## Research Paper

# Benefits and costs of rural sanitation interventions in Ghana

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## ABSTRACT

Community-led total sanitation (CLTS) has triggered households around the world to adopt latrines, but evidence suggests that CLTS does not usually lead to universal latrine coverage. Additional interventions, such as subsidies for the poor, may be necessary to eliminate open defecation. While subsidies can improve sanitation-related outcomes, no prior studies have compared the net benefits of CLTS plus subsidies to CLTS-only. This paper presents a comparative analysis for rural Ghana, where efforts to reduce open defecation have had limited success. We analyze the costs and benefits of: (1) a CLTS-only intervention, as implemented in Ghana, and (2) a variant of CLTS that provides vouchers for latrines to the poorest households in high sanitation adoption communities. We find that CLTS-only fails a deterministic benefit-cost test and that only about 30% of 10,000 Monte Carlo trials produce positive net benefits. CLTS plus subsidies satisfy a benefit-cost criterion in the deterministic case, and in about 55% of the Monte Carlo trials. This more favorable outcome stems from high adoption communities passing the threshold needed to generate positive health externalities due to improved community sanitation. The results suggest that a well-targeted CLTS plus subsidies intervention would be more effective in Ghana than CLTS alone.

**Key words** | community-led total sanitation, benefit-cost analysis, externalities, Ghana, open defecation, WASH

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## INTRODUCTION

Open defecation (OD) rates have steadily declined across rural Sub-Saharan Africa (SSA) for the past two decades. The percentage of people practicing OD in rural SSA dropped from 43 to 29% from 2000 to 2017 (WHO/UNICEF JMP 2019). During this period, community-led total sanitation (CLTS) gained prominence as one of the

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more promising behavior-change interventions for promoting sanitation and was implemented at large or national scale in about 30 countries in the region (Zuin *et al.* 2019). While the introduction of CLTS may have contributed to the decrease in OD in rural SSA, peer-reviewed literature evaluating CLTS interventions in Africa has found that CLTS does not lead to open defecation free (ODF) communities and universal access to latrines (Whittington *et al.* 2020). One potential approach for further reducing OD is to implement variants of CLTS that include additional supportive interventions or incentives. For example, incorporating targeted vouchers or subsidies into CLTS can help reduce OD further, as previously demonstrated in India and Bangladesh (Pattanayak *et al.* 2009; Clasen *et al.* 2014; Patil *et al.* 2014; Guiteras *et al.* 2015; Hammer & Spears 2016).

This benefit-cost analysis (BCA) compares, for the first time, the benefits and costs of implementing a traditional CLTS intervention (CLTS-only) to a variant of CLTS that includes subsidies (CLTS plus subsidies). It builds upon an existing cost-benefit model of CLTS presented in Radin *et al.* (2020). The allows exploration of whether incorporating vouchers increases the net benefits of CLTS plus subsidies, relative to a CLTS-only intervention. We analyze these interventions as if they were implemented in rural Ghana. We choose Ghana as the site of our analysis for several reasons. First, previous work has shown that rates of OD in rural Ghana have been stagnant (decreasing from 32 to 31% between 2000 and 2017), despite increasing development and the country's reclassification as a middle-income country by the World Bank in 2011 (The World Bank 2011; WHO/UNICEF JMP 2019). Second, since Ghana is considered a lower-middle-income country, the cost of implementing CLTS in the country is likely higher than in other countries in SSA, such that the prior analysis presented in Radin *et al.* (2020) seems unlikely to apply (Crocker *et al.* 2017a). Finally, Ghana has continued to invest in efforts to eliminate OD as evidenced by the Social Norms Advocacy Campaign and the National Sanitation Campaign (NSC) to change sanitation norms (UNICEF 2017; Addo 2020), as well as deploying new efforts to target subsidies to the poorest rural households. The NSC includes an ODF Campaign that aims to eliminate OD by 2030 (UNICEF 2017). The ODF Campaign is a component of Ghana's Rural Sanitation Model and Strategy, which endorses CLTS as the main approach for promoting rural sanitation.

Since CLTS was first introduced in Ghana, implementers have observed that many poor and marginalized households struggle to gain access to latrines. In 2018, the Ministry of Sanitation and Water Resources (MSWR) published *Guidelines for Targeting the Poor and Vulnerable* (Guidelines, Ministry of Sanitation and Water Resources 2018) to help address the gap in sanitation access between Ghana's wealthier and poorer households. The Guidelines affirm CLTS as the primary sanitation intervention strategy, but they also suggest subsidizing infrastructure costs to help the poor, and the communities in which they live, to reach universal latrine coverage. The Guidelines specifically call for providing additional support to the poor and vulnerable in communities certified as ODF Basic. The ODF Basic designation is not based on universal coverage with sanitation, but rather means that a community has been verified, by CLTS facilitators, to have no visible fecal matter in public spaces (Ministry of Sanitation and Water Resources 2018). To understand the impact of targeted support to the most vulnerable households, we extend the model from Radin *et al.* (2020) to measure the economic benefits and costs of such a CLTS plus subsidies intervention.

Thus, benefits and costs are estimated and compared for two rural sanitation interventions: (1) the traditional CLTS-only approach and (2) a CLTS plus subsidies variant – inspired by a recent experiment in Ghana (Israel & Shapiro 2019). We specify our analysis to cover a nationally representative set of 100 hypothetical rural communities in Ghana. We model the analysis of the CLTS plus subsidies variation, as it has been implemented thus far in Ghana, i.e., we assume that vouchers are delivered after the CLTS triggering and community mobilization for latrine construction has taken place, and only to communities that show a significant increase in latrine uptake following those activities. Adopting the method used by Radin *et al.* (2020), latrine-uptake rates are assumed to be heterogeneous across communities.

The analysis builds on previous benefit-cost analyses of CLTS and incorporates new information on CLTS implementation in rural Ghana (Whittington *et al.* 2009; Crocker *et al.* 2016a, 2017b; Israel & Shapiro 2019; Radin *et al.* 2020; ODF Ghana Campaign 2017). It serves as an example of how governments and development partners can use context-specific data to evaluate the appropriateness of CLTS, and potential modifications to it, in different locations.

In the second section of this paper, we describe the two sanitation interventions. The third section presents the benefit-cost model. The fourth section discusses some of the key parameter assumptions of the analysis. The fifth section presents the results of the benefit-cost calculations and sensitivity analyses. The sixth and final section concludes.

## INTERVENTIONS

### Community-led total sanitation

CLTS was first implemented in 1999 and is a community-based intervention that focuses on changing sanitation-related community norms (Kar & Chambers 2008). When it was first developed, CLTS represented a significant policy shift in how to eliminate OD. Instead of simply providing latrines for free or at highly subsidized rates and assuming that they will be used (Jenkins & Sugden 2006), CLTS posits that various community exercises can lead to more sustainable changes in community sanitation behavior and ensure continued demand for latrines. CLTS has been implemented in approximately 60 countries worldwide; about 30 of these countries have incorporated CLTS into their national sanitation strategies (Zuin *et al.* 2019).

### CLTS plus subsidies/vouchers

While CLTS remains at the foundation of the rural sanitation program in Ghana, the *Guidelines for Targeting the Poor and Vulnerable* acknowledge that many households have struggled to afford latrines. Numerous CLTS or CLTS-inspired interventions, such as the Total Sanitation Campaign in India, have offered subsidies to the poor in order to boost latrine adoption rates (Pattanayak *et al.* 2009; Clasen *et al.* 2014; Patil *et al.* 2014; Guiteras *et al.* 2015; Hammer & Spears 2016). However, there is no norm or established best practice for the incorporation of subsidies or payment assistance vouchers within CLTS interventions.

