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Article

A disruptive cue improves handwashing in school children in Zambia

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Summary

Behavioral economics hold great promise in changing patterns of behavior that influence human health. Handwashing with soap is one such behavior that is important in reducing exposure to pathogens, and in school-age children, handwashing helps reduce absenteeism through the prevention of respiratory and diarrheal diseases. However, the gap between knowledge on the importance of handwashing and actual handwashing practice, especially with soap, persists. Many traditional behavior change communication approaches have failed in achieving and sustaining improved handwashing practices. Cognitive psychology research on habits as well as nudge theory, a component of behavioral economics predicated on the idea of making a behavior as easy as possible to do, suggests that introducing a disruptive cue into the environment may be able to interrupt current habitual neurological patterns to effect and then sustain behavior change. We used a participatory process to identify and introduce a locally appropriate disruptive cue to improve handwashing behavior in schools in Zambia. We then utilized a school-randomized controlled trial to test the soap-on-a-rope in 50 government schools in Namwala District of Southern Province. Two outcomes were considered among school children; washing hands with water and using soap while washing hands. Following the intervention, soap use was more likely in intervention schools than control schools [Odds ratio = 7.23, 95% confidence interval = (1.76–29.71)], though both intervention and control schools saw an increase in handwashing without soap. This low-cost intervention could be scaled throughout Zambia and may work well in other countries of similar circumstances.

Key words: health-promoting environments, health-promoting schools, health behavior, randomized controlled trial, Nudge theory

INTRODUCTION

Handwashing reduces exposure to many infectious pathogens causing a host of illnesses affecting child health (Ejemot *et al.*, 2008; Jefferson *et al.*, 2011). Handwashing and sanitation in schools is particularly important, as lack of handwashing leads to increased absenteeism and contributes to a cycle of poor health (Jasper *et al.*, 2012). Handwashing is impossible without handwashing facilities; lack of these and sanitation facilities is correlated with poor school attendance, particularly among adolescent girls (Pearson and Mcphedran, 2008). Access to handwashing facilities can reduce absenteeism, and in turn reduce disease and associative costs of curative therapies (Njau, 2016).

Access to handwashing facilities, however, does not always translate into practice of handwashing behavior, and it is handwashing behavior itself that has been linked to improved health and reduced absenteeism in school (Willmott *et al.*, 2016; Mbakaya *et al.*, 2017). Despite decades of work in attempting to improve handwashing behavior, and many successes in improving knowledge of handwashing, a systematic review found that few efforts have sustained actual improved handwashing behavior (Ejemot-Nwadiaro *et al.*, 2015).

The field of behavioral economics holds promise in modifying behaviors associated with human health and wellbeing, such as handwashing. Popularized by the book *Nudge*, behavioral economics posits that the environment is an important driver of habitual behavior, and that small changes to the environment can influence small changes in behavior that lead to large impact (Thaler and Sunstein, 2008). Essentially, by making a target behavior the most obvious and easy choice that target behavior is more likely to be practiced. This theory is built upon principles of neuroscience that have found habitual behavior to be associated with external stimuli or cues (Wood *et al.*, 2005). A disruptive cue, or one that is different from the routine, may help to modify behavior.

A recent pilot study in Bangladesh utilized nudge behavioral theory and disruptive cues to improve handwashing in schools (Dreibelbis *et al.*, 2016). In the Bangladesh example, Dreibelbis *et al.* (Dreibelbis *et al.*, 2016) painted bright footprints on the path back from the latrine that led to the handwashing station, creating a disruptive cue to interrupt the behavior of returning to class and remind the student to use the handwashing station.

