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LEEP cost-effectiveness analysis: Malawi

EXECUTIVE SUMMARY

In late 2020, LEEP conducted a paint study in Malawi and shared the results with the Bureau of Standards in Malawi, who then committed to begin implementing lead paint regulations. This document describes our cost-effectiveness analysis (CEA) of this program.

In order to estimate the benefits of averting childhood lead paint exposure in Malawi, we estimate the number of children newly exposed to lead paint each year in two scenarios:

- **Counterfactual regulation scenario: regulation implemented after nine years.** We are not sure how long it otherwise would have taken for someone to test the paint and bring it to the attention of the government. This estimate is based on the fact that the Bureau of Standards reported that it was not known that lead was present in paint in Malawi, and – to our knowledge – no other actors were working on this problem in Malawi.
- **LEEP program scenario: regulation implemented after one year.** The Director of Testing at the Malawi Bureau of Standards confirmed in month seven they have begun monitoring activities and that this action was taken as a result of our paint study and their interaction with LEEP.

We estimate our impact by considering the difference between the counterfactual and LEEP scenarios.

We include two main benefits in our model:

- **Effects on health:** using estimates from the Global Burden of Disease Study 2019 of all health effects, in units of disability-adjusted life years (DALYs). One DALY averted represents one extra healthy year of life.
- **Effects on income:** using data and modelling results from Attina and Trasande (2013) of the economic costs due to lead exposure in low- and middle-income countries. We estimate the number of years of income in Malawi this represents, and convert to DALY-equivalents using an assumption about the 'moral weight' of a year of health vs a doubling of income.

We then adjust both benefit estimates to account for the proportion of lead exposure *that is due to lead paint*, which we estimate to be 20% (with a 90% confidence interval of 4-60%).

We define costs as the monetary costs that LEEP's program incurs for both LEEP ($80,000 per year for 5 years) and the Malawi government ($75,000 per year for eight years). We discount government spending that is redirected to lead paint regulation by 50% because we expect it would otherwise be spent on less cost-effective activities.

Overall, **we estimate that LEEP's program in Malawi will avert one disability-adjusted life year (DALY) for $14 (90% confidence interval: 6-47 $/DALY-averted)** - see Table 1.[1] It is important to interpret this result cautiously, because it relies on various model assumptions, including predictions of the future and the counterfactual. See the "Where our CEA could go wrong" section for discussion of the key uncertainties.

The result is most sensitive to the proportion of lead exposure caused by lead paint and there is very little data related to this input. According to our model, if 5% of childhood lead poisoning in Malawi were due to lead paint rather than 20%, the cost per DALY-equivalent averted would increase from $14 to $48. If the proportion of lead exposure due to paint were 35% in Malawi, the cost per DALY-equivalent averted would decrease to $7.

Scenario	Cost per DALY-equivalent averted ($)		
	Median	Mean	90% Confidence Interval
Point estimate	11		NA
Uncertainty distributions	14	18	6 - 47

Table 1: Results of the cost-effectiveness model. We construct two models (called 'Scenarios') - one provides a point estimate, and the other runs Monte Carlo simulations to estimate the uncertainty in the results. We use the median result of the Monte Carlo simulations as our main result.

INTRODUCTION

LEEP advocates for lead paint regulation in countries with large and growing burdens of lead poisoning from paint. Our first country of choice was Malawi. After testing all main brands of paint on the market, we demonstrated that local paint contained high levels of lead and did not comply with existing lead paint standards. We presented this data to the Malawi Bureau of Standards, who stated that it was a "wake-up call" and committed to immediately begin implementing their existing paint standards through regular monitoring and enforcement. We were informed that the regulations had not previously been implemented because it was not known that paint in Malawi contained lead. We are currently supporting the local lead paint manufacturers to make the changes necessary to comply with regulation.

[1] In our previous model from April 2021 (see here, here and here), we reported a mean cost-effectiveness of $12/DALY-equivalent. The only major update we have made to the model is the value of GDP per capita in Malawi (from $1104 PPP to $1589 PPP), which was changed by the World Bank.

This document provides an overview of our cost-effectiveness analysis (CEA). We describe the model variables and explain key uncertainties. To view the full model, including in spreadsheet format, please open the CEA and create your own copy. Use the “scenario” tab to view the two versions of the model (one with point estimates and one with uncertainty distributions).