The CLTS plus subsidies intervention that we analyze is modeled on an experiment in Ghana as documented by Israel & Shapiro (2019). While the results of the experiment were not available at the time this analysis was conducted, it offers one of the few approaches for ensuring that CLTS can result in universal latrine coverage. In that experiment, vouchers were provided to poor and vulnerable households in villages that had achieved ODF Basic status. For the purposes of this analysis, subsidies are considered to be offered to eligible vulnerable or poor households in select communities within a few months of the CLTS-only triggering in a community (we assume vouchers are distributed between 3 months and 1 year after the CLTS-only intervention based on the time frame of CLTS stages presented in Kar & Chambers (2008) who suggest it takes around 3 months for a community to achieve ODF status). All households who meet eligibility requirements in selected communities receive a voucher to construct a latrine, whether or not they already have one. This affords these low-income households the opportunity to construct a new latrine or to improve or replace an existing one. Importantly, poor households only become eligible for this subsidy support in communities where the CLTS-only intervention achieves high impact.

## BENEFIT-COST MODEL AND MODEL ASSUMPTIONS

A BCA is conducted of two sanitation interventions in Ghana over a nationally representative set of 100 rural communities. A detailed description of the equations used to calculate costs and benefits of the two interventions is provided in Supplementary Appendix A, and parameter assumptions are summarized in Supplementary Appendix B.

### Common model features for both interventions

We rely on evidence presented in Radin *et al.* (2020) to assume that the response to the CLTS-only intervention is heterogeneous across communities. As in that paper, we assume that there are three levels of uptake (latrine construction) across the 100 communities. In the base case, we assume that 20 of the 100 communities have a large response (high uptake; where latrine coverage increases by 35 percentage points and a community achieves ODF Basic status), 40 communities have a moderate response (medium uptake; where latrine coverage increases by 15 percentage points), and 40 communities have a small response (low uptake; where latrine coverage increases by 5 percentage points) to the intervention.

Accounting for this community-level heterogeneity in uptake affects the calculations of: (1) health impacts of the intervention (externality), (2) time costs of community residents, and (3) latrine-building and operation and maintenance costs. The potential benefits from a positive externality, also known as herd protection, are incorporated in the benefit-cost calculations (for further details, see Radin *et al.* 2020).

The costs and benefits for both sanitation interventions are calculated at the household level in high-, medium-, and low-uptake communities, and then aggregated to the community and regional level. The benefits and costs of the two interventions are calculated for a period of 10 years, and results are reported in terms of two metrics: a benefit-cost ratio (BCR) and a net present value of the time stream of annual benefits and costs over the 10-year planning period. All monetary values are reported in Ghanaian Cedi, GHS (USD 1 = GHS 4.5 in 2018) (Xignite 2018). We also perform three sensitivity analyses: (1) to assess the impact of using different approaches – the value of a statistical life (VSL) or value of a statistical life year (VSLY) methods – to valuing mortality reductions; (2) to assess the impact of using different discount rates, where we follow the guidelines presented in Robinson *et al.* (2019a) and use 8% in the base case (two times the short-term GDP per capita growth of 4%); and (3) to explore an alternative intervention that would provide vouchers to the poorest 40% of households in every community, rather than targeting the poor only in high-uptake communities as is currently done in the experimental intervention we consider in Ghana. We also conduct Monte Carlo simulations to estimate a distribution of likely results, given uncertainty in model parameters. In supplementary appendices to this paper, we present more detailed information about the Monte Carlo simulations (Supplementary Appendix C), a graphical representation of the diarrhea reductions in communities benefiting from the positive sanitation externality (Supplementary Appendix D), and additional tables from the sensitivity analyses (Supplementary Appendix E).

## Model features for the CLTS plus subsidies/vouchers variant

For the CLTS plus subsidies intervention, we additionally assume that households induced to build latrines by the voucher receive the same private benefits as households that build latrines without a voucher. The subsidy payment by the government is thus a transfer payment to households receiving the voucher and is not a net cost in the summation of costs and benefits to all stakeholders. This approach overlooks the fact that households that do not build a latrine after the CLTS-only intervention may have lower demand than those that do. In a typical BCA, the value of a latrine ascribed to a household that only obtained it with a voucher would be less than that ascribed to a household that chose to purchase it at full cost; if a household that only obtains a latrine after it receives a voucher valued the latrine as much as a household that obtained a latrine after the CLTS-only intervention or before the intervention, it would have obtained a latrine before the voucher was offered. However, in the context of a rural community in Ghana, households in the bottom two wealth quintiles also face tight liquidity constraints that may make purchasing a latrine unaffordable, even if it is highly desired. In such a context, a lack of access to credit results in suppressed demand.

The voucher scheme affects the total net benefits through four potential pathways: (1) it increases the number of households who build a latrine, such that additional private benefits are derived from these new constructions; (2) in some communities, it may increase coverage past the threshold level at which the health benefits of the positive sanitation externality kick into the benefit of all households; (3) there is an administrative cost to providing the vouchers to the households in the bottom two wealth quintiles in the high-uptake communities where households become eligible for these discounts; and (4) it increases the total capital costs of latrines constructed because more latrines are constructed when vouchers are offered. We include the capital costs of latrines twice for households that newly acquire a latrine and also redeem the voucher because two latrines are constructed for this household. This may overestimate costs somewhat because a poor household that initially built a low-quality private latrine may have incurred lower cost and might be able to upgrade that first latrine at reduced cost, relative to a new upgraded latrine.

## PARAMETER ASSUMPTIONS

### Assumptions common to both interventions

The model is based around a set of 100 hypothetical average communities in rural Ghana that are targeted by the sanitation program, each having 150 households. These communities have the following characteristics, that are derived from numerous secondary data sources in Ghana: household size (5.37), age composition of a household (0.7 children under 5, 1.5 children between 5 and 14, and 3.2 people 15 and older), daily wages for adults (GHS 4.6 or USD 1.02), diarrheal disease incidence (2.2 for children under 5, 1.15 for children between 5 and 14, and 1.3 for people 15 and older), and case fatality rates for different age groups (0.04% for children under 5, 0.0035% for children between 5 and 14, and 0.02% for people 15 and older) (Crocker *et al.* 2016a, 2017a; Global Burden of Disease Collaborative Network 2017; National Development Planning Commission 2017; Riahi *et al.* 2017; Samir & Lutz 2017; Ghana Statistical Service *et al.* 2018; Radin *et al.* 2020). Therefore, all communities in the analysis are assumed to be observably the same. In reality, communities in rural Ghana are diverse and may vary in both observable and unobservable ways that could affect how communities respond to a CLTS intervention and thus the magnitude of the benefits and costs. Thus, for some districts and communities – and for some households – our estimates of costs and benefits are likely to be too low; for others, they will be high.

Our analysis is based on national data describing conditions in rural Ghana. However, CLTS has already been implemented in every region (but not every community) in Ghana. There may be fundamental differences between communities where CLTS has been implemented and those where it has never been implemented. As such, though the characteristics that we specify to construct each model community are representative of rural Ghana, they may not be representative of the rural communities where CLTS has not previously been implemented.

