**Appendix A:** Description of the Benefit-Cost Model

*Equations for calculations of benefits without the positive sanitation externality*

Consistent with the majority of previous BCAs of sanitation interventions, our estimates of the benefits of the CLTS campaign have two components: 1) health improvements, and 2) time savings. The health benefits from the CLTS intervention result from the reductions in mortality (premature deaths averted) and morbidity (non-fatal cases of diarrhea avoided) that ensue from the lower incidence of diarrheal disease. The economic value of the reductions in mortality risk are calculated using a value of a statistical life (VSL) derived from a benefit transfer approach proposed by Robinson et al. (2019). The value of reduced morbidity risk is calculated using an estimate of the cost of illness (COI) as a proxy for WTP to avoid an episode of illness. The economic value of time savings is estimated as a percentage of the informal wage rate according to guidance in Whittington and Cook (2018). The VSL and the wage component of COI are adjusted to account for real income growth over the 10-year planning horizon following the guidance in Robinson et al. (2018) and Robinson and Hammitt (2018).

We first present the calculations for the case without the externalities and will later detail the calculations for the case with the externalities. The present value of the benefit stream in the hypothetical region in Sub-Saharan Africa is:

(1)

where

*PVB* = total present value of the benefits to all households in the 200 villages in the hypothetical region;

*Nj* = number of villages of type *j*;and

*PV HH Bij* = present value of the benefits for household *i* in village type *j*.

The model assumes heterogeneous responses to the CLTS intervention both across villages and within villages. The benefit a household receives depends on whether its household members construct and use a new latrine, whether members of households that already own a latrine start using a latrine more intensively after the intervention, how long households continue to use their latrines, and whether households in the village receive a positive sanitation externality. The proportion of households in each of these groups varies according to the magnitude of the treatment effect from the CLTS intervention in the three village types (i.e. small, medium, and high-uptake). Village-level benefits in each of these three types of villages are calculated by summing the benefits for each household *i.*

The present value of the household benefits for household *i* in village type *j* is:

, (2)

where

*Bijtk* = value of the benefits for household *i* in village type *j* in year *t* for all household members in age group *k*,

*r* = real (i.e., net of inflation) discount rate, and

T = number of years of the planning horizon

The benefits for each household *i* in village type *j* depend on whether the household owns, and maintains a latrine in year *t* and whether the individual within each age group in the household begin to use the latrine due to the CLTS intervention. We do not account for any changes in household compositions over the ten years of the project horizon.

The benefits to each household in the region are calculated by adding the benefits from reduced diarrhea mortality (premature deaths averted), reduced diarrhea morbidity (nonfatal cases of diarrhea averted), and the time savings from no longer needing to walk somewhere outside the house to defecate. The benefits for all people in age group *k* in household *i* in village type *j* and year *t* are given by:

, (3)

(4)

(5)

where

*Pk* = number of people in age group *k* in household,

*Premature deaths avertedijtk* = number of deaths avoided due to the intervention’s effect on diarrhea risk, in household *i* in village type *j* and year *t*, for each member of age group *k*,

*VSLt* = value of a statistical life in year *t*, and is calculated using a benefit transfer technique,

*VSLus* = $9,400,000,

*GNI0i* = GNI at baseline for household *I*,

*GNI0i* = GNI at baseline for the United States ($58,9600),

*G* = is the projected annual real wage growth rate,

*Nonfatal cases avertedijtk* = number of nonfatal diarrhea cases averted due to the intervention’s effect on diarrhea risk, in household *i* in village type *j* and year *t*, for each member of age group *k*,

*COIk* = the cost of illness for a member of age group *k*,

*Time savingsijtk* = number of hours saved from no longer walking to a defecation place due to the intervention, in household *i* in village type *j* and year *t*, for each member of age group *k*,

*VOTk* = value of time for a member of age group *k*, expressed as a fraction of the estimated informal wage rate, and

*WAGEt* = the average unskilled hourly wage in the informal sector in year *t*.

*WAGE0* = is the average informal wage rate at baseline.

We next calculate the total number of households affected by the project. We assume that a fixed percentage of households adopt a latrine due to the intervention, and that this number is constant for the first five years of the project. The total number of households in the village is assumed to remain the same throughout the ten-year planning horizon. The total number of households using a latrine for the first five years is:

(6)

Where…

*LATijτ*  = one if household *i* in village type *j* has built or owns a latrine due to the intervention in year *τ* (the first five years of the intervention), and is zero otherwise,

*LATij0* = one if household *i* in village type *j* has latrine before the intervention starts, and is zero otherwise, and

*ADOPTj* = is the percentage point change in the number of households in village type *j* to newly adopt a latrine.

