A critique of GiveWell's CEA model for Conditional Cash Transfers for vaccination in Nigeria (New Incentives)

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This is a submission to GiveWell's competition to appraise their cost-effectiveness models. We have chosen to review the model around Conditional Cash Transfers for vaccination.

Modelling approach

Our first critique is the core modelling approach taken for this cost-effectiveness model. We understand the model developed by GiveWell to be a static model; the gold standard of models for vaccination cost effectiveness are dynamic models (1). Models such as Susceptible-Infected-Recovered (SIR) models may be especially suited. However, we understand from the literature that it is not straightforward to estimate the extent to which these types of models provide differing estimates to static models.

A UK based review of cost-effectiveness methodologies for vaccination recommended: "5.1 *Cost-effectiveness analyses ought to consider systematically whether there are important non-linearities in costs, effectiveness and cost-effectiveness with uptake/output due to factors such as, diminishing returns to finding unvaccinated people, and herd immunity, which need to be quantified*" (2). WHO guidance also highlights that CEAs for vaccination programmes should consider incorporating herd immunity (*correction, see note) (3), discussed further below. GiveWell have chosen a static modelling methodology; the fact that other modelling approaches are complex is not a reason to discount them.

Nymark et al conducted a review of modelling approaches to include herd immunity (4). They found that static models often deployed a flow, cohort or Markov approach. If GiveWell do not wish to develop a dynamic model, we recommend that GiveWell review best practices in static modelling approaches to vaccination to assess whether there is room for improvement in their modelling approach.

The nonlinearities raised above present a counter to GiveWell's simple use of a % increase in vaccination. This % increase cannot be assumed to hold for the whole population – it is likely that there are some people who are more likely to take up the CCT who will come forward sooner. Once they have taken up the CCT, future investment in CCTs will likely yield diminishing returns in terms of coverage rates. A better modelling approach would allow for different individuals to have different likelihood of taking up the CCT.

We understand the rationale for measuring a pure percentage increase in vaccination coverage, we also question its applicability in the context of a health effectiveness model. We note that this was raised in a peer review of the model, with the response being given that the model aims to estimate current cost-effectiveness. However, it would arguably be preferable to develop a model that can estimate cost-effectiveness depending on changing conditions. This might require other measures of effect size that reflect the likelihood of individuals to take up the cash transfer.

Herd Immunity

In a systematic review of immunisation cost-effectiveness analyses in Low and Middle Income Countries, Ma et al found that after excluding those results that became cost-saving with herd immunity (1), the inclusion of herd immunity reduced the Incremental Cost Effectiveness Ratio by 28% on average for QALY based studies or 61% on average for DALY based studies (1). The exclusion of the cost-saving results suggests that the real effect is likely higher than 28%. Another review demonstrating the significant impact of herd immunity on cost effectiveness was conducted by Holubar et al (5). While the findings are less immediately applicable within GiveWell's CEA model, they found that herd immunity had a significant impact on cost effectiveness.

We note that GiveWell have given an estimate of 25% for herd immunity effects. However, the scoring system used to weight this is in our view inappropriate for multiple reasons.

- First, mixed evidence would actually require some form of scenario modelling to assess a range of likely scenarios. Modelling of uncertainty is an issue that we will raise with the model in general.
- Second, GiveWell have chosen a static modelling methodology; the fact that other modelling approaches are complex is not a reason to discount the effect chosen.
- Third, consistency with other models should not be a reason to downgrade this effect size – if a consideration is relevant, it should be modelled in the best way feasible. We would also suggest that the criteria on consistency are inadequate – herd immunity is infinitely more relevant in vaccination than in other topics (as it is completely irrelevant in other models).
- We fail to see why these factors cannot be weighted at 100. It seems to be a fundamental question of modelling methodology, why such important variables would be included but weighted down. It seems at first glance that this approach is inconsistent with standard techniques used within the field of health economics.

We argue that the most appropriate solution for GiveWell, in the absence of developing a dynamic model to appropriately account for herd immunity, is to

- use the appropriate effect size from the review by Ma et al (1) - while this is an effect size for QALY based studies rather than those looking at costs per life saved, the range of effects including cost saving and the higher estimate for DALYs show the wide range of potential impacts, and this figure is arguably better than a simple 25% estimate
- not weight this effect size down.

Even if the weight approach was to be used, we would score:

- 3 on objective justification (as there is evidence from Ma et al) (1),
- 3 on methodology (according to Ma et al, static models might generally model herd immunity using a simple effect size) (1), and
- 2-3 on consistency depending on whether our critique of the criteria above is taken into account.

This would suggest a final effect size of at least (0.8 or 0.9) * (28 or 61) – in the lowest case scenario this would be 22.4%, nearly 10% more than the effect size applied by GiveWell. To note, this calculation excludes those cost-effectiveness analyses that became cost saving after herd immunity effects, so the real effect is again likely to be higher.

