Effects of a social norm-based handwashing intervention including handwashing stations, and a handwashing station-only intervention on handwashing with soap in urban Côte d'Ivoire: a cluster randomised controlled trial

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Summary

Background Diarrhoeal diseases are an important cause of mortality in children younger than 5 years in sub-Saharan Africa. We aimed to evaluate the effect of three handwashing interventions on handwashing with soap (HWWS) after toilet use.

Methods In this cluster randomised trial in Abidjan, Côte d'Ivoire, we randomly assigned communal housing compounds (1:1:1) to receive one of three interventions: a theory of normative social behaviour (TNSB) intervention, including provision of handwashing stations; handwashing stations only; and no intervention. The TNSB intervention was designed to shift the outcome expectation associated with HWWS from health to riddance of faeces-related disgust, and to increase the perceived descriptive norm and perceived handwashing publicness. Participants and fieldworkers were masked to the study objectives. The primary outcome was HWWS after toilet use, assessed at 1 month and 5 months follow-ups. Analysis was by intention to treat. This trial is registered at the Pan African Clinical Trial Registry, PACTR201501000892239.

Findings Between April 10 and May 22, 2014, we identified 92 eligible compounds, of which 75 compounds were included. Follow-up data on HWWS were available for 23 compounds for the TNSB group, 25 compounds for the handwashing station-only group, and 25 compounds for the control group. The study ended in April, 2017. Compared with a frequency of 5% (29 of 604 occasions) in the control group, HWWS after toilet use increased to 9% (49 of 557 occasions; adjusted risk ratio 1·89, 95% CI 1·16–3·08) in the handwashing station-only group, and 24% (143 of 588 occasions; 4·82, 3·06–7·59) in the TNSB group, at the 1-month follow-up. The intervention effect was only sustained in the TNSB group (98 [22%] of 450 compounds; 2·68, 1·65–4·34).

Interpretation A social norm-based handwashing intervention combined with disgust-inducing messages, with provision of handwashing stations, was effective at increasing HWWS after toilet use. The provision of handwashing stations alone had little effect. Future studies should investigate whether the same approach, when delivered via mass media, can have a similar effect to the face-to-face delivery used in this study.

Funding None.

Lancet Glob Health 2021; 9: e1707–18

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Introduction

Diarrhoeal diseases account for approximately 15% of deaths among children aged 1–59 months worldwide,[1,2] with the highest burden in sub-Saharan Africa.[3,4] Handwashing with soap (HWWS), after contact with faeces, is considered one of the most cost-effective methods of preventing diarrhoeal diseases.[5–8] HWWS is also promoted as a key intervention to prevent infectious diseases such as Ebola virus disease and COVID-19. However, the frequency of HWWS at key moments is globally low (eg, 5–22% after faecal contact in sub-Saharan Africa).[9]

In a 2020 systematic review[10] assessing the effect of behaviour change handwashing interventions on handwashing practices, of a total of 29 studies included in the review, 18 used health-based messaging, and only four[11–14] used predominantly non-health-based messages, among which one study used only non-health motives.[11] It has been suggested that, although handwashing promotion campaigns have traditionally focused on health benefits, health might not provide a strong motivation for HWWS, outside of disease outbreaks,[15–17] and various motivators of handwashing behaviour have been postulated, including social norms and disgust.[11,16–20] Additionally, environmental enablers (eg, the presence of handwashing facilities)[21–23] might be important determinants of handwashing behaviour, particularly in economically disadvantaged communities in low-income and middle-income countries (LMICs).[24]

In this study, we designed and evaluated the effect of a theory of normative social behaviour[25] (TNSB)-based handwashing intervention, eliciting the emotion

Research in context

Evidence before this study

Diarrhoeal diseases are a leading cause of death in children younger than 5 years. Handwashing with soap (HWWS) after contact with faeces is among the most cost-effective methods of preventing diarrhoea, but HWWS rates around the world are low (estimated at 19%), particularly in low-income countries. A systematic review assessing the effect of behaviour change handwashing interventions on handwashing practices included 29 studies, among which 18 studies predominantly used health-based messages to motivate behaviour change. However, health might not be a key motivator for HWWS practices, outside of epidemics. Having access to handwashing facilities with water and soap at the same location could also be key to triggering HWWS practices.

A cluster randomised trial in India used solely non-health-based motives (including disgust and status) in their handwashing behaviour change intervention. The study reported a positive effect of the intervention on HWWS practices after food-related occasions, but not after faecal contact 6 weeks after intervention delivery. A second cluster randomised trial, undertaken in Nigeria, using non-health-based messages including disgust and affiliation, found weak evidence of an intervention effect on HWWS after faecal contact, but some evidence of an effect on HWWS before food-related occasions. Both studies were small in size (14 clusters each) and conducted in rural areas. The risk of transmission of infectious diseases is often greater in urban than rural areas because of high population density, and therefore greater level of interaction, and living proximity. We have not identified any trial assessing the effect of handwashing facilities alone on HWWS practices in low-income and middle-income community settings.

Added value of this study

We evaluated the effect of an intervention designed using the theory of normative social behaviour (TNSB), using disgust as opposed to health as a motive, along with provision of a handwashing station on HWWS practices after toilet use. The study was undertaken in Abidjan, Côte d'Ivoire. The provision of handwashing stations alone was also assessed. The TNSB intervention led to a substantial increase in HWWS after toilet use, which was sustained for at least 5 months. The provision of handwashing stations alone had only a small, short-term effect on HWWS after toilet use.

Implications of all the available evidence

The COVID-19 pandemic highlights the importance of identifying effective ways of promoting HWWS in epidemic and non-epidemic circumstances. The observed effect of our relatively low-intensity, disgust-focused TNSB intervention on HWWS after toilet use was relatively large compared with the effects reported in similar trials. Further trials should be conducted to evaluate the effects of non-health-based behaviour change interventions on HWWS practices in different settings.

of disgust, along with provision of a handwashing station, on handwashing with soap after using the toilet, and after cleaning a child's bottom, in Abidjan, Côte d'Ivoire. The intervention also used a social marketing approach.[26–28] The effectiveness of the provision of a handwashing station alone was also assessed.

