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Program Evaluation of the WASHmobile PICHA7 Mobile Health and Chlorine E-Voucher Program in the Democratic Republic of the Congo

Christine Marie George[1] | Jean-Claude Bisimwa[2] | Kelly Endres[1] | Justin Bengehya[3] | Jean-Claude Kulondwa[4] | Raissa Boroto[2] | Ghislain Maheshe[5] | Cirhuza Cikomola[2] | Presence Sanvura[2]

[1]Department of International Health, Program of Global Disease Epidemiology and Control, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA | [2]Center for Tropical Diseases & Global Health, Université Catholique de Bukavu, Bukavu, Democratic Republic of the Congo | [3]Bureau de L'information Sanitaire, Surveillance Epidémiologique et Recherche Scientifique, Division Provinciale de la Santé Sud-Kivu, Ministère de la Santé, Bukavu, Democratic Republic of the Congo | [4]Bureau de l'Hygiène et Salubrité Publique, Division Provinciale de la Santé Sud-Kivu, Ministère de la Santé, Bukavu, Democratic Republic of the Congo | [5]Faculty of Medicine, Université Catholique de Bukavu, Bukavu, Democratic Republic of the Congo

Correspondence: Christine Marie George (cmgeorge@jhu.edu)

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ABSTRACT

Targeted water treatment and hygiene (WASH) programs for those residing near diarrhoea patients can be a cost-effective approach during outbreaks to reduce diarrhoea spread by targeting those at highest risk. We designed the WASHmobile mobile health (mHealth) program for high risk populations for diarrhoea. In our previous randomised controlled trials in the Democratic Republic of the Congo (DRC) (PICHA7) and Bangladesh (CHoBI7), WASHmobile delivery to diarrhoea patient households through a healthcare facility visit and mobile messages from a doctor significantly reduced diarrhoea, cholera, and improved child growth. Building on this, we adapted WASHmobile for large scale implementation through a mHealth and e-voucher program for diarrhoea outbreak areas. A pilot program evaluation of this approach was conducted in DRC health areas with ongoing diarrhoea outbreaks among 2022 participants. Voice and SMS messages from a doctor were sent to those within 500 m of diarrhoea patients stating there was a diarrhoea outbreak nearby and emphasising the importance of treating and safely storing household drinking water and handwashing with soap for the next 7-day high-risk period. The SMS messages contained an e-voucher to redeem for free chlorine tablets at a pharmacy or shop. Unannounced spot checks assessed WASH behaviours 7 days after program initiation. Fifty-seven percent of WASHmobile households redeemed e-vouchers. Compared to control, WASHmobile households redeeming e-vouchers had higher stored drinking water with free chlorine concentrations >0.2 mg/L (Odds Ratio: 6.93, [95% Confidence Interval: 1.76, 27.24]) (64% [WASHmobile] vs. 20% [control]), higher stored drinking water completely covered (4.55 [2.68, 7.70]) (73% vs. 38%), and higher presence of a cleansing agent within 10 steps of latrine and cooking areas (latrine: 3.64 [1.47, 9.02] [70% vs. 39%] and cooking: 2.50 [1.31, 4.77] [70% vs. 49%]). The WASHmobile PICHA7 mHealth and e-voucher program significantly increased water treatment, safe water storage and hygiene behaviours in diarrhoea outbreak areas in DRC.

1 | Introduction

Diarrhoea from inadequate water, sanitation and hygiene (WASH) is estimated to contribute to 54 million disability-adjusted life-years (DALYs) and 1 million deaths globally each year [1, 2]. In the Democratic Republic of the Congo (DRC), diarrhoea accounts for 2.3 million DALYs and 2 million inpatient diarrhoea cases annually [2, 3]. Chronic diarrhoea

Christine Marie George and Jean-Claude Bisimwa are contributed equally to this work.

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episodes in children <5 years contribute to undernutrition, increasing the risk of stunting, which is associated with mortality and impaired cognitive development [4–7]. Furthermore, climate change has increased droughts and floods in Africa, driving diarrhoea outbreaks to historic highs in the region [8, 9]. These outbreaks burden healthcare systems in low- and middle-income countries worldwide [2].