Herein we present the results of the first school-randomized controlled trial assessing an intervention resting on nudge behavioral economic theory to increase handwashing behavior in 50 schools in Namwala District, Zambia. The nudge tested in this evaluation was a bar of anti-bacterial soap threaded with a piece of rope (called SOAR, or soap-on-a-rope) which functioned as a hall pass and was given to students going to the school pit-latrines by a teacher (during class) or student monitor (during breaks). Upon returning from the latrine, the teacher or monitor was able to check whether the SOAR had been used and to remind the student to use it if needed. We hypothesized that handwashing behavior and soap use will be increased in intervention schools after training on SOAR compared with control schools, and that this behavior would be maintained over 2 months.

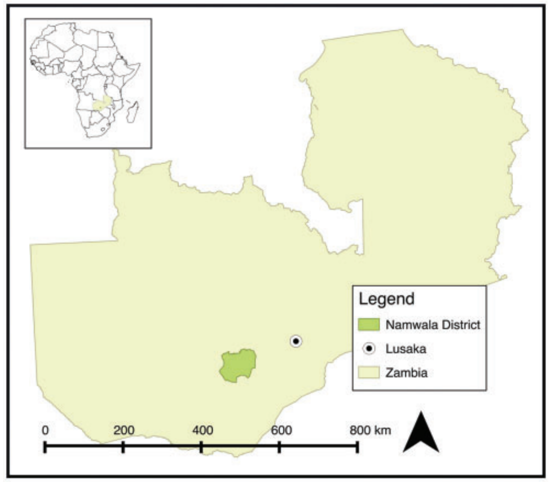

Fig. 1: Map of Zambia with Namwala district is shaded darker.

METHODS

Study setting

Zambia is a landlocked country in Southern Africa with a population of 17 million people (Central Statistical Office, 2010) (Figure 1). Southern Province is one of the 10 provinces in Zambia. Provinces are further divided into districts, of which Southern province has 13. Child health has improved dramatically over the previous 25 years, with accelerated declines in child mortality since 2005 with scale-up of various maternal and child health interventions (Ng *et al.*, 2016). Still, all-cause child mortality is estimated at around 80 per 1000 live births. In Southern Province, malaria transmission has been greatly reduced (Mharakurwa *et al.*, 2012), leading to the major drivers of post-neonatal child mortality being respiratory infections and diarrheal disease (Liu *et al.*, 2015), both of which are prevented through handwashing with soap. Furthermore, trachoma persists, despite increasing efforts to reduce transmission (Astle *et al.*, 2006), which is also preventable with hand and face washing with soap.

The Zambian education system has both public education and private education, although the majority of schools are government-owned and administered (public). To pursue education in Zambia, children start school at a pre-school level, proceed to primary schools (children aged 7–13 and grades 1–7), and thereafter secondary schools and colleges and finally universities. However, not all children in Zambia complete this full education trajectory; there are approximately 500 000 children of primary and secondary school age (18% of eligible population) that are out of school in Zambia

(Ministry of Education, Science, Vocational Training, and Early Education and UNICEF, 2014). Student dropout is attributed to a number of factors which affect demand for education and access to education due to limited or poor quality supply of educational facilities.

In the year 2010, Namwala District had a population of 101 589 with an approximate annual population growth of about 2.1% (Central Statistical Office, 2010). Sixty percent of this population is below the age of 18 years and therefore is of school going age (Central Statistical Office, 2010). Namwala District has a total of 98 schools of which 50 are government-run schools and 48 are community-run schools. In Zambia community schools are typically smaller and less funded than government schools; community schools can transition to government schools after meeting certain criteria of adequacy. In 2015 over 25% of schools across Zambia lacked adequate water access and sanitation facilities (Ministry of Education, Science, Vocational Training, and Early Education and UNICEF, 2014). Since 2015 UNICEF has operated in the district to construct sanitation facilities and handwashing stations in government schools. For the purposes of this trial, community schools are less likely to have water and sanitation facilities than government schools, and so were excluded from the intervention. In government schools in Zambia, the School Health and Nutrition (SHN) Coordinator role is focused on improving the health of school-aged children through various programs such as school feeding or health education.