After five years we assume a constant rate of households will abandon their new latrine:

(7)

*LATijt*  = one if household *i* in village type *j* has built or owns a latrine due to the intervention in year *t*, and is zero otherwise,

*LATijτ*= one if household *i* in village type *j* has newly adopted a latrine due to the intervention, and is zero otherwise, and

*Abandonment Rate*= is the constant proportion of households that abandon their latrine per year.

Using equation 3, individual benefits are aggregated by age group (younger than five, between five and fourteen, and fifteen and older) for each household, and then summed over the three age groups. The economic value of time savings for children under 5 years of age are assumed to be zero (Whittington and Cook, 2018).

Premature deaths avoided and non-fatal diarrhea cases avoided in household *i* in village type *j* and year *t*, for each member of age group *k* are calculated as shown in equations (8) and (9), respectively:

(8)

, (9)

Where…

*LATijt*  = one if household *i* in village type *j* has built or owns a latrine due to the intervention in year *t*, and is zero otherwise,

*PPjtk* = is the percentage of individuals in village type *j* in year *t* in age group *k* that use a latrine,

*DIAikL* = diarrhea incidence rate for a person in household *i* with or without a latrine at baseline *L* in age group *k*,

*CFRk* = diarrhea case fatality rate for a person in age group *k*, and

*DR* = diarrhea risk reduction experienced by members of a household with a latrine.

*LATijt* ensures that health benefits only accrue to households that build a latrine due to the CLTS intervention and still use their latrine in year *t*. The percentage of individuals using a latrine in each village in each year in each age group ensures that benefits only accrue to individuals using a latrine in the case when externalities are not included. Among households that have built and the members are using a latrine, then, premature deaths averted are calculated with a multiplicative function of age-specific diarrhea incidence and case fatality rates, and the diarrhea risk reduction due to the intervention. Nonfatal diarrhea cases averted are calculated using the same equations but removing the case fatality variable.[[1]](#footnote-1)

An avoided case of diarrhea for an individual in age group *k* is valued using the COI:

, (10)

where *…*

*SEEKk* = percentage of diarrhea cases for which individuals in age group *k* seek medical attention,

*HHC* = household financial cost per case among those seeking medical attention,

*POCk* = percentage of diarrhea patients seeking medical care in age group *k* that receive outpatient care,

*PICk* = percentage of diarrhea patients seeking medical care in age group *k,* that receive inpatient care,

*COC =* cost of outpatient care,

*CIN* = cost of inpatient care,

*HLOk* = number of working hours lost due to being sick or caring for a sick person in age group *k* for those receiving outpatient care,

*HLIk*, = number of working hours lost due to being sick or caring for a sick person in age group *k* for those receiving inpatient care,

*HLNCk =* number of working hours lost due to being sick or caring for a sick person in age group *k* for those not receiving care,

We assume that the diarrhea patients not seeking care have no medical expenses and that the only economic cost for these individuals due to the diarrhea episode is the time lost to the illness. All other terms ( and ) are as defined previously.

The cost of illness consists of the treatment costs and the lost productivity[[2]](#footnote-2) due to being sick or caring for a sick child. The treatment costs are calculated as the sum of the average costs incurred by those seeking medical care and the proportion of those seeking care that receive inpatient or outpatient care. These costs may be paid by households themselves, the public sector, or donors. Lost productivity is calculated by adding the hours not working due to sickness or due to caring for a sick household member in each category of care (inpatient, outpatient, or none).

Time savings in household *i* in village type *j* and year *t*, for each member of age group *k*, are calculated as:

, (11)

where

*BLATi* = one for household *i* that owned a latrine before the intervention began, and is zero otherwise and is based on our initial assumptions described elsewhere,

*BUSEi* = one if at least some members of household *i* use a latrine todefecate before the CLTS intervention, and is zero otherwise and is based on our initial assumptions described elsewhere,

*USEijt* = one if at least some members of household *i* use a latrine todefecate after the CLTS intervention, and is zero otherwise and is based on our initial assumptions described elsewhere,

*TRVL* = time spent walking to and from a place to defecate per trip, in minutes,

*TDEF* = number of times a person defecates per day, (*60* is used to convert travel time to hours, and *365* to convert daily to annual time savings).