### Baseline latrine coverage

Data from the WHO/UNICEF Joint Monitoring Program (2020) are used to estimate baseline private latrine coverage by wealth quintile. The benefit-cost calculations assume that the CLTS-only intervention has the same effect on poor and non-poor households, i.e., the same proportion of households from each wealth quintile constructs latrines as a result of the program. We assume the impact is proportional because evidence on how wealth status mediates the impact of CLTS is limited. Cameron *et al.* (2019) find a greater impact among non-poor households, while Pickering *et al.* (2015) finds a greater impact among the poor. We, therefore, assume that 60% of the latrine increase occurs in the households in the top three wealth quintiles (60% of the population), while the other 40% occurs in households in the bottom two wealth quintiles (40% of the population). We also assume that an equal proportion of those practicing OD and using shared latrines at baseline shift to using a private single-household latrine following the intervention. At baseline, approximately 30% of the population engages in OD and 35% uses shared latrines. Of the total population without a private single-household latrine, 46% practice OD (30/65) and 54% (35/65) use a shared latrine. Therefore, 46% of the households adopting a private single-household latrine are assumed to switch from OD, while 54% are households switching from using shared sanitation. There is ongoing debate about the health benefits of shared latrines (Heijnen *et al.* 2014); however, for the purposes of this analysis, it is assumed that shared latrines confer no protection from diarrhea.

### Program costs

The program costs for the CLTS program are assumed to be independent of the level of latrine uptake as most of the intervention costs are spent delivering the intervention, before households have had time to respond to the intervention. However, the time costs for participating in the initial triggering and follow-up activities vary with uptake. Not all households in the communities are assumed to attend triggering activities. Communities where more households attend the meetings have a higher time cost than those that have lower attendance rates. The cost per latrine is assumed to be constant, but the total community costs of building latrines – and the community-level operation and maintenance costs – are higher in communities that have more uptake. Based on empirical evidence from field evaluations in other countries, we assume that for the first 5 years after the intervention, all households constructing a latrine will use their latrine. After 5 years, a constant rate of households that have built private latrines in response to the intervention are assumed to abandon them (Barnard *et al.* 2013; Crocker *et al.* 2017b; Cameron *et al.* 2019; Orgill-Meyer *et al.* 2019), which leads to a reduction in benefits as well as a decline in operation and maintenance costs over time. Program costs (including management, training, and facilitation) and local investments (including time and money related to community activities and latrine constructions) are based on estimates by Crocker *et al.* (2017a).

## Economic value of health benefits and costs

This paper follows the recommendations for health valuation presented in Robinson *et al.* (2019a). We use VSL to estimate the benefits of averted mortality from diarrhea cases. We use a benefit transfer approach to estimate the VSL assuming: (1) GNI per capita (PPP) in the United States (USD 61,019); (2) GNI per capita in purchasing power parity of Ghana in 2017 International Dollars 4,864; (3) an income elasticity for VSL of 1.5; (4) a U.S. VSL of 2017 International Dollars 9.6 million; (5) a growth rate in Ghana that ranges from 4.1 to 3.6% per year over the life of the project, and (6) a 2017 GHS to International Dollar conversion factor. These assumptions imply a VSL of GHS 413,220 (USD 91,827) in 2018 ($413,220_{VSL\ Ghana} = 9,600,000_{VSL\ USA} * (((4,864_{Ghana\ GNI\ per\ capita\ 2017}) / (61,019_{USA\ GNI\ per\ caita\ 2017})) * 1.041_{\mathrm{Ghana\ real\ growth}})^{1.5} * 1.8_{\mathrm{PPP\ Conversion\ Factor\ Ghana\ 2017}}$).

In a sensitivity analysis, we compare the results of this VSL approach to those obtained from a VSLY approach. The latter specifies a constant value for each additional year of life gained due to the intervention, which is calculated based on the VSL – described above – and the average life expectancy in the population of interest (about 65 years for children under 5, 60 years for children between 5 and 14, and 41 years for people 15 and older). The VSLY is estimated to equal GHS 12,556 (USD 2,790). The results of an analysis using VSLY and VSL are likely to differ when the population most affected by an intervention is either much older or much younger than the average person. The benefits will be higher using the VSLY approach if a large number of younger people are affected by an intervention and lower if a small number of older people are affected because preventing the death of a younger person results in more additional years lived in expectation (Robinson *et al.* 2019b). Since diarrhea morbidity and mortality are higher for children under 5, we expect and find that the VSLY analysis has a more favorable benefit-cost result compared with the VSL analysis.

The cost of illness (COI) method is used to value the averted non-fatal morbidity from diarrhea cases, as no willingness-to-pay measure is available (Robinson & Hammitt 2018). The COI includes all direct and indirect costs of getting sick with diarrhea, including the costs paid by the healthcare system and lost productivity time. Based on Nonvignon *et al.* (2018) and the 2017 Maternal Health Survey (Ghana Statistical Service *et al.* 2018), we assume COI for an individual seeking care to be GHS 6.70 (USD 1.48) for outpatient treatment and GHS 87.92 (USD 19.42) for inpatient treatment. Similarly, the cost of a single case of diarrhea to the healthcare system is GHS 15.02 (USD 3.32) for outpatient treatment and GHS 195.89 (USD 43.27) for inpatient treatment. The overall weighted COI estimates per case of diarrhea based on the proportion of people seeking care and inpatient and outpatient cases disaggregated by age are GHS 86 (USD 19) for children under 5, GHS 14 (USD 3) for children 5–14, and GHS 26 (USD 6) for people 15 and older.

Finally, we follow the recommendation of Whittington & Cook (2019) to estimate the value of time as 50% of the local informal wage rate, approximately GHS 40 (USD 8.84) per day, for adults. We assume a value of time for children 5–14 of 25% of the local informal wage rate and do not value the time savings of children under 5. We assume that individuals save 5 min/day when switching from OD to a private single-household latrine or from a shared latrine to a private single-household latrine (J. Crocker, personal communication, November 6, 2018).

## Community response to CLTS activities

While many factors may influence the community response to CLTS, the model assumes that the only difference between low-, medium-, and high-uptake communities is their response to the CLTS-only intervention. The proportion of each of these types of communities in the hypothetical region is based on evidence discussed in Radin *et al.* (2020). The empirical evidence on the heterogeneity of community-level responses does not provide any insight into other, systematic differences between these types of communities. In other words, we do not assume that high-uptake communities, for example, have different rates of diarrheal disease prevalence than low-uptake communities.

## Effects of the CLTS intervention

Radin *et al.* (2020) reviewed 14 studies on CLTS and CLTS-inspired interventions and documented increases in latrine construction ranging from 0 to 50 percentage points, with an average increase of approximately 15 percentage points (Pattanayak *et al.* 2009; Elbers *et al.* 2012; Cameron *et al.* 2013; Clasen *et al.* 2014; Patil *et al.* 2014; Guiteras *et al.* 2015; Pickering *et al.* 2015; Crocker *et al.* 2016a, 2016b; Hammer & Spears 2016; Briceño *et al.* 2017; Luby *et al.* 2018; Null *et al.* 2018; Humphrey *et al.* 2019). In this analysis, we assume an average increase of private household latrine coverage across the full set of communities of 15 percentage points: 5 percentage points for the 40% of communities with low uptake, 15 percentage points for the 40% of communities with medium uptake, and 35 percentage points for the 20% of communities with high uptake.

