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Scaling up integrated prevention campaigns for global health: Costs and cost-effectiveness in 70 countries

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Abstract

Objectives. This study estimated the health impact, cost, and cost-effectiveness of an integrated prevention campaign (IPC) focused on diarrhea, malaria, and HIV in 70 countries ranked by per-capita disability-adjusted life-year (DALY) burden for the three diseases.

Methods. We constructed a deterministic cost-effectiveness model portraying an IPC combining counseling and testing, cotrimoxazole prophylaxis, referral to treatment, and condom distribution for HIV prevention; bed nets for malaria prevention; and provision of household water filters for diarrhea prevention. We developed a mix of empirical and modeled cost and health impact estimates applied to all 70 countries. One-way, multi-way and scenario sensitivity analyses were conducted to document the strength of our findings. We used a societal perspective, discounted costs and DALYs at 3% per year, and denominated cost in 2012 U.S. dollars.

Primary and secondary outcomes: The primary outcome was cost-effectiveness expressed as net cost per DALY averted. Other outcomes included the cost of the IPC; net IPC costs adjusted for averted and additional medical costs; and DALYs averted.

Results. Implementation of the IPC in the 10 most cost-effective countries at 15% population coverage would cost $583 million over three years (adjusted costs of $398 million), averting 8.0 million DALYs. Extending IPC programs to all 70 of the identified high-burden countries at 15% coverage would cost an adjusted $51.3 billion and avert 78.7 million DALYs. Incremental cost effectiveness ranged from $49 per DALY averted for the 10 countries with the most favourable cost-effectiveness to $119, $181, $335, $1,692 and $8,340 per DALY averted for each successive group of 10 countries respectively ordered by decreasing cost-effectiveness.

Conclusion. IPC appears to be cost-effective in many settings, and has the potential to substantially reduce the burden of disease in resource-poor countries. This study increases confidence that IPC can be an important new approach for enhancing global health.

Strengths and limitations of this study.

Strengths

- Synthesizes a large volume of epidemiological data from disparate sources into a unified method for projecting the consequence of IPC implementation in 70 countries.
- Links the “opportunity index” concept with cost-effectiveness.
- Provides a more comprehensive assessment of intervention potential than assessment of cost-effectiveness alone.
- Methods presented here may be applied to other disease areas and facilitate more objective resource allocation decision-making for global health.

Limitations

- Incomplete availability of data relevant to the large number of countries analyzed.
- Infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered.
- Regions or urban areas within countries may have costs and health benefits that depart from the overall country assessments.

Background

For many years, vertical (disease-specific) programming has dominated the sphere of global health funding in an effort to tackle the areas of greatest need [1]. However, there is increasing recognition that, among diseases with complementary prevention strategies and overlapping populations, single-disease approaches to population health improvement create duplication of effort and miss important opportunities for synergies in health benefits and economies of scope [2]. Recent initiatives have therefore sought to integrate programs for multiple diseases, and many have demonstrated feasibility, efficiencies and success [3, 4].

A particularly promising example of integrated programming was a prevention campaign in Western Province, Kenya that targeted diarrhea, malaria, and HIV [5], three diseases that account for a substantial portion of the total disease burden in many parts of the developing world [6]. Over the course of one week, the campaign provided general health education, condoms, insecticide-treated bed nets (ITNs), point-of-use water filters, and HIV testing and counseling to more than 80% of the target population [5]. Those testing positive for HIV were offered on-site CD4 count determination, cotrimoxazole prophylaxis, and referral to comprehensive HIV care and treatment. The campaign yielded large health benefits and net economic savings [7] [8]. Large-scale expansion of this integrated prevention campaign (IPC) has the potential to deliver substantial health benefits and cost savings. In a separate study, we reviewed country-specific data for 70 low- and middle-income countries, finding that the opportunity for a diarrhea, malaria and HIV IPC is not limited to Kenya (Jiwani et al. unpublished, 2013). It is plausible that IPCs can have a large impact on health in many resource-limited settings.

While the cost-effectiveness of this IPC in Western Kenya has been established [8], the economic and health effects of a multi-country IPC initiative are unknown. Using the best available data, we estimated the costs, health outcomes, and cost-effectiveness of IPC implementation in the same 70 low- and middle-income countries. To support decision-making for IPC implementation, we also estimate the increases in budgets that would be required to cover increasing numbers of countries.

Methods

Overview

We modeled the health impact, cost, and cost-effectiveness of a diarrhea, malaria, and HIV IPC [5] in 70 countries by adapting a previously-published spreadsheet-based model that was applied to the original IPC in Western Kenya [8]. Countries were chosen for inclusion in the analysis based on two factors: they were classified as low- or middle-income as defined by the World Bank [9]; and they had a total DALY (Disability-adjusted-life-year) burden for the three diseases addressed by the IPC in the highest tertile of the 214 World Bank-defined economies (i.e., ≥ 87,000 DALYs; assessed in a companion paper (Jiwani et al., under review, 2013 [9]). We derived incidence and case fatality rates for each country from published reports, using regional averages and other approximations when country-specific estimates were missing. We developed a mix of empirical (where available) and modeled (projected from empirical data) cost estimates applied to all 70 countries. Key outcomes examined included the cost of the IPC; net IPC costs adjusting for averted and additional medical costs; deaths and disease episodes averted; DALYs averted due to prevention, and to earlier and more HIV care; and finally, cost-effectiveness expressed as net cost per DALY averted. We used a societal perspective, and discounted long-term costs and DALYs at 3% per year [10]. Costs were denominated in 2012 U.S. dollars.

