Cost of illness averted model spreadsheet

Introduction

This document describes a simple model for estimating the material cost of illness averted (COIA) by health-improving interventions.

In October of 2022, GiveWell includes the COIA as an adjustment in top charity cost-effectiveness analyses (CEAs)[1], but this value is not explicitly modeled. In the course of working on water chlorination, Evidence Action provided evidence that the COIA for chlorination may be substantial. We built an initial, unpublished model that confirmed this, justifying further work that ultimately resulted in this model.

For consistency's sake, if we are modeling the COIA caused by chlorination, we should also model it for other interventions that we would consider funding. And if we will be applying this model to all our CEAs, it should be as simple as possible. That is the rationale for the development of this model.

The simple model sacrifices accuracy for simplicity, and in some cases this sacrifice may be unacceptably large. This document provides guidance for finding the right balance between accuracy and simplicity when using the model.

The model

What it is

The simple COIA model consists of one figure: 0.43 units of value per disability-adjusted life year (DALY) averted. This figure is used to estimate the number of units of value the intervention generates from COIA.

The rationale for this figure is that DALYs capture the health burden of a disease[2], so we might expect the material cost of a condition to be proportional to its DALY burden. In validation analyses discussed in appendix A, this expectation is mostly, but not fully, supported.

There is also a full COIA model for malaria treatment that can be adapted to other interventions, if high-quality cost data are available and the additional uncertainty reduction seems worth the

[1] For example, see this adjustment in the AMF CEA.
[2] "**DALY** is an abbreviation for **disability-adjusted life year**. It is a universal metric that allows researchers and policymakers to compare very different populations and health conditions across time. DALYs equal the sum of years of life lost (YLLs) and years lived with disability (YLDs). One DALY equals one lost year of healthy life. DALYs allow us to estimate the total number of years lost due to specific causes and risk factors at the country, regional, and global levels." Institute for Health Metrics and Evaluation, "Frequently Asked Questions"

time. Systematic country-level cost data for malaria are available from the Institute for Health Metrics and Evaluation (IHME)[3], but we are not aware of such data for other conditions in low-income settings as of October 2022.

How to use the simple model

This is the basic process for using the simple COIA model:

1. Estimate the number of DALYs averted by the intervention. IHME data are useful for this.
2. Multiply the number of DALYs averted by 0.43 (the units of value generated per DALY averted). That yields the estimate of units of value from COIA.
3. Adjust the estimate if there are obvious reasons to do so. Guidelines for selecting an adjustment are described here.
4. Treat these units of value from COIA in the same way as other major benefits (e.g. units of value from mortality averted), incorporating them into a cost-effectiveness estimate before leverage/funging adjustments.

An example of this calculation is here.

When COIA per DALY differs from malaria

A key assumption underlying the simple model is that the material costs of malaria illness are similar to other health conditions, per DALY. This is a big assumption that will undoubtedly not always be satisfied, so the model builder needs to use a liberal amount of judgment in applying the model.

If there are obvious reasons to believe COIA per DALY of the modeled health condition differs substantially from malaria, the model builder can adjust the output of the simple model, as described below. Or, if high-quality data are available on the material cost of the modeled health condition and the uncertainty reduction seems worth the time, they can adapt the full COIA model.

Reasons why the cost of a condition per DALY may be substantially higher or lower than for malaria:

1. Treatment is cheaper or more expensive than malaria relative to its DALY burden. Routine malaria treatment is relatively cheap per DALY, but treatment is expensive for the subset of children who are hospitalized (typically 3-21% of cases, depending on age and location).[4]

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[3] See here.

[4] ● For example, a case of uncomplicated malaria costs a household in Ghana $5.70 (including both direct and indirect household costs), whereas a case of malaria hospitalization costs that household $48.73. For a comparison of malaria costs by severity in Ghana, Tanzania, and Kenya, see Sicuri et al. 2013, table 3.