Methods

Study design

This cluster randomised controlled trial was conducted in Koumassi, an economically disadvantaged commune of Abidjan, Côte d'Ivoire, where communal housing compounds are common. Six of Koumassi's 18 neighbourhoods were included (figure 1). The remaining 12 neighbourhoods were excluded because of security issues or habitat type. Compounds occupied by multiple households that have shared water and sanitation facilities are the most common accommodation type in Abidjan.[29] It is estimated that over 50% of the population in the city lives in such compounds.[29] Dwellings are built around an open courtyard where most daily living activities (such as cooking, washing the dishes, and doing laundry) occur.[30–33] Occupants of one household are typically unrelated to those of other households and most occupants rent their accommodation. Despite most compounds having a piped water supply in our study population, dedicated handwashing facilities are rare, and due to high population density and poor sanitary conditions, the risk of transmission of infectious diseases is substantial.

See Online for appendix

We visited all compounds in the study area. Eligibility criteria were the presence of at least four children younger than 5 years per compound and a maximum of two households with screens (eg, walls in front of individual households to give extra privacy to inhabitants, but which might make it difficult to observe behaviours during data collection). Compounds with handwashing facilities (eg, sinks or handwashing stations) were excluded (appendix p 3). Verbal informed consent was obtained from residents (and landlords when present) to take part in data collection. Separate informed consent was obtained by intervention providers to deliver the interventions (appendix pp 3–4). We obtained ethical approval from Côte d'Ivoire's Bioethics Committee (Comité Consultatif de Bioethique de Côte d'Ivoire; appendix p 5), Côte d'Ivoire's Ministry of Higher Education and Scientific Research (reference 0758/MESRS/CAB 1/gsy), and the London School of Hygiene & Tropical Medicine's Research Ethics Committee (reference 7029).

A summary of the changes made to the trial methods after the trial's start are stated in the appendix (p 6).

Randomisation and masking

Compounds were randomly assigned (1:1:1) to three groups: the disgust-inducing TNSB intervention, or the handwashing station-only intervention, or a non-intervention control group. The interventions could be delivered only at the compound level; therefore, we used a cluster randomisation approach. All compounds were located using a sketch map of the study area. To minimise contamination between study groups, the compounds that presented the least contamination risk were then selected (appendix p 7). Compounds were randomly allocated by the corresponding author (MAA-T) to the control (ie, no intervention) group, or one of the two interventions groups (TNSB or handwashing station-only), using STATA (version 13.1)

The study was supervised by MAA-T and two coauthors (PKB and HAK). They were not masked to the study objectives and hypotheses, but did not participate in data collection or in intervention delivery, except to supervise fieldworkers. To minimise the Hawthorne effect among study participants, inherent to structured observations,[34–36] and minimise the risks of differential misclassification by fieldworkers responsible for data collection, both fieldworkers and participants were masked to the study objectives and hypotheses. They were told that the study sought to understand how compounds were organised, particularly in relation to gender roles and social cohesion among residents. The data collection tools contained items relating to the masking theme. Intervention providers were not masked to the study objectives and were aware of the work undertaken by the fieldworkers. However, fieldworkers were not told about the activities of the intervention providers. Activities were planned to ensure that the two teams never met in the field.

There were no criteria for early trial termination.

Procedures

Details of the interventions are described in table 1.

The disgust-inducing intervention was designed using the TNSB as the behaviour change model,[25] following formative research, and was pilot tested outside the study area in compounds in Treichville commune, in a population similar to the study population. Social norms theory states that the majority of people's behaviour is affected by their perception of the behaviour of other members of their social group.[37–39] Individuals copy what they believe everyone else is doing (perceived descriptive norms)[38] to fit into their social groups.[38,39] In the TNSB, it is argued that four factors moderate the relationship between descriptive norms and behaviour: injunctive norms, outcome expectations, group identity, and ego involvement.[25,40,41] The last three constructs were relevant to our study setting and are defined in the appendix (p 8).

From our formative research, health was identified as the outcome our target population expected from HWWS (perceived outcome expectation). Given the low HWWS frequencies observed in the pilot study (low descriptive norm), we theorised that health was an ineffective handwashing motivator in our study population. The TNSB intervention was therefore designed to shift the outcome expectation associated with HWWS from health to riddance of faeces-related disgust and to increase the perceived descriptive norm (perception of the extent of fellow compound residents' HWWS practices), and perceived handwashing publicness (perception of whether HWWS practices in a compound are visible to others). Handwashing social norms-related scales were designed to measure the perceived descriptive norms, injunctive norms, and behaviour publicness around HWWS after toilet use in our study population.

We also used a social marketing perspective to inform the design of the intervention, with HWWS after toilet use as the product that we offered. The intervention sought to create the need for HWWS after toilet use, to remove the feeling of disgust generated by coming in contact with faeces. HWWS was presented as the most effective product to rid consumers of the negative feeling, compared with its alternatives (handwashing with water only or gel and no handwashing). As part of this marketing approach, the intervention also had a short and easy-to-remember slogan: *"eau et savon après les WC, c'est ça qui marche deh! Bien même!"*, which can be translated as: "water and soap after using the toilet, that's what really works!"

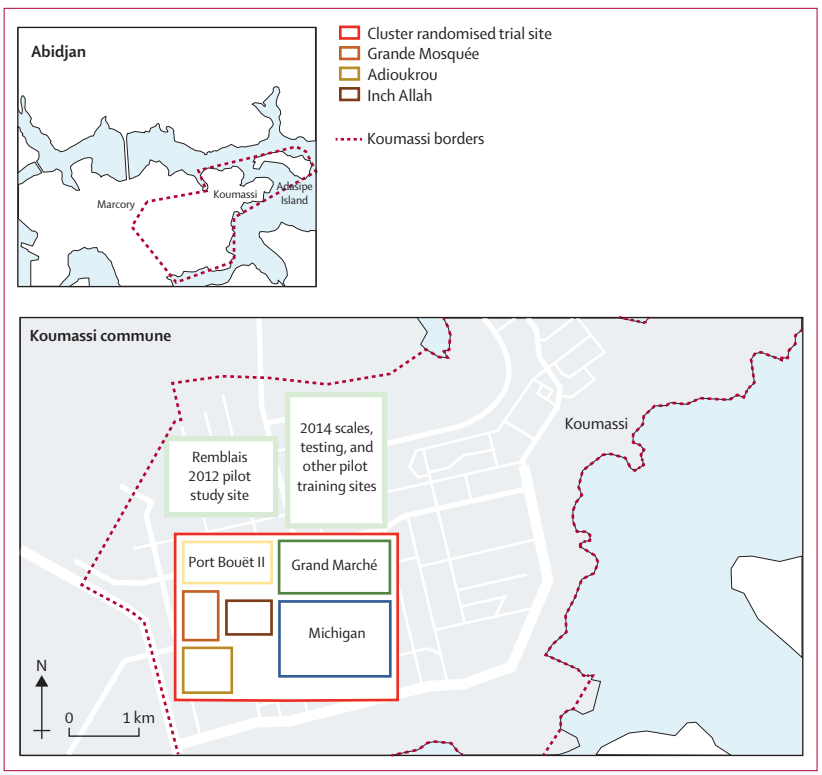

Figure 1: **Map of the cluster randomised trial site, pilot studies, and training sites in Koumassi, Côte d'Ivoire**