Early alert and response systems for diarrhoea outbreaks that target populations at highest diarrhoea risk promote climate resilience and are a critical cost-saving measure to reduce diarrhoea morbidity and mortality compared to a blanket approach. Our research in the DRC has shown that when a diarrhoea patient is admitted to a healthcare facility, individuals living within 500 m are at >12 times higher risk of hospitalization for diarrhoea than the general population for the following 7 days (George et al. submitted). In addition, a previous study in Bangladesh found that those living within 450 m of a cholera case were at significantly higher risk of cholera infections compared to the general population [10], with an additional study conducted in Chad and the DRC finding similar high risk [11]. Targeted WASH programs for those residing near diarrhoea patients represents a cost-effective approach during outbreaks to reduce the spread of diarrhoea by targeting those at highest risk. This type of targeted strategy builds on the status quo of waiting until diarrhoea outbreaks become large before responding with a resource-intensive "blanket approach," where WASH interventions are delivered broadly in-person to large population which is costly and time-consuming [12].

In partnership with the Ministries of Health in the DRC and Bangladesh, we developed the WASHmobile program, a WASH mHealth messaging system for high risk populations for diarrhoea [13, 14]. This approach was evaluated among diarrhoea patient households in two recent randomised controlled trials (RCTs) of WASHmobile: in the DRC (PICHA7 site, $N=2334$ participants) (current site) [15] and in Bangladesh (CHoBI7 site, $N=2626$ participants) [16]. In these RCTs, we found that sending diarrhoea patient households weekly automated WASH-related voice and SMS mHealth messages from a doctor, along with provision of chlorine tablets and soapy water (water and detergent powder) resulted in significantly higher sustained water treatment and handwashing with soap, as well as significant reductions in healthcare visits for diarrhoea, diarrhoea prevalence, cholera, and stunting over a 12-month period [15, 16].

Building on this work, in partnership with the DRC Ministry of Health and South Kivu Division Provincial de la Santé (DPS), we have now adapted the WASHmobile PICHA7 program to serve more beneficiaries through a location-based push notification system based on healthcare facility outbreak surveillance. The system delivers WASH mHealth messages and e-vouchers for chlorine tablets to redeem at local pharmacies and shops for those in high-risk areas for diarrhoea outbreaks. This program is delivered in health areas (a DRC government health administrative unit of ~10,000 individuals) at the beginning stages of diarrhoea outbreaks. Voice and SMS messages are sent to those within 500 m of diarrhoea patients from a doctor stating that there is a diarrhoea outbreak in their health area, emphasizing the importance of treating and safely storing household drinking water and washing hands with soap for the next 7-day high-risk period. The SMS messages also contain an e-voucher to redeem for free chlorine tablets at a local pharmacy.

In this study, we completed a pilot program evaluation to investigate whether delivery of the WASHmobile PICHA7 mHealth and chlorine e-voucher program could increase water treatment, safe water storage and hygiene behaviours among those living within 500 m of diarrhoea patients during diarrhoea outbreaks.

2 | Methods

This study conducted a program evaluation of the WASHmobile PICHA7 mHealth and chlorine e-voucher pilot program implemented between December 2024 and July 2025 during ongoing diarrhoea outbreaks in eastern DRC. Evaluation activities were conducted in Bukavu, a city with a population of >1 million in eastern DRC. During our initial WASHmobile PICHA7 RCT, we found that $>80\%$ of diarrhoea patients admitted to a healthcare facility reported mobile phone ownership in their household, making this a feasible setting to implement a mobile health intervention. A "diarrhea outbreak health area" is defined at our study site as a health area where there are ≥ 5 inpatient diarrhoea cases residing in the same health area admitted to a healthcare facility for treatment within 24 h. This alert of a diarrhoea outbreak health area is based on the location where patients report residing (not the location where patients sought care). Inpatient diarrhoea cases are captured through daily surveillance at 115 public and private healthcare facilities in Bukavu conducted in partnership with the DRC Ministry of Health [17].