2. The condition is not typically treated, either because a treatment does not exist or because it is not available, affordable, or commonly used locally.
3. The condition has a large impact on the income of the affected person, or caregivers, relative to its DALY burden. A case of malaria tends to cause 2-3 days of income loss,[5] and this appears to typically be the main driver of household costs of the condition.[6] Income loss per DALY could be very different for a condition that causes a lot of income-reducing morbidity relative to mortality.
4. The costs of the condition are heavily weighted toward medical system costs borne by governments and/or aid organizations, rather than household costs, or vice versa. The full malaria model estimates that household and medical system costs averted from preventing malaria are similar in USD, but medical system costs are valued more than twice as much as household costs per USD, so units of value are primarily driven by medical system costs averted.[7]

An example of a condition that might have lower COIA per DALY than malaria is drowning, because it is rapidly fatal and there is little opportunity for treatment. Another may be heart attacks in areas where treatment is not available.

Examples of conditions that might have higher COIA per DALY than malaria are chronic obstructive pulmonary disease and dementia, because they are chronic, high-morbidity conditions that have the potential to cause a lot of income loss in affected people and caregivers.[8]

In cases like these, there are obvious reasons to believe COIA per DALY may differ from malaria, so adjustments are appropriate.

Subjective adjustments to the simple model

Below is a semi-quantitative framework that can be used to adjust the COIA per DALY figure in cases where there are obvious reasons to believe it diverges from malaria. These are merely

- For the probability of being hospitalized for malaria by age group and geography, see Sicuri et al. 2013, table 1, "MO" column.

[5] “An average of about 3 days are lost by sick adult, about 2 days by the caretaker while on the average a sick student misses about 2 school days”. Salihu and Sanni 2013, abstract.

[6] "Most of household costs are made of indirect costs (85%) in Tanzania and in Kenya while this proportion falls to about half (46%) in Ghana." Sicuri et al. 2013, p. 6.

"Indirect costs included the carers’ reported productivity loss for the entire episode of malaria." Sicuri et al. 2013, p. 2.

[7] Compare rows 16 and 23 (the cost of illness averted per person for households and medical systems, respectively) to rows 45 and 54 (the units of value from household and medical system costs averted, respectively) in our full COIA model for malaria treatment.

[8] IHME's GBD Results Tool estimates that in low-SDI settings, morbidity (YLDs) from chronic obstructive pulmonary disease accounts for 25% of the total burden of the condition (DALYs) (1,689,133.62 YLDs / 6,718,241.51 DALYs = .2514 or ~25%). For dementia this figure is 24% (252,449.66 YLDs / 1,039,872.30 DALYs = .2428 or ~24%). For comparison, ischemic heart disease is a condition with less morbidity relative to mortality, and this figure is 2% (254,251.08 YLDs / 13,935,069.83 DALYs = .0182 or ~2%). IHME, GBD Results Tool, queried May 8, 2023.

suggestions and can be adapted or ignored if not applicable, for example, if their range is too narrow. Please keep in mind that the cost of an illness includes lost income from being ill or caring for someone who is ill.

Adjustment	Definition
0.33	The cost of a condition per DALY is probably much lower than malaria
0.5	The cost of a condition per DALY is probably lower than malaria
0.8	The cost of a condition per DALY is probably a little bit lower than malaria
1.25	The cost of a condition per DALY is probably a little bit higher than malaria
2	The cost of a condition per DALY is probably higher than malaria
3	The cost of a condition per DALY is probably much higher than malaria

Using the full COIA model

If the simple COIA model is not appropriate, the model builder can adapt the full COIA model to the intervention of interest.

The most time-consuming aspect of this process is likely to be finding reliable estimates of the household and medical system costs of the condition in question, and sense-checking them. Since we are not aware of systematic estimates of the material cost of common illnesses across low-income countries (as of October 2022), this will usually require significant desk research.

Make sure estimates of household costs include indirect costs from income loss, as we have found that these are not consistently included in the scientific literature.