	Intervention components	Number of compound visits	Activities at each visit	Key intervention message
TNSB and handwashing station intervention	10 videos; Glo Germ demonstration; 10 posters; one handwashing station with an initial supply of four 50 cL soapy water bottles	Five	Visit 1: (1) screening of group 1 or group 2* videos in compounds, discussions, and vote to identify key emotions triggered by the negative videos; (2) Glo Germ demonstrations; (3) HWWS set up at toilet entrance or in the middle of compound and discussions held on handwashing station maintenance; (4) posters placed at toilet entrance and on doors inside the toilets. Visit 2 (1 week since previous visit): (1) no intervention; (2) handwashing station facility check for any maintenance issues and equipment replacement when necessary. Visit 3 booster (3 weeks since previous visit): (1) handwashing station rapid assessment (ie, presence of water and soap at facility, and any broken components); (2) rescreening of group 1 or group 2 videos, discussions, and vote to identify key emotions triggered by the negative videos. Visit 4 booster (3 weeks since previous visit): (1) handwashing station rapid assessment (ie, presence of water and soap at facility, and any broken components); (2) screening of group 2 or group 1 videos, discussions, and vote to identify key emotions triggered by the negative videos; (3) change of posters. Visit 5 booster (3 weeks since previous visit): (1) handwashing station rapid assessment (ie, presence of water and soap at facility, and any broken components); (2) screening of group 3 videos, discussions, and vote to identify key emotions triggered by the negative videos; (3) change of posters.	We must wash our hands with soap after using the toilet
Handwashing station-only intervention	One handwashing station with an initial supply of four 50 cL soapy water bottles	Two	Visit 1: handwashing station setting up and discussion on handwashing station water and soap maintenance. Visit 2 (1 week since previous visit): (1) no intervention; (2) handwashing station facility check for any maintenance issues and equipment replacement when necessary.	No handwashing promotion message

HWWS=handwashing with soap. TNSB=theory of normative social behaviour. *We had planned to show the videos in a specific order, although the first and second group of videos were interchangeable. During the pilot, we realised that it would be best to deliver the second video group first in compounds who were predominantly Muslim because the second video group used names and practices (ie, the use of a plastic kettle to rinse hands) that are generally associated with Muslim populations. It was important that residents identified with the characters in the videos from the first intervention delivery session.

Table 1: **Summary of the interventions and implementations**

The intervention included ten videos scripted by MAA-T, PKB, HAK, and two artistic directors from two local communication companies, and depicted everyday scenes typical of compound life. The videos also included comic elements, characteristic of popular local television series that depict societal issues. Each story revolved around a compound resident who used the toilet without washing their hands with soap afterwards. A piloted disgusting substance, generated using a digital effect and representing faeces, appeared on the main character's hands after exiting the toilet (or cleaning a child's bottom). This was then transferred within the compound environment, through the main character's direct (person-to-person) or indirect (person-to-object-to-person) contact with fellow residents. Consequently, the main character or fellow residents was seen ingesting the disgusting substance. The videos were organised in three groups with care taken to ensure that, in each video group, both women and men, and adults and children were represented as main characters. As part of the intervention, a list of questions was developed for each video (appendix pp 8–9), to assess and reinforce participants' understanding of the intervention's key messages.

The intervention also included ten posters (appendix p 10), designed by a local graphics artist based on the videos, to be placed on doors inside the toilet and at the toilet's entrance, a Glo Germ demonstration, and a handwashing station (appendix p 11). The handwashing station also came with an initial supply of four 50 cL bottles containing a supply of soapy water, which the pilot study suggested was perceived as more hygienic to share than other soap types. The facility was to be placed at the toilet's entrance (or middle of the compound, if toilets were located in different areas of the compound).

For more on **Glo Germ** see https://www.glogerm.com/

The key TNSB intervention messages to participants focused on HWWS after using the toilet, and that failure to do so would leave faeces on their hands, which they would pass on to other compound residents and potentially consume. Only the last video group to be implemented included a video promoting HWWS after cleaning a child's bottom, to avoid diluting the key handwashing intervention message of HWWS after toilet use. The intervention was delivered in a participatory rather than a didactic fashion, with the audience playing an active part in the intervention delivery. The pronoun "we" was used in the intervention messages rather than "you". The intervention did not include any health messages. The handwashing station-only intervention comprised of a handwashing station with an initial supply of four 50 cL soapy water bottles. The handwashing station was presented as a gift to make handwashing easier, but no handwashing promotion messages were delivered.

Full details of intervention providers' training and the interventions' implementation methods are in the appendix (pp 12–17).

Three intervention providers were recruited and trained for 6 weeks using role-play sessions in classroom practicals and delivering the interventions in compounds in Treichville commune. The interventions were delivered in late afternoon, when most residents were at home.

The intervention providers delivered the TNSB intervention together, in a total of four sessions per compound. With the exception of the first video group,

which was shown twice (appendix p 6), each video group was shown once in each compound. The posters were changed every time a new video group was introduced. After setting up the handwashing station with the initial soap supply, intervention providers discussed maintenance strategies with residents. A Glo Germ demonstration was shown at the first intervention delivery session only (appendix p 6). For the handwashing station-only intervention, individual intervention providers delivered the station to their assigned compounds. The handwashing station was delivered with the initial soap supply, and maintenance discussions were held with residents.