Our assessment is that even if the core modelling strategy is unchanged but the latest evidence in the field is taken into account, this is sufficient to affect GiveWell's estimates of cost-effectiveness by well over 10%. However, this crucially depends on reaching herd immunity, so presenting two realistic scenarios (one where herd immunity is reached and one where it is not); along with clear assessment of investment required and other critical conditions to reach herd immunity would appear to be the best way to proceed. Nymark et al, for example, suggest that static models are only considered reliable if high quality surveillance data are included (4).

In addition, while GiveWell asserts in its model that "some communities New Incentives serves may be close to herd immunity threshold". This is not immediately obvious from the data used in the model which includes IHME data around coverage at 16% or less, and less than 60% in the spreadsheet around costs.

Inflation

There is evidence that CCTs show significant elasticity, with one study in Nigeria showing the OR of receiving a vaccine increasing from 3.4 to 7.6 (significant at 95% CI) when the value of the CCT increased by a factor of 2.6 (6). With inflation in Nigeria currently at 21% and accelerating upwards (7) and bearing in mind the elasticity of CCTs, the effects of inflation are deeply relevant for this CEA in order for the assumptions of effectiveness underpinning the model to hold true. A review on how cash transfer programmes in high inflation contexts have been adapted demonstrated that most programmes prioritised ensuring the cash transfer value rose in line with inflation (8) to maintain the integrity of the intervention.

Beyond the value of the CCT, inflation will affect all elements of the programme and thus it is not unreasonable to apply an intervention-level adjustment. We note that GiveWell applied a USD intervention-level adjustment for inflation at 10% in the original model. However it appears that this was then not taken into account in the model, for reasons that are not immediately clear to us. Indeed, as the actual the inflation rate is higher than 10%, even if it is applied, this will drastically underestimate the adjusted cost related to nontradable resources such as CCTs. Additionally it fails to take into account the likely reduction in effectiveness of the intervention if the CCT value is losing purchasing power due to inflation.

At a minimum, the CEA should be updated to count the effects of inflation which are particularly pertinent in this situation. Using the cost-effectiveness model, the baseline cost/life saved is $4601. If inflation at the original adjustment of 10% is included, there is an increase in cost/life saved to $4828. However, if we use a conservative adjustment of 20% inflation to reflect current figures, the cost/life saved increases to $5079. However, we would argue that in this context the scoring applied to the intervention-level adjustments should also be adjusted as following.

In this instance, we would score

- 3 on objective justification: there is direct evidence of the current inflation rate, and evidence from various studies including the Sato & Fintan study (6) used by GiveWell which can be used to assess the elasticity of CCT uptake to the size of cash transfer
- 3 on ease of modelling (in that the addition of elasticity factors would require some additional modelling but this does not appear beyond the reach of GiveWell), and
- 2 or 3 on consistency (in that it is more relevant to cash transfers than other interventions)

If the scoring changed as per above, the cost/life saved increases to $5418, an increase of 18% from the original CEA.

Beyond the effects of inflation, we also acknowledge that determining the optimum value of the CCT is complex, with values that are too low failing to provide sufficient incentive but values that are too high risking distortionary effects (9). Although there is significant transparency around what values of cash transfer, it was not evident to us what methodology had been used to arrive at these values for the purpose of the RCT. Given the elasticity of CCTs the value used can have significant effects on the impact of the programme. Therefore a suggestion would be greater attention on how different values could potentially affect impact of the intervention, and the resulting cost-effectiveness. Ideally this would be modelled to demonstrate the optimum value of CCT and how this was arrived at, however simple models showing CEA at different CCT values could be used if there was evidence of different effect sizes at different CCT values.

Finally we acknowledge that inflation does not affect all elements of the programme equally. Inflationary pressures will affect all programmes as costs increase, however many of these costs can be contained or predicted at the procurement and planning stage as they involve 'tradable resources' that are globally purchased and priced. Additionally inflation rates may differ between local currencies and USD. To capture this and arrive at a more accurate CEA we proposed a mixed approach where the costs are stratified into 'tradable' (eg materials) and 'non tradable' (eg personnel, CCTs) resources in which two different inflation rates are applied, as recommended by the Global Health Cost Consortium(10). In terms of the value of the CCT value in a high-inflation environment, there are technically two possible scenarios. In the first, the cash transfer is increased to align with inflation, in which case the costs of the programme should be increased and the cost effectiveness would likely decrease in relation to these costs. Alternatively, the cash transfer is not increased, and the effectiveness decreases. In the latter scenario, a supplemental adjustment could reflect the decrease in effect size. Either way, more explicit modelling would help guide decisions regarding relative cost-effectiveness.