Randomization

All 50 government schools in Namwala District were included in the study. Study managers wrote the name of each school on a slip of paper and placed the slips into a hat. Study managers then randomly drew 25 schools to serve as the intervention group, and the remaining 25 schools served as the control group.

Intervention

Two non-governmental organizations (Akros Global Health and The Manoff Group), with support from Sightsavers International and the United Kingdom Department for International Development, worked with teachers and administrators in Choma District of Southern Province (outside the current study area) to create a disruptive cue to improve handwashing behavior appropriate for the Southern Province context. This cue is a small piece of soap hanging on a piece of rope or cord (Figure 2) that serves as a hall pass. When a student needs to use the toilet during class or break time, the teacher (or an appointed monitor) provides the hall pass. When the student returns, the teacher can check if the hall pass is wet and potentially send the student back out to wash hands if the hall pass is dry.

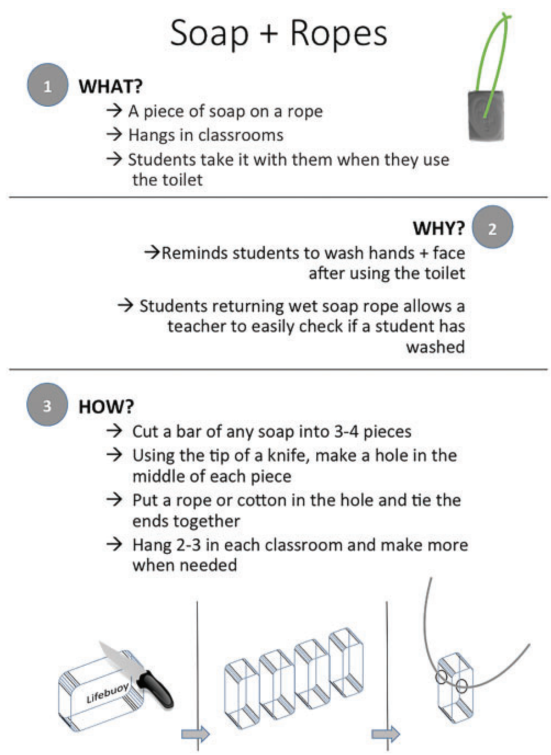

Fig. 2: The SOAR intervention.

The intervention itself, as measured later by analysis, was a training of trainers event. SHN coordinators for each intervention school participated in a 1-h training that included a discussion of the role of the teacher and a demonstration on how to make the SOAR hall pass. A sufficient amount of SOAR hall passes were also provided for the schools for the study period. Following the initial training, SHN coordinators returned to their schools and subsequently trained the teachers. The intervention school SHN coordinators received SOAR training in June 2017 (between T_0 and T_1 in terms of data collection). Control school SHN coordinators received SOAR training in July 2017 (between T_1 and T_2 in terms of data collection). Initial intervention schools did receive a second training at this point.

Data collection

Data collection was conducted using the Open Data Kit (ODK) platform (Hartung *et al.*, 2010). The application supports data collection via a mobile tool, which generally leads to more timely and organized data. ODK was installed on android devices that were made available to the data collectors during the data collection period. Master's of Public Health students from the University of Zambia in Lusaka were recruited to serve as data collectors, or observers, and underwent a 2-day training program in preparation for data collection. The components covered in this training included a basic ethics course provided by the Collaborative Institutional Training Initiative (CITI), the data collection method and an orientation on the data elements. Data collection was conducted at three separate intervals: (i) at the beginning of the study (T_0), (ii) following the intervention in intervention schools (T_1) and (iii) following the intervention in comparison schools (T_2). During collection, data collectors unobtrusively stationed themselves in inconspicuous places where they could see students leaving the latrine and observe public handwashing behavior, and observed students leaving latrines for 6–8 h per day.