We consider unimproved latrines to be private single-household latrines, but shared latrines do not count as private single-household latrines. The adoption of an unimproved or an improved private single-household latrine is assumed to confer health benefits to all people within a household. While many CLTS studies have found that CLTS interventions have a limited impact on diarrhea, some studies have found statistically significant effects (Hammer & Spears 2016; Cameron *et al.* 2019). We adopt the approach used in Radin *et al.* (2020) and assume an average reduction of 20% of the baseline diarrhea rate.

## Positive sanitation externality

Evidence for the presence of a sanitation externality has been discussed in a number of studies in the literature on the health impacts of sanitation interventions. These studies attempt to establish the link between higher rates of community-level improved sanitation behavior and greater reductions in diarrheal disease (Andres *et al.* 2017; Harris *et al.* 2017; Jung *et al.* 2017; Wolf *et al.* 2018). While this herd protection may have benefits that extend beyond reducing diarrheal disease incidence, due to limited data we only consider reductions in diarrhea (Fuller *et al.* 2016). We follow the assumptions presented in Andres *et al.* (2017) and Wolf *et al.* (2018), as well as Radin *et al.* (2020) who operationalize this concept for BCA, specifying a threshold level of 75% coverage beyond which the externality is realized. In the communities where this 75% threshold is exceeded, we estimate the diarrheal risk reduction as follows. Households that construct a new latrine due to the intervention experience a diarrheal risk reduction that increases linearly from 20%, when there are no externality benefits (i.e., when the latrine coverage level in the community is below the 75% threshold), to a maximum of 35% when community coverage reaches 100%. Households in communities with private single-household latrine coverage exceeding 75%, but that do not adopt latrines themselves, experience a diarrheal risk reduction that increases linearly from 0 to 35% as a function of community latrine coverage. Finally, households that already owned private single-household latrines prior to the intervention are assumed to receive a more limited benefit from the externality – a risk reduction rising linearly from 0 to 20% above the threshold – as they previously already experienced the private health benefits of adopting a private single-household latrine. We assume that households that already had a latrine before the CLTS-only intervention but choose to redeem the voucher to obtain a new latrine do not experience any additional health benefits beyond the health externalities that arise once community-level latrine coverage passes the 75% threshold. We present a graphical description of the diarrhea reductions in Supplementary Appendix D. Furthermore, we note here that due to the low baseline sanitation coverage in rural Ghana, this externality is only realized in the second intervention (CLTS plus subsidies) because the assumed impact of the CLTS-only intervention, even in high-uptake communities, does not meet the required externality threshold.

## Assumptions specific to the CLTS plus subsidies/vouchers intervention

The literature on the effect of including subsidies within a CLTS intervention is limited. While a number of studies document the potential for subsidies to complement CLTS, there are no existing benefit-cost studies that demonstrate the additive effects of a post-CLTS voucher program (Pattanayak *et al.* 2009; Patil *et al.* 2014; Guiteras *et al.* 2015).

Importantly, we do not evaluate the appropriateness of the design or implementation of the ongoing subsidy program (Israel & Shapiro 2019). Rather, the benefits and costs associated with the intervention as it is designed are calculated, assuming that the targeting approach implemented is successful and does not lead to perverse incentives or other outcomes. However, we also comment on potential challenges with this targeting policy in the discussion.

### Subsidy eligibility

One important difference in the CLTS plus subsidies intervention included in this analysis and subsidy interventions that have been tried elsewhere is that the subsidies are provided to poor households only *after* the CLTS-only intervention. Because the subsidy disbursement takes place after the CLTS-only intervention, and only if a community has been sufficiently responsive, a relatively large number of households will already have built latrines prior to the poorer community members becoming eligible for subsidies.

Consistent with the policy experiment on which our intervention is based, the CLTS plus subsidies intervention is assumed to provide vouchers to a fraction of households only in those communities where the CLTS-only intervention has already achieved a high impact. Following Radin *et al.* (2020), it is assumed that among the 100 model communities, there are three types of responses: 20 communities have a large response (high uptake; where latrine coverage increases by 35 percentage points and a community achieves ODF Basic status), 40 communities have a moderate response (medium uptake), and 40 communities have a small response (low uptake) to the intervention.

The subsidy component of the CLTS plus subsidies intervention then only applies in the high-uptake communities. In these high-uptake communities, the subsidy provides vouchers that cover 100% of the cost of improved latrines for the poorest 40% of households, regardless of whether or not they have already constructed a latrine. In practice, household eligibility rates in different communities would perhaps be determined based on household wealth, which could result in variation in the share of the subsidy-eligible population across high-uptake communities. Absolute measures of poverty status could be estimated using information on eligibility for existing government programs that are implemented throughout Ghana, such as the National Health Insurance Scheme indigent exemption waiver or Livelihood Empowerment Against Poverty (LEAP) program, while relative measures (to identify the poorest 40% within any given high-uptake community) could be based on guidance from local community leaders and the CLTS committee formed as part of the CLTS-only intervention (Palermo *et al.* 2019). Vouchers, equivalent to the cost of materials for one latrine, could be redeemed at local shops or retailers who would then collect payment from the CLTS implementers and provide receipts of sales to verify latrine purchases. This protocol generally adheres to the Guidelines established by the MSWR, which states that assistance (in this case, subsidies or vouchers) is only to be delivered to poor households in communities which can be classified as high-uptake.

### Voucher redemption

The Guidelines include minimum standards for latrines and identify appropriate technology options, including ventilated improved pit latrines and pour flush latrines (Ministry of Sanitation and Water Resources 2018). Past studies of CLTS have shown that newly built latrines in intervention communities may use low-quality materials and suffer from durability problems (Cavill et al. 2015; Crocker et al. 2017b). Thus, poor households that previously had or built new latrines during the CLTS-only intervention might still choose to redeem the voucher to obtain newer and higher-quality latrines. We have limited information on who would redeem these vouchers, but existing evidence suggests it would not be everyone, due to individual preferences, supply constraints, or difficulties in redeeming vouchers (Banful 2011; Wright et al. 2016). Lacking Ghana-specific data, we draw on evidence from voucher experiments in rural Kenya and Tanzania (Peletz et al. 2017, 2019) to account for the incomplete adoption of subsidies and latrines. Specifically, it is assumed that in high-uptake communities, 80% of subsidy-eligible households (the 40% in the bottom two wealth quintiles) redeem the voucher. This 80% includes those who owned the latrine before the CLTS-only intervention, those who built a new latrine because of the CLTS-only intervention, and those who still practice OD after the CLTS-only intervention. Therefore, households who redeem the voucher do so to either move from practicing OD to using a latrine or from using a lower-quality latrine to a higher-quality latrine. Households that have a newly built a latrine due to the CLTS-only intervention that redeem the vouchers can upgrade their latrine and obtain a higher-quality latrine that adheres to the Guideline standards. Thus, total coverage with improved sanitation among the bottom two wealth quintiles would reach 80%. We allow this redemption rate to range from 70 to 90% in the sensitivity analysis. This redemption rate considers that some poor households build high-quality latrines after the CLTS-only intervention and so do not redeem the voucher.

We assume that the 80% of households in the bottom two wealth quintiles who redeem the vouchers come proportionately from three types of households: (1) those who have access to a private single-household latrine, (2) those who have access to a shared latrine, and (3) those who practice OD. Importantly, however, we assume that the proportions of voucher-redeeming households in each of these three groups are somewhat different than for the community as a whole, reflecting the lower improved sanitation coverage among those with low incomes. Specifically, we assume that at baseline, half of the households in the bottom two wealth quintiles practice OD (20% of the total population). After the CLTS component of the CLTS plus subsidies intervention in the high-uptake communities and before the subsidy component of the intervention is implemented, we assume that 30% of the households in the bottom two wealth quintiles practice OD (or 12.5% of the total population). Once subsidies are disbursed, 80% of this 30% of households in the bottom two wealth quintiles switch to using an improved latrine while the rest continue to practice OD (2.5% of the total population). Although Guiteras et al. (2015) report that subsidies to poorer houses will also result in behavior changes in the wealthier households, we do not assume any additional change among non-poor households due to the implementation of the voucher program.

