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ORIGINAL ARTICLE

# Effect of a theory-based hand hygiene educational intervention for enhancing behavioural outcomes in Ghanaian schools: a cluster-randomised controlled trial

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## Abstract

**Objectives** The study sought to determine whether a hand hygiene educational intervention underpinned by educational and psychosocial theories is effective in enhancing behavioural intention and proper handwashing practices among school children.

**Methods** The study was a cluster-randomised controlled trial, with schools constituting the clusters. At baseline, 717 pupils organised in four clusters were recruited. Techniques for data collection included a structured observation. The Student's *t* test was used for data analysis.

**Results** At follow-up, a statistically significant difference was observed between the study arms with regard to intention to wash hands with soap [after toilet use ($p = 0.032$, $d = 0.5$); before meals ($p = 0.020$, $d = 0.2$)]. Similarly, a statistically significant difference was identified between the study arms with regard to the practice of handwashing with soap (HWWS) [after toilet use ($p = 0.005$); before meals ($p = 0.012$)].

**Conclusions** A theory-driven hand hygiene educational intervention involving school children can have a medium to a very large effect size, with respect to the practice of HWWS, and a low to a medium effect size with respect to behavioural intention.

**Keywords** Hand hygiene · Education · School · Theory based · Intention · Practice

## Introduction

The crucial role which hand hygiene plays in the fight against the spread of infectious diseases in schools is well reported (Ejemot-Nwadiaro et al. 2015). In spite of this, hygiene in schools has not received the attention that it deserves, especially in terms of monitoring and financing. For example, in a global study involving 54 countries, sanitation in schools was identified as the most comprehensively monitored component of the water, sanitation, and hygiene (WASH) sector, whereas hygiene was identified as the least monitored (UNICEF 2015).

Hand hygiene has been defined as "an activity involving the use of soap or other effective local agents in which running water is provided, or the use of a hand rub containing the right proportion of alcohol or related substance, which cleanses the hands of micro-organisms of disease causing potential" (Appiah-Brempong et al. 2018a: 253). It is a simple phenomenon yet characterised by many complexities. With respect to handwashing with soap (HWWS), few people tend to adhere to this practice, even though its effectiveness is well reported in the body of literature (Freeman et al. 2014; Curtis et al. 2009).

In a bid to improve adherence to proper handwashing practices in schools, hand hygiene education appears to be

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the most common behaviour change intervention, especially in the developing world. Conventional hygiene educational interventions have focused on passing information unto people with the aim of enhancing knowledge (cognitive domain) on issues pertinent to safe hygiene. Conventional hygiene education has been viewed by many WASH experts as yielding less success in terms of enabling people to adhere to safe hygienic practices (UNICEF 2008). An alternative, which is a theory-driven hand hygiene education, has been suggested by some authors (Trunnell and White 2005; Mortell et al. 2013).

Ironically, there is a paucity of robust evidence on the effectiveness of a theory-driven hand hygiene educational intervention which targets all three learning domains (i.e. cognitive, affective, and psychomotor). Such a situation raises questions with respect to the legitimacy of the hand hygiene educational interventions being implemented in schools across Africa and beyond. Thus, until robust evidence on the effectiveness of a hand hygiene educational intervention is generated, it may be difficult to justify why these interventions should receive governments' and/or donors' funding support. Similarly, it may also be difficult for policy makers to formulate policies geared towards the institutionalisation of such interventions in schools. This paper attempts to contribute towards building an evidence base with respect to the effectiveness of a theory-driven hand hygiene educational intervention. The study sought to determine whether or not a hand hygiene educational intervention underpinned by educational and psychosocial theories is effective in enhancing behavioural intention and proper handwashing practices among school children in a Ghanaian municipality.

## Methods

### Study design

The design was a two-arm cluster randomised controlled trial (cRCT), with an allocation ratio of 1:1. Schools constituted the clusters, with the individual units being the pupils. Randomisation was done at the school level and not the individual level (i.e. pupils). A cRCT was adopted due to the practical difficulties associated with the randomisation of individual pupils into different study arms.

### Participants and setting

The primary participants of the study were Junior High School (JHS) children. Secondary participants included JHS teachers. The study was based within the Ejisu-Juaben Municipality of Ghana. The rationale for choosing this municipality was that diarrhoea had remained one of the top five leading causes of hospital admissions for three consecutive years (from 2013 to 2015) at the time the study began.

### Eligibility criteria for participating schools and pupils

Schools which participated in the study met the following inclusion criteria:

- Were regulated by the Ejisu-Juaben Municipal Education Directorate.
- Had a JHS section with grades 7, 8 and 9.
- Had a functional water facility sited within school compound.
- Had a functional toilet facility sited within school compound.

On the other hand, a school was excluded if:

- School management did not agree to their participation in the study.
- An intervention judged to be similar to that of this study was being implemented in the school or has been implemented within the past year.

Children who participated in the study met the following eligibility criteria:

- Children who assented to participate in the study.
- Children whose parents/guardians consented to their participation in the study.

### The intervention (HandsCare): description and theoretical basis

The intervention was named *HandsCare* to reflect the need to care for the hands by practicing handwashing with soap (HWWS), under running water, and at critical times. For the purpose of this study, two "critical times" were considered namely HWWS after toilet use and HWWS before meals. The aim of *HandsCare* was to enhance three learning domains namely cognitive (knowledge of hand hygiene), affective (attitudes to HWWS), and psychomotor (handwashing skills). The content and delivery of *HandsCare* were driven by Bloom's Taxonomy of Learning Theory (Bloom et al. 1956) and psychosocial theories including the Theory of Planned Behaviour, Social Cognitive Theory, and the Health Belief Model. The aforementioned theories have demonstrated usefulness in understanding relationships between variables in a range of volitional health behaviours (Eshetu 2013; White et al. 2015; Dreibelbis et al. 2013; Dyson et al. 2011).