Outcomes

While observing students, two separate outcomes were considered. First, observers noted whether students washed their hands upon exiting the latrine. Second, among students washing their hands, observers noted whether students used soap or not. These outcomes were measured for one day at each school at three separate times: (i) in June 2017 before any intervention, (ii) in July 2017 following SOAR training for intervention schools and (iii) in September 2017 following SOAR training for control schools. While observing handwashing behavior, the trained observers did not interact with the student yet noted whether the student was a boy or girl, and whether the student was old or young. Students enrolled in the 1st through the 6th grade (typically 12 years of age or younger) were considered young and students enrolled in the 7th grade or later were considered old. In addition to observing handwashing behavior the observers conducted a school water and sanitation survey developed by UNICEF that measured among other things school enrollment, sanitation facilities available and water access in each school [14]. These measures were incorporated into analyses as discussed later.

Sample size

We powered the SOAR study to detect an absolute difference of 10% in handwashing behavior between groups using sample size calculations for cluster-randomized controlled trials (Hayes and Bennett, 1999). We presumed a coefficient of intercluster variation of 0.25, 80% power, 95% specificity, 100 students using the latrine in each school and 50 different schools.

Blinding

Trained observers were blinded to whether the school they were observing was an intervention or control school. The research team did not notify students that handwashing behavior was being observed. Students and teaching staff were blinded to participation in intervention or control group, in that they did not know about the other group of schools receiving the intervention or not.

Statistical analyses

We used a difference-in-differences approach to assess how the SOAR intervention was associated with the outcomes of interest in an intention to treat analysis. Schools were classified as intervention or control based on random allocation, and children were classified as having received the intervention if they attended an intervention school. Unadjusted differences of handwashing behavior and soap use between intervention and control schools at each time point were assessed in an generalized linear model with a logit link and school as a random intercept that included the following covariates: group, time (T_0, T_1, T_2) and an intervention by time interaction. We then adjusted the probability of a student washing hands and using soap using with the same model and the addition of the following covariates: sex of the student, age of the student (young or old) and whether the school reported having adequate water for their needs. The analyses are detailed with the following equations:

$$y_{ij}|\pi_{ij}\,\text{Binomial}(1, \pi_{ij})$$
$$\text{logit}(\pi_{ij}) = \beta_1\text{Group}_j + \beta_2\text{Time}_j + \beta_3\text{Group}_j \times \text{Time}_j + \chi C_{ij} + \delta S_j \zeta_j\, N(0, \psi)$$

where π_{ij} is a dichotomous outcome for child i in school j, Group_j is whether the school was part of the intervention or control group, Time_j is the time point during which the data were collected, C_{ij} is a vector of child characteristics, S_j is a vector of school characteristics and ζ_j is a random intercept for school j that is assumed to be normally distributed with a mean of zero.

We first tested for a global interaction between intervention group and time using a likelihood ratio test between the full model (no interaction term) and saturated model (with interaction term). We then calculated

Table 1: Characteristics of control and intervention schools

	Control	Intervention
Number of schools	25	25
Mean students enrolled per school (standard deviation)	504 (182)	597 (427)
Mean number of boy students (standard deviation)	243 (103)	290 (209)
Mean number of girl students	261 (97)	307 (103)
Mean number of functional toilets (standard deviation)	11 (11)	9 (21)
Mean students per toilet (standard deviation)	85 (76)	173 (167)
Percentage of schools with functioning water	92%	100%
Percentage of schools with adequate water	68%	84%

specific odds ratios from the saturated model comparing the difference between intervention and control groups before intervention (T_0), after intervention in intervention schools (T_1) and following intervention in control schools (T_2). The same procedure was followed for both outcomes. The soap use analysis was limited to those students who reported washing their hands. We conducted these analyses in R version 3.5.0 (R Core Development Team, 2010).