In both intervention groups, 1 week after initial intervention delivery, intervention providers visited compounds to ensure that there were no issues with the handwashing station (eg, broken stand or tap). Any problems were either immediately addressed (eg, tightening of the tap joint), or the handwashing station was immediately replaced. The intervention providers also had a debriefing session with MAA-T, PKB, and HAK at the end of each intervention delivery session.

Ten fieldworkers were hired and trained for data collection by MAA-T, PKB, and HAK (appendix p 18). Structured observations were used to record handwashing practices after using the toilet, with or without the use of a container filled with water for cleansing (eg, plastic kettle), and after cleaning a child's bottom. The data were recorded by age group and gender. Observations were conducted for 3 h, from 1600 h to 1900 h when most residents would be at home. We also recorded information on handwashing facilities (eg, presence and type of handwashing facility). Each compound was observed on two different days at each data collection round (appendix p 18).

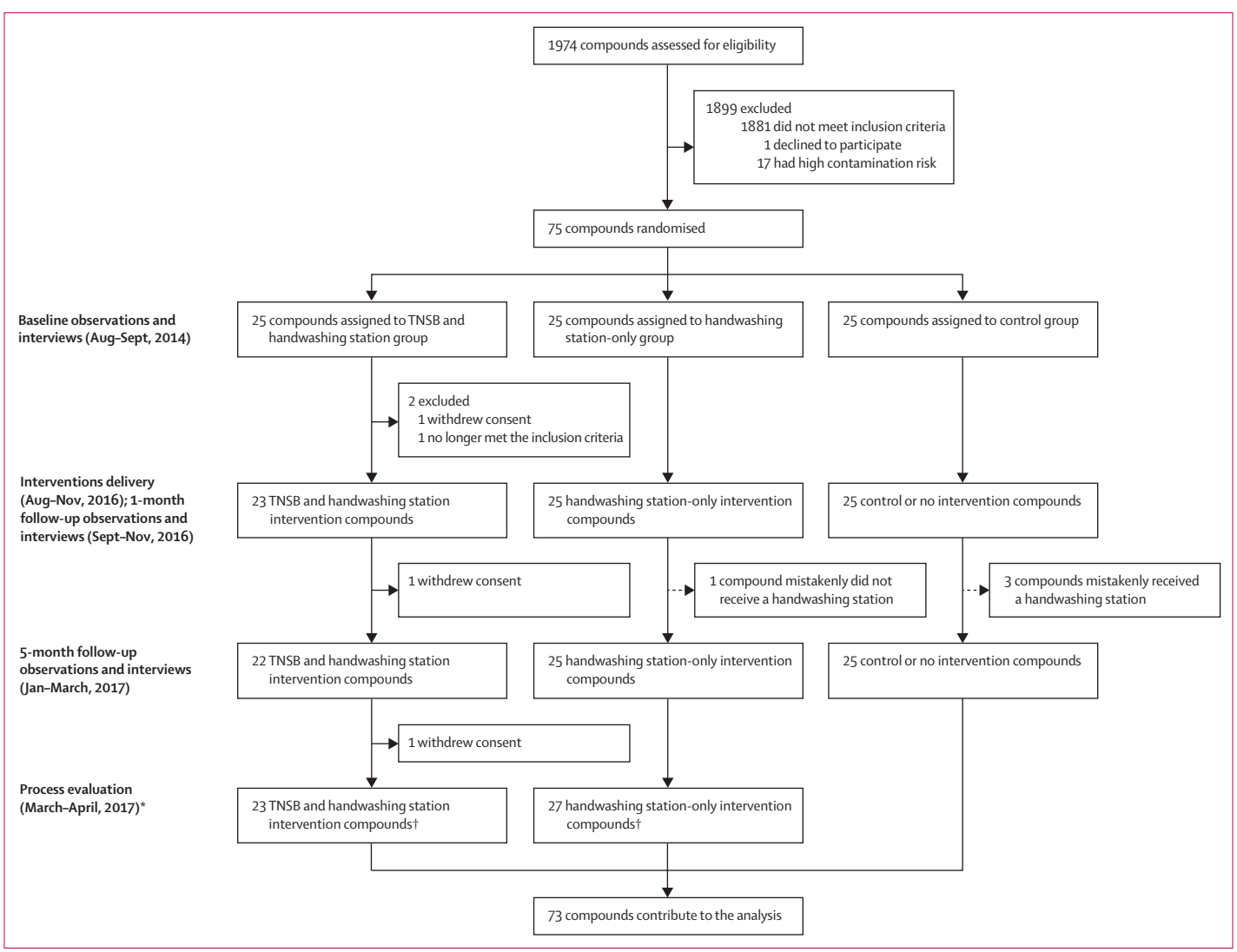

***Figure 2*: Trial profile**
TNSB=theory of normative social behaviour. *Data collected by the intervention providers, from whom no compound withdrew consent. †On-treatment analysis.

	Control group	Handwashing station-only group	TNSB and handwashing station group
Compound-level characteristics			
Number of compounds	25	25	25
Median number of households (range)	8·5 (7–11)	9 (7–12)	9 (7–13)
Household-level characteristics			
Number of households to be surveyed	68	65	70
Number of households actually surveyed	58 (85·3%)	57 (87·7%)	60 (85·7%)
Median family size (range)	5 (1–11)	5 (1–13)	4 (1–11)
Presence of at least one child <5 years	33 (56·9%)	25 (43·9%)	26 (43·3%)
Median number of rooms per household (range)	2 (1–3)	2 (1–4)	2 (1–3)
One person per room	6 (10·3%)	6 (10·5%)	9 (15·0%)
More than one person and up to two people per room	15 (25·9%)	11 (19·3%)	14 (23·3%)
More than two people per room	37 (63·8%)	40 (70·2%)	37 (61·7%)
Median household rent in CFA(range)	20 000 (0–60 000)*	17 500 (0–51 000)†	17 000 (0–50 000)‡
Television ownership	49 (84·5%)	50 (87·7%)	55 (91·7%)
Radio ownership	36 (62·1%)	34 (59·7%)	31 (51·7%)
Individual-level characteristics			
Number of individuals surveyed	58	57	60
Religion			
Christian	20 (34·5%)	17 (29·8%)	18 (30·0%)
Muslim	37 (63·8%)	39 (68·4%)	41 (68·3%)
Other	1 (1·7%)	1 (1·8%)	1 (1·7%)
Marital status			
Married or cohabiting	36 (62·1%)	38 (66·7%)	36 (60·0%)
Single	22 (37·9%)	19 (33·3%)	24 (40·0%)
Female head of household education level			
No schooling	24 (50·0%)§	18 (39·1%)¶	12 (26·7%)‖
Primary	17 (35·4%)§	16 (34·8%)¶	21 (46·7%)‖
Secondary	6 (12·5%)§	8 (17·4%)¶	11 (24·4%)‖
Higher	1 (2·1%)§	4 (8·7%)¶	1 (2·2%)‖

Data are n (%), unless otherwise stated. TNSB=theory of normative social behaviour. *Missing data for four households. †Missing data for five households. ‡Missing data for six households. §No female head of household in ten households. ¶No female head of household in 11 households. ‖No female head of household in 15 households.