While we assume health benefits accrue to all households members in a house that newly adopts latrines, time benefits can also accrue to individuals who did not use a latrine at baseline but lived in households that owned in latrine. Therefore, we include both the people in households newly acquiring a latrine and using the latrine as well as people newly using a latrine but living in households that already had a latrine to calculate total time savings. The other terms in the equation describe the hours saved per year from not needing to walk to and from defecation sites outside the household.

*Estimates of age-specific parameter values*

We assume that the age specific variables in the previous equations are all correlated. Therefore, we used minimum and maximum values of each of these parameters to construct an age specific linear function to estimate the parameter. We use the minimum as the intercept of the linear function and the difference between the maximum and minimum as the slope. A theoretical example is presented below for a parameter relevant to two age groups, 1 and 2.

Where

*Y=* is the parameters of interest for either age group 1 or age group 2,

*m*= is the upper bound of our estimates for parameter Y minus the lower bound of our estimates for parameter Y for each age group,

x = is a correlation factor that is 0.5 in the base case, and

*b=* is the lower bound of our estimates for parameter Y.

As an empirical example, we present the estimation of the total percent of people with diarrhea seeking medical care. We assume that between 25% and 75% of the families with children under 5 with diarrhea seek care, while between 3% and 9% of the people 5 and older with diarrhea seek care. The intercept of our linear functions is then 25% for the under 5 cases (*b1*) and 3% (*b2*) for the 5 and older cases. We then assume a slope of 50% (75%-25%), *m1*, for the under 5 cases and 6% (9%-6%), *m2*, for the 5 and older. We then estimate a joint parameter between 0 and 1, *x*, for the total percent of people with cases of diarrhea that choose to seek care. In our base case we assume that this value is 0.5. Our base case estimates of cases of diarrhea in children under 5 seeking care is 50% and for 5 and older it is 7.5%. We used this approach to calculate age-specific values for diarrheal incidence, case fatality rates, percent of diarrhea cases seeking medical care, percent of patients seeking care receiving inpatient care, health costs of diarrhea (including inpatient costs, outpatient costs, and other household costs), time lost due to sickness (including for people receiving inpatient care, outpatient care, for those not seeking care, and for caring for children under 5 with diarrhea), and the value of time as a percentage of the local wage rate.

*Equations for calculations of benefits including the positive sanitation externality*

Several adjustments are required to incorporate a positive sanitation externality into the benefit-cost model. First, a new estimate for the diarrhea risk reduction among households adopting latrines is specified:

, (12)

where *…*

*DR-EXL* = diarrhea reduction (including the externality) for households that newly adopted latrines after the CLTS intervention,

*MR* = maximum diarrhea reduction that applies if all households in a village own a latrine,

*Σ Ii=1 LATijt* = total number of households in village type *j* that have built or own a latrine due to the CLTS intervention in year *t*,

*HH* = total number of households per village (100), and

*USEijt* = one if at least some members of household *i* use a latrine todefecate before and after the CLTS intervention, and zero otherwise, and

*TH* = threshold level of community coverage required to experience a positive externality.

The first part of this piecewise linear function requires calculating the latrine coverage level in a village in each village type. When this percentage of households with a latrine is greater than or equal to the threshold above which an externality is produced, the village experiences a positive sanitation externality that increases linearly with coverage up to the maximum achievable protection (*MR*). Otherwise, the diarrhea reduction is simply that assumed for the case without an externality (*DR*). Due to latrine disuse and abandonment, villages could lose the externality benefits if coverage in year *t* falls below the threshold.

The diarrheal reduction for households without latrines is shown in equation (13), and the premature deaths and cases averted for these households are presented in equations (14) and (15):

(13)

(14)

, (15)

where *DR-EXNL* = diarrhea reduction for households that do not have latrines following the intervention,

*NLATijt* = one for household *i* in village type *j* that has not constructed a latrine, in year *t*, and zero otherwise.

This calculation assumes that households without latrines experience a positive sanitation externality if there is overall coverage in the village above the threshold required to generate community-level protection, and that the protection again increases linearly with coverage up to the maximum achievable protection (*MR*). Below the threshold, the risk reduction is simply zero.

Finally, households already owning latrines prior to the intervention also experience reductions (albeit smaller ones) in diarrhea mortality (premature deaths averted) and morbidity (nonfatal diarrhea cases averted) above the threshold coverage. The diarrheal reduction for these households is shown in equation (16); premature deaths averted and nonfatal cases averted for these households are then analogous to those in equations (14) and (15), only they use the different protection rate and the binary indicator *BLATij*from above:

(16)

where *DR-EXBL* = diarrhea reduction for households that do not have latrines following the intervention.

