers in exam and surgical rooms in HCFs can carry environmental pathogens.<sup>100</sup>

### Digital Technology

Mobile applications may aid in teaching and promoting good hand hygiene, and new technologies such as non-wearable or wearable sensor systems can be helpful for hand hygiene monitoring. Including users in the design, and pretesting the acceptability of technologies (such as automatic sinks), may increase uptake and efficacy.<sup>101, 102</sup>

Table 5.

<b>Hardware for Handwashing and Soap Efficacy</b>	<b>Location</b>
<b>Hardware in Schools</b>	
In one study of 30 schools, 16 reported having a designated handwashing time before serving food, and only one school had a handwashing area away from the latrines and with piped water. <sup>38</sup>	Ethiopia
An examination of WASH in rural schools revealed that few school were equipped with improved water sources on the premises, improved sanitation, and water and soap for handwashing; provision rates for these ranged from 1% of rural schools in Ethiopia and Mozambique, 2% in Zambia, 5% in Kenya, and 9% in Uganda, to 23% in Rwanda. A survey showed that 0-10% of schools had all 3 recommended HW materials (water, soap/ash, and drying materials). <sup>39</sup>	Sub-Saharan Africa
<b>Hardware in Households</b>	
An analysis of access to household handwashing stations with soap showed large differences in average levels of access (ranging from less than 1% to over 90%), but in all countries, wealthier households were more likely to have soap available. <sup>3</sup>	Multiple Countries
Of 536 households surveyed, less than 10% had latrines equipped with hand-washing facilities including soap. <sup>79</sup>	Tanzania
Only 4.4% of households in a study in the urban slums of Addis Ababa had hand washing facilities within or near a latrine with soap and water access. <sup>19</sup>	Ethiopia
<b>Hardware in Healthcare Facilities</b>	
A study of WASH conducted in 1,318 randomly selected rural healthcare facilities – in Kenya, Ethiopia, Mozambique, Rwanda, Uganda, and Zambia – found that fewer than 25% in each country reported having water, soap, and hand-drying materials always available. <sup>4</sup>	Sub-Saharan Africa
Low-cost portable handwashing water stations were installed in rural Kenyan HCFs in 2011. The improvement of access to handwashing with soap was deemed cost-effective: HCF/\$1,527, \$217/health worker, and \$0.17/individual. <sup>103</sup>	Kenya
Water for handwashing was available in more than 95% of HCFs, but soap was present 67% of the time and hand disinfectant 18% of the time in hospitals observed. <sup>104</sup>	Malawi
In rural HCFs observed, 7 out of 10 had water available at all critical hand hygiene locations, though some services shared a sink due to close proximity. Overall, only about 1/3 of HW locations had soap available, and most of the water access points with soap were found in areas for staff members, not patients or caregivers. <sup>97</sup>	Rwanda
<b>Alcohol-Based Hand Sanitizers</b>	
In this laboratory-based comparative study of antimicrobial effectiveness between presurgical hand hygiene with hydroalcoholic solution versus traditional presurgical hand hygiene, the hydroalcoholic solution significantly decreased colony-forming units, had similar latency time, a lower cost, and saved time more than traditional presurgical hand hygiene. <sup>98</sup>	Spain
In a workplace-based study, rubbing with an ethanol-based disinfectant did not reduce the symptom prevalence of respiratory tract infection or gastrointestinal tract infection, while subjects in the soap-and-water arm reported a 24% lower weekly prevalence of gastrointestinal tract infection. <sup>99</sup>	Finland
In an experimental study evaluating the influence of hand-rubbing duration on the reduction of bacterial counts on the hands of health care workers, hand rubbing for 15 seconds was not inferior to 30 seconds in reducing bacterial counts on hands, and rubbing longer than 30 seconds showed no additional gain in effect. <sup>105</sup>	Switzerland
This study assessed the relative bactericidal efficacy of 10 different marketed ABHS using agar diffusion and broth dilution assays along with the viable bacteria count reduction assay. For all ABHS products, pre-treatment levels of viable bacteria on hands were higher than post-treatment, but results varied widely, with only one showing strong inhibitory effects on all kinds of bacteria. Findings emphasize the need for regulation to monitor antibacterial susceptibility of all brands of ABHS. <sup>106</sup>	Ghana
Hand lotion is needed by many healthcare workers, as the prevalence of eczematous hand lesions among HC workers is between 20% and 40%. In an experimental study that investigated the effect of a hand lotion on hygienic hand antisepsis using an alcohol-based handrub (with 5 minutes of interval between lotion and the alcohol) using 2 treatment groups and 1 control group, the effectiveness of hand antisepsis was not significantly affected in any of the groups using the tested hand lotion. <sup>107</sup>	Austria