Uncertainty

We also believe that uncertainty should be incorporated much more strongly in the model – through adopting simulations that take into account the uncertainty in starting assumptions and assess its impact on the end result. This could be, for example, through a Monte Carlo simulation approach, as recommended by the UK review of methodologies (2).

Another way to incorporate uncertainty would be in running high end estimates and low end estimates. For every variable in the model, it is possible to assign 3 values – a high, middle and low estimate, drawing on existing uncertainty in the underlying data. If the variable increasing would lead to higher cost-effectiveness, the high value is assigned in the high scenario, and if the variable increasing would lead to lower cost-effectiveness, then the high value is assigned in the low scenario. Intuitively, given the significant uncertainties inherent in the analysis, this is likely to lead to a wide range of plausible cost-effectiveness. We note that GiveWell's lack of sensitivity analysis has been previously raised (11).

This argument is supported by a review by Onwuchekwa et al (12) which found a range of different possible effect sizes in settings that appear to be highly relevant. These studies are themselves different to the ones used by GiveWell in their review of studies to inform their prior. In addition, the Banerjee paper used by GiveWell itself displays a wide confidence range around its effect size. Even the RCT of New Incentives used by GiveWell carried a wide uncertainty range around its estimated effect size.

It is not immediately obvious how these impacts would affect the estimated cost effectiveness of the intervention, as the impact would depend on exact methodology used and inputs used as part of that approach. However, given the significant uncertainty around the core input to the model around effectiveness of the intervention, it would seem this could lead to a wide range of plausible cost effectiveness, intuitively easily 5% different to GiveWell estimates and likely more as the effective would be cumulative.

Impact of COVID-19 pandemic

Another major, but perhaps unavoidable, issue with the CEA is that it was both performed in a pre-COVID era, and based on data from an RCT also performed pre-COVID. However, the COVID-19 pandemic and aftermath likely had a greater impact on the CEA of this programme compared with others for the following reasons:

- COVID-19 had a serious impact on childhood vaccination programmes worldwide, but particularly in Low and Middle Income Countries (LMICs), with one systematic review showing twenty one of 26 studies showing a decrease in the childhood vaccination rate during the pandemic (13). The WHO estimates 25 million children under the age of 1 year did not receive basic vaccines, which is the highest number since 2009 (14). The reasons for this could be multifold and include increased parental hesitation due to fear of infection, supply chain disruptions and social distancing requirements increasing costs associated with vaccinations and inconsistent messaging around vaccines and routine services during the pandemic. All of these factors have the potential to affect CEA going forward. The baseline coverage rates in Nigeria are likely to be lower now than in the original model which could impact overall cost-effectiveness.
- With vaccination performing a central position in efforts to combat COVID-19, it is unavoidable that the huge amount of investment into COVID-19 vaccination in LMICs will interact with other vaccination programmes. The effects of this are unpredictable. On the one hand, funds such as COVAX included investments into improving vaccination delivery systems in LMIC. Therefore there may be impacts on other vaccination programmes which will potentially benefit from improved access to warehousing, cold-chain equipment, distribution capacity and trained vaccination staff. This will affect the efficiency of childhood vaccination programmes, and thus impact the cost-effectiveness. On the other hand, there may be negative impacts resulting from the focus on ongoing COVID-19 booster vaccination programmes such staff shortages.
- The focus on COVID-19 vaccination programmes may have unpredictable consequences on perceptions of vaccines overall. Safety concerns around the COVID-19 vaccines may increase vaccine scepticism overall, and there may be an element of 'vaccine fatigue' after caregivers have been asked to attend for multiple vaccines and boosters (15). There may be increased costs associated with regaining public confidence in vaccines- for example, using safety protocols by the vaccinators or limiting the number of people in clinics. Conversely, the increased amount of public education on vaccination may have increased awareness and willingness for vaccines which may benefit the programme.
- As acknowledged by GiveWell there is also the risk of crowding out of other incentives. There is little evidence of what happens when intrinsic motivation to get vaccinated is replaced by extrinsic reward. This may mean that for districts where CCTs for childhood vaccinations are given, it may be more difficult to achieve high COVID-19 vaccination rates if no cash incentive comes with the vaccine. There are also the wider unknowns; for example, what happens to vaccination rates in neighbouring districts where there is no CCT programme, or new vaccination programmes (eg HPV) that do not come with CCTs (16).

We note the global adjustment factor related to COVID-19 ("COVID-19 leading to greater effects of cash incentives and vaccination") has been applied both ways, reflecting the uncertainty about overall direction of effect. However the rationale for this adjustment is based in the situation mid-pandemic and does not take into account the current landscape. Given the highly contextual nature of each of these elements we would recommend the most effective way of making these judgements would be speaking to people in the field to understand the effect the pandemic has had in each of these categories and gathering evidence that would help provide a more accurate adjustment factor that reflects the current situation.