This calculation again assumes that households who previously owned latrines experience a positive sanitation externality when coverage in the village rises above the threshold required to generate community-level protection. In this case, since households have already received protection *DR* from private latrine ownership, the additional protection increases linearly with coverage up to a maximum achievable protection of . Below the threshold, the additional risk reduction is simply zero.

*Equations for Costs Calculations*

The cost estimates of implementing a CLTS intervention consist of estimates for administrative, logistic, and human resource costs. These include costs for transportation, educational materials, and administrative overhead, as well as the time of government officials, project facilitators, local leaders, and village residents required to implement a CLTS campaign. If a household decides to build a latrine after the CLTS intervention, it will incur latrine construction and maintenance costs, which are included as well.

The total costs of a CLTS intervention are calculated as the sum of the household-level costs in each village type *j* multiplied by the total number of villages of each type *j*:

, (17)

where

*PVC* = present value of the cost of the CLTS intervention for the 200 villages in the hypothetical region in Sub-Saharan Africa,

*PV HH Cij* = present value of cost per household *i* in village type *j*, and *Nj* ,

The present value of the costs per household *i* in village type *j* is then:

, (18)

where

*Program* = total program (implementation) cost per village, including the management, training, facilitation, and the time costs of local actors required for a CLTS intervention, which is all incurred in year 0 of the intervention,

*Capitalij* = capital cost for latrine construction incurred by household *i* in village type *j, which* is all incurred in year 0 of the intervention,

*CLTS timeij* = cost of time spent by household *i* in CLTS activities in village type *j* , which is all incurred in year 0 of the intervention,

*O&Mijt* = operation and maintenance costs for household *i* in village type *j* in year *t* (a household must pay *O&M* as long as it continues to use a latrine).

The first three costs are one-time expenditures incurred in year 0 of the CLTS program. CLTS program costs in each village are calculated as:

, (19)

where *Management* includes non-infrastructure fixed costs, e.g., office supplies and transportation, as well as time costs for government and program managers. *Training* includes materials, accommodation, per diems, facilities, and time spent in training to capacitate facilitation staff. *Facilitation* includes the transportation, material, and time costs of actually planning and implementing CLTS pre-triggering, triggering, and follow-up sessions. Finally, *Local actor* costs are for the value of time spent by members of village committees on CLTS promotion and village-level monitoring.

In classical (“pure”) CLTS interventions households are responsible for building or purchasing a latrine with their own resources. Capital costs for latrines constructed by a household *i* in village type *j* are calculated as the sum of materials and time spent by a person assumed to be older than fifteen years of age:

, (20)

where *CAP* = capital cost of a latrine,

*CNST* = time in hours required for constructing a latrine,

*VOTk=3* = value of time for people fifteen or older.

The major CLTS activity is the triggering session. During triggering, which occurs in year 0, village residents are led through a number of exercises designed to engender community behavior change. The sessions take place when a facilitator or health official is able to schedule a meeting. Many residents may be busy and unable to attend. Additional follow-up meetings or monitoring activities may also occur. Time costsfor a household *i* in village type *j* are calculated as:

(21)

where *…*

*NATijk* = one if a person from age group *k* in household *i* and village type *j* participated in CLTS activities, and zero otherwise,

*TRGT* = time in hours spent in a triggering session in year 0, and

*CLTS* = time spent in hours in non-triggering CLTS meetings and activities in year 0.

This expression considers the number of people from each age group in a household in period t=0 who participate in the CLTS triggering and other activities, and the amount of time spent. This time is then multiplied by an age-specific value of time in period t = 0. As with the time benefits calculations, our analysis only includes the time costs for children older than five and for adults.

The final cost is for operation and maintenance. This includes the time and expense required for upkeep of a latrine. Households must regularly clean latrines and replace or repair parts of the latrine and its superstructure. Since these costs occur over the lifetime of the latrine, they are calculated on an annual basis and discounted appropriately. O&M costs per household in each village type are calculated as:

, (22)

where *OPEX* is the annual expenditure on operation and maintenance activities, which is assumed to be 10% of initial capital costs.

