TECHNICAL APPENDIX

Table 1. Economic evaluation methods, decision rules and implications for structural interventions

|  |  |  |  |
| --- | --- | --- | --- |
| Method  | Outcome unit  | Implications for structural interventions  | Decision rule (how should resources be allocated?) |
| Cost Minimisation Analysis (CMA)  | n.a.  | Assumes interventions have identical outcomes - highly unlikely with structural interventions with different primary objectives  | Intervention with the lowest cost  |
| Cost-Effectiveness Analysis (CEA)  | Natural unite.g. HIV infection averted or AIDS death averted | Considers variations in effectiveness between intervention optionsBut single outcome analysis impedes the incorporation of multiple outcomes within HIV (treatment and prevention interventions cannot be compared) and beyond HIV | Intervention with the lowest cost-effectiveness ratio (CER)Rank interventions from lowest to highest CER in a league table and allocate fixed budget starting from the lowest CER until the budget is spent |
| Cost-Utility Analysis (CUA)  | Disability-Adjusted Life Year (DALY)Quality-Adjusted Life Year (QALY) | Allows for HIV-wide and health sector wide comparisonsBut single health outcome makes it difficult to take non-health outcomes into account  | Intervention(s) with the lowest CERs League tables (see above) Below $25-150/DALY averted in LICs and $100-500/DALY in MICsBelow 1x or 3x GDP/capita per DALY averted |
| Cost-Benefit Analysis (CBA)  | Monetised outcome  | Benefits from all sectors can be accounted for and monetised  | Every intervention option where Benefits > Costs (or Benefit-Cost Ratio>1) In a ranking, interventions with the largest net benefit should be prioritised |
| Cost-Consequence Analysis (CCA) | Multiple natural units  | Used to present multiple outcomes, where CBA is not feasibleDoes not combine measures of benefit into a single measure so cannot be used to rank  | No rule  |

**ZOMBA CASH TRANSFER TRIAL**

The Zomba trial was implemented by the World Bank from January 2008 to December 2009. This randomised controlled trial is described in detail elsewhere [[1](#_ENREF_1)]. All never-married girls aged 13-22 at the end of 2007 in a random sample of 176 enumeration areas in the rural district of Zomba, Malawi were invited to take part in the trial. Of these, 3,796 were enrolled at baseline, of which 1,225 were randomised to the treatment group and were offered monthly cash transfers. The majority (789) were already in school at baseline while the others were girls that had dropped out of school (436). Among the baseline schoolgirls, 506 were randomised to the conditional arm, whereby their receipt of the monthly cash transfer was dependent on their 80% school attendance. The unconditional arm received the cash regardless of their attendance.

***Methods for estimating the Willingness to Pay***

In order to estimate how much each sector would be willing to pay for this intervention, we started by determining which (sub-)sectors would be interested in the first place, based on which outcomes were found to be significantly impacted by the intervention. Various reports from the trial provided evidence that the intervention had statistically significant impacts on prevalent HIV, prevalent HSV-2, school enrolment, English test scores, school drop-out rates, pregnancy rates and cases of depression. We therefore consider that the HIV budget holder, the sexual and reproductive health budget holder, the mental health budget holder and the education budget holder would see value in investing in such an intervention.

Table 2. Sample sizes of Control and intervention groups and Intervention cost estimates

|  |  |  |
| --- | --- | --- |
| **Participants in Control Group** | **Amount** | **Source** |
|  Schoolgirls Only | 1495 | [[1](#_ENREF_1)] |
| Dropouts Only | 453 | [[1](#_ENREF_1)] |
|  Total Participants |   | 1948 | [[1](#_ENREF_1)] |
| **Participants in Intervention Group** |  |  |
|  Dropout Pooled | 436 | [[1](#_ENREF_1)] |
|  Schoolgirl Pooled  | 789 | [[1](#_ENREF_1)] |
|  *Schoolgirl Unconditional Only*  | 283 | [[1](#_ENREF_1)] |
|  *Schoolgirl Conditional Only* | 506 | [[1](#_ENREF_1)] |
|  Total Participants |   | 1225 | [[1](#_ENREF_1)] |
| **Intervention Cost (2009 US$)** |  |  |  |
|  Cost per Pupil (Lower Estimate) | $90[[1]](#footnote-1) | [[2](#_ENREF_2)] |
|  Cost per Pupil (Upper Estimate) | $225 | [[2](#_ENREF_2)] |
|  Total Intervention Cost (Lower Estimate) | $110,250 | Cost per pupil x Total girls in Intervention group |
|  Total Intervention Cost (Upper Estimate) | $275,625 | Cost per pupil x Total girls in Intervention group |