Detailed model features

We adapted a Microsoft Excel spreadsheet that we had previously constructed to analyze the cost-effectiveness of the Kenya IPC. Details of the model have been published elsewhere [8]. The model estimates the health and cost benefits of prevention for malaria, diarrhea, and HIV separately. For HIV, it also estimates the DALYs averted and costs incurred due to earlier diagnosis and treatment arising from HIV testing. Cost-effectiveness of the IPC was compared to the cost-effectiveness of ART in each of the 70 countries. This metric was selected since, with the current aspiration of universal access to ART [11], provision of ART is on the active policy agenda for most HIV-affected countries.

Cost estimates and projection methods. Campaign costs for the Kenya IPC were obtained from published empirical data supplemented by filter repair and replacement costs [7, 8]. We estimated campaign costs for each country using the Kenya IPC as a benchmark, translating to other countries according to type of cost, as follows. Program costs were classified as commodity, personnel and other costs. Commodities were further categorized as tradable and non-tradable. Tradable commodities are those purchased on the international market and include bed nets, filters, and condoms, and required no adjustment from the dollar-denominated costs incurred by the Kenya IPC [7]. The cost of non-tradable items, primarily personnel, were adjusted according to the per-capita GDP ratio, in International dollars, between Kenya and each study country [12].

For each country, we estimated the costs of averted medical care due to the IPC by adjusting the costs for health care incurred per fatal and non-fatal case in the Kenya campaign by the ratio of GDP per capita in the target country versus Kenya. We selected per capita GDP rather than per capita health care spending as the basis for these adjustments, because the latter reflects overall access to care and our model accounts for access separately: For malaria, we used global average rates of treatment access, estimated at 68% for malaria based on published literature [13-18]. For diarrhea, we used country-specific estimates based on demographic and health survey data on the percent of children under five years of age with diarrhea in the two weeks preceding the survey who received any kind of treatment for diarrhea [19]. We used an average rate of access to ART of 70%. This is considerably higher than the 56% access reported for sub-Saharan Africa [20] and reflects likely increases in access in the context of the global commitment to access [11].

We calculated the per person-year cost of ART for each country by using published estimates for countries where available [21-42]. The non-drug portion of each published unit cost figure was inflated to 2012 US dollars using the U.S. CPI [43]. We then derived from the set of published figures an average figure for low-income, lower middle-income excluding India, and upper-middle income countries as defined by the World Bank [9]. We applied these country income-category averages to the larger set of countries for which published ART unit cost estimates were unavailable, according to their respective income categories. ART cost-effectiveness for each country was estimated by adjusting $883 per DALY averted which is the average for 45 sites studied in Zambia [23]. To arrive at country-specific estimates we calculated the ratio of per-capita income between each country and Zambia and applied this factor to the average portion of overall ART costs for low-income countries which is non-tradable, 36.9%. This figure was derived from the ART unit cost studies described above which includes the breakdown of costs by major component.

First versus second campaign health benefits. The health benefits of a second campaign would be lower than that of the initial campaign. For malaria and diarrhea, this is due to the limited functional life of nets and filters. For HIV, this is due to interval HIV incidence lower than HIV prevalence during the initial campaign. For the second campaign we estimate that the incidence of malaria and HIV would decrease to 33% of baseline levels and that of diarrhea to decrease to 58%. (Details in technical supplement).

Disease specific data and projection methods. We obtained country estimates of the prevalence of HIV in the adult (15–49 years) population [44-46]. For each country, we derived estimates of the baseline cases of malaria per person-year by dividing WHO-adjusted estimates of the annual number of cases [47] by the total country population [48]. For diarrhea, we estimated the average number of cases per person-year in the overall population using DHS data on the number of cases per year in children under 5 [49] (details in technical supplement) [50, 51]). Multiplying each estimate by the total population [48] yields the estimated number of cases in each country.

We calculated country-specific case fatality rates for malaria and diarrhea as the number of deaths due to the disease [52, 53] divided by the number of cases. We set an upper-bound malaria case fatality rate of 15% based on published findings of a Delphi survey of malaria experts [54]. We assumed a case fatality rate for HIV of 100%.

Using a discount rate of 3% [10], we estimated the DALYs incurred with each fatal case of malaria and diarrhea at 28 based on life expectancy at age 25 in Kenya (the estimated average age of death from malaria and diarrhea) of 61 years [55]. We derived estimates of the DALYs incurred per non-fatal case of each disease as the product of the disability weight (0.191 for malaria and 0.105 for diarrhea) [56] and the average duration of each case (7 days for malaria [57]; 4.43 days for diarrhea, a severity weighted duration for children and adults [58]); or 0.0037 and 0.0013 DALYs for each non-fatal case of malaria and diarrhea, respectively. Assuming 70% access to ART, we estimated 10.6 DALYs incurred per HIV infection, and 8.8 discounted DALYs averted per treated case of HIV, an assumption based on 22 years of antiretroviral therapy (ART), average age of ART initiation of 35 years, and a life expectancy at age 35 in Kenya of 37 years [55]. Each untreated HIV case incurs 15.1 discounted DALYs.