The curriculum of the intervention was compiled to enhance pupils' knowledge on hygiene (by presenting facts

on hygiene), pupils' attitudes (using emotive stories on hygiene), and pupils' skills (through practical training on proper handwashing steps). *Knowledge* is a construct which emanates from the Bloom's Taxonomy of Learning Theory, as well as the Social Cognitive Theory. *Attitude* emanates from the Theory of Planned Behaviour, while *skill* is a construct which emanates from the social cognitive theory. In addition, the stories used in the curriculum emphasised on the fact that every school child can be infected with diarrhoea and that diarrhoea is deadly. These expressions were meant to enhance the children's *perceived susceptibility* and *severity*—key constructs of the Health Belief Model.

Furthermore, the delivery of the intervention was done using teachers recruited from the participating schools. Teachers tend to be the *significant others* of school children and therefore can enhance the subjective norms of children by specifically enhancing normative beliefs (a sub-variable of the subjective norm construct (see Bennet and Murphy 1997). Subjective norms emanate from the Theory of Planned Behaviour. Figure 1 presents the intervention's theory of change. Detailed information on the theoretical framework is published already (see Appiah-Brempong et al. 2018a).

## Outcome objectives of HandsCare

The aim of the intervention was to increase knowledge, influence attitudes, and develop skills for proper handwashing practice. In line with this aim, the outcome objectives were the following:

(a) Existing sociocultural beliefs about diarrhoea identified.
(b) Knowledge about the transmission and prevention of diarrhoea pathogens increased.
(c) Knowledge about the consequences of diarrhoea to health and educational aspirations enhanced.
(d) Positive attitudes to HWWS enhanced.

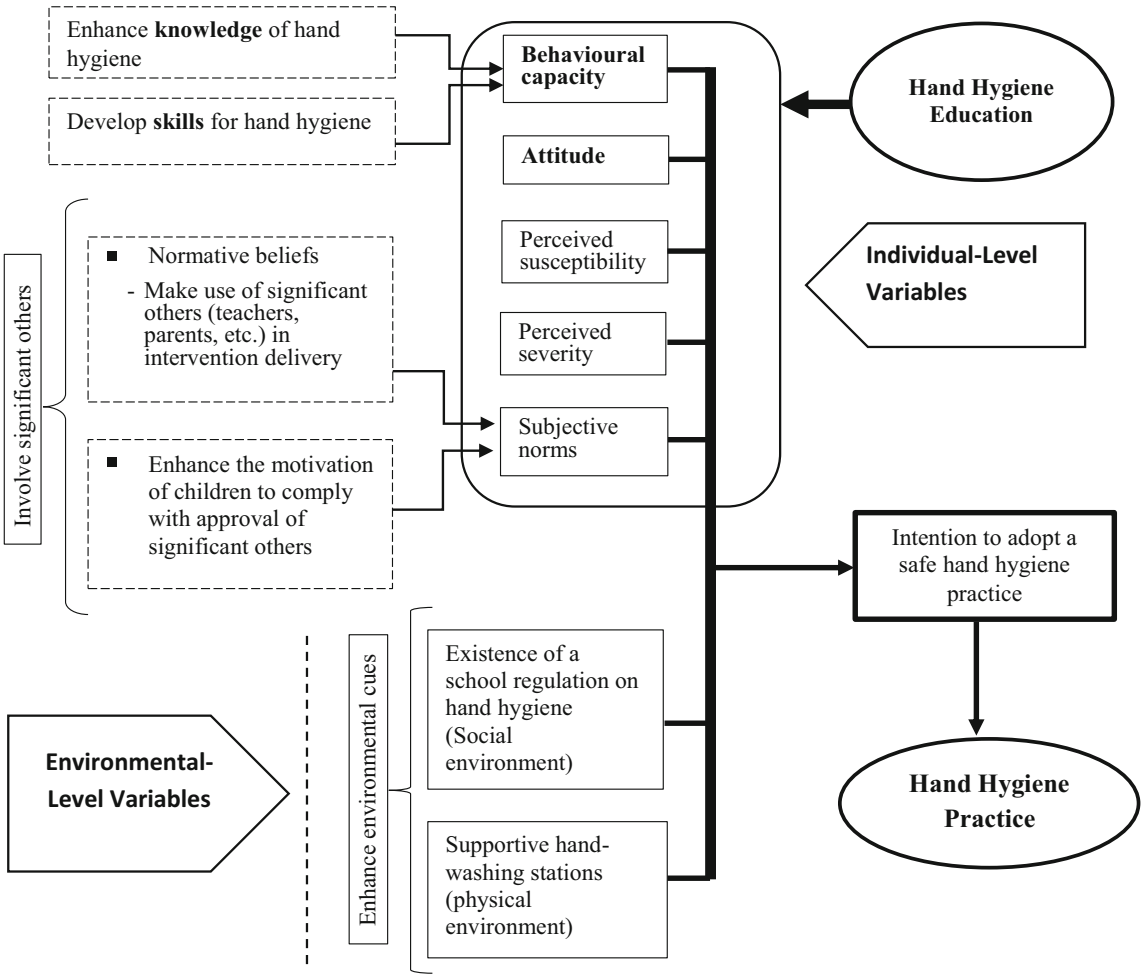


**Fig. 1** A theory-based framework for designing a hand hygiene educational intervention in schools. *Source*: Adapted from Appiah-Brempong et al. (2018a)

(e) Participants' skills for practicing proper HWWS improved.

## Training of teachers and intervention delivery

*HandsCare* was delivered by teachers, selected from intervention schools and trained prior to the intervention delivery. Methods employed for training teachers included topical discussions, demonstration of proper handwashing practice, and role plays. All training sessions were facilitated by the principal investigator, who has an advance training in health education and promotion and teaches health education at the postgraduate level. The training was done within two (2) days and lasted for a period of five (5) hours per daily session.