Consent procedures

The SOAR intervention and trial were approved by the Ministry of General Education for deployment in Namwala District, Zambia. We sought and obtained ethical clearance for the data collection for the school-randomized trial from ERES Converge IRB in Lusaka Zambia (#2017-May-046) and Syracuse University IRB in Syracuse, New York, USA (#17-113). Prior to any data collection the Ministry of General Education informed the government schools in Namwala District via official letter about the trial and intervention. Data collectors then traveled to the school and sought informed written consent from school headmasters or designated teachers to conduct the survey and observe handwashing behavior. School children were not notified that they were part of the trial, however data collectors only observed public behavior and did not interact with the students in any way.

RESULTS

Participants and schools

Across the 50 schools included in the trial, 49 had sanitation facilities. The school that did not have sanitation facilities (from the intervention group) was removed from analyses assessing the intervention. Intervention schools typically had more students and fewer toilets than control schools (Table 1). Also more of the intervention schools reported that their water was adequate for the school's needs.

Excluding the school without a sanitation facility or non-functioning water sources, over the three time points a total of 10 732 children were observed exiting the latrine, 5529 in the control group and 5203 in the intervention group. Approximately 42% of the students observed were boys (no statistical difference between intervention and control groups), and approximately 44% of the students observed were older (no statistical difference between intervention and control groups).

Handwashing analysis

Of the 10 732 children exiting the latrine, 58.4% were observed washing their hands (Table 2). Handwashing behavior was similar between groups at baseline before the intervention (T_0), increased in both intervention and control schools following the intervention (T_1) and then dropped off slightly 2 months after the control schools received the intervention (T_2) (Figure 3). There was a significant time by intervention group interaction [Likelihood ratio (LR) test $= -39.95$, $p < 0.0001$], however after adjusting for child demographics and water situation at the school there were no differences in handwashing behavior between intervention and control schools at any time point (Table 3). Boys were less likely than girls to wash their hands [adjusted odds ratio (AOR) = 0.72, 95% confidence interval (CI) = 0.66–0.80]. And older students were more likely than younger students to wash their hands (AOR = 1.70, 95% CI = 1.53–1.89).

Soap use analysis

Of the 6268 children washing their hands after using the latrine, 47.5% used soap (Table 2). Soap use was similar between intervention and control schools at baseline (T_0); following the intervention, soap use among students washing hands exceeded 75% in intervention schools and rose slightly in control schools (T_1)

Table 2: Number of students observed leaving the latrine

	Time 1 Control	Time 1 Intervention	Time 2 Control	Time 2 Intervention	Time 3 Control	Time 3 Intervention
Exited latrine	1666	1608	2949	2353	2962	1242
Washed hands	594	691	1767	1664	2151	772
Used soap	109	62	518	1246	1110	567