Household size and beneficiaries per household. Using country-specific data of rural household size as reported in the most recent Demographic and Health Survey, divided by the number of participants per household as observed in the Kenya IPC campaign, we obtained the number of beneficiaries per campaign participant. For bednets, we assumed fewer incremental beneficiaries per participant on the assumption that there was some prior access to bednets, 15.1% on average, as observed in the Kenya campaign. For HIV we assumed the same number of adult participants on average, 2.5, as the basis for calculating the number of beneficiaries per campaign participant.

For the remaining health inputs, we assumed values equal to those used in the Kenya analysis for all countries [8]. See Table 1 for base case values and sources for data inputs.

Table 1 about here

Relationship of opportunity to cost-effectiveness
In a companion article, we identified the countries in which scale-up of a diarrhea, malaria, and HIV IPC would be most beneficial, by summarizing country-specific epidemiological data related to the disease burden and shortfall in current intervention coverage (Jiwani et al, under review, 2013). We created three "opportunity indices," ranking countries by 1) DALYs per capita across the three diseases of the IPC, 2) a sum of burden ranks for each disease, and 3) a composite of burden and intervention opportunity. Here, we extend this opportunity analysis by examining the relationship between a country's opportunity rank (in DALYs per capita) and its cost-effectiveness for IPC implementation.

Sensitivity analyses. To assess the effect of uncertainty in inputs, we conducted one-way and multi-way Monte Carlo sensitivity analyses for three countries: Kenya, a low-income country where the IPC trial was performed and is at the 44th percentile for cost-effectiveness of the 70 countries analyzed; Nigeria, a lower-middle income country at the 75th percentile (relatively favorable); and Bangladesh, a low-income country at the 25th percentile. Each of 31 model inputs examined in the sensitivity analyses (Table 2) was assigned a beta distribution with alpha and beta parameters of 2, in order to ensure symmetry around the mean. Maximum and minimum values were set as 1.5 and 0.5 times the base case, except for access to malaria and diarrhea treatment (0.75 to 1.25 of base case) and access to HIV treatment (0.6 to 1.4 times base case). Figures in bold font reflect parameter values that vary by country. Finally, we examined the effect of variations in important inputs on the cost-effectiveness of IPC in all 70 countries grouped in order of cost-effectiveness.

Table 2 about here

Results

Across the 70 high opportunity countries, the cost-effectiveness of the first campaign ranges from $7 (Guinea-Bissau) to $15,886 (China) per DALY averted (IQR $96 - $1,071 per DALY averted) (Table 3). At $182 per DALY averted, Pakistan is at the 50th percentile for cost-effectiveness. With the exception of Afghanistan, the 30 counties with the most favorable cost-effectiveness are in sub-Saharan Africa. The cost-effectiveness of IPC compares favorably to the cost-effectiveness of ART in 51 countries. The 30 countries with the lowest cost-effectiveness estimates are geographically more diverse and include only three in sub-Saharan Africa (Swaziland, South Africa, and Namibia). See Technical Supplement for detailed results.

As shown in Figure 1 per-capita disease burden as measured by the opportunity index is highly correlated with cost-effectiveness. See Technical Supplement for relationship between opportunity index and cost-effectiveness for campaign 2.

Table 3 and Figure 1 about here.

Table 4 displays the cumulative results, grouped in 10-country increments, assuming 15% population coverage, and moving from most to least attractive cost-effectiveness. IPC in the top 10 countries would cost $583 million for the three-year campaign, with a net cost after adjusting for effects on health care spending of $398 million for the first three-year campaign and $468 million for the second and subsequent campaigns. The first and second campaigns would avert 8.0 and 5.7 million DALYs respectively with an average cost-effectiveness of $49 and $82 per DALY averted, respectively. As shown in the right-hand two columns, the incremental cost-effectiveness rises rapidly (becomes less favorable) after coverage of the top 50 countries. In particular, if expanding from the top 50 to 60 countries and from 60 to all 70 countries, large net incremental costs are associated with relatively modest increases in health benefits. The cost per DALY averted in expanding from 60 to 70 countries is $8,340 and $19,728 for campaigns 1 and 2, respectively.

For each stratum of 10 countries ranked from most to least cost-effective, Table 5 displays the median cost-effectiveness for the first three-year campaigns, for possible second campaigns, and for ART. The cost-effectiveness of the first campaign compares more favorably to ART by a wide margin for each of the 10-country strata. For the second campaign ART is more cost-effective than IPC for the 51st – 60th and for the 61st – 70th country, as ranked by IPC cost-effectiveness.

Tables 4 and 5 about here.

Results for Kenya, Bangladesh, and Nigeria illustrate reasons for variation across countries.

In Nigeria, the IPC cost-effectiveness ratio is $94 per DALY averted, 18th of 70 countries ranked by cost-effectiveness. This result represents high health benefits for malaria and diarrhea, and modest benefits for HIV. For every 1,000 IPC participants, the first campaign averts an estimated 13.4 deaths: 6.0 due to malaria, 3.4 due to diarrhea, and 4.0 due to HIV. The campaign costs are $40,479, with net costs of $34,769 after offsetting savings from averted care needs.

