The impact of a school-based hygiene education intervention on student knowledge in Kenya
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ABSTRACT
Recent research indicates that investments in infrastructure for safe water and sanitation provision do not significantly reduce the incidence of water-borne diseases in the developing world unless they are accompanied by education in water handling and hygiene practices. School-based hygiene education initiatives are popular, but there is little evidence that they are effective in teaching students about safe water-handling practices. This study compared the outcomes of two approaches to teaching schoolchildren about the links between hygiene, water handling, and water-borne diarrhea. One approach combined messages about safe water handling and hygiene practices with water testing; the other used messages alone. A quasi-experimental design was used with 120 middle-school students. Forty students received messages alone, 40 received messages and tested water quality, and 40 served as a control group. An evaluation 1 week after the interventions measured students’ hygiene knowledge. Results showed significant improvement in knowledge among students who received messages and tested water, compared to their counterparts who received intervention through hygiene messages only. Evaluation after 12 months showed that the hygiene knowledge gained in both groups was retained. Including participatory water testing in hygiene education interventions can improve students’ knowledge about safe water handling and hygiene practices.

Key words | drinking-water quality, hand washing, hygiene education, Kenya, schoolchildren, water-borne diarrhea

INTRODUCTION
About 780 million of the world’s people lack access to safe water and must rely on sources that are contaminated (WHO 2010). Contaminated water is the leading cause of diarrheal illness, especially in children in developing nations (WHO 2010). Despite much evidence supporting the effectiveness of point-of-use (POU) water treatment and storage measures in controlling water-borne diarrhea, secondary contamination of drinking water persists, and many households still live in unsanitary conditions and use poor water storage and hygiene practices (Mintz et al. 1995; Mirza et al. 1997; Roberts et al. 2001).

Schoolchildren are among those who suffer most from inadequate hygiene and unsafe water, particularly those attending schools in informal settlements and in peri-urban and rural areas of developing countries (APHRC 2002). In these places, use of unsafe water persists because of knowledge gaps and traditional attitudes, making children unable to develop and use adequate hygiene habits (Wasonga et al. 2014). A recent study in Ghana underscored the need for integrated communication programs for promoting hygiene because mass media are unlikely to benefit socio-economically marginalized groups (Scott et al. 2008). The objective of this study was to find out whether school-based hygiene education intervention that combined messages with participatory water testing increased students’ knowledge about safe water handling and hygienic practices more than an intervention that used messages only.
Water, sanitation, and hygiene interventions in schools

The majority of primary schools in slums in sub-Saharan Africa lack basic water and sanitation infrastructure (Mugisha 2006). Thus, besides hauling water for domestic needs, children also carry water from home or collect it from contaminated sources to drink while they are in school. Poor water quality and/or unhygienic water collection and handling practices cause water-borne illnesses among children and thus contribute to student absenteeism (Freeman et al. 2012; Garn et al. 2013). In other words, they have harmful effects on educational attainment as well as on health. Recent studies have also found that lack of infrastructure, particularly toilets, is a major reason for low enrollment of girls in primary schools (Mugisha 2006). The problems of poverty, inadequate water and sanitation infrastructure, low school enrollment rates (especially for girls), poor hygiene practices, and high incidence of diarrheal illnesses are all intertwined. To mitigate these problems, donors and governments have increased investments in improved water and sanitation infrastructure in primary schools in the slums (UNICEF 2010). Efforts, which began in the 1990s, include providing schools with a piped water supply, rainwater harvesting and storage, protection of wells, and building of toilets (O’Reilly et al. 2008; AWF 2010; Greene et al. 2012).

Despite massive investments in physical infrastructure, achieving real gains in student hand-washing has been slow and has revealed several underlying problems that often create unexpected outcomes (Greene et al. 2012). For instance, a recent study in Western Kenya found higher rates of fecal contamination on the hands of students in schools with new investments in toilet facilities than on those of students in a control group at schools with no such investments (Greene et al. 2012). The study suggested several reasons for the findings, including lack of knowledge about hand-washing and hygiene practices, and lack of sufficient water and/or soap for cleaning. The recent work by Greene and others (2012) raises concerns that toilet building alone may be insufficient to improve hygiene outcomes among schoolchildren. Further interventions are needed to improve children’s knowledge about basic hygiene and change their behaviors (Roberts et al. 2001; Cairncross et al. 2010).