MODEL INPUTS AND ASSUMPTIONS

Percentage of homes painted with unregulated paint

We define unregulated paint as paint that is manufactured without proper regulatory oversight and that is therefore likely to contain substantial amounts of lead. As the proportion of paint that is regulated grows, we expect the amount of lead in paint to fall proportionally.

The starting assumption is that the current percentage of homes painted is equivalent to the percentage of the population that lives in urban areas. This is because currently in Malawi homes in urban areas are predominantly painted, whereas homes in rural areas are unpainted. All homes that are currently painted are painted with unregulated paint, as regulation had not been implemented at the time of painting.

Before regulation is implemented the percentage of homes painted with unregulated paint is assumed to grow in proportion to the growth in the paint market, minus population growth. This assumes that house size and the number of people per house remain the same. Growth in the paint market in southern Africa is estimated to be roughly 5%, which also corresponds to the growth rate of the urban population of 4.4%. We assume that this growth rate in the paint market will continue for 20 years, then decrease over time to approximately correspond to population growth.

Once regulation is implemented and compliance to regulation begins to increase, newly painted homes and repainted homes will be painted with regulated paint and so the percentage of all homes painted with unregulated paint will fall. The change in the percentage of homes painted with unregulated paint takes into account the growth in the paint market, compliance to regulation, population growth, and replacement or repainting of homes. The frequency of replacement or repainting of homes is assumed to be 2% per year – in other words, we assume that the average home is repainted or replaced once every 50 years.

Children newly exposed to lead due to paint

The number of children with lead poisoning in Malawi (blood lead level over 5 µg/dL) is estimated by the Institute of Health Metrics and Evaluation to be 3.4 million. We estimate that the number of children newly exposed to lead in the first year is equivalent to the average number of children with lead poisoning in a one-year age cohort (3.4 million divided by 18 years). This assumes that newly exposed children develop lead poisoning that lasts their entire childhood. It could also be the case that many more children are exposed per year but have lead poisoning for a shorter time period. This assumption does not impact cost-effectiveness, but does mean that our estimate for the number of children with lead poisoning averted is conservative. In other words, it's likely that a greater number of children have smaller degrees of lead poisoning averted.

We adjust down the number of children newly exposed to lead each year for the proportion of lead exposure that is estimated to be due to lead paint. Over time the number of children newly exposed to lead paint each year changes in proportion to population growth and the percentage of homes painted with unregulated paint.

Health effects

The health effects of lead exposure are estimated in the Global Burden of Disease Study 2019. The study estimates the impact in disability-adjusted life years (DALYs) on a range of health outcomes, including intellectual disabilities, cardiovascular diseases, and kidney diseases. We then adjust the estimate to account for the proportion of lead exposure that is due to lead paint, which we assume to be 20% (see "Proportion of lead exposure that is due to lead paint" subsection). The estimated DALYs due to these health effects that occur each year is proportionate to the number of children newly exposed to lead paint.

Income effects

The income effects of lead exposure in low- and middle-income countries are estimated by Attina and Trasande (2013). We raise the estimate in line with inflation. As with the health effects, it is also adjusted down to account for the proportion of lead exposure due to lead paint. We apply a 50% discount to the income loss estimate. This is because the estimates in Attina and Trasande assume that a unit increase in IQ is associated with a 2% increase in earnings. We use a more conservative estimate of 1% in our model, which is also consistent with GiveWell.

Estimates for additional economic costs, such as healthcare and crime costs estimated by Gould (2009), were not included because of uncertainty about how these would apply in the Malawi context.

Moral weights

We convert the income effects into DALY-equivalents using moral weights. They are estimated based on GiveWell's and IDinsight's previous research on how people make trade-offs between income and health. In its CEA model for Fortify Health, GiveWell assumes that 2.8 years of income is equivalent to one DALY. We use this assumption in our analysis.

Time discount

We discount future costs and benefits at a rate of 4% per year, in line with GiveWell. There is debate over the appropriate discount rate. Haacker, Hallett, and Atun 2020 found that 85% of 188 global health CEAs used a discount of 3% for both health and costs.

Years until benefits will be felt

We estimate that on average benefits to health and income will be felt 20 years in the future from the time childhood lead exposure is averted, taking into account that some of the benefits will be felt sooner and others later. For example, the intellectual disability benefits will be felt sooner after the regulation but the earnings impact will be felt some time later once the non-exposed children reach working age.