How the models were created

We initially built full models for two malaria prevention interventions (bed nets and seasonal malaria chemoprevention (SMC)) and water chlorination.[9] This was to evaluate initial estimates suggesting that the COIA for chlorination interventions accounts for a substantial share of benefits, and to see how much COIA varies across interventions.

We found it difficult to consistently identify reliable estimates of the cost of illnesses that passed sense checks. We have the greatest confidence in our estimates for malaria because IHME publishes systematic country-level estimates of the medical system and household cost of

[9] The COIA model for chlorination is internal and unpublished. A sense-check during review suggested that the COIA it estimates is implausibly high. It has not been updated since then, and it is not being used in our cost-effectiveness analyses (CEAs). The latest version of the full malaria model is here.

malaria.[10] However, these do not include household indirect costs, which we believe account for the majority of household costs in most locations.[11] As of October 2022, IHME has not published systematic cost estimates for other diseases.

Once we had estimates of the medical system and household costs of malaria (and of enteric infections for our water chlorination model), we adapted our GiveDirectly CEA to estimate the value of household COIA, and used a standard GiveWell figure for the value of government spending to estimate the value of medical system COIA.

The full models are too complex for routine use in modeling, so we sought a way to simplify the modeling process. We found that units of value per DALY, calibrated using the full model for Against Malaria Foundation (AMF), captures much of the variation between malaria prevention interventions, but it is less reliable for capturing variation between locations within a single malaria prevention intervention. The simple model trades accuracy for simplicity. Validation of the model is described in appendix A.

We chose to use the average units of value per DALY for AMF to calibrate the simple model because 1) it is based on systematic IHME cost estimates for malaria, which we have greater confidence in than piecemeal academic sources for enteric infections, and 2) the AMF COIA model is a bit simpler than the Malaria Consortium (MC) COIA model and requires fewer assumptions.[12]

Model assumptions and uncertainties

Both COIA models rely on multiple uncertain assumptions and inputs, and therefore generate uncertain outputs. Outputs of the simple model are more uncertain than those of the full model because they require a larger number of uncertain assumptions.

Below are major assumptions and uncertainties of the full model. This list is not intended to be exhaustive, but rather to highlight what we view as the most important drivers of uncertainty in the model.

- We assume that COIA per DALY averted figures for current AMF locations are generally representative of locations with a high burden of malaria.
- We rely on IHME estimates of the medical system and household costs of malaria. We have not deeply investigated the methodology of these estimates so we have some uncertainty about their accuracy.

[10] See IHME, Global malaria spending, 2000-2017.
[11] We estimate these separately in the model. "Household and health system costs per malaria episode ranged from approximately US$ 5 for non-complicated malaria in Tanzania to US$ 288 for cerebral malaria with neurological sequelae in Kenya. On average, up to 55% of these costs in Ghana and Tanzania and 70% in Kenya were assumed by the household, and of these costs 46% in Ghana and 85% in Tanzania and Kenya were indirect costs." Sicuri et al. 2013, abstract.
[12] See the additional adjustments applied in our Malaria Consortium COIA model here.

- We rely on estimates of indirect costs as a percentage of the total household cost of malaria from Sicuri et al. 2013. These estimates come from three countries: Ghana, Tanzania, and Kenya. Although the figures vary substantially between countries in this study (46-85%),[13] we average them together and apply that average to all countries in our model because we do not have direct estimates of indirect household costs for most AMF/MC countries. This average suggests that 72% of household costs are indirect, which we assume comes mostly from lost wages. This method ignores potentially significant differences between countries.
- For the Malaria Consortium model, we assume that the cost of malaria in children under 5 is proportional to their higher malaria DALY burden relative to the population as a whole. This is a crude assumption, but IHME does not provide estimates of the cost of malaria in under-5s.[14]
- The model assumes the AMF and MC CEAs' multiplier for non-malaria illness averted, which is very uncertain.
- When estimating consumption, the model adjusts World Bank consumption survey figures for inflation but not for income gains over time. Since the survey data are from different years depending on location (2012-2019)[15], and some locations have experienced substantial income gains,[16] this introduces uncertainty.
- The model assumes that all medical system costs averted are valued at our standard rate for government spending. In reality much of this cost is borne by aid organizations. To the extent that this spending has a different value vs. government spending, this adds uncertainty to the model's estimates.