The larger issue here, which goes beyond the specific case of sub-Saharan Africa, is that compared with the investments in building infrastructure, there has been limited research in finding effective ways to educate people, especially children, about the links between water collection and handling behavior and health outcomes (Mintz et al. 1995; Bartlett 2003). Scott et al. (2008) emphasized the need to utilize a variety of complementary channels to communicate hand hygiene messages. Hygiene practices are habits that are embedded in social and cultural norms, and this can hinder the effectiveness of messages (Cairncross et al. 2010). Even when behavioral change is initiated, it is often difficult to sustain (Biran et al. 2014). Hygiene education is considered one of the most economically efficient ways to improve health outcomes, especially in schools in informal settlements, peri-urban and rural areas of the developing countries where children are at high risk of contracting diseases related to poor sanitation (Bartlett 2003).

Hygiene education campaigns are most effective with the young, and students can be both beneficiaries and agents of behavioral change in their families and their communities (WHO 2014). Because hygiene practices are habitual, hygiene messages are most effectively imparted at an early enough age to influence habit formation (Mobley & Evashevski 2000; Curtis et al. 2011). Children are more receptive to new ideas and amenable to change than adults. Children bear most of the responsibility for water collection, so it makes sense to educate them to become agents of change in their communities (Naidoo et al. 2008). Finally, children are more vulnerable to unsafe water and poor sanitation conditions than adults: it is estimated that 1.3 million children under 5-years old die every year from water-borne diarrheal disease (Black et al. 2010).

Over the past decade, several sub-Saharan countries have tried to improve health outcomes for children by including hygiene education in school curricula (Onyango-Ouma et al. 2005). In Kenya, hygiene education begins in first grade, but public schools have limited resources and crowded classrooms, which together make learning about any subject difficult. Moreover, mounting pressure on the government to provide free primary education has led to an increase in enrollment that exceeds the human and physical infrastructure capacities of public schools (Mugisha
Also, because hygiene literacy is not evaluated by the country's national examinations, teachers pay only cursory attention to it.

This study sought a simple and innovative way to help children who live in slums understand the links between water handling, hygienic practices, and water contamination. The study aimed to answer the following questions:

1. Do students who participate in a health education intervention that combines hygiene messages with participatory water testing learn more about the links between water handling, hygienic practices, and water contamination than students who participate in an intervention consisting of hygiene messages only?

2. Are learning gains retained better by students who get hygiene messages and participate in water testing than by their counterparts who learn through hygiene messages alone?

**Participatory water testing in hygiene WASH interventions**

Recent advances in water testing technology make it possible for educators to include participatory water testing in hygiene education. Today, chromogenic enzymes (CE) can simultaneously measure the presence/absence of both total coliforms and *Escherichia coli*; older methods (e.g., most probable numbers, membrane filtration) required up to 72 hours to produce results. CE tests provide complete data in 18–24 hours, or even less when higher numbers of coliforms/*E. coli* are present in test samples (Allen et al. 2010). Such rapid microbial methods can improve public health protection (Allen et al. 2010).

Colilert is a β-galactosidase and β-glucuronidase-based commercial culture method used to assess water quality (Edberg et al. 1988). To test for the presence/absence of *E. coli* in a water source, one needs Colilert media from the manufacturer and sterile glass tubes. A sample of the water to be tested is collected using a sterile Whirl-Pak. Using a sterile pipette, 10 mL of water sample is immediately transferred to the glass tubes pre-dispensed with the Colilert media. The tubes are then incubated at 35 ± 0.5 °C for a period of 12–24 hours (Chao 2006). A color change (for total coliform bacteria) or UV-fluorescence (for *E. coli*) indicates the presence of the bacteria. Colilert is reported to be 97.7% sensitive (Hörman & Hänninen 2006).

Commercially available CE methods such as Colilert require minimal training to implement accurately and consistently (Allen et al. 2010). The challenge is how to get these techniques into the classroom and use them to make connections between hygiene practices and water quality. Individuals or institutions with access to the techniques will need to collaborate with schools to design and implement hygiene education interventions and teach students and teachers to use the techniques. In this paper, I use the case of a study conducted in May–June 2012 with six schools in Western Kenya to demonstrate how such intervention can be designed, implemented, and evaluated.

**INTERVENTION DESIGN, WATER TESTING, AND EVALUATION OF LEARNING OUTCOMES**

**Intervention design**

The study used a quasi-experimental design with pre-tests and post-tests for grade-six students at six primary schools. Two schools participated in an intervention comprising hygiene messages only, and two participated in an intervention that involved hygiene messages and water testing. Two other schools served as a control group and did not receive any intervention at all.