Since we equate willingness to pay (WTP) per (sub-)sector with sector-specific normative or positive thresholds, we first need to estimate the intervention’s impact in absolute terms and in the units of outcome for which thresholds exist. For all health outcomes, we therefore need to estimate impact in DALYs, which can be derived from infections/cases averted. For education outcomes, we found that cost-effectiveness ratios exist for enrolment in percentage, additional years of schooling, drop-outs averted, and 0.1 standard deviations in test scores. We therefore calculated absolute impact for these indicators, using the percentage-point difference between control and treatment groups and multiplying by the size of the sample in the trial. For the HIV, HSV-2 and teenage pregnancy outcomes, we used the unweighted percentage-point difference, rather than the weighted percentages estimated by the authors, as a more conservative estimate [[3-5](#_ENREF_3)], but we also conduct a sensitivity analysis using the weighted ones.

It is important to note that the effect was only significant for certain treatment groups, i.e. school girls that were in school at baseline, girls that had dropped out of school at baseline, or only among baseline school girls in the conditional arm. We only applied the impact to the specific sample for which it was significant, as shown in Table 4.

***Identification of lower and upper bound WTP thresholds in the education literature***

We used the review of cost-effective education interventions in developing countries conducted by J-PAL for school attendance. Findings are summarised on their website, at the following link: <http://www.povertyactionlab.org/policy-lessons/education/student-participation>. Four interventions are included for Africa, namely information on returns to education for parents (Madagascar); deworming through primary schools (Kenya); free primary school uniforms (Kenya); and merit scholarships for girls (Kenya). Each intervention’s cost-effectiveness ratio is presented as the number of additional years of school participation obtained per US$ 100 spent. We translated this in a cost per additional year of participation ($100/CER). A member of J-PAL informed us that these were in 2010 US$, so we deflated the costs to 2009 US$ using the United States 2009 inflation rate World Bank (World Development Indicators)[[6](#_ENREF_6)]. We used the lowest CER as the lowest WTP for an additional year of schooling and the highest CER as the highest WTP, i.e. providing parents with information on the returns to education and merit scholarships for girls respectively.

For school enrolment and test scores, we adopted the review by Evans and Ghosh (2006)[[7](#_ENREF_7)] as a starting point. From this review, we retained and reviewed studies evaluating interventions that were implemented in sub-Saharan African countries had the lowest and the highest cost-effectiveness ratio. For test scores, we used the CER figures reported in Evans and Ghosh (2006) for studies with randomised designs, since they were expressed in the same unit (0.1 standard deviation gain) as what we had calculated for the Zomba trial. We kept the CERs that adjusted for the deadweight loss associated with the intervention.

For school enrolment, we selected and reviewed in detail the studies from Sub-Saharan Africa with the lowest (Glick & Sahn, 2005) and highest CER (Handa, 2002), including non-randomised designs (there was only one study with a randomised design from SSA). Glick & Sahn (2005) modelled the cost-effectiveness of school consolidation with multigrade elimination, which had the lowest CER expressed per additional student enrolled (translated from Malgashy francs to US$ based on the 1994 exchange rate reported in the study).

For Handa (2002), the highest estimated CER that the authors concluded was worth considering was for another supply-side intervention consisting of the construction of additional schools to improve accessibility (70 schools per province). The total cost was estimated at US$ 49 million (assumed 1998 US$). The projected enrolment gain was 13%, but the authors did not indicate how much this represented in absolute numbers of additional students enrolled. We used data from the other intervention modelled in the paper to deduce the total primary school age population under consideration. For the adult literacy intervention, the authors indicate that there are 490,000 illiterate household heads are in the bottom quartile, which represent 59% of all households in this quartile). We therefore calculate that there are 490,000/0.59 x 4= 3,322,033 households in total. In the survey sample of 8,250 households, there were 2,293 (girls) and 2,203 (boys), or 4,496 children, between 7 and 11 years old – the primary school age. The ratio of households to students was therefore used to estimate the total number of school aged children targeted with the school construction intervention, i.e. 3,322,033/1.835= 1,810,408. The 13% increase in enrolment in this population therefore corresponded to an additional 235,353 children enrolled, or a CER of US$ 208 (1998 US$).