Proportion of lead exposure that is due to lead paint

Only a proportion of lead exposure is due to lead paint. Historically the most common source has been leaded gasoline, but this has been successfully phased out across the world. In the US, after the elimination of lead in gasoline, lead paint has been estimated to be the source of 70% of childhood lead exposure. Generally, experts indicate that lead paint is an important current and future source of exposure in low- and middle-income countries, particularly those still using lead paint. We could not find evidence for the proportion of lead exposure that is due to paint in low- and middle-income countries, and therefore discount the 70% US estimate substantially to an estimate of 20% in Malawi. This is a major area of uncertainty. We are currently developing another method to estimate the impact of lead paint in homes on children's blood lead levels. We will update this section once this research is complete.

Years taken to implement regulation with LEEP program

The Malawi Bureau of Standards confirmed in January (month four) that they would immediately implement existing regulation, which had not been implemented due to the perception that there was no lead in paint. In April (month seven) the Bureau confirmed that they would be going ahead with implementation and paint samples would be collected to monitor for compliance.

Years regulation brought forward

Malawi already had lead regulation within existing mandatory paint standards, but it had never been implemented. This was reported to be because it was not known that lead was present in paint in Malawi. Before our paint study, discussions with the Bureau of Standards indicated that action would not be taken towards reducing lead in paint without evidence that it was a problem. Once we presented our study showing high levels of lead in paint, the Bureau of Standards confirmed that they would implement the regulation with monitoring and enforcement as a result of the new data. It seems likely that the regulation would not have been implemented until a study like this was carried out and evidence was presented showing lead in paint. Eight years is an uncertain estimate for the number of years by which regulation was brought forward by LEEP's program.

Compliance once regulation is implemented

Once regulation is implemented compliance is assumed to be 25% in year one, 50% in year two, then increase to reach 100% in year 15. In Malawi we expect this level of compliance to be achievable in part because the Bureau of Standards has testing facilities and capacity for enforcement. As well as this, there are only four local manufacturers and two imported brands of paint to monitor. In India regulations were introduced in 2019 and by 2020 compliance was 80% according to Charity Entrepreneurship's interview with Toxics Link.

We expect LEEP's paint industry outreach to increase the likelihood of compliance. LEEP has been in contact with the four local manufacturers that produce all of the lead paint identified in our paint study. We offered to provide technical and practical advice to support their switch to lead-free, and they have engaged with us positively. All of the local lead paint manufacturers expressed willingness to switch to lead-free if alternative ingredients are locally available at a reasonable price. Based on analysis of the results of our paint study, lead-free ingredients are already being used locally in certain paints. This suggests that they are locally available and in a comparable price range. We are collating the details of these lead-free alternative ingredients and their suppliers to provide a list to paint manufacturers. We will continue to engage manufacturers to support their switch and also follow up with a repeat paint study to quantify compliance.

Population of Malawi

The population and future population of Malawi is estimated by UN population projections.

GDP per capita of Malawi

The GDP per capita of Malawi and its growth rate are estimated by the World Bank. The growth rate is assumed to continue for the time frame of the model. This assumption does not impact cost-effectiveness in the model.

Probability of regulation implementation with LEEP program

We estimate this probability to be high (80%), because in January the Director of Testing at the Malawi Bureau of Standards confirmed verbally and in writing that the Bureau would begin enforcing lead paint regulation immediately due to the findings of our paint study, and has since confirmed that enforcement had begun. The Bureau continues to engage in communication with us regarding our outreach to the paint industry to support the switch to lead-free. They have also encouraged us to repeat our paint study in a few months to compare our market samples to their internal monitoring. Altogether this suggests that regulation is being implemented through the Bureau of Standards' monitoring and enforcement.

Time frame

We include the health and income effects brought about by the program over a 20-year time frame starting from when regulation is implemented. See Outputs section in the mode. This is probably conservative, given the long-lasting impact of lead paint in homes.

Annual charity costs

LEEP's annual charity costs are estimated based on our budget for year one, and are approximately the fixed costs of continuing to run the organisation without scale-up. This is a conservative estimate because the year one budget also covers activity in two to three other countries, and in future years a lower proportion of this budget will be required for ongoing activities in Malawi. We do not account for the counterfactual impact of funding and personnel time in LEEP's costs.

Charity years operating in Malawi

The annual charity costs are assumed to continue for four years after implementation of regulation, as we expect to continue operating in Malawi to support the paint industry's switch to lead-free and to support monitoring and enforcement if needed.