In Kenya, cost-effectiveness is somewhat less attractive, at $157 per DALY averted, 31st of 70 countries. This is due to lower malaria and diarrhea benefits than in Nigeria, and more discovered HIV. For every 1,000 IPC participants, the campaign averts an estimated 10.9 deaths: 1.6 due to malaria, 2.4 to diarrhea, and 7.0 to HIV. The campaign costs $34,280. Although reduced disease creates offsetting savings in care needs, there are $81,000 in *added* HIV costs due to earlier and additional detection of HIV. The net cost of the campaign is $46,149, or $157 per DALY averted. This is less than the $883 per DALY averted for ART in Kenya.

In Bangladesh, the IPC cost-effectiveness ratio is $1,168 per DALY averted, 53rd of 70 countries. This is due to lower health benefits overall. For every 1,000 IPC participants, the campaign averts an estimated 0.9 deaths: 0.1 due to malaria, 0.8 due to diarrhea, and only 0.1 due to HIV. The campaign costs are $35,658. When adjusted for modest offsetting savings from averted care, the net cost of the campaign is $30,236. Cost-effectiveness is comparable with the estimated $1,046 per DALY averted for ART for HIV. See Table 4 of the technical supplement for detailed results for all three countries.

Sensitivity analyses

One-way sensitivity analysis. Figure 2 is a tornado graph of the sensitivity of IPC cost-effectiveness to the model inputs displayed in Table 2 for Nigeria. IPC participants per household had the greatest effect on IPC cost-effectiveness (range, $126 per DALY averted), followed by the multiplier that reflects prevention of secondary HIV transmission, the duration of the prevention benefits of HIV interventions (range, $122 per DALY averted each), cost of the IPC campaign (range, $110 per DALY averted), and the reduction in mortality due to reduced HIV transmission (range, $83 per DALY averted).

Figure 2 about here

For Bangladesh, the inputs with the greatest effect on cost-effectiveness are duration of benefits for diarrhea prevention and the baseline cases of diarrhea per 1,000 person-years (range, $1,506 per DALY averted for both), campaign cost (range, $1,377 per DALY averted), IPC participants per household (range, $1,305 per DALY averted), and protective benefit against diarrhea mortality (range, $1,140 per DALY averted). For Kenya, the variables with the most influence on cost-effectiveness are the multiplier that reflects prevention of secondary HIV transmission and the duration of the prevention benefits of HIV interventions (range, $236 per DALY averted each), the reduction in mortality due to reduced HIV transmission (range, $161 per DALY averted), cost of the IPC campaign (range, $117 per DALY averted), and the number of participants per household (range, $103 per DALY averted). See Technical Supplement Figures 2 and 3 for one-way sensitivity analysis tornado graphs for Bangladesh and Kenya respectively.

Figure 3 shows how variation in three inputs affects incremental cost-effectiveness as each successive 10 countries are added to a scaled-up IPC program. Up to 50 countries, IPC remains cost-effective compared with ART even if the least favorable end of the input estimate range is used.

Figure 3 about here

Multivariate Monte Carlo sensitivity analysis. Table 6 displays the 80% confidence interval for a 20,000-trial simulation for three outcomes: DALYs averted, net costs, and net cost per DALY averted (cost –effectiveness). For Kenya and Nigeria the least favorable end of the cost-effectiveness range is more favorable than the cost-effectiveness of ART for HIV, \$304 versus \$883 per DALY averted for Kenya and \$208 versus \$747 per DALY averted for Nigeria. For Bangladesh, the least favorable end of the cost-effectiveness range, \$2,547 is *less* favorable than the estimated \$1,046 per DALY averted for ART. For Nigeria the five most important variables in order of their correlation with cost-effectiveness (net cost per DALY averted) are, the duration of the HIV prevention benefits (r = -0.51); prevention of secondary HIV transmission (r = -0.50), the number of IPC participants per household (r = 0.33), cost of the IPC campaign (r = 0.31), and the reduction in mortality due to reduced HIV transmission (r = -0.24), (Figure 4). See Technical Supplement figures 4 and 5 for multivariate sensitivity analyses correlations coefficients for Kenya and Bangladesh, for projection of IPC costs and benefits in Kenya for 30 years and for a scenario analysis in which the payer s not responsible for HIV program costs and benefits.

Scenario Analysis: IPC cost-effectiveness with HIV costs and outcomes omitted. Finally, we report on the cost and cost-effectiveness of the IPC program if HIV program costs and health benefits are ignored. These results reflect the perspective of a payer who assumes responsibility for the diarrhea and malaria components only. When future HIV-related costs and benefits are disregarded, including both additional care costs due to more and earlier detection and reductions in care costs due to prevention, the cost per DALY averted decreases from \$157 to \$129 in Kenya; from \$94 to \$31 in Nigeria; and increases from \$1,168 to \$819 in Bangladesh.

Table 6 and Figure 4 about here.