Table 2: **Baseline characteristics of compounds, households, and individuals by study group**

After the completion of the observations, a masked questionnaire aimed at measuring the relevant social norms-related constructs around HWWS after toilet use and collecting socioeconomic data was administered on a separate day, at each data collection round. Eligible participants for the survey were adults (≥16 years) who were permanent compound residents and consented to be interviewed (appendix p 19). The questionnaire ended with one question that assessed the effectiveness of the masking items. Respondents were asked how they would describe the theme of the survey to fellow compound residents. Only a sample of households, selected using systematic random sampling, were interviewed at each data collection round, with the aim of interviewing all compound households by the end of the follow-ups.

Outcomes

The primary outcome was the proportion of occasions on which hands were washed with soap after using the toilet. There were two secondary outcomes: the proportion of occasions on which hands were washed with soap, after using the toilet with a container for cleansing, and the proportion of occasions on which hands were washed with soap, after cleaning a child's bottom. The outcomes were measured at 1 month and 5 months after initial intervention delivery (counting from the first day intervention delivery began in a compound) to measure the short-term and long-term effects of the intervention.

Statistical analysis

To estimate the required sample size, we assumed that the frequency of HWWS after using the toilet would be 5% in the control group, and that it would increase to 25% in the TNSB intervention group.[11,42] Assuming a between-cluster coefficient of variation (k) of 0·25,[43] and a harmonic mean number of events of 16 observations per compound, a sample size of 66 compounds (22 compounds per group), was estimated to provide 80% power (α=0·05). To allow for possible losses to follow-up, we planned to recruit 75 compounds. The study was not powered to detect an effect on HWWS after cleaning a child's bottom, given the small number of observed events during a previous pilot study (harmonic mean 2). The handwashing station-only group was included to enable the effect of the TNSB intervention to be distinguished from that of the handwashing station.

Data were analysed using STATA (versions 15.0 and 15.1). The analyses were done for each follow-up point. During intervention implementation, three control compounds mistakenly received a handwashing station, and one handwashing station-only intervention compound mistakenly did not receive a handwashing station. Therefore, both intention-to-treat and on-treatment analyses were done.

All statistical analyses took into account the cluster randomisation.[43] When assessing intervention effects, we used a generalised estimating equations (GEE) approach with a log link to estimate the risk ratios (RRs). If the GEE models failed to converge, binomial regression with a log link and robust standard errors was used. Both unadjusted and adjusted analyses were done. We adjusted for gender and age group of the person observed, educational level of female household heads in the compound, and the baseline HWWS frequencies in each compound.

The trial is registered at the Pan African Clinical Trial Registry, PACTR201501000892239.

Role of the funding source

There was no funding for this study.

Results

Between April 10 and May 22, 2014, 1974 compounds were screened, of which 92 (5%) met our inclusion

	Control group	Handwashing station-only group	Risk ratio (95% CI)	Adjusted risk ratio* (95% CI)	TNSB and handwashing station group	Risk ratio (95% CI)	Adjusted risk ratio* (95% CI)
Baseline†							
Number of events observed	698	710	..	..	709	..	..
Hands washed with soap	40 (5·7%)	24 (3·4%)	..	..	46 (6·5%)	..	..
Hands washed with water only or gel	205 (29·4%)	189 (26·6%)	..	..	199 (28·1%)	..	..
Hands not washed	453 (64·9%)	497 (70·0%)	..	..	464 (65·4%)	..	..
1 month‡							
Number of events observed	604	557	..	..	588	..	..
Hands washed with soap	29 (4·8%)	49 (8·8%)	1·96 (1·13–3·39)	1·89 (1·16–3·08)	143 (24·3%)	5·45 (3·36–8·86)	4·82 (3·06–7·59)
Hands washed with water only or gel	183 (30·3%)	199 (35·7%)	..	..	195 (33·2%)	..	..
Hands not washed	392 (64·9%)	309 (55·5%)	..	..	250 (42·5%)	..	..
5 months§							
Number of events observed	437	456	..	..	450	..	..
Hands washed with soap	30 (6·9%)	40 (8·8%)	1·31 (0·70–2·22)	1·06 (0·63–1·79)	98 (21·8%)	3·03 (1·84–4·98)	2·68 (1·65–4·34)
Hands washed with water only or gel	137 (31·3%)	104 (22·8%)	..	..	122 (27·1%)	..	..
Hands not washed	270 (61·8%)	312 (68·4%)	..	..	230 (51·1%)	..	..

Data are n (%), unless otherwise stated. TNSB=theory of normative social behaviour. *Adjusted for gender, age group, the education level of the female head of household, and baseline handwashing with soap estimates. †August–September, 2014. ‡September–November, 2016. §January–March, 2017.

Table 3: **Observed handwashing behaviours after using the toilet**

criteria. The main reason for non-eligibility was the presence of more than two households with screens per compound. To minimise the risk of contamination, we classified compounds into two groups. One group contained the list of compounds with the lowest contamination risk (41 compounds). These were compounds on blocks with only one or two eligible compounds per block, and where compounds were not on the same side of the block (appendix p 7). All compounds in this group were selected. The remaining 51 compounds were those with moderate to high contamination risk. 34 compounds were selected from this second group giving a total of 75 compounds (figure 2). All study compounds had at least one shared water tap and at least one shared toilet.

Before the 1-month follow-up, one (1%) compound no longer met the inclusion criteria, and therefore was excluded, and one (1%) compound withdrew. After each of the 1-month and 5-month follow ups, an additional compound withdrew (1%). All withdrawals were only from the data collection activities conducted by the fieldworkers, but not from the work conducted by the intervention providers. The analysis of the interventions' effects on HWWS was based on data from 73 (97%) compounds.

