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Major Article

Handwashing, but how? Microbial effectiveness of existing handwashing practices in high-density suburbs of Harare, Zimbabwe

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Background: Consistent domestic hand hygiene can reduce diarrhea-related morbidity and mortality and the spread of other communicable diseases. However, it remains uncertain which technique of handwashing is most effective and practicable during everyday life. The goal of this study is to determine how the handwashing technique, as performed in the daily life by the participants of this case study in Harare, Zimbabwe, influences microbial handwashing effectiveness.

Methods: Handwashing technique of 173 primary caregivers was observed in their homes and hand rinse samples were collected before and after handwashing. Samples were analyzed for *Escherichia coli* and total coliform concentrations. Generalized linear models were used to predict fecal hand contamination after washing from observed handwashing technique.

Results: Cleaning under fingernails, scrubbing the fingertips, using soap, and drying hands through rubbing on clothes or a clean towel statistically significantly reduced *E coli* contamination of hands after washing. Tap use, scrubbing fingertips, and rubbing hands on clothes to dry them statistically significantly reduced total coliform contamination.

Conclusions: Recommendations for effective and practicable domestic handwashing in Harare, Zimbabwe, should include performing specific handscrubbing steps (ie, cleaning under the fingernails and rubbing the fingertips), and soap and tap use. This calls for further research to develop behavior change interventions that explicitly promote effective handwashing technique at critical times.

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Consistent hand hygiene can reduce diarrhea-related morbidity and mortality. Diarrhea is among the leading causes of childhood mortality worldwide.[1] Fischer Walker et al[2] estimated that in 2011, 700,000 children died of diarrhea, with highest rates in South East Asia and Africa. According to estimations by Prüss-Ustün et al,[3] 297.000 deaths were caused by inadequate hand hygiene worldwide during 2012. Handwashing at critical times, such as before eating, cooking, or other contact with food and after defecation and other contact with feces was shown to be among the most cost-effective methods to reduce diarrhea.[4-7] Despite its importance, handwashing with soap is only practiced by a small proportion of people worldwide.[4] This calls for effective handwashing promotion on a large scale.

Among others, the Centers for Disease Control and Prevention (CDC) and the World Health Organization provide recommendations on effective handwashing in health care settings.[8,9] For domestic handwashing, the CDC[10] recommends the following 5 steps:

1. Wet your hands with clean, running water (warm or cold), turn off the tap, and apply soap.
2. Lather your hands by rubbing them together with the soap. Be sure to lather the backs of your hands, between your fingers, and under your nails.
3. Scrub your hands for at least 20 seconds.
4. Rinse your hands well under clean, running water.
5. Dry your hands using a clean towel or air-dry them.

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However, the microbial effectiveness of the recommended steps is only partly substantiated. Further, it remains uncertain whether performing the steps throughout the daily routine is acceptable for potential participants of handwashing-promotion activities.

Comprehensive evidence to sustain the importance of the recommended steps is limited to soap use[11-14] and does not corroborate the remaining steps. To our knowledge, there are no studies corroborating the first step's suggestion for running water: No studies have compared the effectiveness of handwashing with running water versus, for example, stored water. With regard to characteristics of handwashing water, field experiments suggest that increased water volume and quality of handwashing water are associated with cleaner hands after washing.[15] Further, the influence of thoroughness of handwashing, described by both length[12,16-18] and scrubbing steps[19] is uncertain. Evidence on which hand-drying technique is most effective are mixed[20-22] and recontamination of hands from contaminated clothes is likely.[23] None of the existing studies evaluate the relative importance of different handwashing steps. Further, most presented findings originate from laboratory or field experiments that compared prespecified handwashing regimens, in which singular handwashing steps were manipulated while the remaining handwashing technique remained constant.[11,12,16,19] The studies therefore do not represent handwashing as performed by community members in their daily life, which some authors have suggested should be tested.[12,24]

Handwashing campaigns should promote a technique of handwashing that is both effective in the local context and acceptable for the target population. Everyday life compliance with washing hands according to complex guidelines is assumed to be low.[18,24] Particularly in developing countries, the CDC guidelines may be difficult to follow because running water from a tap and a clean towel, for instance, are often not available.[25] In addition, local customs may suggest different handwashing procedures, such as in Zimbabwe where hands are traditionally moistened and rinsed in a bowl of water.[26] As a consequence, investigating which handwashing steps are already in practice in the target population and determining their effectiveness in the context where they are usually performed is needed to decide which handwashing technique should be promoted.