To summarize, this second intervention includes the entire CLTS-only intervention plus a post-CLTS provision of vouchers to the 40% poorest households in the 20 high-uptake communities in the hypothetical region.

### Program costs and benefits

The redeemed vouchers are assumed to shift the cost of latrine construction from the household onto the funder of the CLTS plus subsidies program since the retailers from whom vouchers are exchanged receive payment from funders. A fixed administrative cost is incurred by implementers in each community where the subsidy vouchers are provided. This is the only change to program costs.

In the low- and medium-uptake communities, benefits accrue only to those households that build latrines. In high-uptake communities, however, benefits accrue to all households because community latrine coverage surpasses the threshold that is assumed to be necessary to experience the positive sanitation externality.

## RESULTS

For both the CLTS-only and the CLTS plus subsidies interventions, Table 1 shows the number of non-fatal statistical cases of diarrhea avoided, premature deaths averted, and hours saved by each age group for the low-uptake, medium-uptake, and high-uptake communities and at the

**Table 1** | Estimates of cases of diarrhea avoided, premature deaths averted, and hours saved – for CLTS-only and CLTS plus subsidies interventions (totals over 10-year planning horizon)

| | Low-uptake community | Medium-uptake community | High-uptake community | All communities ($n = 100$) |
|---|---|---|---|---|
| *CLTS-only* | | | | |
| Statistical cases avoided total[a] | 103 | 309 | 721 | 30,910 |
| <5 | 21 | 64 | 150 | 6,430 |
| 5–14 | 24 | 73 | 169 | 7,240 |
| ≥15 | 58 | 172 | 402 | 17,240 |
| Premature deaths averted total | 0.021 | 0.063 | 0.15 | 6.3 |
| <5 | 0.009 | 0.026 | 0.060 | 2.6 |
| 5–14 | 0.001 | 0.002 | 0.006 | 0.2 |
| ≥15 | 0.012 | 0.035 | 0.081 | 3.5 |
| Hours saved total | 265 | 796 | 1,856 | 79,550 |
| 5–14 | 85 | 256 | 597 | 25,600 |
| ≥15 | 180 | 540 | 1,259 | 53,950 |
| *CLTS plus subsidies* | | | | |
| Statistical cases avoided total[a] | 103 | 309 | 1,179 | 40,065 |
| <5 | 21 | 64 | 245 | 8,335 |
| 5–14 | 24 | 73 | 276 | 9,380 |
| ≥15 | 58 | 172 | 658 | 22,350 |
| Premature deaths averted total | 0.021 | 0.063 | 0.24 | 8.1 |
| <5 | 0.009 | 0.026 | 0.10 | 3.3 |
| 5–14 | 0.001 | 0.002 | 0.0089 | 0.30 |
| ≥15 | 0.012 | 0.035 | 0.13 | 4.5 |
| Hours saved total | 265 | 796 | 2,440 | 91,230 |
| 5–14 | 85 | 256 | 785 | 29,360 |
| ≥15 | 180 | 540 | 1,655 | 61,870 |

[a]We note here that the statistical cases avoided refers to non-fatal diarrhea cases.

regional level over the 10-year planning horizon. We estimate that in the region with 100 communities, the CLTS-only intervention leads to a decrease of 30,910 non-fatal statistical diarrhea cases, averts a total of 6 premature deaths, and saves 79,550 h over the 10-year expected life of the latrines built due to the intervention. When subsidies are offered, we estimate that in the region of 100 communities, the intervention leads to a decrease of about 40,065 statistical diarrhea cases, a total of 8 premature deaths are averted, and 91,230 h are saved over the 10-year expected life of the latrine.

Table 2 presents the benefits, costs, NPV, BCR, and NPV per household targeted, and per household adopting a latrine for the two interventions for communities with low, medium, and high uptake of private single-household latrines calculated at a discount rate of 8%. Across the full set of 100 hypothetical Ghanaian communities, the present value of the total benefits of the CLTS-only intervention is GHS 3,643,915 (USD 809,759), an amount that increases to GHS 5,212,990 (USD 1,158,442) when subsidies are offered. The present value of the costs of the CLTS-only intervention in the region of 100 communities is GHS 3,865,050 (USD 858,900), which increases to GHS 4,681,175 (USD 1,040,261) when subsidies are offered. This cost increase is due to the cost of administering the subsidy program in eligible communities, the costs of providing subsidies to households in the bottom two wealth quintiles, and the cost of the additional latrines built for households newly adopting latrines and for households upgrading latrines. The BCR of the CLTS-only intervention in the region is 0.94 and increases to 1.1 for CLTS plus subsidies. The overall net benefits per household in the region (the

**Table 2** | Summary of results of BCA for CLTS-only and CLTS plus subsidies interventions: low, medium, and high-uptake communities (8% discount rate)

| | Low-uptake community | Medium-uptake community | High-uptake community | All communities ($n = 100$) |
|---|---|---|---|---|
| *CLTS-only* | | | | |
| Benefits | GHS 12,145 | GHS 36,440 | GHS 85,025 | GHS 3,643,915 |
| Mortality benefits | GHS 8,635 | GHS 25,905 | GHS 60,445 | GHS 2,590,540 |
| Morbidity benefits | GHS 3,105 | GHS 9,315 | GHS 21,730 | GHS 931,380 |
| Time savings | GHS 405 | GHS 1,220 | GHS 2,850 | GHS 121,995 |
| Costs | GHS 23,835 | GHS 38,905 | GHS 67,780 | GHS 3,865,050 |
| Program costs | GHS 15,625 | GHS 15,625 | GHS 15,625 | GHS 1,562,445 |
| Time costs | GHS 1,330 | GHS 2,635 | GHS 3,985 | GHS 238,305 |
| Capital costs | GHS 4,115 | GHS 12,355 | GHS 28,825 | GHS 1,235,250 |
| O&M costs | GHS 2,765 | GHS 8,290 | GHS 19,345 | GHS 829,050 |
| Net benefits | (GHS −11,690) | (GHS −2,465) | GHS 17,245 | (GHS −221,135) |
| BCR | 0.51 | 0.94 | 1.3 | 0.94 |
| Net benefits per HH | (GHS −80) | (GHS −16.5) | GHS 115 | (GHS −15) |
| Net benefits per latrine adopting HH | (GHS −1,560) | (GHS −110) | GHS 330 | (GHS −100) |
| *CLTS plus subsidies* | | | | |
| Benefits | GHS 12,145 | GHS 36,440 | GHS 163,475 | GHS 5,212,990 |
| Mortality benefits | GHS 8,635 | GHS 25,905 | GHS 99,650 | GHS 3,374,655 |
| Morbidity benefits | GHS 3,105 | GHS 9,315 | GHS 36,085 | GHS 1,218,435 |
| Time savings | GHS 405 | GHS 1,220 | GHS 3,740 | GHS 139,900 |
| Voucher | GHS 0 | GHS 0 | GHS 24,000 | GHS 480,000 |
| Costs | GHS 23,835 | GHS 38,905 | GHS 108,585 | GHS 4,681,175 |
| Program costs | GHS 15,625 | GHS 15,625 | GHS 15,625 | GHS 1,562,445 |
| Time costs | GHS 1,330 | GHS 2,635 | GHS 3,985 | GHS 238,305 |
| Capital costs | GHS 4,115 | GHS 12,355 | GHS 38,020 | GHS 1,419,160 |
| O&M costs | GHS 2,765 | GHS 8,290 | GHS 25,515 | GHS 952,485 |
| Voucher | GHS 0 | GHS 0 | GHS 24,000 | GHS 480,000 |
| Voucher administration | GHS 0 | GHS 0 | GHS 1,440 | GHS 28,780 |
| Net benefits | (GHS −11,690) | (GHS −2,465) | GHS 54,890 | GHS 531,815 |
| BCR | 0.51 | 0.94 | 1.5 | 1.1 |
| Net benefits per HH | (GHS −80) | (GHS −16.5) | GHS 365 | GHS 35.5 |
| Net benefits per latrine adopting HH | (GHS −1,560) | (GHS −110) | GHS 1,045 | GHS 235 |