Findings obtained through two different decision making methods suggest that alcohol-based antiseptic solution (ABAS) has the highest utility (0.86) and priority (0.69) among the choices for specialists in IDCM (infectious diseases and clinical microbiology) to prevent nosocomial infection. <sup>108</sup>	Turkey
<i>C. difficile</i> infections increased 31% in a 19-month study period which could be associated with the use of alcohol-based hand sanitizer and sanitizer wipes instead of handwashing with soap, since the latter is recommended for use to prevent the spread of <i>C. difficile</i> . <sup>27</sup>	USA
An informal literature review comparing the efficacy of handwashing methods had mixed results; of 14 studies, 5 found ABHS to be more effective than HWWS for removing organisms, while 7 found HWWS more effective than ABHS, and two found no significant difference. <sup>109</sup>	N/A
<b>Antimicrobial Soaps</b>	
In a laboratory-based study that investigated the influence of key variables (soap volume, lather time, water temperature, product formulation) on handwashing efficacy, an antimicrobial soap formulation (1% chloroxylenol) was not significantly more effective than bland soap for removing <i>E. coli</i> under a variety of test conditions. <sup>110</sup>	N/A
Washing with antimicrobial soap was more effective for reducing bacteria ( <i>E. coli</i> and <i>E. faecalis</i> ) on soiled hands than was washing with water or non-antimicrobial soap. However, the persistence or growth of bacteria in the rinse water still poses health risks. <sup>111</sup>	Mexico
<b>Soapy Water</b>	
A nonrandomized trial of the feasibility and acceptability of strategies for promotion of handwashing in a rural setting found that soapy water may increase habitual handwashing by addressing barriers of cost and availability of handwashing agents near water sources. Post-intervention, uptake of soap or soapy water was found in: 18% of households with only promotion; 60% of households with promotion and handwashing station; 71% in households with promotion, station, and detergent refill, compared to 6% in houses with no intervention. <sup>71</sup>	Bangladesh
<b>Low or no-cost cleansing agents and methods</b>	
Low- or no-cost hand cleansing agents, such as ash, were rarely observed in households in any of the countries included in an analysis of 51 LMICs. <sup>3</sup>	Multiple LMICs
<b>Surgical Glove Use</b>	
Investigators assessed the effect of hand hygiene and glove use on maintenance of reusable surgical instruments cleanliness and found that RSI inspection, assembling, lubricating, and packing should be performed using either gloves or within 1 hour of washing hands. The longer hands remained unwashed (e.g., 2 or 4 hours) before packing RSI, the higher the contamination. <sup>112</sup>	Brazil
A study investigating contamination of nonsterile examination gloves in an Emergency Department setting according to type of dispenser used to access the gloves demonstrated that disposable gloves were contaminated; glove boxes and dispensers available to healthcare workers are often contaminated by daily exposure to environmental organisms. A newly designed glove dispenser, such as a downward-facing one, may reduce contamination. <sup>100</sup>	USA
An evaluation of hand hygiene programs aimed at improving compliance at a rural hospital in Rwanda showed that although gloves were often available in different departments in a rural hospital, there were often no waste containers for safe glove disposal. <sup>52</sup>	Rwanda
<b>Monitoring Systems</b>	
A new automated hand hygiene compliance system was trialed as an alternative to human observers in an ICU and found to be a promising new tool for fine-grained assessment of hand hygiene compliance. <sup>113</sup>	N/A
Morphological Analysis can play a role in developing and improving the efficacy of hand hygiene monitoring in healthcare. Condition monitoring measures, such as staff satisfaction, may also improve hand hygiene monitoring. <sup>114</sup>	N/A
A quasi-experimental study on the effect of a simplified prevention bundle on the incidence of early-onset ventilation-associated pneumonia demonstrated that a knowing, internal hand hygiene audit or monitoring system provided better and faster improvement in practice compared to unaware, external audit. <sup>115</sup>	Taiwan
Researchers developed and validated a Real Time Location System (the Elpas II system) to reliably monitor everyday activities in natural contexts, and determined it to be a valuable, unobtrusive, robust, and flexible monitoring system for behaviors such as handwashing. An RTLS combines	N/A

wearable and environmental sensors to identify, track and log the time and physical location of actions and actors. <sup>116</sup>	
A new, user-designed mobile application supports peer monitoring and training in hand hygiene, and aims to contribute to evidence on reductions in HCAs in surgical ICUs in Sri Lanka. Preliminary insights demonstrate important steps toward user behavior change. <sup>11</sup>	Sri Lanka
<b>Technology</b>	
This study used a version of the technology acceptance model to assess user experience and acceptance towards two modes of handwashing, using a new automated sink compared to a normal sink. Perceived Ease of Use and Satisfaction of Use were significantly lower for the automated sink, compared to the conventional sink ( $p < 0.005$ ). <sup>102</sup>	United Kingdom
Study found that an educational mobile game application called Arbi Care (for Android) was effective as a means to prevent diarrhea, increase handwashing practice, and build self-efficacy in handwashing among preschool children. <sup>101</sup>	Indonesia
<b>Other</b>	
Ultraviolet spectrum markers were validated with a microbiology-based assessment. Statistical evaluation revealed that the method – disinfecting with UV-dyed hand-rub solution after contamination – indicated correctly disinfected areas with 95% sensitivity and 98% specificity. <sup>117</sup>	N/A
In a laboratory-based study on the influences of key variables, such as soap volume, lather time, water temperature, and product formulation on handwashing efficacy, water temperature as high as 38°C and as low as 15°C did not have a significant effect on the reduction of bacteria during handwashing. <sup>110</sup>	N/A

## Abbreviations

ABHS	alcohol-based hand sanitizer (or rub)
CI	confidence interval
CLTS	Community-Led Total Sanitation
DALY	disability-adjusted life years
EVD	Ebola virus disease
GBD	Global Burden of Diseases, Injuries, and Risk Factors Study (2016)
HCAI	healthcare-associated infection
HCW	healthcare worker
HH	hand hygiene
HW	handwashing
HWWS	handwashing with soap
ICU	intensive care unit
IPC	infection prevention and control
LMICs	lower and middle income countries
MDGs	Millennium Development Goals (1990-2015)
ODF	Open Defecation Free status
OR	odds ratio
PHH	patient hand hygiene
RCT	randomized controlled trial
SDGs	Sustainable Development Goals (2016-2030)
SSA	Sub-Saharan Africa
WASH	water, sanitation, and hygiene
WHO	World Health Organization

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