In terms of drop-outs averted, we only found one study with this measure and programme costs, i.e. Duflo et al (2006), which evaluated an intervention in Kenya to reduce the costs of primary schooling by providing free uniforms. This intervention is also considered above for additional years of schooling. The study reported a reduction in drop-out rates among girls from 12.4% to 9.9%. It benefited an average of 28 girls in 328 schools, or 9,184 girls in total. The reduction in drop-out thus corresponds to 230 female drop-outs averted. At a total cost of US$ 93,152 (=284 per school in 328 schools), this represent a cost per drop-out averted of US$ 406 (2005US$).

All the CERs from these reviews were adjusted to 2009 US$ using the United States inflation rates from the World Bank (World Development Indicators)[[6](#_ENREF_6)]. Where the year of the currency was unclear, we assumed that it was for the year before the study was submitted for publication (Handa, 2002) or published (Duflo et al, 2006).

Finally, all CERs in 2009 US$ were adjusted to Malawi using the ratio of the CER to the 2009 GDP per capita of the country in which the intervention was implemented [[6](#_ENREF_6)]. For example, the cost per drop-out averted of 2009 US$ 455 in Kenya (Duflo et al, 2006) represented 60% of Kenya’s 2009 GDP per capita of US$755 in 2009 US$; or US$ 204 in Malawi (59% of Malawi’s 2009 GDP per capita US$339).

***Conversion of health outcomes to DALY***

We estimated the health outcomes of the Zomba trial in the following natural units: HIV infections averted, HSV-2 infections averted, teen pregnancies averted and depression cases averted. Since the WHO cost-effectiveness thresholds that we use are for costs per DALY averted, we had to translate these into DALY equivalents.

For HIV infections averted, we estimated the associated DALYs, based on standard DALY formulae [[8](#_ENREF_8)] and parameters relevant for the target population, with both a no ART and a full ART scenario (see Table 3). We estimate 25.76 DALYs per HIV infection in a no ART scenario and 15.66 DALYs per HIV infection in a scenario with full ART coverage. We use the latter more conservative estimate in our analysis.

Table 3. DALY Parameters [[9](#_ENREF_9)]

| Parameters | Value | Source |
| --- | --- | --- |
| Age-weighting modulation constant | 1 | Murray et al, 2006[[8](#_ENREF_8)] |
| Discount rate | 3% | Murray et al, 2006[[8](#_ENREF_8)] |
| Age weighting constant | 0.04 | Murray et al, 2006[[8](#_ENREF_8)] |
| Adjustment constant for age-weights | 0.1658 | Murray et al, 2006[[8](#_ENREF_8)] |
| Disability weight pre- AIDS | 0.221 | Salomon et al, 2012[[10](#_ENREF_10)] |
| Disability weight AIDS – no ART | 0.547 | Salomon et al, 2012[[10](#_ENREF_10)] |
| Disability weight AIDS receiving ART | 0.053 | Salomon et al, 2012[[10](#_ENREF_10)] |
| Duration pre-AIDS | 8 years | Hogan et al, 2005[[11](#_ENREF_11)] |
| Duration ART | 13 years | Cleary et al, 2008[[12](#_ENREF_12)] |
| Duration AIDS (no ART) | 2.9 years | Cleary et al, 2008[[12](#_ENREF_12)] |
| Age of onset of HIV (ART) | 16 years | Baird et al, 2012[[1](#_ENREF_1)] |
| Disability weight major depressive disorder – mild episode | 0.159 | Salomon et al, 2012[[10](#_ENREF_10)] |
| Disability weight major depressive disorder – moderate episode | 0.406 | Salomon et al, 2012[[10](#_ENREF_10)] |
| Disability weight major depressive disorder – severe episode | 0.655 | Salomon et al, 2012[[10](#_ENREF_10)] |
| Duration of an untreated depressive episode | 0.5 year | Chisholm et al, 2004[[13](#_ENREF_13)] |
| Lifetime suicide risk for affective disorders, ages 15-45 | 9% | Chisholm et al, 2004[[13](#_ENREF_13)] |
| Weighting of mild untreated depressive episodes  | 30% | Chisholm et al, 2004[[13](#_ENREF_13)] |
| Weighting of moderate untreated depressive episodes | 47% | Chisholm et al, 2004[[13](#_ENREF_13)] |
| Weighting of severe untreated depressive episodes | 23% | Chisholm et al, 2004[[13](#_ENREF_13)] |
| Expectation of life at 15-19, females, Malawi, 2011 | 49.77 | WHO life tables[[14](#_ENREF_14)] |
| Expectation of life at 25-29, females, Malawi, 2011 | 40.90 | WHO life tables[[14](#_ENREF_14)] |
| Expectation of life at 35-39, females, Malawi, 2011 | 34.22 | WHO life tables[[14](#_ENREF_14)] |
| Age at onset of depressive episode | 15 years | Baird et al, 2012[[1](#_ENREF_1)] |