total net benefits of the interventions divided by the total number of households, which is 15,000 households) was GHS −15 (USD −3.3) for the CLTS-only intervention and GHS 35.5 (USD 7.9) for the CLTS plus subsidies intervention. The net benefits per household adopting latrines (the total net benefits of the interventions divided by the total number of households who built latrines, which is 2,250 households) was GHS −100 (USD −22) for the CLTS-only intervention and GHS 235 (USD 52) for the CLTS plus subsidies intervention.

As detailed in Table 2, there is a large difference in benefits by community type. In communities with high uptake, the CLTS-only intervention has a BCR of 1.3 and the CLTS plus subsidies intervention has a BCR of 1.5. In medium-uptake communities, the BCR is the same (0.94) for both the CLTS-only and the CLTS plus subsidies intervention because no subsidies are provided. Similarly, in low-uptake communities, the BCR for both interventions is 0.51. While increasing the proportion of high-uptake communities would make the interventions much more beneficial, it is very difficult to identify these communities before implementation.

We present the results of our sensitivity analyses using different discount rates and VSLY to measure mortality benefits rather than VSL as well as a more detailed distribution of the costs and benefits to each of the stakeholders in Supplementary Appendix E.

Table 3 presents the results of the analysis assuming all households in the bottom two wealth quintiles in all communities within the region receive vouchers. This analysis shows slightly higher NPVs and BCRs than the results when subsidies are only targeted to the high-uptake communities. These results are slightly more favorable because the subsidies lead to large increases in uptake in the low-uptake and medium-uptake communities (for low-uptake communities latrine coverage increases from 39 to 60% and for medium-uptake communities from 49 and 66%), and many more households benefit from improved sanitation. The increase in uptake additionally brings medium-uptake communities very close to the externality threshold. In reality, this threshold is uncertain and whether it would be induced by wider targeting of pro-poor subsidies is an important question. Of course, these results assume that voucher redemption rates within a community are independent of the size of latrine uptake due to the intervention, which may not be the case.

The results of the Monte Carlo analysis show that a wide range of outcomes are possible for the two CLTS interventions. Figure 1 presents the cumulative density functions of the NPVs and BCRs, for the two interventions (CLTS-only and CLTS plus subsidies). The Monte Carlo simulation shows that the NPV of the CLTS-only intervention is greater than zero in fewer than 30% of simulations. The NPV of CLTS plus subsidies is greater than zero in about 55% of simulations. These results suggest that the Government of Ghana is likely to have other investment opportunities that are more attractive than both of these CLTS interventions, though CLTS with subsidies appears more attractive than CLTS alone.

We also present a one-way sensitivity analysis, where we only vary the value of one parameter while keeping all others constant and identify the ten parameters that explain the most variation in these NPV results (Figure 2).

**Table 3** | Summary of results of BCA with subsidy/voucher for all: low, medium, and high-uptake communities (8% discount rate)

| | **Low-uptake community** | **Medium-uptake community** | **High-uptake community** | **All communities ($n = 100$)** |
|---|---|---|---|---|
| *CLTS plus subsidy* | | | | |
| Benefits | GHS 85,370 | GHS 101,660 | GHS 163,475 | GHS 10,750,970 |
| Mortality benefits | GHS 44,230 | GHS 55,970 | GHS 99,650 | GHS 6,000,980 |
| Morbidity benefits | GHS 15,900 | GHS 20,120 | GHS 36,085 | GHS 2,162,680 |
| Time savings | GHS 1,240 | GHS 1,570 | GHS 3,740 | GHS 187,310 |
| Voucher | GHS 24,000 | GHS 24,000 | GHS 24,000 | GHS 2,400,000 |
| Costs | GHS 77,755 | GHS 88,450 | GHS 108,590 | GHS 8,819,845 |
| Program costs | GHS 15,625 | GHS 15,625 | GHS 15,625 | GHS 1,562,445 |
| Time costs | GHS 1,330 | GHS 2,635 | GHS 3,990 | GHS 238,300 |
| Capital costs | GHS 21,160 | GHS 26,780 | GHS 38,020 | GHS 2,677,895 |
| O&M costs | GHS 14,200 | GHS 17,970 | GHS 25,515 | GHS 1,797,295 |
| Voucher | GHS 24,000 | GHS 24,000 | GHS 24,000 | GHS 2,400,000 |
| Voucher administration | GHS 1,440 | GHS 1,440 | GHS 1,440 | GHS 143,910 |
| Net benefits | GHS 7,615 | GHS 13,210 | GHS 54,885 | GHS 1,931,125 |
| BC ratio | 1.1 | 1.1 | 1.5 | 1.2 |