Annual government costs

Our estimate for annual government costs is relatively low because the Malawi Bureau of Standards has existing capacity, including testing facilities, paint sampling audits, and a certification scheme for paints. In addition, the paint industry currently consists only of four local paint manufacturers and two imported paint brands, reducing costs of monitoring and enforcement. Costs are expected to consist only of additional staff time to follow monitoring and enforcement processes. We assume that our program is only responsible for the costs that occur in the years that regulation is brought forward. We also assume that the government costs will begin immediately.

Discount to government costs

We discount government spending that is redirected to lead paint regulation because we expect it would otherwise be spent on less cost-effective activities, making it less counterfactually valuable. Our approach is to discount government costs by 50%. This is an approach that GiveWell has used in the past, for example in its CEA of pesticide regulation.

WHERE OUR CEA COULD GO WRONG

- The estimated benefits rely on an estimate for the proportion of lead exposure that is from paint in Malawi. As discussed above, this estimate is very uncertain. According to our model, if 5% of childhood lead poisoning in Malawi were due to lead paint rather than 20%, the cost per DALY-equivalent averted would increase from $14 to $48. If the proportion of lead exposure due to paint were 35% in Malawi, the cost per DALY-equivalent averted would decrease to $7.

- The estimated benefits rely on uncertain estimates of the growth of the paint market, which influence the rate at which the proportion of homes painted with unregulated paint decreases after regulation implementation. We are uncertain about these estimates, which are based on several sources on the paint market in Africa. This may not be an accurate estimate for the growth rate in the relevant part of the paint market, which is solvent-based paints in Malawi. Solvent-based paints can contain lead, whereas water-based paints typically do not. In the Middle East and Africa solvent-based paints are currently estimated to take up 60% of the market share. We would expect this to decrease over time, perhaps to become more similar to Europe and North America, where solvent-based paints take up 20-30% of market share. We have not accounted for this in our model because it is not clear that this change would take place within the relevant time frame, and even in countries with predominantly water-based paint markets, solvent based-paints are still used in homes on windows and doors due to higher durability. Paint on windows and doors is thought to be a significant contributor to lead dust and flakes due to mechanical wear.

- Our impact relies on a very uncertain estimate for the number of years that regulation implementation is brought forward due to LEEP's activity. In our analysis we assume that lead paint regulation would have been implemented and enforced eight years later if LEEP had not been active. This is a guess. If it would have been implemented four years later without LEEP, cost-effectiveness would be $21 per DALY-equivalent averted, and if it would have been implemented 12 years later, cost-effectiveness would be $12 per DALY-equivalent averted.

- Compliance with regulation is another uncertain estimate that influences the rate at which the proportion of homes painted with unregulated paint decreases after regulation implementation. If monitoring and enforcement by the Bureau of Standards is ineffective and/or if our industry outreach and support for switching to lead-free is insufficient, compliance may be slower to increase than expected. In our model compliance is 25% in the first year, 50% in the second year, then increases by four percentage points per year. If compliance is 25% for the first two years, then increases by four percentage points per year thereafter, the cost per DALY-equivalent averted is $17 rather than $14.

- The future earnings benefits, which make up the majority of the benefits of this program, rely on an estimate from one key study (Attina and Trasande 2013). This estimate is widely cited, and estimates of benefits in high-income countries are similarly large (Gould 2009, Grosse 2002, Salkever 1995). It would be ideal to have multiple estimates for the effect in low-income countries given how reliant the program is on this single study. To account for uncertainty we have discounted the impact estimate used in the Attina and Trasande study by 50%. The study assumes that a unit increase in IQ is associated with a 2% increase in earnings, while we assume a 1% increase in earnings. If we were to discount the impacts cited in the study further to 25%, estimated cost-effectiveness would be $23 per DALY-equivalent averted.

- We assume a discount rate of 4% per year for future costs and benefits. Given the 20-year timeframe of this model, this is an important factor (a value of 1 in year 1 discounted by 4% per year would be 0.46 in year 20). If we were to use a discount rate of 3%, the median cost-effectiveness would be $10/DALY-equivalent; for 5% it would be $15/DALY-equivalent.

- In our model, we do not account for the counterfactual impact of personnel time and funding. Interpreting the CEA estimates directly may overestimate the benefits, because we do not account for the fact that some of the resources would have gone to high-impact programs otherwise.

We only model the impact of LEEP working towards lead paint regulation in Malawi. The cost-effectiveness estimate may not be cross-applicable to our other countries of choice.