DALYs associated with cases of depression were estimated in the same way, with specific depression parameters from the 2004 WHO CHOICE exercise [[13](#_ENREF_13)] and the latest Global Burden of Disease study [[8](#_ENREF_8)]. We assume that 91% of cases of depression will consist of a single untreated episode of 6 months (weighted to include mild, moderate and severe episodes), followed by full recovery and no loss of life. This is conservative as it excludes remission, which is known to be quite high. For the remaining 9%, we assume that the 6-month episode will be severe and end in suicide. This may be an overestimate of years of life lost, since 9% is the lifetime suicide risk in this age group, not the risk per episode. Nonetheless, we estimate 34.77 DALYs in 9% of cases and 0.31 DALYs in 91% of cases, or a weighted average of 3.41 DALYs per depressive disorder.

For teen pregnancies, we estimated DALY equivalents from the second edition of the Disease Control Priorities Project. We used the figures reported for family planning, with a US$ 131 per birth averted in sub-Saharan Africa corresponding to US$ 34 per DALY averted [[15](#_ENREF_15)], or 3.8 DALYs per birth averted. This does not appear unreasonable given Malawi’s high maternal and infant mortality rates, as well as increased risks among young adolescent women [[16](#_ENREF_16), [17](#_ENREF_17)].

In terms of HSV-2 infections averted, we decided to use a very conservative estimate from a high-income setting [[18](#_ENREF_18)], which only considers the psychosocial adult morbidity of genital herpes psychosocial, leading to lower mental health scores. This excludes potential sequelae from meningitis, erythema multiforme and neonatal herpes [[19](#_ENREF_19)], for lack of data parameters. Also, to avoid double-counting, we do not take into account the cofactor effect of HSV-2 on HIV transmission [[20](#_ENREF_20)]. In Canada, it was estimated that the cost per case of genital herpes averted through screening would be $8,200. Based on the quality of life weights derived from this study, authors estimate that this would correspond to $140,000 per quality-adjusted life year gained [[18](#_ENREF_18)]. We consider that this corresponds to 0.06 QALYs per genital herpes infection and convert this directly to 0.06 DALYs per HSV-2 infection.

***Cost-benefit modelling assumptions for the fair share approach***

The WTP estimates in the above were used as equivalents of monetised HIV benefits (HIV DALYs averted x WTP threshold of GDP per capita). The other long-term benefits of such an intervention were modelled by adopting the benefit-cost ratio from a previous study (King et al., 2007) that estimated the costs and benefits of conditional cash transfers to young women. For every US$ 1 invested, between US$ 3.49 and US$ 26.12 could be generated in benefits through increased future earnings and DALYs averted from child mortality, under various discount rate assumptions (3% and 5%) and DALY value assumptions (US$ 1,000 and $5,000).

For consistency, we monetised HIV DALYs in the base case at US$ 1,000 and included the higher valuation of $5,000 in the sensitivity analysis.