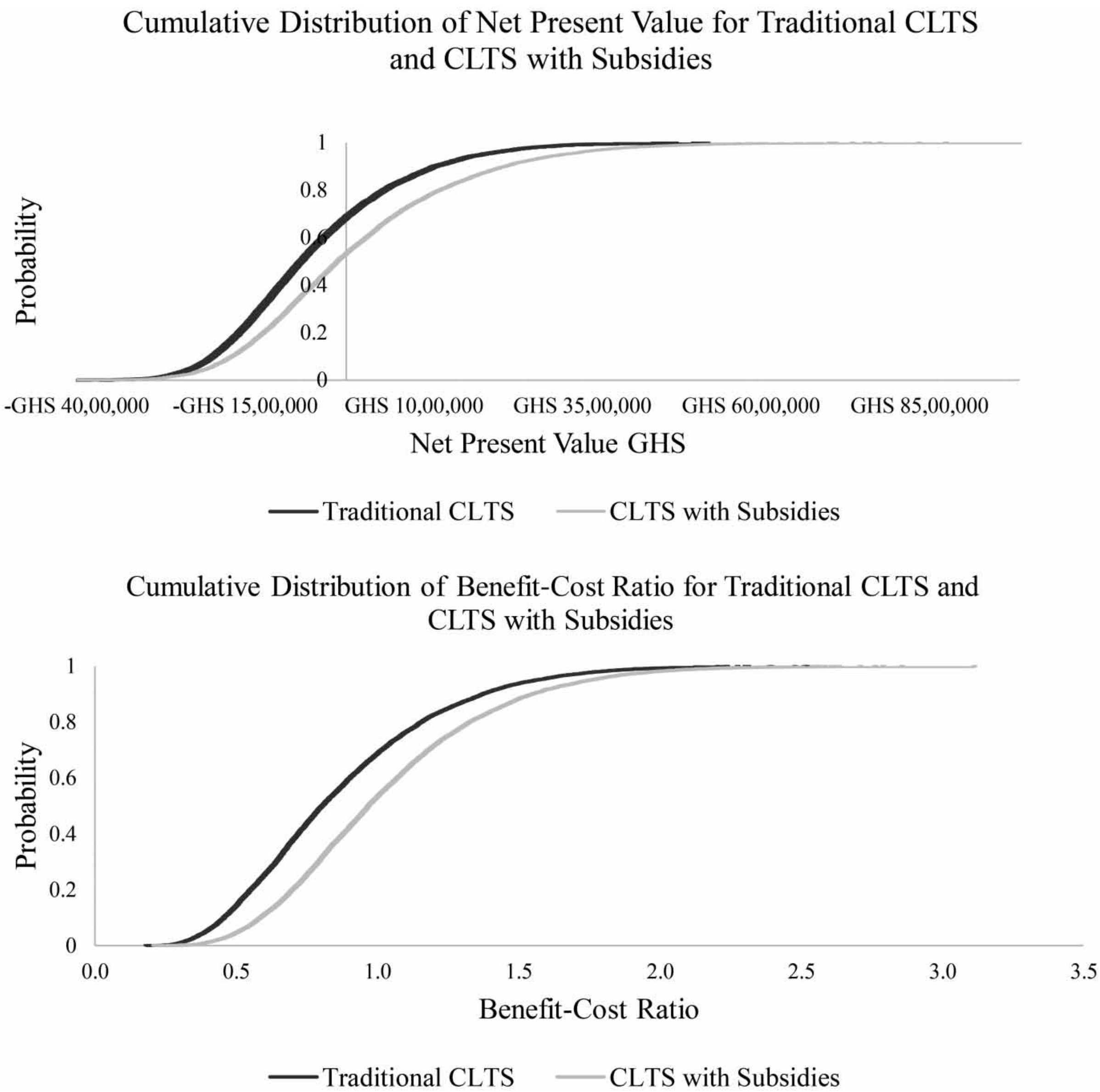


**Figure 1** | Cumulative distribution of results from Monte Carlo simulation (10,000 draws) of traditional CLTS and CLTS with subsidies: NPV and BCR.

For both interventions, the diarrhea reduction for households newly adopting latrines, the case fatality rate, and the cost of the latrine were the three most influential variables, in that order. For CLTS-only, the next most influential variables are (1) the discount rate, (2) the cost of operation and maintenance as a percent of the total latrine cost, (3) CLTS facilitation costs, (4) baseline diarrheal incidence rate, (5) the percent of communities with low-uptake, (6) the percentage point increase in latrines in low-uptake communities, and (7) the percentage point increase in latrines in medium-uptake communities. For CLTS with subsidies, the next most influential variables are (1) the percent of communities with low uptake, (2) the percentage point increase in latrines in high-uptake communities, (3) the externality threshold, (4) the discount rate, (5) the cost of operation and maintenance as a percentage of the total latrine cost, (6) the baseline diarrheal incidence, and (7) CLTS

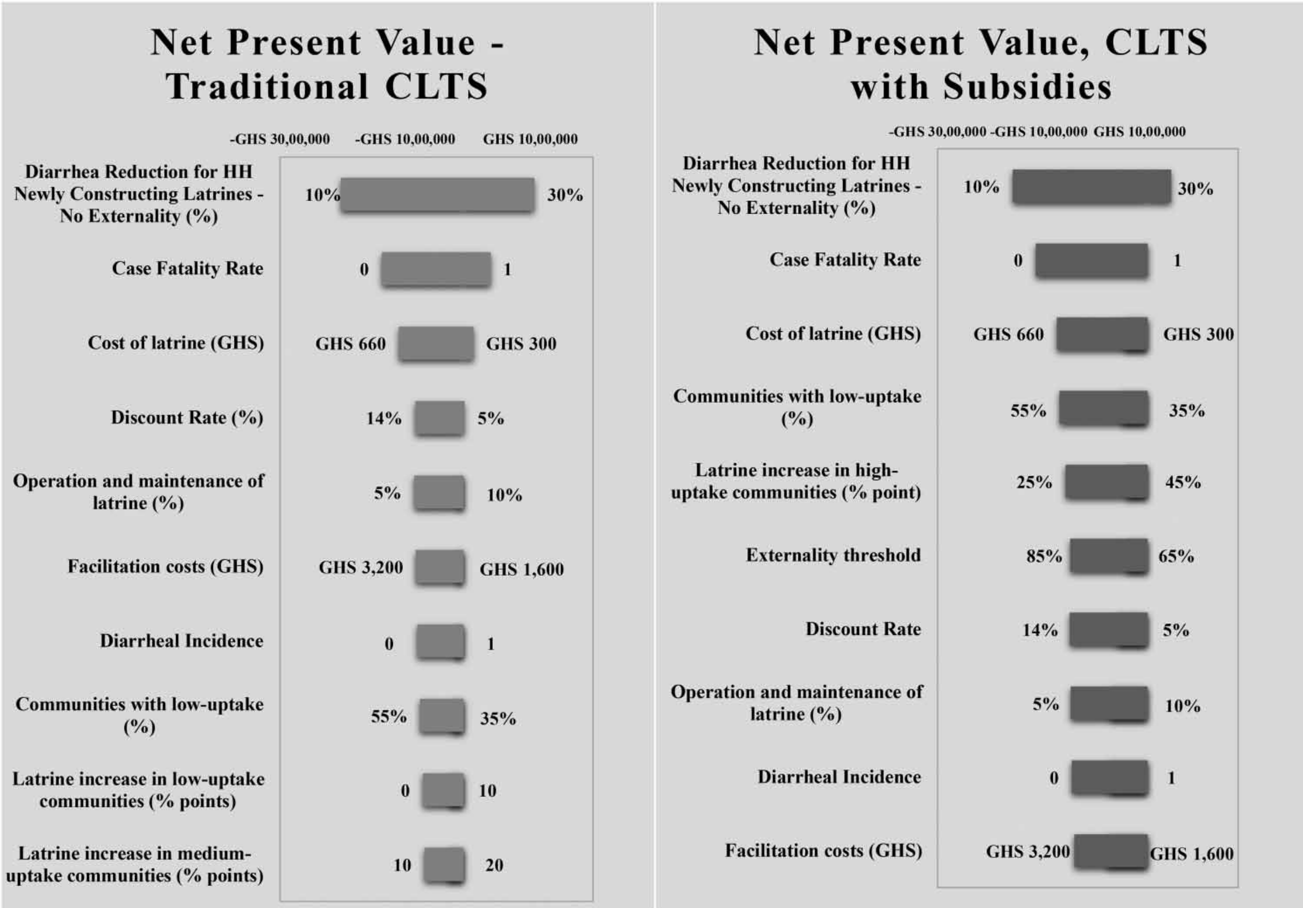


**Figure 2** | Sensitivity analyses: effect of selected parameters on NPV with and without externality (holding other parameters at base case values).

facilitation costs. Such sensitivity analyses may help CLTS program implementors identify those communities where net benefits are most like to be high. For example, communities with higher diarrheal morbidity and mortality, or where latrines implementing CLTS would be cheaper, or where the response to the CLTS intervention would be greatest are good candidates to receive a CLTS intervention. However, to use such guidance in practice to target the activities of a future CLTS campaign may be difficult as more remote communities are likely to have higher diarrheal morbidity and mortality while less remote communities are likely to have cheaper latrine and implementation costs. Furthermore, there is insufficient evidence to allow identification of those communities that would have the largest response to a CLTS intervention.