Appendix B: Parameter Value Assumptions

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | Base Case or function | Low | High | Source | Parameters | Base Case or function | Low | High | Source |
| Number of villages (N) | 200 |  |  | Authors’ assumption | Time cost (TC) | .5 | 0 | 1 | Authors’ assumption |
| Low-uptake villages (NL) | 80 | 120 | 66 | Authors’ assumption | Working hours lost for outpatient /not seeking care <5 (HLO<5/HLNC<5) | =4+8\*TC | 12 | 32 | Lamberti et al (2012a) and Lamberti et al (2012b) |
| Medium-uptake villages (NM) | 80 | 60 | 66 | Authors’ assumption | Working hours lost for inpatient <5 (HLI<5) | =8+8\*TC | 24 | 48 | Lamberti et al (2012a) and Lamberti et al (2012b) |
| High-uptake villages | =N- NL- NM | | | Authors’ assumption | Working hours lost for outpatient/not seeking care ≥5 (HLO≥5) | =8+16\*TC | 8 | 20 | Lamberti et al (2012a) and Lamberti et al (2012b) |
| Households per village | 100 |  |  | Crocker et al. (2016a) and Harris et al. (2017) | Working hours lost for inpatient ≥5 (HLI≥5/HLNC≥5) | =16+16\*TC | 16 | 32 | Lamberti et al (2012a) and Lamberti et al (2012b) |
| Average children <5 per household | 1 |  |  | DHS | Value of time (VOT) | .5 | 0 | 1 | Authors’ assumption |
| Average children 5-14 per household | 2 |  |  | DHS | Value of time spent caring for <5 % of wage (VOT<5) | =25%+.5\*VOT | 25% | 75% | Whittington and Cook (2018) |
| Average people ≥15 per household | 2 |  |  | DHS | Value of time % of wage for 5-14 (VOT5-14) | =.5\*VOT | 0% | 50% | Whittington and Cook (2018) |
| Baseline latrine coverage | 45% | 30% | 60% | DHS and CLTS studies | Value of time % of wage for ≥15 (VOT≥15) | =25%+.5\*VOT | 25% | 75% | Whittington and Cook (2018) |
| Increase in latrine for low-uptake | 5% | 0% | 10% | Authors’ assumption | % of Work day spent caring for sick child under 5 | 25% | 0% | 50% | Authors’ assumption |
| Increase in latrine for medium-uptake | 15% | 10% | 20% | Authors’ assumption | US VSL | $9,400,000 |  |  | Robinson et al. (2018) |
| Increase in latrine for high-uptake | 35% | 25% | 45% | Authors’ assumption | US GNI per Capita | $58,960 |  |  | World Bank (2018) |
| Diarrhea Incidence (DIA) | .5 | 0 | 1 | Authors’ assumption | Annual GNI per capita in intervention area | $2,000 | $1,500 | $2,500 | Based on World Bank (2016) GNI per capita |
| Diarrhea reduction for households adopting latrines (DR) | 20% | 10% | 30% | Wolf et al. (2018) and CLTS studies | VSL in intervention area | $60,380 | $39,215 | $84,385 | Calculated based on Robinson et al. (2018) |
| Maximum diarrhea reduction with externalities (DR-EX) | 35% | 25% | 45% | Authors’ assumption | GNI per capita growth | 2% | 0% | 4% | Author assumptions |
| Average diarrhea incidence <5 (DIA<5) | =2+.8\*DIA | 2 | 2.8 | 2016 Global Burden of Disease | Latrine abandonment | 10% | 5% | 15% | Authors’ assumption |
| Diarrheal incidence <5 w/o latrine (DIA<5L=0) | = DIA<5/((1-BLAT)+(1-DR)\*BLAT) | | | Authors’ assumption | Market wage per hour (2016 International Dollars) | 0.2 | 0.6 | 1.0 | United States Department of State (2017) |
| Diarrheal incidence <5 w/ latrine (DIA<5L=1) | = DIA<5L=0\*(1-DR) | | | Authors’ assumption | Discount rate | 3% | 0% | 12% | Authors’ assumption, Wilkinson et al. 2016, and Claxton et al. 2019 |
| Average diarrhea incidence 5-14  (DIA5-14) | =.4+.2\*DIA | .4 | .6 | 2016 Global Burden of Disease | Round trip time spent on open defecation | 8 | 4 | 12 | BDS-Center for Development Research (2016), Dickinson et al. (2015), Hickling and Hutton (2014). |
| Diarrheal incidence 5-14 without latrine (DIA5-14,L=0) | = DIA5-14/((1-BLAT)+(1-DR)\*BLAT) | | | Authors’ assumption | Round trips to defecate site per day | 1 | 1 | 2 | Whittington et al (2009). |
| Diarrheal incidence 5-14 with latrine (DIA5-14,L=1) | = DIA5-14,L=0\*(1-DR) | | | Authors’ assumption | Usage of new latrine in low-uptake villages | 60% | 50% | 65% | Barnard et al. (2013), Anteneh and Kumie. (2010), and Garn et al. (2017) |