Discussion

We examined the costs and health benefits of IPC for 70 countries with a high combined burden of diarrhea, malaria and HIV. Together these countries comprise 76% of the world population [48, 50] and 98% of its disease burden (author calculation based on the total DALYs attributed to diarrhea, malaria and HIV; Jiwani et al, under review, 2013). If implemented with 15% population coverage in the top 40 of the 70 countries as ordered by cost-effectiveness, 47.3 million DALYs could be averted at a net cost of \$4.9 billion, or \$104 per DALY averted. As shown in Table 3, this compares favorably with the cost-effectiveness of ART in each of those 40 countries. The DALYs averted constitute 58% of the disease burden due to HIV, malaria and diarrheal disease in these countries. $4.9 billion is considerably less than the President's request to the United States Congress for FY 2013 for $6.4 billion for the PEPFAR program [76] and thus might be affordable from a donor's perspective, especially if the current trend of greater host country financial contribution to HIV programs continues. With the exception of Afghanistan, all 30 of the countries in which IPC was most cost-effective are in sub-Saharan Africa and in 51 countries, the cost-effectiveness of IPC compared favorably to ART.

The cost-effectiveness of IPCs varies greatly among the 70 countries we examined. This wide divergence is due primarily to differences in disease burden and therefore to the higher levels of incremental health benefit generated per incremental dollar spent for prevention. For example, Nigeria ranks 4th of the 70 countries based on DALYs per capita in the three diseases of the IPC, and Bangladesh ranks 55th. As shown in Figure 1, per-capita disease burden as measured by the opportunity index is highly correlated with cost-effectiveness. In the case of a single disease-intervention pair such a finding would be unsurprising since the cost-effectiveness of most prevention interventions depend importantly on incidence. It is more noteworthy here since the relative prevalence of the three diseases varies greatly between the countries we studied, and the effect on medical care costs of intervening also varies substantially among the three diseases. In spite of this variability, the opportunity index is a reasonably good guide to cost-effectiveness.

Costs of program delivery also matter. Swaziland, Botswana and South Africa have relatively unfavorable cost-effectiveness in relation to their disease burden. This is due primarily to their high per-capita GDP and thus the higher estimated non-commodity (mainly personnel) portion of their campaign costs. However, IPC cost-effectiveness still compares favorably to that of ART in all three countries.

Sensitivity of findings within each country reflects how the IPC interacts with local disease burden. Diarrhea is the largest contributor to the disease burden in Bangladesh, accounting for 87% of the DALYs averted by the IPC campaign. Not surprisingly, the most important determinant of cost-effectiveness was the estimated duration of the benefits of the water filter and the baseline incidence of diarrhea. Kenya has a far larger HIV epidemic, with a prevalence of 6.3% rather than 0.06% of adults as in Bangladesh. Accordingly, the largest determinants of IPC cost-effectiveness in Kenya were HIV-related in both one-way and multivariate sensitivity analyses. Nigeria's HIV prevalence of 3.6% is close to the average of 3.5% of the 70 countries examined. Nigeria's high IPC cost-effectiveness ranking is due to its high incidence of malaria and diarrhea, 252 and 765 cases per 1,000 person-years respectively, compared with median values of 52 and 521 for malaria and diarrhea respectively for the 70 countries studied.

Among the strengths of the current study are its synthesis of a large volume of epidemiological data from disparate sources into a unified method for projecting the consequence of IPC implementation in 70 countries, and the linking of the "opportunity index" concept with cost-effectiveness. This provides a more comprehensive assessment of intervention potential than assessment of cost-effectiveness alone. This data-driven process may be applied to other disease areas and facilitate more objective resource allocation decision-making.

Limitations of our approach include incomplete availability of data relevant to the large number of countries analyzed. Methods for approximation were therefore necessary. For example, the costs of the campaigns themselves were extrapolated from empirical Kenya-specific data using per-capita GDP ratios between Kenya and the other countries to estimate the non- tradable commodity portion of costs. For other variables such as the protective effects of HIV prevention, bed nets and water filters where country-specific information was absent we employed wide ranges in the sensitivity analyses to ensure that we accounted for uncertainty, and this produced wide confidence intervals around the model outcomes.

Because we looked at a large number of countries, we could not explore specific countries in detail. It was infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered. Comparing IPC with the estimated cost-effectiveness of ART for HIV does not account for the potential intervention options that are more efficient than both IPC and ART. Finally, there may be substantial regions or urban areas within countries that have costs, health benefits that depart from the overall country assessments to which our analysis is confined. The current analysis should not displace investigation of potential opportunities for efficient IPC implementation in high disease burden areas within countries.

This study increases confidence that IPC can be an important new approach for enhancing global health. IPC appears to be cost-effective compared to ART for HIV in many settings, and has the potential to substantially reduce the burden of disease in poor countries. If implemented with 15% population coverage in the top 40 of the 70 countries as ordered by cost-effectiveness, 47.3 million DALYs could be averted at a net cost of \$4.9 billion, or \$104 per DALY averted. The specific countries, or number of countries, a donor may want to fund will depend on resource availability, and this analysis provides substantial guidance to decision makers aiming to predict the costs and benefits of various levels of investments in IPC programs. If taken to scale, IPC can be a highly efficient strategy for improving global health.

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Author contributions

EM conceived and designed the study, conducted the analyses, and drafted and revised the paper. AJ provided data for the study, helped with the analyses and drafting and revision. AR provided data for the study and revised the draft paper. SV and JW critiqued the analysis helped with specifying data inputs, and revised the draft paper. JGK helped guide design and implementation of the study, helped with specifying data inputs and edited the paper.

Conflicts of interest

None declared.

Table 1. Base case values and sources for data inputs.