In-class hand hygiene education was done with the aid of relevant posters and a user-friendly educational manual. The manual was organised into three (3) modules and subsequently into sessions, with concise modular and sectional objectives which are in consonance with the key objectives of this research. Interventions lasted for approximately two (2) hours per working day. Within the intervention schools, specific days were allocated for in-class educational activities. Similarly, specific days were allocated for the practical sessions where each pupil had an opportunity to develop proper handwashing skills.

## Intervention fidelity

The fidelity of the intervention delivery was assessed using data obtained from a direct observation. This strategy has been described as being more reliable when compared to other strategies which rely on self-reported data (Breitenstein et al. 2010; Mellard 2010). An observer checklist adapted from Mellard (2010) was used for data collection. The broad parameters considered for assessment included; adherence to instructions for intervention delivery, duration of intervention delivery, quality of delivery and students' responsiveness. Field observers were to tick YES/NO to indicate whether or not a particular measurement item under the broad parameters was observed. The data gathered was subsequently analysed quantitatively and showed that intervention delivery largely conformed to the study protocol.

## Key intervention outcomes

The primary outcomes which *HandsCare* sought to enhance were *HWWS after toilet use* and *HWWS before meals*. The intermediate outcomes were *intention to practise HWWS after toilet use* and *intention to practise HWWS before meals*. Key explanatory variables assessed pre and post included hand hygiene related *knowledge*, *attitudes* to hand hygiene, and *skills* for practicing proper handwashing. The study adopted a 2-week post-intervention assessment for reasons including the quest to control for "maturation effect" which has the tendency to adversely affect the internal validity of post-intervention data (Cottrell and McKenzie 2011).

## Sample size estimation

Four clusters were estimated to detect at least a 60% reduction in the proportion of pupils who do not practise proper handwashing at follow-up. Statistical power was set at 80%, while significance level was set at 5%. The average cluster size was estimated to be 153, and the intra-cluster correlation coefficient (ICC) was assumed to be 0.03 based on published studies (Hutchison 2009; Pickering et al. 2013). The assumed ICC was subsequently used for estimating the design effect (DE) which was required to adjust for clustering at the design stage. A formula developed by Thabane (2004) was used for estimating the sample size. All children present in schools at baseline who assented to participate and whose parents had given a consent to their participation were recruited into the study. A total of 328 children were recruited from the intervention arm, while a total of 389 were recruited from the control arm at baseline. Control schools received no intervention.

## Randomisation and blinding

Schools were randomly allocated into the intervention and control arms using a *random number table*. Allocation of study arms and the key outcomes measured were concealed to school children, their teachers, field enumerators, and the school management. This was a measure to control for threats to internal validity of the research data.

## Data collection

### Description of measurement techniques and tools

Two key techniques were adopted for measuring study variables—self-report by participants and a structured observation. Psychosocial variables were measured using a 5-point Likert scale. Sub-variables were tested for internal reliability using the Cronbach alpha score set at $\alpha \geq 0.7$. For example, Alpha scores generated were $\alpha = 0.80$ for behavioural intention and $\alpha = 0.75$ for attitude. The knowledge variable was, however, measured using a set of statements on hand hygiene for which participants were to provide the correct answers. The skill variable was assessed by directly observing participants demonstrate the steps for proper HWWS at a handwashing station.

The attitude variable was measured using a set of three items for each of the two key moments (i.e. attitude to HWWS after toilet use and before meals). For example, on a 5-point scale, participants were asked to indicate how they feel about HWWS, with the two extreme points of the scale being "important" and "not important", "good" and "bad", "useful" and "useless". Behavioural intention was measured using a set of two items for each of the two key moments for handwashing. For example, a participant was asked to indicate on a 5-point scale the extent to which he/she agrees or disagrees with a statement that said "Within the next month, I plan to wash my hands with soap anytime I use the toilet". Regarding the practice of HWWS, a structured observation was used with the aid of a tool adapted from Pickering et al. (2014). A daily structured observation gathered binary data and lasted for a period of 7 hours continuously.

#### Measures for addressing potential confounders

At the design stage, several measures were used to address potential extraneous variables which were classified into history effect, maturation effect, testing effect, selection bias, attrition effect, spillover or diffusion effect, implementation effect, and effect of unreliable data gathering instruments. Further information on this is available on request. At the analysis stage, potential threats to internal validity such as clustering effect and varying cluster weights were adjusted for statistically.

### Data analysis

A cluster-level analysis using an independent samples *t* test was used for computing the differences between study arms with respect to study outcomes. This approach tends to be more robust in an analysis involving a few number of clusters (Eldridge and Kerry 2012; Hayes and Moulton 2009). Also, an independent samples *t* test is robust even when some parametric test assumptions are violated (Hayes and Moulton 2009; European Medicines Agency 2003). Furthermore, the *t* test can be used for any cluster-level summary measure [e.g. means, proportions (in the case of binary outcomes)] (Eldridge and Kerry 2012).

The first step of the analysis involved computing aggregate cluster-level summaries for all individual level variables—a measure which controls for data clustering (Campbell and Walters 2014; Hayes and Moulton 2009). The second step involved determining the statistical difference between the two sets of clusters (intervention and control) post-intervention, with respect to the variable being measured. The third step was to adjust for variations in cluster sizes. All analyses were done using S*tata/SE* 14 (Stata Corp., College Station, Texas).

In computing for cluster-level means and proportions, *Stata's collapse* command was used. Afterwards, an independent samples *t* test was used to determine an initial statistical difference between the two study arms. The results of the *t* test were further weighted to adjust for variations in cluster sizes, using the *regress* command in *Stata*. Statistical significance was set at alpha score $p < 0.05$ (95% confidence interval), while effect sizes were classified using the Cohen's classification table (Cohen 1992). This table categorises effect sizes into small, medium, large, and very large. With respect to pre- and post-analysis of difference, a dependent samples *t* test was used. This analysis adjusted for clustering using the robust standard errors. All statistical tests were done using S*tata/SE* 14 (Stata Corp., College Station, Texas).