2.1 | WASHmobile PICHA7 mHealth and Chlorine E-Voucher Program

The WASHmobile PICHA7 mHealth and chlorine e-voucher program builds on our previous program through: (1) broadening the scope of the program from focusing on diarrhoea patient households to including those residing in diarrhoea outbreak health areas, allowing the program to serve more beneficiaries; and (2) leveraging new technologies: (i) location-based push notifications; and (ii) chlorine e-vouchers to be redeemed at local pharmacies and shops. The program is designed to be delivered in health areas during the initial phase of a diarrhoea outbreak, triggered by a diarrhoea outbreak health area alert as described above.

The WASHmobile PICHA7 mHealth and chlorine e-voucher program includes the delivery of three automated voice calls and three SMS messages (including a chlorine e-voucher) from a doctor at the provincial hospital during the 7-day high-risk period after the diarrhoea outbreak alert in the health area. When a diarrhoea outbreak health area is identified, a health worker collects the phone number of the inpatient diarrhoea case at the healthcare facilities where patients are identified and contacts the community health worker in their health area to collect the GPS location of the patient household. In the DRC, public community health workers are embedded in the health system at the health area level, making this approach feasible to deliver at scale. Within 48 h

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of a diarrhoea outbreak alert in the health area, a voice and SMS message from the WASHmobile PICHA7 mHealth and e-voucher program are sent to all phone subscribers within an approximately 500 m radius of the diarrhoea patient. This can be done either through location-based push notification sent by mobile network operators or by the community health worker collecting the numbers of individuals residing within 500 m of the diarrhoea patient household. When coordinating with mobile network operators (with governmental approval), mobile network operators can send notifications to all phones located within the specific geographic area with no census information or phone number collection necessary by program implementers. The web-based engageSPARK platform is used to send program messages [18]. Messages are sent in the evening at 8 PM when most individuals are home. No internet is needed for message delivery. If mobile networks are down at the time a message is sent, the message is automatically sent when network connection is reestablished.

All mHealth messages were reviewed and recorded by author RB, a physician in the cholera treatment ward at the Provincial Hospital who sent messages under the name Dr. Picha to align with the name of the intervention program. Mobile messages include interactive voice response (IVR), voice and SMS messages. For IVR messages, participants are asked to respond 1 or 2 in response to a question, after which they receive a response with the correct answer. There is no charge to the phone subscriber receiving IVR or voice calls or SMS messages. If a phone subscriber did not answer a voice or IVR call, two re-attempt calls were made automatically through the engageSPARK platform.

The SMS message contains a unique chlorine e-voucher ID (e.g., 6DE78-86518) and the location of a designated pharmacy or shop in the phone subscriber's health area where the e-voucher can be redeemed for free chlorine tablets. Commonly used pharmacies and shops in health areas that supplied chlorine tablets were selected. Phone subscribers have 7 days from the time the SMS message is sent to bring this unique e-voucher number (either on their phone or written down) to their designated pharmacies or shops to redeem for 8 chlorine tablets (160 L of treated water) for free. When phone subscribers bring the e-voucher number to the pharmacy or shop, the pharmacy or shop employee enters a short code into their phone with the unique e-voucher ID and they receive a reply on whether the e-voucher is valid (e.g., unexpired and unused). No smart phone capability is needed for e-voucher validation, a feature phone can be used. If the e-voucher ID is valid, phone subscribers are provided the chlorine tablets. The date and time the e-voucher was redeemed is recorded through the database designed on engageSPARK platform. After the 7-day high-risk period in the diarrhoea outbreak health area is complete, pharmacy or shop staff receive a stipend for participation in the program and reimbursement for all e-vouchers redeemed. An example voice, IVR and SMS message from the WASHmobile PICHA7 program are shown in Figure 1.

The Theory of Change for the WASHmobile mHealth and e-voucher program is that if the program is able to increase water treatment, safe water storage and handwashing with soap behaviours among high-risk populations residing in close proximity to diarrhoea patients during diarrhoea outbreaks, this will reduce diarrhoea for this population and prevent the spread of diarrhoea outbreaks.