	Malaria	Diarrhea	HIV		Source(s)		
	LLIN	**Filters**	**VCT**	**Condoms**	**LLIN**	**Filters**	**VCT / condoms**
Health inputs							
Campaign participant per household	2.5				Post-campaign survey		
Number benefiting per campaign participant	**1.563**	**1.840**	0.950	0.361	Post-campaign survey		
Baseline cases per year per individual benefiting	**0.057**	**0.542**	0.004	0.009	[47, 48]	[49-51]	[8, 59-61] Post-campaign survey (see text)
Proportion of cases that are fatal	**0.012**	**0.001**	1	1	[47, 52, 54]	[48, 49, 51, 58, 62]	Assumption
DALYs incurred with each fatal case	28.0	28.0	15.1	15.1	[55]	[55]	[55]
DALYs incurred with each non-fatal case	0.0037	0.0012	n/a	n/a	[56, 57]	[56, 58]	N/a
Protective effect against mortality	0.50	0.63	0.50	0.26	[63], expert opinion	[64]	[65, 66]
Protective effect against non-fatal cases	0.5	0.63	n/a	n/a	[63]	[64]	N/a
Multiplier to capture secondary benefits	n/a	n/a	2	2	[67]	N/a	[68] (see text)
Years of benefit	3	3	1	1	[69, 70] Adjusted to 3 years per post-campaign evaluation.	[71] Adjusted to 3 years per post-campaign evaluation.	[65]
Access to care	0.684	**0.678**	0.700	0.700	[13-17, 72]	[19]	Assumption
Cost inputs							
Campaign cost	**$34,280**				[7] $31,980 plus additional $2,300 in revised filter maintenance costs		
Discount rate	3.0%				[10]		
Health care incurred with each fatality	**$65**	**$104**	**$12,213**	**$12,213**	[61, 73]	[74]	Authors' construction based on 22 years on ART at $766 per person-year discounted at 3% per annum.
Health care incurred with each non-fatal case	**$7.80**	**$7.00**	n/a	n/a	[75]	[74]	N/a

Table 2. Sensitivity analysis variables, base case, minimum and maximum values. All variables have beta distributions with alpha and beta parameters of 2. Minimum and maximum values are 0.5 and 1.5 of base case values, respectively, except for access to diarrhea disease care and malaria care which have minimum and maximums of 0.6 and 1.4, and access to HIV ART which has a minimum and maximum of 0.75 and 1.25. Bold figures represent values that change with each country.

	Nigeria			Kenya			Bangladesh		
Input parameter	Base case	Min	Max	Base case	Min	Max	Base case	Min	Max
Campaign cost	**$40,479**	**$20,239**	**$60,718**	**$34,280**	**$17,140**	**$51,420**	**$35,658**	**$17,829**	**$53,486**
Cost per fatality malaria	**$97.50**	**$48.75**	**$146.25**	**$65.00**	**$32.50**	**$97.50**	**$72.22**	**$36.11**	**$108.33**
Cost per fatality diarrhea	**$156.00**	**$78.00**	**$234.00**	**$104.00**	**$52.00**	**$156.00**	**$115.56**	**$57.78**	**$173.34**
Cost per non-fatal case malaria	**$11.70**	**$5.85**	**$17.55**	**$7.80**	**$3.90**	**$11.70**	**$8.67**	**$4.33**	**$13.00**
Cost per non-fatal case diarrhea	**$10.50**	**$5.25**	**$15.75**	**$7.00**	**$3.50**	**$10.50**	**$7.78**	**$3.89**	**$11.67**
Annual cost ART	**$938**	**$469**	**$1,407**	**$766**	**$383**	**$1,150**	**$766**	**$383**	**$1,150**
Discount rate	0.03	0.015	0.045	0.03	0.015	0.045	0.03	0.015	0.045
Access to care Diarrhea	**0.565**	**0.424**	**0.706**	**0.678**	**0.509**	**0.848**	**0.663**	**0.497**	**0.829**
Access to care Malaria	0.684	0.513	0.854	0.684	0.513	0.855	0.684	0.513	0.854
Access to ART	0.7	0.42	0.98	0.7	0.42	0.98	0.7	0.42	0.98
Years on ART	22	11	33	22	11	33	22	11	33
HIV prevalence	**0.036**	**0.018**	**0.054**	**0.063**	**0.032**	**0.095**	**0.0006**	**0.0003**	**0.0009**
Baseline cases p1000py Malaria	**351.6**	**175.8**	**527.5**	**57.0**	**28.5**	**85.5**	**6.13**	**3.06**	**9.19**
Baseline cases p1000py Diarrhea	**765.3**	**382.7**	**1148.0**	**542.0**	**271.0**	**813.0**	**299.81**	**149.91**	**449.72**
Propor fatal Malaria	**0.008**	**0.004**	**0.012**	**0.012**	**0.006**	**0.018**	**0.004**	**0.002**	**0.006**
Propor fatal Diarrhea	0.001	0.001	0.002	0.001	0.001	0.002	0.0007	0.0004	0.0011
Participants per HH	2.5	1.25	3.75	2.5	1.25	3.75	2.5	1.25	3.75
DALYs fatal malaria	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs fatal diarrhea	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs non-fatal malaria	0.366	0.183	0.549	0.366	0.183	0.549	0.366	0.183	0.549
DALYs non-fatal diarrhea	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191
Protect. mortality malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality diarrhea	0.630	0.315	0.945	0.630	0.315	0.945	0.630	0.315	0.945
Protect. non fatal malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. non fatal diarrhea	0.628	0.314	0.941	0.628	0.314	0.941	0.628	0.314	0.941
Protect. mortality HIV transmission	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality HIV acquisition	0.255	0.128	0.383	0.255	0.128	0.383	0.255	0.128	0.383
Multiplier: Secondary effects HIV	2	1	3	2	1	3	2	1	3
Duration of benefit malaria	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Duration of benefit diarrhea	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Duration of benefit HIV	1	0.5	1.5	1	0.5	1.5	1	0.5	1.5

Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most favorable to least favorable cost-effectiveness (net cost per DALY averted). The grey highlighted cells indicate CE ratio is less favorable than investment in ART. Results shown are for the first 3-year campaign.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$29,459	$7,814	40.7	10,523	1,143.3	$26	$7	$1,005
2	Senegal	Lower middle	0.050	$34,969	$12,190	10.7	5,735	306.0	$114	$40	$768
3	Sierra Leone	Low	0.119	$31,525	$20,112	16.0	4,118	446.7	$71	$45	$764
4	Burkina Faso	Low	0.126	$31,525	$22,206	16.4	4,124	459.4	$69	$48	$819
5	Somalia	Low	0.121	$26,015	$22,754	16.8	3,682	470.5	$55	$48	$1,535
6	Niger	Low	0.110	$28,081	$21,620	14.8	4,967	419.7	$67	$52	$1,095
7	Mali	Low	0.124	$29,459	$23,016	15.9	4,222	445.8	$66	$52	$888
8	Afghanistan	Low	0.057	$28,770	$18,906	12.7	4,146	356.6	$81	$53	$935
9	Chad	Low	0.120	$35,658	$24,848	15.3	4,335	424.6	$84	$59	$807
10	Lesotho	Lower middle	0.115	$35,658	$47,366	31.3	1,756	779.4	$46	$61	$738
11	Guinea	Low	0.095	$29,459	$22,324	12.6	4,272	353.8	$83	$63	$928
12	Congo, DR	Low	0.112	$24,637	$25,488	13.4	3,517	375.9	$66	$68	$1,493
13	Sudan	Lower middle	0.057	$38,413	$15,241	6.9	4,907	198.8	$193	$77	$703
14	Liberia	Low	0.092	$26,704	$25,526	11.9	3,401	332.6	$80	$77	$1,025
15	Burundi	Low	0.118	$26,015	$33,639	14.3	2,267	389.9	$67	$86	$987
16	Benin	Low	0.083	$33,591	$25,345	10.0	3,096	280.0	$120	$91	$910
17	Côte d'Ivoire	Lower middle	0.084	$33,591	$35,069	14.1	4,021	387.2	$87	$91	$801
18	Nigeria	Lower middle	0.133	$40,479	$34,769	13.4	3,102	369.3	$110	$94	$747
19	Mozambique	Low	0.141	$30,147	$59,145	22.2	3,816	590.0	$51	$100	$1,109
20	Cen. African Rep.	Low	0.105	$27,392	$37,525	13.8	2,819	373.3	$73	$101	$1,230
21	Uganda	Low	0.105	$31,525	$40,192	14.9	3,492	399.8	$79	$101	$749
22	Congo, Rep.	Lower middle	0.067	$54,254	$33,944	11.5	2,981	318.5	$170	$107	$756
23	Togo	Low	0.075	$29,459	$32,147	10.4	2,849	288.7	$102	$111	$864
24	Angola	Upper middle	0.088	$64,586	$35,794	11.5	3,268	320.8	$201	$112	$674
25	Tanzania	Low	0.075	$33,591	$38,453	12.1	3,122	326.9	$103	$118	$935
26	Zambia	Lower middle	0.128	$33,591	$69,806	21.8	3,107	564.3	$60	$124	$826
27	Ethiopia	Low	0.057	$30,147	$29,630	8.6	1,986	235.7	$128	$126	$1,139
28	Rwanda	Low	0.071	$31,525	$34,034	9.6	2,216	266.1	$118	$128	$768
29	Malawi	Low	0.110	$28,081	$59,745	18.3	2,965	462.2	$61	$129	$996
30	Cameroon	Lower middle	0.100	$37,724	$52,388	14.3	3,115	388.4	$97	$135	$741
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Mauritania	Lower middle	0.042	$36,346	$28,117	5.8	2,607	164.2	$221	$171	$955
33	Yemen	Lower middle	0.025	$37,035	$21,139	4.3	3,128	122.9	$301	$172	$719
34	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	428.8	$59	$178	$1,731
35	Pakistan	Lower middle	0.020	$41,856	$19,714	3.8	2,748	108.1	$387	$182	$904
36	Ghana	Lower middle	0.063	$44,612	$35,624	6.8	1,966	189.9	$235	$188	$746
37	Madagascar	Low	0.043	$28,770	$24,895	4.5	1,910	127.8	$225	$195	$1,025
38	Eritrea	Low	0.033	$27,392	$26,438	4.3	1,942	120.5	$227	$219	$1,753
39	Botswana	Upper middle	0.080	$137,595	$185,872	26.8	1,111	734.1	$187	$253	$577
40	Haiti	Low	0.028	$30,836	$31,570	4.4	3,128	123.0	$251	$257	$869
41	Swaziland	Lower middle	0.150	$58,387	$198,392	29.1	2,230	724.2	$81	$274	$632
42	Guatemala	Lower middle	0.016	$57,698	$22,134	2.4	3,143	70.1	$823	$316	$627
43	South Africa	Upper middle	0.097	$99,713	$180,284	21.5	1,150	561.0	$178	$321	$582
44	Gabon	Upper middle	0.060	$29,826	$84,306	9.3	1,876	255.0	$117	$331	$613
45	India	Lower middle	0.027	$48,744	$34,973	3.7	1,255	104.9	$464	$333	$733
46	Myanmar	Low	0.026	$31,525	$28,249	2.9	1,306	83.7	$377	$337	$1,354
47	Papua New Guinea	Lower middle	0.018	$40,479	$25,117	2.4	2,868	71.2	$568	$353	$864
48	Iraq	Upper middle	0.009	$53,565	$25,989	1.9	2,587	55.8	$960	$466	$758
49	Namibia	Upper middle	0.038	$75,606	$204,271	15.6	1,528	402.7	$188	$507	$606
50	Cambodia	Low	0.014	$38,413	$31,172	1.9	1,341	54.3	$708	$574	$739
51	Nepal	Low	0.010	$30,836	$28,994	1.4	1,135	39.8	$776	$729	$883
52	Morocco	Lower middle	0.006	$58,387	$42,818	1.9	1,623	54.8	$1,066	$782	$650
53	Bangladesh	Low	0.007	$35,658	$30,236	0.9	1,076	25.9	$1,377	$1,168	$1,046
54	Algeria	Upper middle	0.008	$73,540	$51,390	1.4	1,304	41.0	$1,793	$1,253	$606
55	Uzbekistan	Lower middle	0.006	$45,989	$25,637	0.6	2,352	18.2	$2,523	$1,406	$717
56	Ukraine	Lower middle	0.006	$74,228	$68,364	1.2	623	33.6	$2,210	$2,036	$600
57	Thailand	Upper middle	0.005	$90,759	$100,377	1.8	455	48.7	$1,863	$2,061	$622
58	Indonesia	Lower middle	0.008	$56,321	$46,677	0.7	814	20.8	$2,708	$2,244	$793
59	Bolivia	Lower middle	0.010	$56,321	$30,994	0.4	2,015	13.5	$4,178	$2,299	$668
60	Vietnam	Lower middle	0.005	$45,989	$40,910	0.6	828	17.6	$2,616	$2,327	$664
61	Colombia	Upper middle	0.003	$95,580	$63,657	0.6	1,419	20.5	$4,652	$3,098	$598
62	Peru	Upper middle	0.004	$95,580	$59,439	0.6	1,497	19.0	$5,026	$3,126	$613
63	Brazil	Upper middle	0.004	$104,534	$65,501	0.6	1,385	19.2	$5,431	$3,403	$581
64	Philippines	Lower middle	0.003	$51,499	$39,031	0.3	1,289	10.9	$4,746	$3,597	$724
65	Russian Federation	High: nonOECD	0.007	$143,794	$121,954	1.1	735	31.2	$4,607	$3,907	$579
66	Argentina	Upper middle	0.003	$147,238	$101,854	0.6	1,097	18.1	$8,155	$5,642	$577
67	Malaysia	Upper middle	0.004	$138,284	$104,408	0.6	930	17.6	$7,858	$5,933	$591
68	Turkey	Upper middle	0.001	$29,459	$58,058	0.1	1,784	6.1	$4,821	$9,501	$582
69	Mexico	Upper middle	0.003	$127,264	$134,901	0.3	0	9.6	$13,197	$13,989	$583
70	China	Upper middle	0.001	$84,560	$74,564	0.1	486	4.7	$18,015	$15,886	$638