Comparability

In presenting the findings primarily as a cost/life saved, the GiveWell team do not present easily comparable data with other estimates of vaccine cost effectiveness. This makes comparison of the findings with other estimates difficult. The comparison of models would enable validation and sense checking of GiveWell's results with wider fields of evidence. At a minimum, this could be a ball park assessment, but could also be a more sophisticated model comparison as described by den Boon et al (17).

The DALY and QALY are internationally recognised and used measures of health benefits. While we understand the rationale given by GiveWell for using other measures, we feel that GiveWell should also calculate and provide the incremental cost effectiveness ratio as measured by the cost/QALY or cost/DALY to enable comparison with other models. GiveWell have argued extensively for their use of moral weights; for transparency they should also report effects unadjusted for moral weights that enable ease of comparison (18).

We urge GiveWell to ensure that models adhere to key guidance from the field and common practice for modelling strategies, included factors and reporting. For the latter, GiveWell would do well to present its modelling method in descriptive form, much as a typical peer-reviewed publication would do and conforming to CHEERS reporting standards (19).

This would enable a much more transparent assessment of quality and easier comparison with other models. For example, we are unclear of the methodology undertaken in summing up the risks related to relevant infectious diseases, and as such cannot be assured that the data analysis around this is appropriate. There are a number of other domains of the CHEERS statement which we do not believe have been presented, although the way in which GiveWell present their assumptions and models make it challenging to rapidly appraise all relevant considerations.

Wider considerations

It is inherently complex to model the cost effectiveness of incentives for vaccine programmes (20). This is due to the positive externalities that vaccines have both for the wider community which can include positive effects on antimicrobial resistance due to reduced antibiotic use (21) as well as the inherent complexity of infectious disease transmission within populations.

Despite seemingly straightforward from a health economics perspective, CCTs for vaccinations are also an inherently complex intervention to assess at a global level. On the one hand, they have the potential to alleviate poverty and therefore improve social determinants of health, leading to positive externalities that are hard to quantify. There are wide range of benefits from vaccination that can be incorporated into cost effectiveness analysis that could be considered in future CEAs (22). Vaccine programmes may also have positive equity impacts The equity dimension itself could be incorporated in modelling as per emerging approaches in health economics. On the other hand, there is the potential for distortionary effects depending on the size of the CCT (9) and ethical concerns that in some situations financial incentives for vaccination could be construed as coercive or exploitative (23). As they don't address intrinsic motivation for vaccination, their impact likely wanes when discontinued (16). There is also the opportunity cost that occurs by biasing towards interventions that have a favourable CEA as opposed to programmes where the outputs/outcomes may be more complex and therefore less amenable to CEAs.

Vaccination is one of the most cost-effective interventions and any programme that increases coverage rates is likely to score highly using CEAs, and therefore by GiveWell metrics this programme is a top-rated charity. Notwithstanding the difficulties in estimating true cost-effectiveness of the programme, we also would be mindful of the wider implications of this approach.

Conclusion & recommendations

In conclusion, we have addressed a wide range of considerations in relation to GiveWell's CEA for New Incentives. We recommend:

1. Consider the use of a dynamic model, incorporating key nonlinear dynamics

2. If a dynamic model is not used, review best practice static modelling approaches to consider their use

3. Incorporate herd immunity and inflation using more appropriate inputs, and consider modelling the impacts of the COVID-19 pandemic using updated inputs

4. Model uncertainty explicitly

5. Present model method and outputs according to best practice to enable comparisons

6. Present the cost effectiveness for CCT of vaccination within the consideration of wider contextual issues related to the intervention

7. Revise procedures for downward weighting intervention level adjustments, when there is good evidence and factors are deemed relevant for a model

From our perspective, despite good efforts at transparency GiveWell appears to have developed certain idiosyncratic approaches to modelling which make robust appraisals of its models challenging. Part of this may be due to trying to incorporate multiple layers of complexity into a static model rather than using a dynamic model. Modelling CEAs for vaccines is complex and new evidence and approaches have emerged during the COVID-19 pandemic. We recommend the team reviews it's strategies and update the model to reflect the post-COVID19 landscape which may be markedly different. Ultimately, our critique raises fundamental questions regarding modelling methods and highlighted several factors which could skew the findings by more than 10%.

Due to the rapid nature of this review and the complexity of the subject, we present our best reasoning, acknowledging the complexity of the field and the likelihood that there are other relevant factors that we have not considered.

*Correction note December 2022: A minor correction was made to this sentence to reflect nuance in WHO guidance. The importance of herd immunity effects differs by condition and this should be taken into account when performing CEAs for vaccination programmes covering multiple conditions.

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