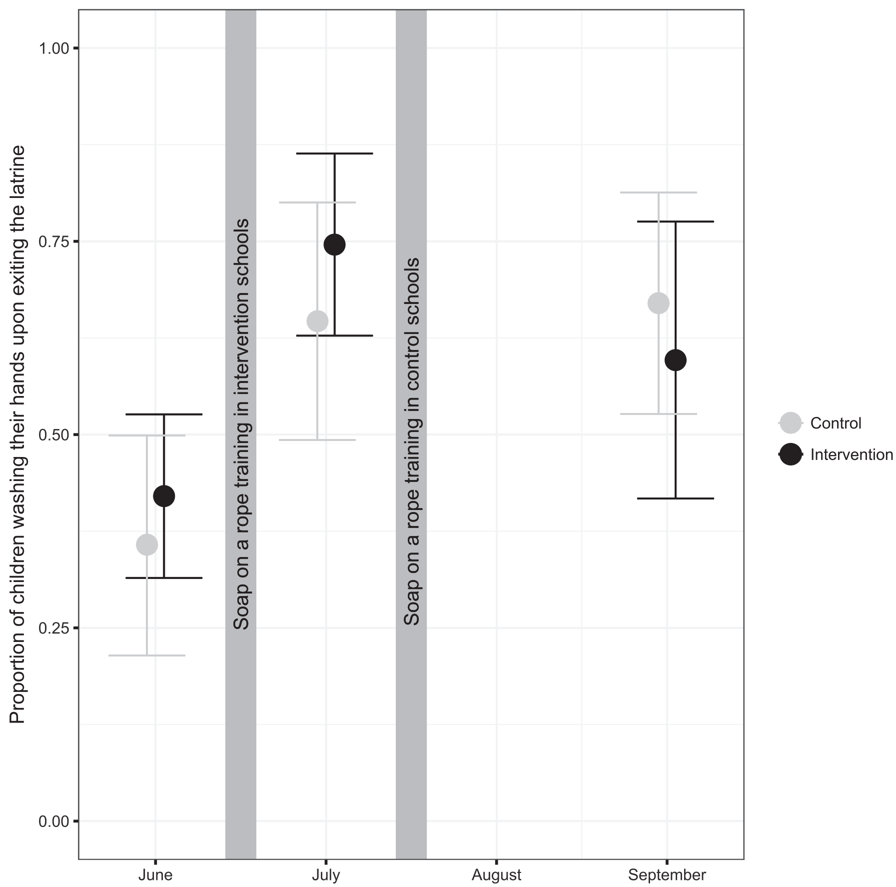

Fig. 3: Proportion of school children washing their hands upon exiting the latrine.

(Figure 4). Two months following the end of the trial and the intervention in the control schools soap use dropped slightly in intervention schools and rose slightly in control schools (T_2). From regression analysis there was a significant time by intervention group interaction (LR test = −143.97, $p < 0.0001$). At baseline, soap use was no different between intervention and control schools (Table 4). Following the intervention (T_1), soap use was more likely in intervention schools than control schools (AOR = 7.23, 95% CI = 1.76–29.61). After control schools were trained in the intervention (T_2) there was no longer a difference in soap use between intervention and control schools (AOR = 2.39, 95% CI = 0.57–9.96). Unlike handwashing, there was no difference between boys and girls using soap, nor between older and younger students.

DISCUSSION

In accordance with our hypothesis, the observed increase in soap use during handwashing was apparent following the SOAR intervention being implemented in

Table 3: Adjusted analyses of students washing hands upon exiting the latrine

Factor	Categorization	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Time 1	Control	Reference	Reference	Reference	Reference
	Intervention	1.84 (0.80–4.20)	0.149	1.48 (0.66–3.33)	0.345
Time 2	Control	Reference	Reference	Reference	Reference
	Intervention	2.22 (0.97–5.06)	0.059	1.79 (0.80–4.03)	0.158
Time 3	Control	Reference	Reference	Reference	Reference
	Intervention	1.04 (045–2.39)	0.931	0.82 (0.36–1.86)	0.634
Sex of the student	Girl	Reference	Reference	Reference	Reference
	Boy	0.75 (0.68–0.82)	< 0.0001	0.72 (0.66–0.80)	< 0.0001
Age of the student	Young	Reference	Reference	Reference	Reference
	Old	1.80 (1.63–2.00)	< 0.0001	1.70 (1.53 - 1.89)	< 0.0001
Water situation at school	Inadequate water	Reference	Reference	Reference	Reference
	Adequate water	2.58 (1.02–6.51)	0.045	2.59 (1.02–6.58)	0.045

Notes: Schools with no functioning toilets were removed from the analyses. Presence of an interaction between time and intervention was confirmed using a likelihood ratio test between full and saturated models (LR $= -39.95$, $p < 0.0001$). $N = 49$ schools; 10 520 students.