2.2 | Study Design for Program Evaluation

The WASHmobile PICHA7 mHealth and chlorine e-voucher program was delivered in two Bukavu health areas (Irambo and Burhiba) to those phone subscribers within 500 m of diarrhoea patients. Diarrhoea patients were screened at 115 public and private surveillance healthcare facilities. In control areas, we enrolled diarrhoea patients in diarrhoea outbreak health areas and 10–12 households within 500 m of each of these patients. Evaluation activities consisted of conducting unannounced spot checks of water treatment, safe water storage and hygiene indicators and collecting mobile messaging and e-voucher data through the engageSPARK platform (e-voucher redemption, message receipt and interaction). Households were enrolled and spot checks were conducted within 7 days of the alert of a diarrhoea outbreak in the health area. During enrollment, the number of individuals living in the household was ascertained. Mobile message and e-voucher data were automatically collected through the engageSPARK platform after mHealth message delivery. Intervention households were eligible for evaluation activities if they received the intervention within the past 7 days. Control areas were selected based on health areas that met our diarrhoea outbreak definition during our surveillance period. All households within 500 m of the diarrhoea patient household were eligible to participate.

Unannounced spot checks were conducted in WASHmobile PICHA7 program and control households. Spot checks were unannounced to prevent households preparing for our arrival. During spot checks, a household stored drinking water sample was collected to test for free chlorine. Chlorine was measured using a digital colorimeter (Hach, Loveland, CO, USA). The World Health Organization (WHO) guideline for free chlorine in household stored drinking water of >0.2 mg/L was used as the cutoff for chlorination (water treatment outcome) [19]. During unannounced spot checks, the covering status of household stored drinking water (safe water storage outcome: proxy indicator of safe water storage behaviours) and the presence of a cleansing agent (bar soap, liquid soap, soapy water or ash in a container) and water within 10 steps of the latrine and cooking area (hygiene outcome: proxy indicator of handwashing with soap behaviour) were observed [20]. Information was also collected on the type of drinking water storage container and on household water source type using the categories defined by the WHO/UNICEF Joint Monitoring Program [21, 22]. Process evaluation indicators of mHealth message delivery were collected using the engageSPARK platform on the percentage of unique voice, IVR and SMS messages received by program households.

2.3 | Statistical Analysis

The sample size was based on the number of WASHmobile program and control areas that could be enrolled given security considerations due to ongoing armed conflict in the area using convenience sampling. Main outcomes for the pilot evaluation included redemption of chlorine e-vouchers, water treatment,

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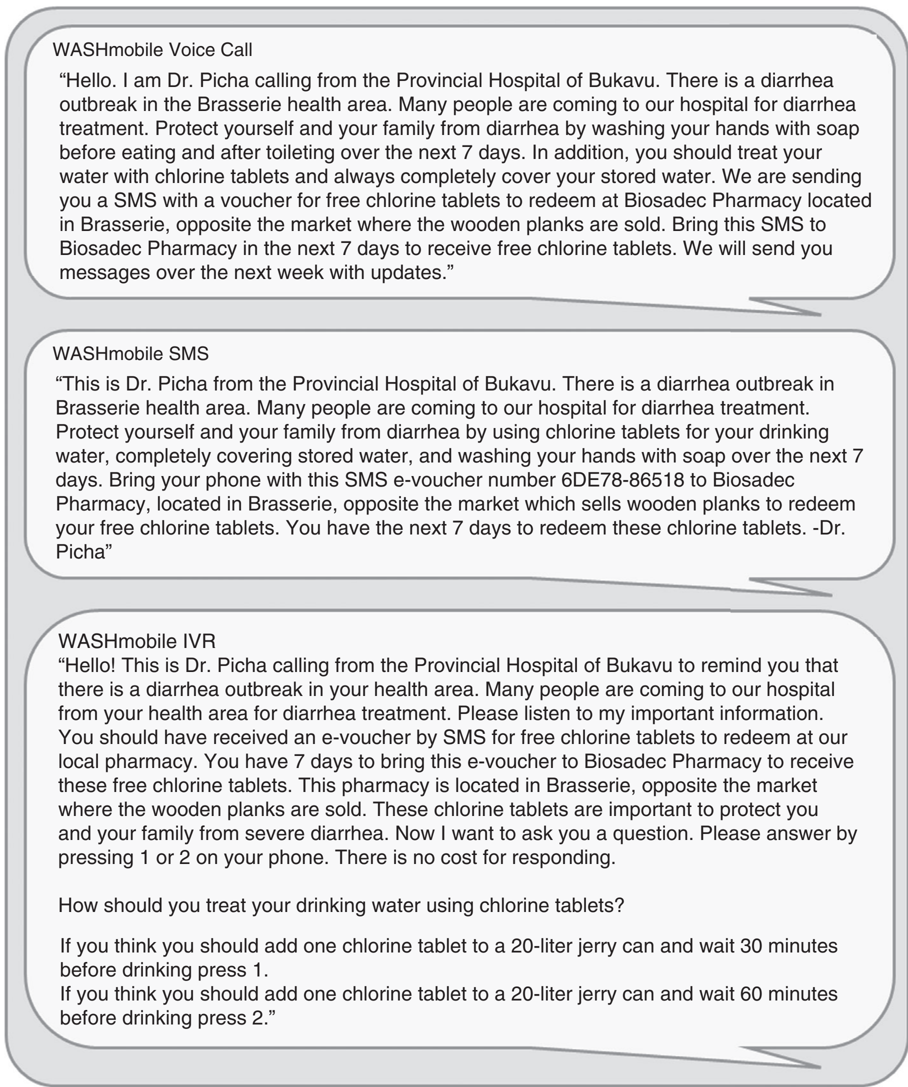