School principals were informed about the study and invited to participate. After all schools had agreed, a draw was held where a representative of each school drew a number indicating which intervention the school would receive. Three teachers at each school were trained to facilitate implementation of the intervention.

The study population consisted of 120 middle-school students (including the control group). The school principals gave written consent for the schools to participate. Students and their parents gave verbal consent to participate. The learning activities were based on the standard curriculum.

Each school implemented the intervention independently, guided by a written protocol. All six schools had male and female students. The teachers used a simple random sampling method, random numbers, to select 10...
boys and 10 girls from their classes to participate in the intervention. Participants’ ages ranged from 10 to 12 years. After completion of the study (including the 12-month evaluation), participants from the control schools were provided with training in implementing the intervention. The entire study protocol was approved by the Arizona State University Institutional Review Board and the National Commission for Science, Technology and Innovation (Kenya).

Training materials

The hygiene education training materials were developed using resources from UNICEF (2000), Pridmore (1997), and the grade-6 science books that the Kenyan Government recommends for middle-school students. The main science text introduces pupils to water-borne diseases, but does not cover water treatment and storage measures, and/or participatory water testing. NGOs implementing WASH in various schools in western Kenya do introduce households and schools to the various POU measures (O’Reilly et al. 2008). The materials were used with teachers in a 1-day training session. They explained the basic facts about safe water handling and hygiene; the different ways that drinking water gets contaminated during collection, transportation, and storage; methods of treating drinking water at home; and safe methods of storing drinking water. The materials also provided basic facts about cholera symptoms and treatment, and outlined the connections between drinking-water quality, sanitation, and hygiene. The two schools that participated in hygiene education combined with water testing received additional materials with simple information about bacteriological water quality testing using Colilert, how the test works, the potential sources of error and ways to minimize errors, and how to interpret the results. Each teacher was provided with a guidebook with simple steps for conducting Colilert field tests, including photo illustrations, developed by Metcalf & Stordal (2010).

Education intervention 1: hygiene messages only

In the hygiene messages only schools, teachers trained students through short lectures and question and answer discussions. Lectures and discussions focused on topics such as water-borne diarrheal diseases, water supply and treatment, safe water storage, hand washing, and domestic and environmental hygiene and sanitation. Facilitators used guided questions to find out what the students already knew, to stimulate discussions, and to find solutions to problems. The presentations and discussions were supplemented by pamphlets and work sheets.

Education intervention 2: hygiene messages combined with participatory water testing

In the intervention that combined hygiene messages with participatory water testing, teachers trained students through short lectures, group discussions, and activities. Lectures and group activities focused on the same topics as did the hygiene messages only interventions.

In addition, teachers gave presentations about the links between personal, domestic, and environmental hygiene and the microbial quality of water. The presentations described the tests that scientists do to determine the quality of drinking water. They introduced students to the Colilert method for determining the presence or absence of E. coli in water, as an indicator of fecal contamination. They described how the technique works and how results of the test are interpreted.

The goal of water testing was to reinforce the hygiene messages, and to provide an inquiry-driven process for student learning. The author worked with teachers and students to help them collect and analyze water samples from the school’s water supply, storage containers, and from the water that students brought to school to drink. In each of the two schools, 50 samples were analyzed using Colilert. The researcher provided each school with his own hand-held, long-wave UV light equipment for E. coli tests. For quality control, samples were collected and analyzed in duplicate. In addition, additional samples were collected for analysis at the Eldoret Water and Sewerage Company laboratory (P.O. Box 8418, 50,100 Eldoret, Kenya).

Impact evaluation: pre- and post-tests of hygiene knowledge

All student participants (including students from the two control schools) completed a standardized hygiene quiz administered by teachers 1 week before the interventions. A post-test was administered 1 week after the interventions.
Questions on the post-test were similar to those on the pre-test. The final quizzes were administered 12 months after the interventions. The quizzes were anonymous.

Quizzes covered the following topics: transmission of water-borne diarrhea, water contamination, water treatment and storage methods, personal, domestic and environmental hygiene. Questions were adapted from a survey conducted by O’Reilly et al. (2008) to assess middle school students’ knowledge about safe water storage and treatment (see Appendix, available online at http://www.iwaponline.com/washdev/005/134.pdf). A few questions related to domestic and environmental hygiene were added to O’Reilly et al.’s survey. Primary school science teachers reviewed the appropriateness of the quiz and grading protocol. Three independent teachers, none of whom knew which intervention group participants belonged to, graded the quizzes, thus eliminating any possibility of bias in scoring. The maximum possible score on the test was 46 points.