In addition to the assumptions and uncertainties above, the simple model has these assumptions and uncertainties:

- The simple model assumes that COIA per DALY is the same across conditions and contexts, and that malaria is representative of other health conditions. This is a very big assumption that we believe will sometimes be grossly violated, and we provide guidance above on how to deal with this. The simple model papers over several potential sources of variability in COIA per DALY.

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[13] "Household and health system costs per malaria episode ranged from approximately US$ 5 for non-complicated malaria in Tanzania to US$ 288 for cerebral malaria with neurological sequelae in Kenya. On average, up to 55% of these costs in Ghana and Tanzania and 70% in Kenya were assumed by the household, and of these costs 46% in Ghana and 85% in Tanzania and Kenya were indirect costs." Sicuri et al. 2013, abstract.

[14] The IHME data on the cost of malaria are reported as cost per capita, rather than being broken down by age group. See the "Cost estimates from IHME" tab of our COIA model for malaria.

[15] See cell notes in this row.

[16] For example, between 2000 and 2021 (the most recent estimate as of May 9, 2023), the World Bank estimates that in constant US dollars, GDP per capita increased 3.7-fold in Nigeria. The World Bank, "GDP per capita (current US$) - Nigeria"

GDP per capita in 2000: $565.3
GDP per capita in 2021: $2065.7

$2065.7 / $565.3 = 3.65

- Variation in the cost of treatment, per DALY, across contexts.
- Variation in the share of costs that are borne by households vs. the medical system across contexts.
- Variation in median consumption across contexts.
- Variation in household income lost, per DALY, across conditions.

Appendix A: Validation of the simple model

The performance of the simple model has been tested in several ways. Overall, we think the model's performance is adequate for its intended use, but it trades off accuracy for simplicity. Substantial inaccuracy can occur both at the level of interventions and at the level of locations within an intervention, and we recommend using judgment in applying the model.

To test the simple model's ability to model COIA for malaria interventions, we compared units of value outputs for the full vs. simple models for AMF and MC. The simple:full ratio of units of value for AMF is 1.04, and for MC it is 1.08. AMF is a "within-sample" estimate so the model's good performance is not very informative, but the model's good performance for MC is more informative.

To test the simple model's ability to model COIA across locations within malaria interventions, we used scatterplots to compare units of value outputs for the full vs. simple models for AMF and MC.

- For AMF and MC together, the full and simple models correlate with a R^2 value of 0.41.
- For AMF alone, the full and simple models correlate with a R^2 value of 0.05.
- For MC alone, the full and simple models correlate with a R^2 value of 0.63.

This suggests that the model's ability to capture between-location variability in COIA per DALY is more limited and not reliable.

We also tested the model's performance for modeling COIA for chlorination.[17] The results are less informative because the full chlorination model did not pass a sense check during review, suggesting that its estimates are implausibly high. However, the simple model returned intervention-level COIA estimates of 50-68% of the full chlorination model, which is reassuring since we believe the latter is an overestimate.

Scatterplots indicated that the simple model does a decent job of modeling differences across locations, with R^2 values of 0.41-0.69.

We also tested the model for intermittent preventive treatment for malaria in schoolchildren (IPTsc), another intervention we were evaluating. Superficially, the simple model performs fairly well, but the strong correlation between the simple and full models across locations is driven in

[17] The COIA model for chlorination is unpublished and has not undergone our formal vetting process.

large part by wide variation in the cost of treatment per beneficiary. Standardizing cost per beneficiary across locations reveals poorer performance, with the simple model underestimating benefits by about half relative to the full model, and large variability across locations.[18]

This is an example of a situation in which the simple model fails to fully capture local context that impacts the COIA.

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[18] The COIA models for IPTsc are unpublished models that have not undergone our formal vetting process.