## DISCUSSION

When deciding whether to invest in a new CLTS intervention, planners should consider the local realities in their specific program area, which may be more or less favorable for the intervention than the conditions analyzed here. And so, the results of the benefit-cost calculations presented here should be viewed as potential outcomes, given the substantial heterogeneity in baseline sanitation infrastructure, health, and socioeconomic conditions across rural communities in Ghana. Moreover, since CLTS has already been implemented in every region in Ghana, it is possible that the government officials and development organizations strategically chose to first implement CLTS in communities where they believed it would be most effective. An analysis for a specific region of Ghana or a different country, particularly one in which costs would be lower than in Ghana, might yield different results (Crocker *et al.* 2017a; Cha *et al.* 2020).

This analysis suggests that communities with average diarrheal morbidity and mortality rates and similar costs to those assumed here will likely not experience large positive net benefits from the CLTS-only intervention. For Ghana, implementing CLTS-only interventions in many communities would not achieve the goals of ending OD set forth by the NSC. Experimenting with complementary interventions, however, such as the inclusion of a targeted subsidy provision, could lead to the development of a package of CLTS and subsidies that would achieve the NSC goals.

However, the evidence base on the relative effectiveness of various subsidy-related modifications to the CLTS program is thin. Little is known about the relative merits of different types of sanitation subsidy programs and how the following features affect outcomes: (1) selection criteria for identifying eligible beneficiaries, (2) type and amount of subsidy, (3) time point within the intervention at which the support is provided, and (4) how the subsidy is disbursed (Pattanayak *et al.* 2009; SNV 2010; Boisson *et al.* 2014; Venkataramanan 2014; Guiteras *et al.* 2015; Coffey *et al.* 2017; Garn *et al.* 2017; Augsburg *et al.* 2019; Batmunkh *et al.* 2019). Moreover, the broader literature in economics on the challenge of delivering subsidies (see, e.g., Devereux *et al.* 2017) points to potential problems related to the type of targeting being implemented in Ghana.

As discussed, our analysis of the CLTS with subsidies intervention is based on an experiment currently being implemented in rural Ghana. That experiment offers vouchers only to poor households in communities that have been declared ODF Basic (Ministry of Sanitation and Water Resources 2018; Israel & Shapiro 2019). This might appear odd at first glance – why offer subsidies where universal sanitation has already been achieved without them? However, in practice, the ODF declaration does not require universal coverage with high quality (improved) sanitation in Ghana. Nonetheless, this particular policy has several potential drawbacks. First, as word spreads about the design of the incentive, households that are eligible to receive the subsidy will have an incentive to hold out until the subsidy is administered, which would suppress the gains from CLTS efforts. This also means that poor households who do construct latrines and contribute to reaching a minimum coverage needed to receive the subsidies may construct lower-quality ones because of lack of initial funding, which would be wasteful spending if these are then replaced when subsidies arrive.

Second, there is also an important equity concern. Poor households that are effectively 'triggered' and spend significant resources on latrines may resent a policy that delivers subsidies to their less involved neighbors. Third, communities may engage in strategic behavior, organizing in ways that superficially meet the 'high uptake' standards for receiving vouchers without making real behavior change, which is what is needed for a CLTS intervention to truly reduce health risks. Fourth, when scaling-up the policy to the national level, administrative hurdles for this type of nuanced policy, which requires effective monitoring and timely disbursement of subsidies to maintain momentum toward ending OD, are likely to be high. The broader evidence in support of conditional subsidies, rather than unconditional ones, is mixed, and details of design and implementation matter a great deal (SNV 2010; Venkataramanan 2014; Guiteras *et al.* 2015; Coffey *et al.* 2017; Garn *et al.* 2017; Augsburg *et al.* 2019).

BCA estimates the social benefits and costs, not just costs to program implementers. The total costs presented in this analysis are not all borne by implementers. This distinction is important for at least two reasons. First, the government and implementers must develop budgets for CLTS programs that are feasible from a public sector or donor budgeting perspective. The CLTS intervention that includes subsidies costs an additional GHS 480,000 (USD 106,031) that the government or other implementers would somehow need to pay for. However, from the perspective of a social BCA, these costs are not additional as they only shift the subsidized costs from the household ledger to that of the implementer. Therefore, assuming that the subsidy is efficient and well-targeted, reducing the size or number of households receiving a subsidy only affects the overall benefit-cost results through reductions in uptake (and therefore the extent to which the positive externality is captured), but it would affect the implementers' budget. There are also challenges with implementing subsidy schemes to limit leakage, which we have are not incorporated into this analysis.

Second, private costs borne by households – in terms of time spent participating in CLTS activities, money or in-kind expenditures for construction of latrines, and even aesthetic costs associated with using lower quality on-site sanitation facilities – are precisely the types of barriers that prevent more widespread adoption of sanitation improvements (Guiteras *et al.* 2015; Coffey *et al.* 2017; Crocker *et al.* 2017a). Subsidies can play an important role in lowering these costs but put greater strain on the public sector or donor budgets.

Complementary interventions that either increase the effectiveness of CLTS or reduce the cost of implementation would make investments in these interventions more attractive. Sanitation marketing is one approach that could both increase uptake by focusing on demand generation and decrease latrine cost by supporting innovative technology (Devine & Kullmann 2011; Devine & Sijbesma 2011). However, these additional interventions, including other water, sanitation, or hygiene interventions, may be costly themselves and sometimes prove to be compliments or substitutes (Bennett 2012; Duflo *et al.* 2015). They would need to be analyzed to better understand their returns relative to other potential interventions (Abramovsky *et al.* 2019).

Moreover, researchers need to develop a stronger evidence base for understanding the effects of sanitation improvements and especially the nature of the positive externality from sanitation. The only health improvements included in the analysis presented here were those due to diarrhea reduction because data on other health effects were not available (Pearson & McPhedran 2008; Prüss-Ustün *et al.* 2014). Underscoring the importance of this issue, one-way sensitivity analysis revealed that the externality threshold assumption has a large effect on the predicted social net benefits of the CLTS plus subsidies intervention. The results in this analysis contrast with those in Radin *et al.* (2020), which found that the impact of the externality only had a modest impact on social net benefits from CLTS. The difference is due to differing assumptions about baseline conditions in that analysis and those in Ghana (including latrine coverage, diarrheal incidence, case fatality rates, and relevant costs). In principle, the herd protection could also be achieved by a CLTS-only intervention. That did not occur in this analysis because average baseline latrine coverage in rural Ghana is low and the latrine coverage increases documented in peer-reviewed impact evaluations of CLTS-only interventions were not sufficient to reach the threshold above which the externality was induced. Thus, only high-uptake communities targeted with CLTS plus subsidies achieve the level of community coverage necessary to generate the community externality. If this threshold was lower than assumed here or the additional decrease in diarrhea from herd protection was greater, the case for investment in CLTS-only interventions might improve.

This analysis demonstrates the importance of conducting economic analyses using context-specific data rather than simply assuming that global or regional analyses can help decision-makers prioritize local investments. To best support decision-making, future analyses should continue to incorporate real-world data that are specific to a region or local area.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this paper is available online at https://dx.doi.org/10.2166/washdev.2020.066.

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