Statistical methods for evaluation

Statistical analyses were carried out using SPSS-21 software (SPSS Inc., Chicago, Illinois). A one-way analysis of variance (ANOVA) was conducted to compare the differences in scores between pre-test and 1 week post-test, with treatment condition as a between-subjects factor. A follow-up pairwise comparison on score differences was done using Tukey’s Honest Significant difference (HSD) to find out which differences in mean scores were significant. In addition, one-way ANOVA was conducted to compare the differences in scores between the post-tests administered 1 week after the intervention and those administered after 12 months, to test whether hygiene knowledge gained during the intervention was sustained.

RESULTS

Changes in knowledge during the intervention

Table 1 shows changes in test scores. Pre-test scores were as follows: control (mean = 28, SD = 5.5); hygiene messages only (mean = 28.1, SD = 5.8); and hygiene messages combined with participatory water testing (mean = 27.4, SD = 5.0). The differences in pre-test scores among the three groups were not statistically significant, \( F(2, 117) = 0.18, p = 0.83 \). One week after the intervention, participants in the hygiene messages only groups and the hygiene plus water testing group demonstrated a significant increase in hygiene knowledge as measured by the quiz. The greatest increase occurred in the hygiene message combined with water testing group (mean increase 12.6, vs. mean increase of 5.1 for hygiene messages only groups, \( p < 0.01 \)). The differences in pre- and post-test knowledge scores for the control group were not significant. Results of one-way ANOVA on the differences in scores between pre-test and post-test (1 week after the intervention), with condition as a between-subjects factor were statistically significant, \( F(2, 117) = 27.68, p < 0.01, \eta^2 = 0.32 \).

There were no significant changes between scores on the post-tests administered 1 week and those administered 12 months after the intervention, \( F(2, 107) = 1.83, p = 0.17 \). This suggests that the gain in hygiene knowledge during the intervention was sustained in both treatments – hygiene messages with or without water testing.

Pre-test scores showed that most participants’ level of knowledge about water-borne diseases was relatively high; however, knowledge on water contamination, hand washing, water treatment, and safe storage was inadequate. For instance, over 90% of the participants got the following

<table>
<thead>
<tr>
<th>Group</th>
<th>Difference between pre-test and post-test score after 1 week</th>
<th>SD</th>
<th>p-value</th>
<th>Difference between post-test score after 1 week and post-test score after 12 months</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.05</td>
<td>7.68</td>
<td>0.39</td>
<td>-1.95</td>
<td>7.62</td>
<td>0.11</td>
</tr>
<tr>
<td>Hygiene messages only</td>
<td>5.08</td>
<td>7.28</td>
<td>0.00</td>
<td>0.45</td>
<td>7.94</td>
<td>0.15</td>
</tr>
<tr>
<td>Hygiene messages plus participatory water testing</td>
<td>12.58</td>
<td>6.03</td>
<td>0.00</td>
<td>0.85</td>
<td>5.35</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Note: The table shows changes in mean score on a scale of 0–46. Knowledge increased significantly for both intervention types relative to the control group. Changes in knowledge 1 week and 12 months after the interventions were not significantly different.
TRUE/FALSE answer question wrong: ‘Households that collect water from open springs must treat their water before drinking, however, if households have access to a protected spring then they do not have to treat water before drinking’—True/False’. Most participants did not know that measures to protect springs and wells, such as cement slabs and covers, do not guarantee that the water is safe. According to WHO (2010), protected wells and springs are considered improved water sources.

Results of the pre-tests showed that most participants did not know traditional wide-mouthed earthen pots to store drinking water can compromise its quality even when the pots have covers, and/or the water has been boiled or disinfected. A majority of the households in Kisumu slums lack private connections and have to collect water from stands (KNBS 2010). When households collect water from distant stand pipes, they need a way to store it in the home. Over 70% of households in Kisumu’s slums store water in the traditional wide-mouthed pots (Nzengya in press). Traditional pots and other wide-mouthed storage containers have been shown to be unsafe for storing drinking water (Mintz et al. 1995). A study in Ethiopia found that diarrheal prevalence among small boys was associated with drinking water obtained by dipping cups into wide-mouthed containers, while water source and amount consumed were not significant risk factors (Teklemariam et al. 2000). The students who received the intervention that included water testing compared: (i) microbial quality of water from schools’ rainwater harvesting and storage tanks, and protected springs and wells; and (ii) water from a clean source with water from their homes and students’ storage containers. The tests showed that water from most home storage containers had been contaminated. Samples of water collected from home and school storage units were independently analyzed at the Eldoret Water Laboratory; the results of the analyses were consistent with the students’ test results.