| Average baseline diarrheal incidence ≥15 (DIA≥15) | =.9+.2\*DIA | .9 | 1.1 | 2016 Global Burden of Disease weighted by DHS data | Usage of new latrine in medium-uptake villages | 65% | 60% | 70% | Barnard et al. (2013), Anteneh and Kumie. (2010), and Garn et al. (2017) |
| Diarrheal incidence ≥15 without latrine (DIA≥15,L-0) | = DIA≥15/((1-BLAT)+(1-DR)\*BLAT) | | | Authors’ assumption | Usage of new latrine in high-uptake villages | 85% | 75% | 95% | Barnard et al. (2013), Anteneh and Kumie. (2010), and Garn et al. (2017) |
| Diarrheal incidence ≥15 with latrine (DIA≥15,L=1) | = DIA≥15,L=0\*(1-DR) | | | Authors’ assumption | Baseline latrine usage | 45% | 30% | 60% | Sinha et al. 2017, Crocker et al. 2016b, Anteneh and Kumie 2010, and Barnard 2013 |
| Case fatality rate (CFR) | .5 | 0 | 1 | Authors’ assumption | Management cost per village | $1,500 | $1,250 | $1,750 | Crocker et al. (2017b) derived from average |
| Diarrheal case fatality rate <5 (CFR<5) | =.05%+.04\*CFR | 0.05% | 0.09% | 2016 Global Disease Burden | Training cost per village | $700 | $400 | $1,000 | Crocker et al. (2017b) derived from average |
| Diarrheal case fatality rate 5-14 (CFR5-14) | =.01%+.02\*CFR | 0.01% | 0.03% | 2016 Global Disease Burden | Facilitation costs per village | $2,500 | $1,500 | 3,500 | Crocker et al. (2017b) derived from average |
| Diarrheal case fatality rate ≥15 (CFR ≥15) | =.02%+.03\*CFR | 0.02% | 0.05% | 2016 Global Burden of Disease weighted by DHS data | Local actor costs per household | $200 | $100 | $300 | Crocker et al. (2017b) derived from average |
| Percent seeking care (SEEK) | .5 | 0 | 1 | Authors’ assumption | Percent participation in CLTS in low-uptake village | 40% | | | Authors assumption |
| % of cases seeking care <5 (SEEK<5) | =.25%+.05\*SEEK | 25% | 75% | Range of number of cases for <5 seeking care from DHS and MIS | Percent participation in CLTS in medium-uptake village | 50% | | | Authors assumption |
| % of cases seeking care ≥5 (SEEK≥5) | =.03%+.06\*SEEK | 3% | 9% | Ratio of severe and moderate diarrhea in older 5/under 5 | Percent participation in CLTS in high-uptake villages | 60% | | | Authors assumption |
| % of cases seeking treatment receiving inpatient care (PIC) | .5 | 0 | 1 | Authors’ estimate | Triggering time per person | 4 | 3 | 6 | Crocker et al. (2017b) |
| % of cases seeking treatment receiving inpatient care <5 (PIC<5) | =.3%+.2\*PIC | 30% | 50% | Kotloff et al. (2013) | Follow up time per participating person | 20 | 15 | 25 | Crocker et al. (2017b) |
| % of cases seeking treatment receiving inpatient care ≥5 (PIC≥5) | =.02%+.8\*PIC | 2% | 10% | Lamberti et al (2012a) and Lamberti et al (2012b) | Planning horizon for the latrine | 10 | | | Meyer et al. (2018)/author assumption |
| % of cases seeking treatment receiving outpatient care <5 (POC<5) | =100-PIC<5 | | |  | Capital cost of a latrine | $50 | $35 | $65 | Cole et al. (2012) and Crocker et al. (2017b) |
| % of cases seeking treatment receiving outpatient care ≥5 (POC≥5) | =100- PIC≥5 | | |  | Operation and maintenance expenses for toilet (% of cost of toilet) | 10% | 5% | 15% | Author assumption |
| Health Costs (HC) | .5 | 0 | 1 | Authors’ assumption | Time constructing toilet (hours) | 30 | 25 | 35 | BDS-Center for Development Research 2016, Crocker et al. (2017) |
| HH cost per case seeking care (HHC) | =$2+HC\*4 | $2 | $6 | Rheingans et al. (2012) | Externality threshold | 60% | 75% | 80% | Wolf et al. 2015, Andres et al. 2014, and Jung et al. 2017 |
| Health system cost per outpatient case (COC) | =$5+.5\*10 | $5 | $15 | Aikins et al. (2010) and Sigei et al. (2015) |  |  |  |  |  |
| Health system cost per inpatient case (CIN) | =$100+.5\*200 | $100 | $300 | Ngabo et al. (2016), Aikins et al. (2010), and Sigei et al. (2015) |  |  |  |  |  |