## Results

### Progression of clusters and pupils through phases of cRCT

A total of 37 potentially eligible schools were subjected to the study's inclusion criteria which resulted in the exclusion of 33 schools on the basis of a lack of functional water and toilet facilities within schools' compound. A functional water facility in a school was crucial for developing and assessing the handwashing skills of study participants. On the other hand, the existence of a toilet facility on a school's compound was crucial as it enhanced the validity of observational data on the practice of HWWS after toilet use. Figure 2 is a flow chart on the progression of clusters and pupils through the respective phases of the trial.

### Baseline characteristics of study arms

In a bid to reduce selection bias to the barest minimum, intervention and control arms were assessed statistically to determine similarity at baseline. The result of the assessment indicated that intervention and control arms were largely similar in terms of individual level characteristics of participants as well as relevant cluster-level characteristics. All participating schools had functional handwashing stations (i.e. a set-up providing running water and soap for handwashing purposes) at baseline and follow-up, and these handwashing stations were accessible to pupils. Further information on the distribution of hand hygiene facilities across a range of schools (including the four participating schools) is published already (see Appiah-Brempong et al. 2018b). Using baseline samples from the two study arms, the observed rate of HWWS after toilet use was 2%, while that of HWWS before meals was 1%. Table 1 compares the baseline characteristics of the intervention and control arms.

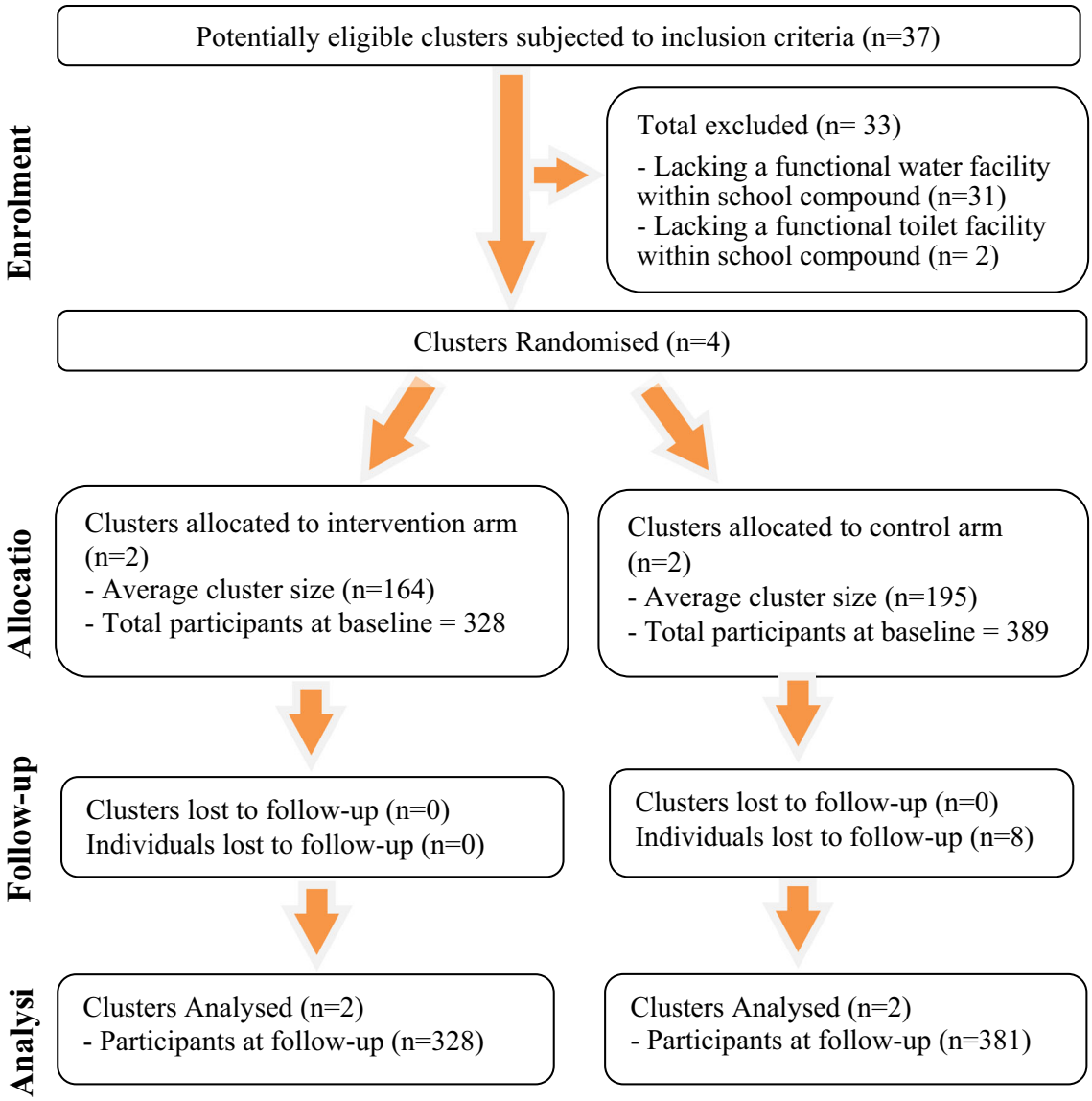


**Fig. 2** A flow chart of the progression of clusters and individuals through phases of trial

## Post-intervention effect of HandsCare

The results section highlights the intervention variables (i.e. knowledge, attitudes, and skills) as well as the intermediate and outcomes variables (behavioural intention and practice of HWWS). Results relating to the variables perceived susceptibility, perceived severity, normative beliefs, and motivation to comply are not presented in Table 2 as there were no significant between-group differences at follow-up, with respect to these variables.

## Group differences: behavioural intention and practice of HWWS

At 2 weeks follow-up, a statistically significant difference was identified between the intervention and control arms with regard to the practice of HWWS at the two critical times [after toilet use ($p = 0.005$), (80% difference between the two arms); before meals ($p = 0.012$), (17% difference between the two arms)]. The size of effect was $d = 2.6$ with regard to HWWS after toilet use and $d = 0.5$ with regard to HWWS before meals. Furthermore, at follow-up, a statistically significant difference was identified between the intervention and control arms with regard to *intention to wash hands with soap* [after toilet use ($p = 0.032$, $d = 0.5$); before meals ($p = 0.020$, $d = 0.2$)]. Further information is presented in Table 2.