**DISCUSSION**

A recent UN report noted that, ‘The resources required to provide teaching and learning, particularly in relation to hygiene education, are frequently absent in schools. Moreover, use of creative techniques to convey the key hygiene messages are rarely part of the teacher training programme’ (IRC 2004, p. 8). This study aimed to help fill this gap by bringing the most current user-friendly, economical, qualitative microbial water testing technologies into the classroom, and ensuring that science teachers and students were able to use them to analyze water quality.

The significant gain in hygiene knowledge in the messages group compared to the control group highlights an important benefit of education messages that include POU water treatment and storage. Two-thirds of Kenya’s children live in rural households that do not have private connections (KNBS 2010); thus, emphasis on POU treatment and storage is important to ensure drinking-water safety. Most schools also lack private connections and children must rely on improved water sources that are often distant from their classrooms. They have to collect, transport, and store water in little containers that they bring to class; or, they must bring drinking water from home because the rainwater harvesting and storage tanks at schools hold water only during the rainy season (O’Reilly et al. 2008). Thus, POU measures need to be taken at school, as well as at home.

But even if POU measures are adequate, the problem of secondary contamination will persist if we do not find effective ways of educating school children to avoid re-contaminating their water. Hygiene education messages have been limited to posting of messages on schools’ water tanks, toilets, and in classrooms. It is assumed that school-children will pay attention to these messages; however, as the findings of this study show, the effectiveness of such an approach may be limited. Hands-on water testing reinforced the hygiene concepts students learned. Students learned how drinking water from safe sources can become unsafe as a result of the way it is collected, handled, and stored.

The study was innovative in evaluating the impact of the intervention 12 months after its implementation. As Saboori et al. (2011) have noted, monitoring school water, sanitation, and hygiene project endpoints over time for variables such as continued beneficiary use, knowledge, and health is important to assess program impact, but it is rarely undertaken because of financial constraints. Evaluation after 12 months revealed that participatory water testing helped students to retain hygiene knowledge gained.
Limitations of the study

Owing to financial constraints, the author did not use structured methods to observe the impact that the interventions had on student behavior at school or at home. However, the author did notice immediate replacement of the teachers’ drinking water storage unit, a superdrum, with a narrow-mouthed jerrican in one of the two schools that participated in the hygiene messages plus water testing intervention. In both schools that participated in this intervention, the head teachers took immediate initiative to warn students not to collect drinking water from rivers, open springs, or wells. The schools further required students who brought water from home to school to ensure that their containers had lids, and that the water had been treated.

More research will be necessary to systematically investigate the impact of interventions that combine hygiene messages with participatory water testing on the behavior of students and on their effectiveness in communicating messages about safe water handling and hygienic practices relative to peers who receive interventions based on hygiene messages only. If such research finds that households of students who understand the connections between hygiene practices and water handling continue to contaminate their drinking water during collection, handling, and storage, more investigation will be required to identify the barriers to adopting safe water handling practices.

CONCLUSION

This study demonstrates the value of a new school-based hygiene education intervention to increase hygiene knowledge outcomes. The intervention, which combined messages with participatory water testing, substantially increased students’ acquisition of knowledge, and that knowledge was retained after the intervention. Affordable qualitative water testing kits such as Colilert can be used in school hygiene education programs to improve schoolchildren’s knowledge about safe water collection and storage. If we focus on giving children the tools and knowledge that can change their behavior, we can prepare future generations to protect their families and communities from water-borne diarrhea (Wasonga et al. 2014).

The hygiene education provided to students in this research study was intended to help students make scientifically informed decisions about water collection and storage, and adopt hygiene behavior that minimizes the risks of contracting water-borne diarrhea. Collecting water is a daily chore for the majority of children in low-income nations (UNDP 2011). Teaching children how to avoid contaminating drinking water can empower them to make a positive impact on community health (Onyango-Ouma et al. 2005).

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