FIGURE 1 | Example WASHmobile mobile health messages.

safe water storage and hygiene outcomes. To evaluate the effectiveness of the WASHmobile PICHA7 program compared to control areas, logistic regression models were performed to compare WASH outcomes in households with beneficiaries that redeemed chlorine e-vouchers (WASHmobile program) to control households at day 7 after diarrhoea outbreak alerts in health areas. Logistic regression models were performed using general estimating equations to account for clustering within health areas (geographic area) and approximate 95% confidence intervals. To compare water source type and drinking water container type, we performed a Fisher exact test due to sample size constraints. Statistical analyses were conducted using SAS 9.4 software (Cary, NC, USA).

3 | Ethical Approval

Ethical approval was obtained from the institutional review boards of the Johns Hopkins School of Public Health and Catholic University of Bukavu. Written informed consent was obtained from all individuals or their guardians participating in data collection activities. Clinical trial number not applicable.

4 | Results

Program evaluation activities assessed WASH and mHealth outcomes among 2022 participants, with 872 participants in diarrhoea outbreak health areas receiving the WASHmobile PICHA7 mHealth and chlorine e-voucher program and 1150 participants in control areas (Table 1). Enrolled participants resided in a total of nine health areas. No significant differences were observed in water source type, with 79% of WASHmobile households having a basic water source compared to 74% of control households ($p = 0.74$) during unannounced spot checks.

Ninety-nine percent of unique voice messages (271/274) and 97% (411/422) of IVR messages sent to WASHmobile households were answered by households (messages received: voice calls 2 [range: 1–2] and IVR calls: 3 [range: 1–4]). Eighty-nine percent (608/686) of unique SMS messages were received (mean number of SMS received: 6 [range: 5–6]). All WASHmobile households received the SMS chlorine e-voucher at least once ($N = 132$). Fifty-seven percent of households (75/132) that received chlorine e-vouchers redeemed them for chlorine tablets at their designated pharmacies.

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TABLE 1 | Study population and WASHmobile mHealth intervention received.

	WASHmobile E-voucher households			Control households		
	%	***n***	***N***	**%**	***n***	***N***
Total Participants			872			1150
Participants per household (median ± sd (range))	6 ± 2.53 (1–15)			7 ± 2.89 (2–16)		
Households			132			157
PICHA7 mHealth messages received				—	—	—
Voice messages	99%	271	274	—	—	—
Per household (median ± sd (range))	2 ± 0.15 (1–2)			—	—	—
IVR messages	97%	411	422	—	—	—
Per household (median ± sd (range))	3 ± 0.58 (1–4)			—	—	—
Text messages	89%	608	686	—	—	—
Per household (median ± sd (range))	5 ± 0.09 (5–6)			—	—	—
Chlorine e-voucher received	100%	132	132	—	—	—
Chlorine e-voucher redeemed	57%	75	132	—	—	—

Abbreviations: IVR = interactive voice response; Received = unique messages received (answered for voice and ivr); SD = standard deviation.