Taken together, there are substantial gaps in the understanding of which handwashing technique to promote to achieve microbial effective domestic handwashing in a specific target population. The goal of the present study is to determine how the handwashing technique, as performed in the daily life by the participants of this case study in Harare, Zimbabwe, influences handwashing effectiveness. Based on the findings, substantiated and parsimonious recommendations for effective handwashing in the target population are provided.

MATERIALS AND METHODS

Participants

This study was implemented during June and July 2014 in 10 high-density and low-income suburbs of Harare, Zimbabwe. One working day before data collection, participants were recruited through random route sampling by selecting every fifth household starting from junctions in the study area. Because this study was part of a larger study, households needed to have at least 1 child attending the local primary school to be included in the sampling frame. Within each household, the primary caregiver was selected for the study and informed written consent was obtained. Nonresponding, ineligible, and refusing households were replaced by the fifth-next household on the sampling route. In total, 198 primary care givers were sampled.

Enumerator training

Before data collection, enumerators were enrolled in a 1-week training on sampling, observation, and interviewing techniques. To maximize standardization in the enumerators' assessment of handwashing techniques, enumerators performed the different components of handwashing themselves and practiced observation of each other's handwashing technique under supervision during the training. During a second training week, enumerators practiced data collection in the field and performed handwashing observations under supervision in at least 1 household before the actual data collection.

Data collection

Microbial contamination of hands was measured using hand rinse samples as previously reported.[27] The data collector randomly selected the first hand to be sampled through the random function of OpenDataKit software (Department of Computer Science and Engineering, University of Washington, Seattle, WA) on a tablet computer.[28] The selected hand of the participant was placed in a 2,040 mL sterile sampling bag (NASCO Corp, Fort Atkinson, WI) filled with 350 mL bottled water containing 17.5 mg/L sodium thiosulfate. Sodium thiosulfate had been added to inactivate residual chlorine potentially present in the water. The bag was fastened around the participant's wrist with a flexible rubber strap. The participant's hand was massaged in a standardized way. First, the palm of the hand, excluding fingers, was massaged for 10 seconds. Then, for each finger, the palm and back of the finger were simultaneously massaged for 5 seconds, both sides of the finger were simultaneously massaged for 5 seconds, the tip of the finger was massaged for 5 seconds, and the webbing to the subsequent finger for 5 seconds. Finally the back of the hand was massaged for 10 seconds. The participant's hand was withdrawn from the bag and the bag was closed and immediately placed in a cooler box with ice. The participant's hand was dried with a paper towel. Enumerators wore new nonsterile gloves for each hand sampling.

Subsequently, the participant was requested to wash hands in the way the participant would usually do either "before handling food" or "after contact with feces." The prompt concerning which of the 2 critical moments the enumerator stated was determined through the OpenDataKit random function. The respondent was explicitly reminded to demonstrate the way he or she would usually wash hands in such occasions. Structured observation of the demonstrated handwashing technique was performed while the total time that the respondent washed hands was determined with the stopwatch function of the enumerator's wristwatch. Handwashing steps observed included method of moistening hands, soap or other detergent use, performed scrubbing steps, method of rinsing hands, and way of drying hands (Table 1).

The second hand rinse sample was taken immediately after the handwashing demonstration from the hand that had not yet been sampled. The same procedure as described for the first sample was applied. After the second sampling, the enumerator recorded the handwashing observation data on the tablet computer.

The sociodemographic characteristics of participants were subsequently collected in a standardized face-to-face interview. The questionnaire had been developed in English, translated into the local Shona language, and retranslated into English to reduce risk of potential translation mistakes. It was programmed with OpenDataKit and filled on tablet computers. Spot-check observations regarding the presence of separate handwashing facilities for food- and stool-related handwashing, presence of soap and water at these locations, and type of the device to dispense water were performed at the end of each household visit.

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