DHS studies refer to the following studies: Agence Nationale de la Statistique et de la Démographie and ICF (2017), Central Statistical Agency and ICF (2016), Ghana Statistical Service, Ghana Health Service, and ICF (2017), Instituto Nacional de Estatística, Ministério da Saúde, Ministério do Planeamento e do Desenvolvimento Territorial, and ICF (2017), Ministère à la Présidence chargé de la Bonne Gouvernance et du Plan, Ministère de la Santé Publique et de la Lutte contre le Sida, Institut de Statistiques et d’Études Économiques du Burundi, and ICF (2017), Ministério da Saúde, Instituto Nacional de Estatística, and ICF (2015), Ministry of Health, Community Development, Gender, Elderly and Children, Ministry of Health, National Bureau of Statistics, Office of the Chief Government Statistician, and ICF (2016), National Institute of Statistics of Rwanda, Ministry of Health, and ICF International (2015), National Malaria Control Programme, Kenya National Bureau of Statistics, and ICF International (2016), National Malaria Elimination Programme, National Population Commission, National Bureau of Statistics, and ICF International (2016), National Statistical Office and ICF (2017), Programme National de Lutte contre le Paludisme , Institut National de la Statistique, INFO-STAT, Institut National de la Recherche en Santé Publique, and ICF International (2016), Uganda Bureau of Statistics & ICF (2018), and Zimbabwe National Statistics Agency and ICF International (2016).

Appendix C: Assumed Associations between Selected Parameters, for Monte Carlo Sensitivity Analysis

|  |  |
| --- | --- |
| Parameter Associated with **Baseline Diarrheal Incidence** | Size of the Association |
| Baseline latrine coverage | -0.5 |
| Baseline latrine usage | -0.5 |
| Case fatality rate | 0.5 |
| % of cases seeking care | 0.5 |
| % of cases seeking care receiving inpatient care | 0.5 |
| Working hours lost for inpatient treatment | 0.5 |
| Working hours lost for outpatient treatment/not seeking care | 0.5 |

|  |  |
| --- | --- |
| Parameter Associated with **Informal Wage Rate** | Size of the Association |
| Annual GNI per capita in intervention area | 0.7 |
| Healthcare costs | 0.5 |
| Training costs per village | 0.5 |
| Facilitation costs per village | 0.5 |
| Local actor costs per village | 0.5 |
| Value of time | 0.5 |

Appendix D: Summary of Results of Benefit-Cost Analysis Including Only Time Savings Benefits

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Low-Uptake Villages | Medium-Uptake Villages | High-Uptake Villages | All Villages |
| No Externalities |  |  |  |  |
| Benefits | $1,605 | $3,480 | $9,670 | $793,485 |
| Mortality Benefits | $0 | $0 | $0 | $0 |
| Morbidity Benefits | $0 | $0 | $0 | $0 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | ($4,000) | ($2,995) | $1,285 | ($508,500) |
| BC ratio | 0.3 | 0.5 | 1.2 | 0.7 |
| ERR | -19% | -10% | 6% | -8% |

\*We only include the results without an externality since there are no positive sanitation externalities if we assume no

health benefits.