At baseline (August–September, 2014), we collected data on 175 (86%) households (between 57 and 60 households surveyed per trial group), of 203 households selected to be surveyed (table 2). Six (3%) households refused and 22 (11%) were absent. The characteristics of compounds, households, and individuals were generally similar across study groups (table 2). There were some imbalances regarding the presence of at least one child younger than 5 years in the household, radio ownership, and the level of education of the female head of household.

HWWS was uncommon in all trial groups at baseline. We observed 2117 occasions on which the toilet was visited (table 3). Most observed occasions involved adults (appendix pp 20–22). Hands were washed with soap on 40 (6%) of 698 occasions in the control group, 24 (3%) of 710 occasions in the handwashing station-only intervention group, and 46 (6%) of 709 occasions in the TNSB intervention group. Restricting attention to HWWS after toilet use with a cleansing container yielded similar results (appendix p 23). We observed very few occasions when a child's bottom was cleaned (148 occasions across all three groups; table 4). Hands were washed with soap on 11 (22%) of 49 occasions in the control group, nine (20%) of 46 occasions in the handwashing station-only intervention group, and 18 (34%) of 53 occasions in the TNSB group.

Because of a contractual dispute with the local company that produced the intervention videos, intervention delivery took place 2 years after the baseline survey. The characteristics of compounds, households, and individuals at 1 month and 5 months after intervention follow-ups are reported in the appendix (pp 24–25).

1 month after intervention delivery, we observed some increase in HWWS after toilet use in the handwashing station-only group (49 [9%] of 557 occasions) compared with the control group (29 [5%] of 604 occasions; adjusted RR 1·89, 95% CI 1·16–3·08, p=0·011; table 3).

	Control group	Handwashing station-only group	Risk ratio (95% CI)	TNSB+ handwashing station group*	Risk ratio (95% CI)
Baseline†					
Number of events observed	49	46	..	53	..
Hands washed with soap	11 (22%)	9 (20%)	..	18 (34%)	..
Hands washed with water only or gel	15 (31%)	13 (28%)	..	13 (25%)	..
Hands not washed	23 (47%)	24 (52%)	..	22 (42%)	..
1 month‡					
Number of events observed	29	28	..	20	..
Hands washed with soap	9 (31%)	13 (46%)	1·38 (0·72–2·63)	13 (65%)	2·10 (1·16–3·81)
Hands washed with water only or gel	7 (24%)	11 (39%)	..	3 (15%)	..
Hands not washed	13 (45%)	4 (14%)	..	4 (20%)	..
5 months§					
Number of events observed	22	26	..	18	..
Hands washed with soap	9 (41%)	9 (35%)	0·81 (0·37–1·79)	7 (39%)	0·83 (0·40–1·75)
Hands washed with water only or gel	5 (23%)	4 (15%)	..	3 (17%)	..
Hands not washed	8 (36%)	13 (50%)	..	8 (44%)	..

Data are n (%), unless otherwise stated. TNSB=theory of normative social behaviour. *Adjusted for gender, age group, the education level of the female head of household, and baseline handwashing with soap estimates. †August–September, 2014. ‡September–November, 2016. §January–March, 2017.

Table 4: **Observed handwashing behaviours after cleaning a child's bottom, by trial phase and trial group**

At 5 months after intervention delivery, no evidence of a difference was detected in the handwashing station-only group (40 [9%] of 456 occasions) compared with the control group (30 [7%] of 437 occasions; 1·06, 0·63–1·79, p=0·83). In the TNSB group, there was strong evidence of a large increase in the proportion of occasions on which HWWS was done after using the toilet after 1 month (143 [24%] of 588 occasions; 4·82, 3·06–7·59, p<0·0001). The change observed was largely sustained 5 months after intervention delivery (98 [22%] of 450; 2·68, 1·65–4·34, p<0·0001).

Comparing the TNSB group with the handwashing station-only group, we found strong evidence that the TNSB intervention was more effective at increasing HWWS after toilet use, both 1 month after intervention delivery (adjusted RR 2·56, 95% CI 1·72–3·80, p<0·0001) and 5 months after intervention delivery (2·53, 1·58–4·04, p<0·0001).

Similar results were observed for HWWS after using the toilet with a cleansing container (appendix p 23). 1 month after intervention delivery, we observed some increase in HWWS after toilet use with a cleansing container in the handwashing station-only intervention group (34 [9%] of 400 occasions) compared with the control group (17 [4%] of 441 occasions; adjusted RR 2·38, 95% CI 1·30–4·36, p=0·005). At 5 months after intervention delivery, no evidence of a difference was detected in the handwashing station-only group (34 [10%] of 344 occasions) compared with the control group (21 [6%] of 328 occasions; adjusted RR 1·20, 95% CI 0·66–2·17, p=0·55). In the TNSB intervention group, there was strong evidence of a large increase in the proportion of occasions on which HWWS was done after using the toilet with a cleansing container after 1 month (88 [21%] of 427 occasions; RR 4·85, 95% CI 2·64–8·94, p<0·0001). The change observed was largely sustained 5 months after intervention delivery (65 [20%] of 330 occasions; adjusted RR 2·38, 95% CI 1·28–4·45, p=0·006).

Hands were more commonly washed with soap after cleaning a child's bottom than after toilet use (table 4). There was little evidence of an effect of either intervention on HWWS after cleaning a child's bottom, although the CIs are wide.

The results of the on-treatment analysis were similar to those of the intention-to-treat findings (appendix pp 26–28).

A comparison of the assumed parameter values used for the sample size calculation and those observed are presented in the appendix (p 29).

The intervention ability to trigger disgust feelings was assessed during the videos screening at each intervention delivery session, using pictorial vote, and as part of a process evaluation. 620 (83%) of 747 TNSB intervention attendees who partook in the vote reported finding the intervention videos disgusting (all four intervention implementation visits combined, and with over 170 attendees per session).

Although the level of the handwashing norms-related constructs were low at baseline, we found evidence that the interventions had an effect on these constructs, with the strongest effect observed in the TNSB group, at the 1-month follow-up (p<0·0001). These changes were not sustained at the 5-month follow-up (appendix p 29).