## Intra-cluster correlation coefficients (ICCs)

In consonance with acceptable practice, the study computed for intra-cluster correlation coefficients (ICCs) using

**Table 1** Baseline characteristics of study arms, Ghana, 2015–2018

| Variables | Arm | | | | *p* values (2-tailed) | |
|---|---|---|---|---|---|---|
| | Intervention | | Control | | | |
| | *n* | Mean (SD)/% | *n* | Mean (SD)/% | Crude | Adjusted* |
| *Individual level* | | | | | | |
| Age (mean) | 327 | 14.0 (1.42) | 389 | 13.7 (1.30) | 0.001 | 0.74 |
| Females (%) | 328 | 48 | 389 | 54 | 0.08 | 0.07 |
| Religion | | | | | | |
| Christianity (%) | 328 | 87 | 389 | 94 | 0.001 | 0.01† |
| Islam (%) | 328 | 12 | 389 | 5 | 0.001 | 0.03† |
| Parent educated to tertiary level (%) | 328 | 27 | 389 | 52 | 0.001 | 0.04† |
| Attitude—after toilet use (mean score) | 328 | 14.7 (1.17) | 389 | 14.6 (1.45) | 0.23 | 0.38 |
| Attitude—before meals (mean score) | 328 | 14.5 (0.08) | 389 | 14.5 (0.07) | 0.80 | 0.87 |
| Knowledge (mean score) | 328 | 7.8 (0.53) | 389 | 8.7 (0.32) | 0.001 | 0.17 |
| Skill (mean score) | 328 | 4.8 (1.32) | 389 | 4.8 (1.40) | 0.97 | 0.98 |
| Normative beliefs (mean score) | 328 | 13.6 (1.81) | 389 | 13.7 (1.72) | 0.60 | 0.86 |
| Perceived susceptibility (mean score) | 328 | 18.2 (0.25) | 389 | 17.5 (0.43) | 0.19 | 0.25 |
| Perceived severity (mean score) | 328 | 9.3 (0.16) | 389 | 9.4 (0.03) | 0.33 | 0.29 |
| Motivation to comply (mean score) | 328 | 13.4 (1.88) | 389 | 13.4 (1.80) | 0.88 | 0.95 |
| Intention—after toilet use (mean score) | 328 | 8.7 (1.49) | 389 | 8.8 (1.63) | 0.19 | 0.50 |
| Intention—before meals (mean score) | 328 | 8.4 (1.67) | 389 | 8.4 (1.71) | 0.75 | 0.86 |
| *Cluster level* | | | | | | |
| Observed HWWS[1]—after toilet use (%) | 65 | 0 | 34 | 6 | 0.05 | 0.42 |
| Handwashing duration—after toilet use (mean) | 65 | 12 (8.25) | 34 | 10 (5.33) | 0.04 | 0.87 |
| Observed HWWS—before meals (%) | 118 | 1 | 77 | 0 | 0.42 | 0.48 |
| Duration for handwashing—before meals (mean) | 118 | 5 (0.08) | 77 | 2 (1.4) | 0.06 | 0.28 |

*$p$ values were adjusted for clustering, and variance in cluster sizes

†Examined statistically to determine whether or not these were confounders. Results indicated they were not

[1]Handwashing with soap

primary data from this research. The ICCs derived from the analyses were 0.17 for the variable *practice of HWWS*, 0.04 for *intention to wash hands with soap*, 0.07 for *knowledge on hygiene*, and 0.01 for *attitude to HWWS*.

### Intervention effect: pre- and post-scores

Regarding the intervention arm, a statistically significant difference was detected for all variables considered for the analysis ($p < 0.001$). With regard to the control arm, there was no statistically significant difference between pre- and post-scores with respect to variables considered for the analysis. The intervention arm recorded an 88% difference with respect to the practice of HWWS after toilet use, while an 18% difference was recorded with respect to HWWS before meals. The difference in pre- and post-scores for the control arm was only 2% for each of the variables measured under the practice of HWWS. Figures 3 and 4 gives a visual impression of the pre- and post-scores for behavioural intention and practice of HWWS.

## Discussion

### Intervention effect on behavioural intention

At 2-week, the difference in behavioural intention between the two study groups was statistically significant. Thus, *HandsCare* demonstrated effectiveness in positively influencing pupils' intention to wash hands with soap at the two critical times adopted for the study. Nonetheless, the size of effect when Cohen's classification guideline was used could be described as from "low" and "moderate" for the two critical times ($d = 0.2$ and 0.5). It is worth mentioning that there is a paucity of studies in the body of literature which have sought to determine the effect of a hand hygiene educational intervention on behavioural intention, though few studies exist in other domains such as physical activity (Sniehotta et al. 2005).

From a theoretical perspective, the TPB has posited that behavioural intention is the closest determinant of behaviour. But that notwithstanding, there is ample evidence to