Appendix E: Summary of BCA Results using Value of a Statistical Life Year (VSLY) to Value Mortality Benefits\*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Low-Uptake Villages | Medium-Uptake Villages | High-Uptake Villages | All Villages |
| No Externalities |  |  |  |  |
| Benefits | $4,170 | $11,185 | $27,655 | $2,335,215 |
| Mortality Benefits | $1,560 | $4,670 | $10,900 | $934,455 |
| Morbidity Benefits | $1,010 | $3,035 | $7,085 | $607,275 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | ($1,435) | $4,710 | $19,270 | $1,033,230 |
| BC ratio | 0.7 | 1.7 | 3.3 | 1.8 |
| ERR | -5% | 14% | 41% | 15% |
|  |  |  |  |  |
| Externalities |  |  |  |  |
| Benefits | $4,170 | $11,185 | $33,800 | $2,580,855 |
| Mortality Benefits | $1,560 | $4,670 | $14,570 | $1,081,145 |
| Morbidity Benefits | $1,010 | $3,035 | $9,560 | $706,225 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | ($1,435) | $4,710 | $25,415 | $1,278,870 |
| BC ratio | 0.7 | 1.7 | 4.0 | 2.0 |
| ERR | -5% | 14% | 56% | 19% |

**\***We assume the YLL equals Int’l $1,250 in the first year of the project and is based on our base case VSL (Int’l $58,960), but the VSLY grows each year along with income growth. We assume that the average expected life within the population is 47 year and that those under 5 have a life expectancy of 60 years, those who are between 5 and 14 have a life expectancy of 57.5 years, and those who are 15+ have a life expectancy of 33 years.

Appendix F: Summary of Benefit-Cost Results using a Value of Statistical Life (VSL) of 2016 Int’l $200,000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Low-Uptake Villages | Medium-Uptake Villages | High-Uptake Villages | All Villages |
| W/o Externalities |  |  |  |  |
| Benefits | $6,625 | $18,545 | $44,820 | $3,806,240 |
| Mortality Benefits | $4,010 | $12,025 | $28,065 | $2,405,480 |
| Morbidity Benefits | $1,010 | $3,035 | $7,085 | $607,275 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | $1,020 | $12,070 | $36,435 | $2,594,255 |
| BC ratio | 1.2 | 2.9 | 5.3 | 1.9 |
| ERR | 4% | 32% | 74% | 33% |
|  |  |  |  |  |
| With Externalities |  |  |  |  |
| Benefits | $6,625 | $18,545 | $59,470 | $5,357,815 |
| Mortality Benefits | $4,010 | $12,025 | $40,240 | $3,858,105 |
| Morbidity Benefits | $1,010 | $3,035 | $9,560 | $706,225 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | $1,020 | $12,070 | $51,085 | $4,055,830 |
| BC ratio | 1.2 | 2.9 | 7.1 | 4.1 |
| ERR | 4% | 32% | 108% | 41% |

**Appendix G:** Summary of Benefit-Cost Results using a Value of Statistical Life (VSL) of 2016 Int’l $320,000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Low-Uptake Villages | Medium-Uptake Villages | High-Uptake Villages | All Villages |
| No Externalities |  |  |  |  |
| Benefits | $9,430 | $26,960 | $64,445 | $5,488,705 |
| Mortality Benefits | $6,815 | $20,440 | $47,690 | $4,087,945 |
| Morbidity Benefits | $1,010 | $3,035 | $7,085 | $607,275 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | $3,825 | $20,485 | $56,060 | $4,186,720 |
| BC ratio | 1.7 | 4.2 | 7.7 | 4.2 |
| ERR | 11% | 49% | 104% | 41% |
|  |  |  |  |  |
| Externalities |  |  |  |  |
| Benefits | $9,430 | $26,960 | $83,610 | $6,255,130 |
| Mortality Benefits | $6,815 | $20,440 | $64,380 | $4,755,420 |
| Morbidity Benefits | $1,010 | $3,035 | $9,560 | $706,225 |
| Time Savings | $1,605 | $3,480 | $9,670 | $793,485 |
| Costs | $5,605 | $6,475 | $8,385 | $1,301,985 |
| Program Costs | $4,900 | $4,900 | $4,900 | $980,000 |
| Time Costs | $325 | $405 | $490 | $77,760 |
| Capital Costs | $280 | $835 | $1,945 | $166,875 |
| O&M Costs | $100 | $335 | $1,050 | $77,350 |
| Net Benefits | $3,825 | $20,485 | $75,225 | $4,953,145 |
| BC ratio | 1.7 | 4.2 | 10.0 | 24.8 |
| ERR | 11% | 49% | 155% | 49% |

1. This assumes that households in which members die from diarrhea also incur the full cost of illness. [↑](#footnote-ref-1)
2. We estimate the loss in productivity as the loss of income that an individual would have earned by working had they not gotten sick. [↑](#footnote-ref-2)