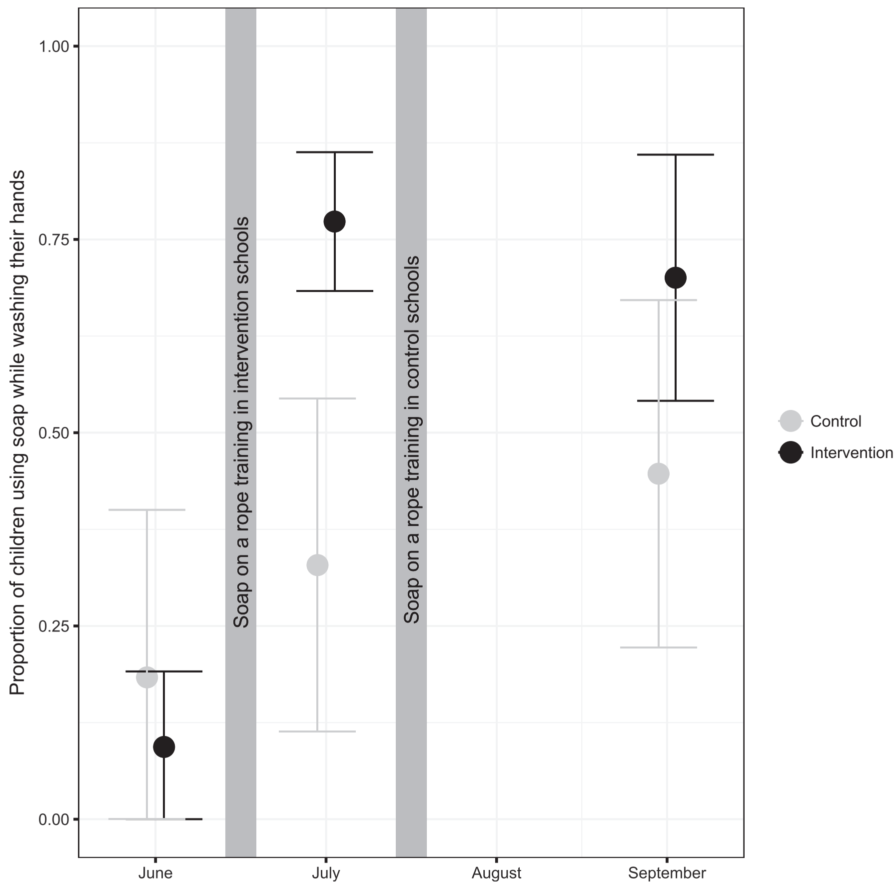

Fig. 4: Proportion of school children using soap while washing their hands after using the latrine.

Table 4: Adjusted analyses of students using soap while washing hands

Factor	Categorization	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Time 1	Control	Reference	Reference	Reference	Reference
	Intervention	0.30 (0.07–1.30)	0.108	0.30 (0.07–1.30)	0.106
Time 2	Control	Reference	Reference	Reference	Reference
	Intervention	8.99 (2.22–36.36)	0.002	7.23 (1.76–29.71)	0.006
Time 3	Control	Reference	Reference	Reference	Reference
	Intervention	3.14 (0.77–12.86)	0.112	2.39 (0.57–9.96)	0.23
Sex of the student	Girl	Reference	Reference	Reference	Reference
	Boy	0.84 (0.75–0.96)	0.012	0.88 (0.76–1.03)	0.104
Age of the student	Young	Reference	Reference	Reference	Reference
	Old	1.36 (1.18–1.57)	< 0.0001	1.06 (0.90–1.26)	0.467
Water situation at school	Inadequate water	Reference	Reference	Reference	Reference
	Adequate water	2.66 (0.58–12.17)	0.206	2.71 (0.50–14.67)	0.247

Notes: Schools with no functioning toilets were removed from the analyses. Presence of an interaction between time and intervention was confirmed using a likelihood ratio test between full and saturated models (LR = −143.97, $p < 0.0001$). $N = 49$ schools; 6082 students.

25 randomly allocated schools (T_1). Given the lack of success of handwashing promotion efforts in lower income countries to improve handwashing behavior, these results are promising for the SOAR intervention (De Buck *et al.*, 2017). These are also the first results of which we are aware, of a randomized controlled trial utilizing behavioral economics to improve handwashing behavior. Although showing great promise, empirically robust evidence is lacking in the behavioral economics field (Lin *et al.*, 2017). Furthermore what evidence does exist (Matjasko *et al.*, 2016), is focused on improving health behaviors that are less habitual such as getting a vaccination or becoming an organ donor.