**Table 2** Intervention effects at 2-week follow-up (based on cluster summaries), Ghana, 2015–2018

| Variables | Arm | | *p* values (2-tailed) $p < 0.05$ (adjusted*) | Effect estimate (Cohen's *d*)† | 95% CI |
|---|---|---|---|---|---|
| | Intervention | Control | | | |
| Number of clusters | 2 | 2 | | | |
| Number of individuals enrolled at Baseline | 328 | 389 | | | |
| Number of individuals assessed at follow-up | 328 | 384 | | | |
| *Primary outcomes* | | | | | |
| Observed HWWS[1]—after toilet use | | | | | |
| Proportions (SE[2]) | 0.88 (.004) | 0.08 (.077) | 0.005 | 2.6 | 1.9–3.3 |
| Observed HWWS—before meals | | | | | |
| Proportions (SE) | 0.19 (.011) | 0.02 (.022) | 0.012 | 0.5 | 0.2–0.8 |
| Behavioural intention | | | | | |
| Intention—after toilet use [mean (SD[3])] | 9.34 (.093) | 8.82 (.154) | 0.032 | 0.5 | 0.3–0.6 |
| Intention—before meals [mean (SD)] | 9.08 (.042) | 8.82 (.049) | 0.020 | 0.2 | 0.1–0.3 |
| *Ancillary outcomes* | | | | | |
| Duration for handwashing [mean (SD)] | 32 (.813) | 11 (.636) | 0.002 | 0.9 | 0.4–1.4 |
| Knowledge [mean (SD)] | 8.37 (.026) | 9.01 (.209) | 0.067[a] | – | – |
| Attitude [mean (SD)] | 14.62 (.048) | 14.29 (.086) | 0.040 | 0.21 | 0.1–0.4 |
| Skill [mean (SD)] | 9.10 (.382) | 5.01 (.001) | 0.004 | 3.2 | 2.9–3.4 |

*Adjusted for clustering and variations in cluster weights

†Small effect = 0.2, medium effect = 0.5, large effect = 0.8, very large effect = 1.3 (Cohen 1992)

[a]Examined further to determine possible pre- and post-difference

[1]Handwashing with soap

[2]Standard error

[3]Standard deviation

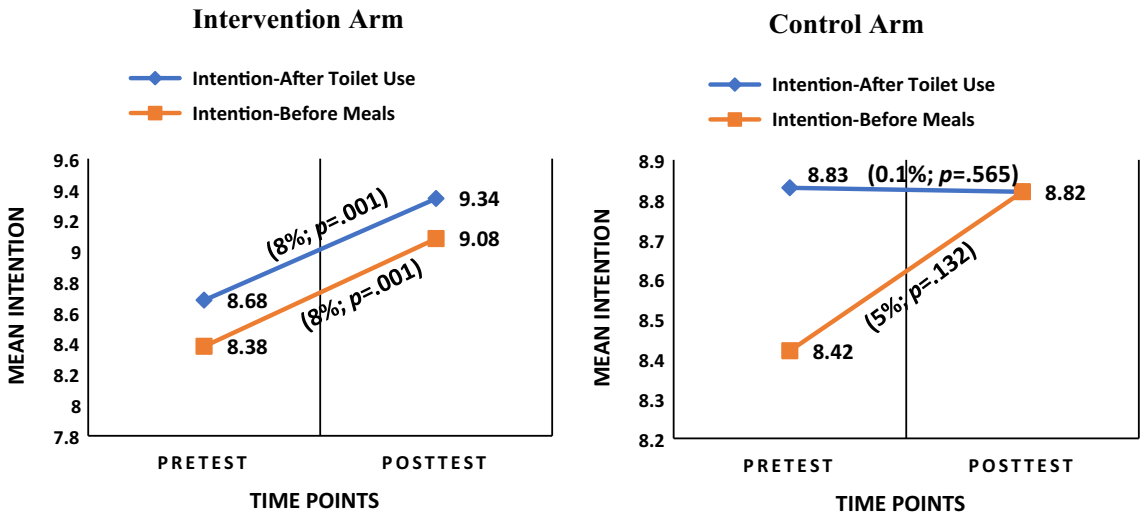


**Fig. 3** Behavioural Intention pre-intervention and post-intervention, Ghana, 2015–2018

suggest that a high intention does not necessarily predict behaviour. This phenomenon has been described as the "intention-behaviour gap" (Sniehotta et al. 2005; Godin et al. 2005). In the field of physical activity, for example, Rhodes and Yao (2015) have reported a decline in the practice of behaviour after intention was increased in an experimental manipulation. In spite of these recent reports on the intention-behaviour gap, the crucial role of intention in influencing the practice of behaviour remains widely accepted.

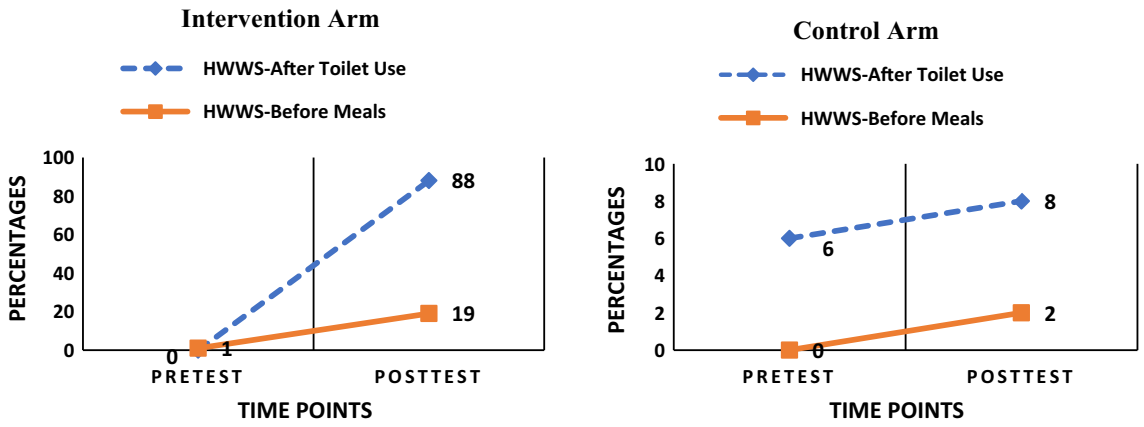


**Fig. 4** Observed practice of handwashing with soap (HWWS) pre-intervention and post-intervention, Ghana, 2015–2018

## Intervention effect on practice of HWWS

The size of effect was observed to be very large ($d = 2.6$) with respect to the proportion of pupils practicing HWWS after toilet use, when Cohen's classification guideline was used. Regarding the proportions of pupils practicing HWWS before meals, the size of effect was identified to be medium ($d = 0.5$). With respect to the pre- and post-test scores, the intervention arm recorded an 88% difference for the practice of HWWS after toilet use, while an 18% difference was recorded for the practice of HWWS before meals. The difference in handwashing behaviour at the two critical times could be explained by the innate variable "Disgust" which may characterise toilet use (Curtis 2007).