46 (92%) of 50 compounds had handwashing stations that showed evidence of maintenance at the 1-month follow-up, compared with 32 (65%) of 49 compounds at the 5-month follow-up (appendix p 30).

The process evaluation, intervention effects on the handwashing norms-related constructs and handwashing station maintenance findings will be reported in detail in separate papers.

We found only weak evidence of differences in the ability of respondents to cite hygiene as the key survey theme at each trial phase, with a higher proportion seen in the TNSB group at the 1-month follow up (p=0·048; appendix p 30).

Discussion

We observed a very low frequency of HWWS events after using the toilet at baseline (around 5%), consistent with previous findings from Côte d'Ivoire.[44] 1 month after intervention delivery, we found some evidence of a small effect on HWWS practices after using the toilet among

the handwashing station-only group. In the disgust-inducing TNSB group, we found evidence of a much larger intervention effect, which was largely sustained 5 months after intervention delivery.

Our intervention was designed to elicit feelings of disgust at the thought of ingesting faeces if hands were not washed after toilet use. It also rested on the notion that, if participants did not wash their hands with soap, not only would they consume their faeces, but so would their fellow compound residents.

We found evidence that disgust was the dominant emotion triggered by the TNSB intervention at all intervention delivery sessions, and that the extent of the handwashing norms-related constructs were stronger in the TSNB group than in the handwashing station-only and control groups at the 1-month follow up, but not at the 5-month follow up. These results will be presented in detail in separate subsequent papers.

Our study has several limitations. First, masking is difficult to implement for behaviour-change studies of handwashing interventions. We made considerable efforts to mask participants and outcome assessors, including complete separation of the intervention delivery team from the data collection team. Both teams separately obtained informed consent for their activities, and the two teams never crossed paths in the field. We also used masking items during data collection using themes relevant to the study population. The results of our masking assessment suggest that, at the 1-month follow up, masking might not have been entirely successful in the TNSB intervention group, who were more likely to identify hygiene as the key theme of the questionnaire than were the other two groups. This finding raises the possibility that the increase in HWWS practices, observed at 1 month, could have been partly due to a Hawthorne effect.[34] However, this difference in identification of hygiene as the key theme of the questionnaire was no longer evident at the 5-month follow up, whereas the TNSB intervention effect on HWWS was sustained. This finding suggests that the change in HWWS observed in this group was not solely due to a Hawthorne effect. The low handwashing rates observed in the handwashing station-only group, which did not receive any handwashing intervention messages, suggest that, if participants assumed that handwashing was expected of them, it had minimal effect on their actual behaviour. The fact that compound withdrawals were only from the structured observation and survey part of the trial (ie, the work done by the fieldworkers), and not from the intervention providers' activities provides some reassurance that our masking strategy was effective. Although the results of the masking assessment should be interpreted with caution, as the number of respondents surveyed was small, the results are valuable, given that few behaviour-change handwashing studies have reported on efforts to reduce performance and detection bias.[13,42,45,46] Future studies should include strategies to assess masking success.

Second, contractual issues with the local production company that produced the intervention video resulted in a longer 2-year gap between the baseline and follow-up phases. We did not attempt to confirm that the same residents were still living in the study compounds, and some movement will undoubtedly have taken place, potentially affecting the baseline comparability of the different groups (ie, just before the delivery of the intervention), although the randomised design provides some protection against imbalances between groups.

Third, we cannot exclude the possibility that some HWWS took place inside the toilet as opposed to in an area observable to fieldworkers. However, in a pilot study, no residents identified inside the toilet as a possible location for handwashing. Furthermore, we were not able to distinguish between visits to the toilet to defecate and those for the purposes of urination (and trial messages promoted HWWS after all visits to the toilet). We thus cannot assess HWWS practices after defecation, which could differ from HWWS practices after urination. To try to address this issue, we planned an analysis restricted to occasions when participants entered the toilet with a container for cleansing, as it is common custom in the study population for a container filled with water to be used for anal cleansing after defecation. However, 1548 (73%) of 2117 occasions observed involved the use of a container for cleansing. This result suggests that the use of a cleansing container is not a good proxy indicator of defecation events in the study population, and an analysis restricted to occasions involving the use of a container produced very similar results to the analysis of toilet occasions.

Fourth, the handwashing station-only intervention was erroneously implemented in three control compounds and not implemented in one compound where it should have been. The results of an on-treatment analysis were similar to those of the intention-to-treat analysis. The low HWWS rates observed in both the control and handwashing station-only groups provide circumstantial evidence of low, if any, spillover of the TNSB intervention to the other groups.

Fifth, our follow-up period was only 5 months from the start of the intervention. Between 1 and 5 months, there was very little decline in HWWS rates in the TNSB intervention group, although the intervention implementation had ended 2 months before the 5-month follow up. However, we have no way of knowing if these rates were sustained over a longer period.

Sixth, the small proportion of compounds that met the trial inclusion criteria (which was mainly due to the number of households with screens in many compounds, exceeding the number allowed by the inclusion criteria) raises questions about the generalisability of the study findings. Some compounds that met the inclusion criteria at enrolment subsequently erected screens but were retained in the trial. Our experience was that, in practice, the presence of screens did not affect our ability to observe

handwashing behaviour as water-related activities tend to take place close to the centrally located, publicly observable water source, to avoid carrying water around and the potential for spillages within households. Additionally, the included compounds were not systematically different, nor isolated from, the excluded ones, as shown in the appendix (p 7). Although our trial was conducted in a small geographical area, multiple occupancy compounds with shared water and sanitation facilities are the most common accommodation type in Abidjan,[29] and this type of housing is very common in other west African countries. For example, in Ghana the proportion of populations living in communal housing compounds with shared water and sanitation facilities is also estimated at over 50%,[47] whereas in Burkina Faso, there is a popular TV series called Cour Commune (communal housing compound) based on life in such compounds.[48] We thus believe that our results are likely to be generalisable to settings not only in Côte d'Ivoire, but also to other countries with similar cultures and living arrangements. However, our findings might not be generalisable to settings where toilets or water sources are located within individual households.