Compared to control households, stored drinking water free chlorine > 0.2 mg was significantly higher in WASHmobile households during unannounced spot checks (Odds Ratio [OR]: 6.93, 95% Confidence Interval [CI]: 1.76, 25.24) (64% [WASHmobile] vs. 20% [control]) (Table 2). Household stored drinking water being completely covered was also significantly higher in WASHmobile households compared to control areas (OR: 4.55, 95% CI: 2.68, 7.70) (73% vs. 38%).

For hygiene indicators, presence of a cleansing agent within 10 steps of latrine and cooking areas was significantly higher in WASHmobile households compared to control households (latrine areas: OR: 3.64, 95% CI: 1.47, 9.02 [70% vs. 39%] and cooking areas: OR: 2.50, 95% CI: 1.31, 4.77 [70% vs. 49%]). Consistent with this, the presence of water and a cleansing agent was also significantly higher within 10 steps of latrine and cooking areas in WASHmobile households compared to control households (latrine areas: OR: 3.99, 95% CI: 1.05, 15.22 [51% vs. 21%] and cooking areas: OR: 2.11, 95% CI: 1.51, 2.95 [53% vs. 35%]). Bar soap was the most common cleansing agent within 10 steps of latrine (64% [WASHmobile] vs. 38% [control]) and cooking areas (66% vs. 47%). ORS was present in 2% (1/47) of WASHmobile households compared to 4% (5/140) of control households ($p = 1.00$).

5 | Discussion

Delivery of the WASHmobile PICHA7 mHealth and chlorine e-voucher program in diarrhoea outbreak areas resulted in increased water treatment, safe water storage, and hygiene behaviors. The majority of households redeemed e-vouchers for chlorine tablets at local pharmacies or shops. Furthermore, most of the households redeeming e-vouchers had chlorine in stored drinking water > 0.2 mg/L, stored drinking water completely covered and a cleansing agent in cooking and latrine areas; all of which were significantly higher than control households. This is the first study we are aware of that has used e-vouchers for chlorine tablet distribution. Through this study, we were able to demonstrate the technological feasibility and acceptability of e-voucher redemption for WASH products in the DRC. These findings suggest that the WASHmobile PICHA7 program, which combines mHealth messaging with e-vouchers for chlorine tablets in diarrhoea outbreak areas, presents a promising approach to increase water treatment, safe water storage and proper hygiene practices during diarrhoea outbreaks in the DRC.

The high voucher redemption rate and water treatment adherence observed with our WASHmobile PICHA7 program are consistent with two previous RCTs conducted in Malawi and Kenya which used paper vouchers for chlorine products [23, 24]. An RCT in Malawi found that a higher proportion of households that received monthly paper vouchers for free chlorine had chlorine present in stored drinking water compared to control households receiving free chlorine distribution directly through community health workers' home visits [24]. Additionally, paper vouchers for chlorine significantly reduced diarrhoea among children compared to control households, with no observed impact for households receiving chlorine directly through community health workers' home visits. In Kenya, an earlier RCT found that monthly paper vouchers for free chlorine that could be redeemed at a shop or clinic led to similar rates of chlorine presence in stored household drinking water to chlorine distribution through home or clinic visits (35% vs. 34%) [23]. These promising results demonstrate the positive impact of chlorine vouchers on water treatment behaviours. Future studies are needed that test our WASHmobile mHealth and chlorine e-voucher service delivery model in different contexts globally and compare this to the status quo of blanket door-to-door chlorine product distribution programs.

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TABLE 2 | Unannounced spot checks of WASH indicators comparing WASHmobile households where E-Vouchers were redeemed to control households.