In estimating the sample size of this trial, it was conjectured that the intervention will be able to detect (at follow-up) a 60% reduction in the proportion of pupils who do not practise proper handwashing. In the light of this, it can be observed that the intervention succeeded in achieving a post-test score higher than the anticipated 60%, with regard to HWWS after toilet use (88%); but lower than the 60%, with regard to HWWS before meals (18%). Regarding the control arm, the difference in pre- and post-scores was only 2% for each of the variables measured under the practice of HWWS (i.e. HWWS after toilet use and HWWS before meals). It is evident from the aforementioned summary that *HandsCare* demonstrated a positive influence in the enhancement of the outcome variables of the study. In a study conducted in Egypt which used a quasi-experimental design, authors reported that a health educational programme was effective in improving handwashing practices (Moussa et al. 2015). Conversely, a cluster-randomised trial by Graves et al. (2011) conducted in Kenya which combined the provision of handwashing facilities with a poster contest reported that the intervention was not effective in improving handwashing practices.

## Explanation for intervention effect on behavioural intention and practice of HWWS

With respect to the variables which might contribute to explaining the intervention effect on intention and practice of HWWS, there were no significant between-group differences at follow-up with respect to the variables perceived susceptibility, perceived severity, normative beliefs, and motivation to comply. It may be early days to draw any conclusions on this particular result, except to suggest that these variables be subjected to further enquiries. Table 2 shows a significant between-group difference for handwashing skill ($p = 0.004$; $d = 3.2$) and attitude ($p = 0.040$; $d = 0.21$), but not knowledge ($p = 0.067$). The above could mean that *HandsCare* is not a knowledge-based intervention but rather an intervention which has the strength to enhance positive attitudes and skills. Although the intervention effect on attitude was low ($d = 0.21$), it can be observed that its effect on handwashing skill was very large ($d = 3.2$), according to the Cohen's classification guideline. It is worth noting that the variables *attitude*, *skill*, and *knowledge* are intervention variables and therefore the enhancement of these has implications on the post-intervention scores of behavioural intention, as well as practice of HWWS. Though there was not a significant between-group difference in the knowledge scores at follow-up, the pre- and post-scores for knowledge increased by 7% in the intervention arm, but 4% in the control arm. The increase occurring in the control arm could potentially be attributed to the testing effect (i.e. resulting from baseline assessment).

From both empirical and theoretical perspectives, it is known that the variable "*knowledge*" alone may not trigger intention and also the adoption of a behaviour (Lopez-Quintero and Freeman 2009). From this study, it can be observed that although the control arm had a higher knowledge score at baseline, this did not translate into

improved intention and practice. The significant between-group difference for handwashing skill ($p = 0.004$; $d = 3.2$) and attitude ($p = 0.040$; $d = 0.21$) could explain the intervention effect on behavioural intention and practice of HWWS. Handwashing skill and attitude emanate from the Social Cognitive Theory and the Theory of Planned Behaviour, respectively. Thus, the variable which might have contributed the highest to the intervention effect on study outcomes is handwashing skill, with its very large effect size ($d = 3.2$).

## Reflection on analysis procedures

There is a long-standing debate on whether or not data derived using Likert scale questions could be subjected to parametric tests. The opposing schools of thoughts have raised what could be described as convincing arguments to buttress their respective perspectives. This section of the paper does not intend to join the debate but rather to indicate that in the absence of a universal consensus against the use of parametric test for data derived using Likert scales, the analysis procedures adopted for this study have utility for answering the question on effectiveness of a theory-based hand hygiene educational interventions on behavioural outcomes.

## Potential limitations

The geographic scope of this study was limited to the Ejisu-Juaben Municipality of Ghana. In the light of this, the generalisability of study results may be limited to geographic locations and settings which share in the socio-economic and cultural characteristics of the aforementioned municipality. In addition, self-reported data were used for measuring certain variables such as attitude to HWWS; this could potentially result in reporting bias. Also, the use of a small number of schools for the cluster-randomised controlled trial has the potential to limit external validity of study results. In spite of the potential limitations, we adopted robust procedures aimed at ensuring that threats to internal validity were reduced to the barest minimum.

## Conclusion

The results of this study indicate that a theory-driven hand hygiene educational intervention involving school children and targeting the three learning domains has a medium to a very large effect size, with respect to the practice of handwashing with soap. However, with respect to behavioural intention, the intervention yielded a low to a medium effect size. As the study has shown that knowledge of hand hygiene may not influence positive intentions and trigger the adoption of proper handwashing behaviour, it would be expedient for future interventionists to strategies towards the positive enhancement of participants' handwashing skills and attitudes to handwashing. This could be crucial in ensuring that intervention effects are maximised.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that there is no conflict of interest.

**Ethical approval** In order to ensure that standard research protocols have been adhered to right from the design stage of the research, the research proposal was submitted to the Committee on Human Research (CHRPE), Publications and Ethics of the Kwame Nkrumah University of Science and Technology for review and subsequently ethical clearance was granted unconditionally.

**Informed consent** The study sought for assent from eligible pupils, and subsequently a written informed consent from parents or guardians.