In addition, on the cost side, we deducted the cost savings from averted antiretroviral treatment. The discounted lifetime ART costs of 2002 US$9,435 or 2009 US$11,303 were taken from a South African study [[21](#_ENREF_21)]. Fifty percent of the costs were considered drug-related and therefore internationally comparable (not adjusted) and the other 50% were adjusted to Malawian prices, based on the ratio of Malawi's GDP per capita to South Africa's GDP per capita (i.e. US$ 5,511 per person on treatment or US$ 35,966 for the 6 HIV infections averted by the trial).

***Welfare Loss Calculation***

Welfare loss was calculated for the silo approach as the net benefit that could be achieved from implementing the intervention. The total benefits were the net intervention benefits of US$ 478,373 plus the HIV treatment cost savings (US$ 35,966). The implementation costs (US$ 110,250) were deducted from this total of US$ 514,338 to estimate the net benefit of US$404,088.

Table 4. Detailed inputs and data sources

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| (Sub-)Sector | Outcome metric | Impacted group | Control | Treatment | Gain | Source | DALYs per unit (health) | Source | Conversion to DALYs averted | WTP per unit (min) | Source | WTP per unit (max) | Source |
| Education | Drop-outs re-enrolled (additional student enrolled) | All baseline drop-outs | 12.3% | 56.6% | 193 | [[1](#_ENREF_1)] | Not applicable | 16.81 | [[22](#_ENREF_22)] | 220.42 | [[23](#_ENREF_23)] |
| Years of full school attendance | Baseline schoolgirls conditional arm | 80.1% | 90.2% | 77[[2]](#footnote-2) | [[24](#_ENREF_24)] | 3.91 | [[25](#_ENREF_25)] | 163.33 | [[25](#_ENREF_25)] |
| English test scores 0.1 standard deviations gained | n.a. | 0.14 higher than control  | 708 | [[24](#_ENREF_24)] | 1.54 | [[7](#_ENREF_7)] | 3.29 | [[7](#_ENREF_7)] |
| Drop-outs averted | All baseline schoolgirls | 83.5% | 86.6% | 24 | [[26](#_ENREF_26)] | 16.81 | [[22](#_ENREF_22)] | 204.45 | [[27](#_ENREF_27)] |
| HIV | HIV infections averted | All baseline schoolgirls | 2.13% | 1.43% | 6 | [[1](#_ENREF_1)] | 15.6 | See above | 83 | 339\* | [[6](#_ENREF_6)] | 1,017*†* | [[6](#_ENREF_6)] |
| Mental health | Depression cases averted | All baseline schoolgirls | 24.5% | 18.7% | 46 | [[28](#_ENREF_28)] | 3.41 | See above | 10 | 339\* | [[6](#_ENREF_6)] | 1,017*†* | [[6](#_ENREF_6)] |
| Sexual & Reproductive Health | Teen pregnancies averted | Baseline schoolgirls unconditional arm | 4.23% | 0.75% | 10 | [[1](#_ENREF_1)] | 3.8 | See above | 38 | 339\* | [[6](#_ENREF_6)] | 1,017*†* | [[6](#_ENREF_6)] |
| HSV-2 infections averted | All baseline schoolgirls | 3.00% | 1.02% | 16 | [[1](#_ENREF_1)] | 0.06 | See above | 78 | 339\* | [[6](#_ENREF_6)] | 1,017*†* | [[6](#_ENREF_6)] |
| Health sub-total  |  |  |  | 208 |  |  |  |  |

*\* Malawi GDP per capita in 2009 (adjusted to 2009 US$ with United States inflation measured by GDP deflator) from World Bank’s World Development Indicator*

 *†3 times Malawi’s 2009 GDP per capita*

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1. Assumes more reasonable administrative costs at scale (excluding the trial costs) and reducing the average cash payment amount to US$ 5 per month, which Baird and colleagues estimated could be achieved without affecting the intervention’s impact (Baird et al., 2012). [↑](#footnote-ref-1)
2. 51 additional full years of schooling in conditional arm (506\*0.902-506\*0.801) over 18 months of implementation (1.5 years) = 77 additional years of schooling. [↑](#footnote-ref-2)