	WASHmobile households where e-vouchers redeemed			Control households			Logistic regression	
	%	n	N	%	n	N	OR (95% CI)	p
Unannounced spot check households			47			140		
Stored water—free chlorine > 0.2 mg/L	64%	30	47	20%	28	138	6.93 (1.76, 27.24)	0.006
Household stored drinking water completely covered	73%	33	45	38%	52	138	4.55 (2.68, 7.70)	< 0.0001
Water and a cleansing agent within 10 steps of the latrine	51%	24	47	21%	29	140	3.99 (1.05, 15.22)	0.043
Cleansing agent present within 10 steps of the latrine	70%	33	47	39%	55	140	3.64 (1.47, 9.02)	0.005
Bar soap	64%	30	47	38%	53	140		
Liquid soap	0%	0	47	0%	0	140		
Soapy water	34%	16	47	6%	8	140		
Ash in a container	2%	1	47	1%	2	140		
Hand sanitizer	4%	2	47	0%	0	140		
Water and a cleansing agent within 10 steps of the cooking area	53%	25	47	35%	49	140	2.11 (1.51, 2.95)	< 0.0001
Cleansing agent present within 10 steps of the cooking area	70%	33	47	49%	68	140	2.50 (1.31, 4.77)	0.006
Bar soap	66%	31	47	47%	66	140		
Liquid soap	0%	0	47	1%	1	140		
Soapy water	40%	19	47	3%	4	140		
Ash in a container	0%	0	47	6%	9	140		
Hand Sanitizer	6%	3	47	0%	0	140		

Note: One spot check is conducted per household. Cleansing agents include bar soap, liquid soap, soapy water or ash in a container. *p* value calculated using chi square test. Logistic regression models were performed using general estimating equations to account for clustering within health areas (geographic area) and approximate 95% confidence intervals.
Abbreviations: CI = confidence interval; OR = odds ratio.

Targeted delivery of WASH mHealth messages and chlorine e-vouchers to high-risk populations for diarrhoea outbreaks has several advantages over the status quo approach of blanket door-to-door community-based WASH programs. First, this approach reduces wastage by targeting households that will likely benefit the most from the use of chlorine products. Previous studies have shown that chlorination rates are similar when chlorine is provided through vouchers compared to free distribution [23, 24]. However, free door-to-door distribution leads to a much larger number of chlorine products being handed out that may ultimately go unused. Redeeming vouchers comes with a "hassle cost," since households must take the time to travel to shops or pharmacies to exchange them for chlorine tablets [23, 24]. As a result, households that are not truly interested in using chlorine products are less likely to redeem vouchers, even though they might have accepted the products if they were delivered directly to their homes. Second, delivering mobile messages with e-vouchers through automated, location-based push notifications from mobile network operators to individuals within 500 m of patients reduces the burden for already overextended community health workers, who would otherwise need to make door-to-door visits and reduces program costs. The bulk cost of mHealth message delivery for the WASHmobile mHealth and chlorine e-voucher program at our site in the DRC is 0.32 USD for 3 voice calls and 3 SMS (no charge to mobile user), and 0.40 USD for an SMS e-voucher for 8 free chlorine tablets (160 L treated water) to redeem at a pharmacy or shop (including a stipend for the pharmacist). Third, the e-voucher system requires households to come to pharmacies or shops, which has the potential to increase market demand for chlorine products and strengthen chlorine product supply chains, reducing stockouts.

Beyond its impact on chlorination of stored household drinking water, the WASHmobile PICHA7 mHealth and chlorine e-voucher program also significantly increased covering of stored drinking water and the presence of a cleansing agent at household latrine and cooking areas. The WASHmobile program included IVR, voice and SMS messages on safe water storage and

handwashing with a cleansing agent at food and stool related events. These promising findings demonstrate the effectiveness of this program on safe water storage and hygiene behaviours in the household even without the provision of bar soap and a water storage vessel. Future studies should assess the impact of this intervention approach on handwashing with soap behaviour assessed through structured observation among both program and control households.

The majority households in the WASHmobile arm redeemed their chlorine e-vouchers for chlorine tablets. Based on our previous formative research and the observations of the study team, potential reasons households did not redeem e-vouchers include distance to the pharmacy, lack of time to pick up chlorine at pharmacies, dislike of the taste of chlorine in drinking water and low perceived susceptibility to diarrhoea (e.g., because no one was ill with diarrhoea in their household and/or the belief that chlorine tablets were a treatment for diarrhoea) [13, 25]. Potential reasons participants redeemed e-vouchers but did not use them include insufficient quantity of water for treatment (at least 20 L of water needed) or saving tablets for use when someone in their household had diarrhoea [23, 24]. In 2016, Dupas et al. found a negative association between household wealth and redemption of chlorine vouchers, concluding that this relationship was likely because richer household have a higher value of time [23]. This association should be explored for redemption of e-vouchers in a future study. Future studies should explore the reasons for households not redeeming chlorine e-vouchers and for the lack of chlorine use among some of the households that have redeemed e-vouchers.