Finally, it should be noted that the trial overlapped with the west African Ebola virus epidemic that affected Côte d'Ivoire's neighbours, Liberia and Sierra Leone, very badly. The epidemic started in early 2014 and ended around June, 2016,[49] and received a lot of media attention in Côte d'Ivoire. The epidemic resulted in a high-intensity, national handwashing promotion campaign, including promotion of HWWS after toilet use. Prevention messages were shown on television several times daily, at peak viewing times, over almost the entire duration of the epidemic. During the trial, at least one community-level campaign for Ebola virus disease prevention took place in the study area, and there were other campaigns in schools. Although we did not measure the Ebola virus campaign's coverage, it is likely that most people were aware of it. Nevertheless, our baseline handwashing rates, measured a few months after the start of the Ebola virus epidemic were very low after toilet use (approximately 5%) suggesting little, if any, sustained effect of the Ebola virus campaign on HWWS rates after toilet use. The effectiveness of Ebola virus campaign's health messages is likely to depend on communities' perceptions of the health threat referenced in the promotion messages. We would argue that the threat was quite real in Côte d'Ivoire, given the number of Ebola virus disease cases in neighbouring countries. The low HWWS rates observed in the control group and handwashing station-only intervention, despite having been exposed to a high-intensity handwashing campaign over 2 years, could suggest an inability of such health-based mass media interventions to achieve sustained behaviour change in this population, at least with regards to HWWS after toilet use.

Our trial investigated the effect of handwashing stations-alone (ie, without handwashing promotional messages) on HWWS practices after using the toilet. In our setting, access to water was not a constraint, as all residents had access to at least one shared piped water source within the compound. Thus, our findings suggest that the lack of handwashing facilities and products alone does not explain the low rates of HWWS frequently observed in low-income settings such as Abidjan, Côte d'Ivoire. The large difference in intervention effects between the TNSB intervention and handwashing station-only intervention implies that, without internalisation of the importance of HWWS, the presence of handwashing facilities will not substantially increase the practice. This finding is consistent with the suboptimal HWWS frequency observed after using the toilet in high-income countries (range 43–59%),[9,24] despite almost everyone having access to handwashing facilities with water and soap in these settings.[24] Although the absence of water and soap from the handwashing location suggests that HWWS is not regularly taking place, the presence of water and soap at the designated handwashing location does not signify that HWWS is taking place. Therefore, the mass distribution of handwashing kits (including handwashing stations, soap, and antibacterial gels) during epidemics such as COVID-19 might not lead to the adoption of good handwashing practices, if the handwashing promotion messages are not designed using motives which are meaningful to the population.

The effect of the TNSB intervention we observed was large compared with most of the trials identified in the systematic review by Staniford and Schmidtke.[10] Of the nine trials undertaken in LMIC community settings, none had an effect size that was larger than our 1-month estimate (RR 4·82, 95% CI 3·06–7·59) and only one trial[42] reported an effect size larger than our 5-month estimate (3·54 *vs* 2·68). Thus, our intervention appears to have been more effective than many other handwashing intervention trials.

Although HWWS rates after toilet use were low in our population, HWWS after cleaning a child's bottom appeared to be more common. However, the number of such occasions observed was relatively small (around 100 occasions over the whole course of the trial). Our estimate of the frequency of HWWS after cleaning a child's bottom is, therefore, rather imprecise, as shown by the wide CIs. We found little evidence of an intervention effect on HWWS after cleaning a child's bottom; however, given the small number of events observed, this result should be interpreted cautiously.

It is important to note that we cannot be certain of the relative contributions of the different components of the TNSB intervention. On the basis of interactions with intervention providers and participants' negative reactions to the Glo Germ demonstration, we reduced the number of times this intervention component was implemented from a planned four times (once at each visit) to only once (during the first visit; appendix p 6). We therefore believe the effect of Glo Germ was minimal.

We also know that the effect of the handwashing station alone was small (from the handwashing station-only intervention group). With respect to the effect of the videos, we cannot disentangle the medium from the effect of the active engagement with participants by the intervention providers. We also cannot assess the effect of the posters alone.

Despite a substantial increase in HWWS after toilet use, our intervention still has a long way to go to achieve universal HWWS. The TNSB intervention was implemented at the compound level, over four sessions, separated by about 3 weeks, and each lasting for 45–90 min, and was thus of relatively low intensity. Some elements of the intervention (ie, videos and posters) were designed to be easily delivered through mass media (eg, television or social media), to allow for a scalable and high-intensity intervention. Future studies should investigate whether the TNSB intervention, when delivered via mass media, can have a similar or greater effect than the face-to-face delivery used in this study. Studies assessing the intervention effect in the absence of handwashing station provision are also needed. Additionally, the COVID-19 pandemic highlights the importance of identifying the most effective ways of promoting HWWS in epidemic and non-epidemic circumstances because these situations might differ. More trials evaluating HWWS interventions using emotion-based motives are needed in other settings in both ordinary and epidemic circumstances. In times of epidemics, combining health-based messages with non-health-based messages might be more effective than health-based messages-alone.

Contributors

MAA-T designed the study with input from SC, JM, PN-D, and AB and developed the data collection tools with input from SC, JM, and AB. MAA-T designed the pilot studies that informed the trial with input from all coauthors. MAA-T designed the theory of normative social behaviour intervention, and the handwashing station-only intervention with input from PKB, HAK, SC, and JM. MAAT implemented the study with guidance from SC, and input from PN-D. MAA-T, PKB, and HAK trained the fieldworkers and intervention providers, and supervised data collection. MAA-T and SC accessed and verified the data. MAA-T analysed the data with guidance from SC, and prepared the first draft of the manuscript. All coauthors contributed to the interpretation of the results and revisions to the manuscript. MAA-T had full access to all the data in the study, and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

The consent form stated that the data collection would be accessed only by trial staff, supervisors, and the participants involved in the study.

Acknowledgments

This study was self-funded by MAA-T, as part of their PhD research. MAA-T had no role in data collection, but oversaw all field activities. We thank all the fieldworkers for their hardwork and dedication, and the intervention providers for the extraordinary work that they accomplished, and the quality with which they delivered the interventions; Koumassi commune, and the study participants for having opened their homes to us, and for their kindness throughout the study; and Ahmed Touré for his support in the translation of the abstract into French, and for having kindly taken the time to read and provide an external opinion on our responses to reviewers' comments. This research is in loving memory of Sipha Kamagate who contributed tremendously to the fieldwork logistics, from the pilot studies in 2012 to the end of the trial in 2017, but sadly passed away.

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