Both groups of schools had increased soap use behavior following the intervention being implemented in the control schools (T_2 compared with T_0), however in intervention schools soap use behavior had declined 3 months after the intervention relative to 1 month after the intervention (T_2 compared with T_1). Maintaining habitual behavior change is perhaps the most challenging aspect of improving health behaviors, and of great importance to handwashing. Practicing good handwashing behavior at school can influence home behaviors of students, in turn influencing older generations and younger siblings in the household (Blanton *et al.*, 2010). These downstream effects are more likely to be realized if handwashing behavior becomes habitual. In this study we assessed the stickiness of the behavior change at 3 months following the initial training, which suggests that there was some drop off in improved handwashing behavior. Subsequent studies should consider a lengthier follow-up time to assess the permanence of the behavior change.

In contrast to our hypothesis, handwashing behavior (without soap use) was no different between intervention and control schools at T_1, after only the intervention schools had received the intervention. Handwashing behavior is challenging to observe without influencing the student under observation, and we suspect that some level of contamination occurred. Specifically, schools participating in the study were aware that we were assessing handwashing, and because handwashing is socially desirable they may have emphasized handwashing behavior with their students. At its core, the SOAR intervention is basically just a reminder to wash one's hands, and as such the increased handwashing behavior while inconvenient for quantifying the impact of the intervention, could have been expected given our understanding of the behavior. However, we expect the increase in soap use in intervention schools compared with control schools at T_1 to be due to the SOAR intervention. The question of whether or not the underlying social desirability pressure at play might itself be leveraged through a system of monitoring for key behaviors like handwashing warrants further exploration.

The SOAR has an additional benefit beyond the behavioral change component of the concept; it helps preserve the soap itself. From conversations with school staff, government schools in Namwala district do purchase soap, but it often goes missing or is eaten by animals when left outside. The introduction of the SOAR 'hall pass' instilled responsibility in the teacher and the pupils to ensuring soap was available in the classroom, which may reduce the likelihood of soap being eaten, stolen or misplaced. Additionally, though the data collected does not focus on acceptability of this intervention, anecdotally, data collectors found the concept was well received and easily accepted by the teachers and the pupils.

Evaluating the SOAR intervention presented numerous challenges. In order to reduce social desirability bias influencing handwashing behavior among students, data collectors observed but did not interact with students. The ethics review boards approved collecting publicly observable data without the students' knowledge or consent, with the consent of the school headmaster. This type of data collection would have been more challenged if handwashing stations were not in public view. Although addressing the issue of social desirability bias, the lack of interaction with students created some limitations in the analysis. Presumably, some of the handwashing events were repeated events from the same student, either within the same time period or in subsequent time periods. Without an identifier linking students across time, we were unable to account for repeated measures in the analysis. We did, however, include school as a random intercept in the analysis, which accounted for repeated probability of handwashing across time within each school. Another limitation of the study is that the availability of soap was not measured on the days of observation. Despite these limitations, we consider the analysis to add value in understanding that handwashing behavior was positively influenced by the SOAR intervention.

A large strength to the SOAR intervention is its simplicity. Both the soap and the rope can be made from locally sourced material. The cost is minimal, requiring a short training. This low-cost, and accepted intervention would be relatively easy to scale through a training of trainers model; and given the positive effect the SOAR appears to have on handwashing behaviors, scaling this intervention should be explored.

CONCLUSION

The results of this study suggest that creative and innovative applications of nudge theory can improve handwashing and other hygiene behaviors. The SOAR intervention was significantly associated with improved handwashing with soap and should be scaled as well as continued to be adapted, including the adaptation of these models to translate successful practice in schools to improved practices in the home.

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