The service delivery model for WASHmobile must be tailored to the context for which the program will be implemented. For example, rural and internally displaced people (IDP) camps may vary from urban contexts on factors such as market availability of chlorine products and cellular network connectivity. A market analysis of supply chains and suppliers of chlorine products should be performed prior to implementing WASHmobile to ensure chlorine product availability and to prevent stockouts. In remote rural areas and some IDP contexts with low cellular network coverage and mobile phone ownership, paper vouchers will likely be needed to complement mobile messages and e-vouchers for those without cellular access. Community health workers will likely also need to be engaged in WASH promotion and providing paper vouchers for these households. Furthermore, the type of healthcare facilities where diarrhoea patients seek treatment will vary between urban, rural, peri-urban and IDP contexts. Therefore, it will be important that diarrhoea patient surveillance includes the different types of healthcare facilities where patients seek treatment to ensure diarrhoea outbreaks can be detected early and controlled. In addition, the definition for diarrhoea outbreaks will likely vary based on the context and diarrhoea outbreak definition used by the respective ministries of health. Thus, the diarrhoea outbreak definition and subsequent intervention delivery should be tailored to be most appropriate in the context where it is delivered.

This study has a few limitations. First, we did not assess health outcomes such as reported diarrhoea or assess enteric pathogens such as cholera. Health outcomes should be included in future studies. Second, we did not follow households longitudinally to assess whether the intervention resulted in sustained water treatment practices over time nor investigated the role of seasonality in the WASH behaviours promoted. This should be investigated in future studies. Third, ongoing conflict at the time our study was being conducted limited our sample size and resulted in convenience sampling in areas where it was safe for our team to travel. Furthermore, because of this conflict and the need to limit the time spent in the field we could not obtain a detailed assessment of household demographic characteristics. Finally, our study only focused on delivery outcomes in an urban context. Future studies should evaluate WASHmobile delivery in rural, IDP camp and peri-urban contexts, as well as expanding evaluation activities to include factors such as a chlorination supply chain analysis and a complete review of program barriers and facilitators of program adoption. Research is also needed to better understand the potential operational challenges of implementing this program at scale (e.g., management challenges, insufficient training, infrastructural limitations and limited access to equipment and supplies), and to identify complementary approaches to deliver this intervention in places where there is limited cellular coverage (e.g., CHW paper voucher distribution).

This study has several strengths. First, the inclusion of a control area where diarrhoea patients resided but did not receive the intervention builds on traditional before-and-after comparison for program evaluations without a control area. Second, the study included process evaluation data on the number of mobile messages received in addition to chlorine e-vouchers redeemed. This allowed us to determine whether households were answering program voice and IVR calls and receiving SMS messages. Third, unannounced spot checks were conducted to assess the covering status of household stored drinking water and the presence of a cleansing agent and water in household cooking and latrine areas. This builds on previous studies that typically only include chlorine presence in stored drinking water.

The WASHmobile PICHA7 mHealth and e-voucher program significantly increased water treatment, safe water storage and hygiene behaviours in diarrhoea outbreak areas in the DRC. Furthermore, our findings demonstrate the technological feasibility and acceptability of delivery of WASH mHealth messages and chlorine e-vouchers to those in diarrhoea outbreak areas in an urban context in the DRC. These findings suggest that the WASHmobile PICHA7 mHealth and e-voucher program presents a promising, low-cost service delivery model to increase WASH behaviours during diarrhoea outbreaks. We are currently partnering with the DRC Ministry of Health to develop strategies to scale this program in the DRC.

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Disclosure

This is the preprint of a different study. A preprint version of this manuscript has been published on medRxiv: Sanvura P, Endres K, Rusanga J-C, Perin J, Cikomola C, Bengehya J, et al. Process Evaluation for the Delivery of a Water, Sanitation and Hygiene Mobile Health Program: Randomised Controlled Trial of the PICHA7 Mobile Health Program. medRxiv. 2025:2025.02.26.25322956.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Household water source type and quality.

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