## References

Appiah-Brempong E, Harris MJ, Newton S, Gulis G (2018a) A framework for designing hand hygiene educational interventions in schools. Int J Public Health 63:251–259

Appiah-Brempong E, Harris MJ, Newton S, Gulis G (2018b) Examining school-based hygiene facilities: a quantitative assessment in a Ghanaian municipality. BMC Public Health 18:1–8. https://doi.org/10.1186/s12889-018-5491-9

Bennet P, Murphy S (1997) Psychology and health promotion. Open University Press, Buckingham

Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR (1956) Taxonomy of educational objectives, handbook I: the cognitive domain. David McKay Co Inc., New York

Breitenstein SM, Gross D, Garvey CA et al (2010) Implementation fidelity in community-based interventions. Res Nurs Heal 33:164–173. https://doi.org/10.1002/nur.20373

Campbell M, Walters S (2014) How to design, analyse and report CRTs in medicine and health related research. Wiley, London

Cohen J (1992) A power primer. Psychol Bull 112:155–159. https://doi.org/10.1037/0033-2909.112.1.155

Cottrell R, McKenzie J (2011) Health promotion and education research methods: using the five-chapter thesis/dissertation model, 2nd edn. Jones and Bartlett Publishers, Toronto

Curtis V (2007) A natural history of hygiene. Can J Infect Dis Med Microbiol 18(1):11–14

Curtis VA, Danquah LO, Aunger RV (2009) Planned, motivated and habitual hygiene behaviour: an eleven country review. Health Educ Res 24:655–673. https://doi.org/10.1093/her/cyp002

Dreibelbis R, Winch PJ, Leontsini E, Hulland KRS, Ram PK, Unicomb L, Luby SP (2013) The integrated behavioural model for water, sanitation, and hygiene: a systematic review of behavioural models and a framework for designing and evaluating behaviour change interventions in infrastructure-restricted settings. BMC Public Health 13(1):1

Dyson J, Lawton R, Jackson C, Cheater F, Health A (2011) Does the use of a theoretical approach tell us more about hand hygiene

behaviour? The barriers and levers to hand hygiene. J Infect Prev 12(1):17–24

Ejemot-Nwadiaro RI, Ehiri JE, Meremikwu MM, Critchley JA (2015) Hand washing promotion for preventing diarrhoea (review). Cochrane Database Syst Rev Art. No.: CD004265. https://doi.org/10.1002/14651858.CD004265.pub2

Eldridge S, Kerry S (2012) A practical guide to cluster randomised trials in health services research. Wiley, London

Eshetu G (2013) Involving children for handwashing behavior change. Anchor Academic Publishing, Hamburg

European Medicines Agency (2003) Points to consider on adjustment for baseline covariates. EMEA, London

Freeman MC, Stocks ME, Cumming O et al (2014) Systematic review: hygiene and health: systematic review of handwashing practices worldwide and update of health effects. Trop Med Int Heal 19:906–916. https://doi.org/10.1111/tmi.12339

Godin G, Conner M, Sheeran P (2005) Bridging the intention-behaviour 'gap': the role of moral norm. Br J Soc Psychol 44:497–512. https://doi.org/10.1348/014466604X17452

Graves JM, Daniell WE, Harris JR et al (2011) Enhancing a safe water intervention with student-created visual aids to promote handwashing behavior in Kenyan primary schools. Int Q Community Health Educ 32:307–323. https://doi.org/10.2190/IQ.32.4.d

Hayes R, Moulton L (2009) Cluster randomised trials. CRC Press, London

Hutchison D (2009) Designing your sample efficiently: clustering effects in education surveys. Educ Res 51:109–126. https://doi.org/10.1080/00131880802704806

Lopez-Quintero C, Freeman PNY (2009) Hand washing among school children in Bogota, Columbia. Am J Public Health 99:94–102

Mellard D (2010) Fidelity of implementation within a response to intervention (RtI) framework: tools for schools. In: National center on response to intervention webinar. https://webnew.ped.state.nm.us/wp-content/uploads/2018/03/Fidelity-of-Implementation-guidev5-1.pdf. Accessed 11 Sept 2017

Mortell M, Balkhy HH, Tannous EB, Thiee M (2013) Physician 'defiance' towards hand hygiene compliance: Is there a theory–practice–ethics gap? J Saudi Heart Assoc 25:203–208. https://doi.org/10.1016/j.jsha.2013.04.003

Moussa M, Moussa M, Hassan N, Abdella A (2015) Effectiveness of a training program on improving the hand washing among children in primary schools. Int J Adv Nurs Stud 4:49–54. https://doi.org/10.14419/ijans.v4i2.4447

Pickering AJ, Davis J, Blum AG et al (2013) Access to waterless hand sanitizer improves student hand hygiene behavior in primary schools in nairobi, Kenya. Am J Trop Med Hyg 89:411–418. https://doi.org/10.4269/ajtmh.13-0008

Pickering AJ, Blum AG, Breiman RF et al (2014) Video surveillance captures student hand hygiene behavior, reactivity to observation, and peer influence in Kenyan primary schools. PLoS ONE 9:1–7. https://doi.org/10.1371/journal.pone.0092571

Rhodes RE, Yao CA (2015) Models accounting for intention-behavior discordance in the physical activity domain: a user's guide, content overview, and review of current evidence. Int J Behav Nutr Phys Act. https://doi.org/10.1186/s12966-015-0168-6

Sniehotta FF, Scholz U, Schwarzer R (2005) Bridging the intention–behaviour gap: planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. Psychol Health 20:143–160. https://doi.org/10.1080/08870440512331317670

Thabane L (2004) Sample size determination in clinical trials. https://fammedmcmaster.ca/research/files/sample-size-calculations. Accessed 16 July 2016

Trunnell EP, White GL (2005) Using behavior change theories to enhance hand hygiene behavior. Educ Heal 18:80–84. https://doi.org/10.1080/13576280500042879

UNICEF (2008) More than soap and water: taking handwashing with soap to scale: UNICEF handwashing training module. http://globalhandwashing.org/wp-content/uploads/2015/03/HWWS-More-Than-Soap-and-Water_Training-Module.pdf. Accessed 8 July 2016

UNICEF (2015) Advancing WASH in schools monitoring. UNICEF Press, New York

White KM, Starfelt LC, Jimmieson NL et al (2015) Understanding the determinants of Australian hospital nurses' hand hygiene decisions following the implementation of a national hand hygiene initiative. Health Educ Res 30:959–970. https://doi.org/10.1093/her/cyv057