Table 4. IPC costs, DALYs averted, and cost-effectiveness compared with no intervention, and incremental cost-effectiveness for 70 countries in increments of 10, ranked by cost-effectiveness. "Net costs" consist of IPC campaign costs adjusted for medical costs averted or added due to the campaign. Results assume 15% of population covered by IPC in each country. Costs in 2012 US$.

Countries	Campaign cost	Net cost		DALYs averted		Cost-effectiveness (compared with no intervention)		Incremental cost-effectiveness (compared with previous row)	
		Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2
Top 10	$583,177,366	$397,894,640	$468,463,768	8,047,765	5,708,048	$49	$82	n/a	n/a
Top 20	$2,387,027,516	$2,054,199,874	$2,067,515,989	27,062,539	16,290,756	$76	$127	$87	$151
Top 30	$3,714,990,510	$3,553,721,721	$3,338,446,785	39,613,366	23,819,194	$90	$140	$119	$169
Top 40*	$5,614,207,760	$4,942,809,191	$4,858,446,157	47,308,985	29,163,714	$104	$167	$181	$284
Top 50*	$16,236,860,722	$13,421,640,706	$13,946,462,307	72,652,651	49,829,348	$185	$280	$335	$440
Top 60	$22,258,435,675	$18,632,238,223	$19,414,467,973	75,731,913	51,855,152	$246	$374	$1,692	$2,699
Top 70	$51,294,946,151	$43,498,730,679	$46,290,783,278	78,713,520	53,217,470	$553	$870	$8,340	$19,728

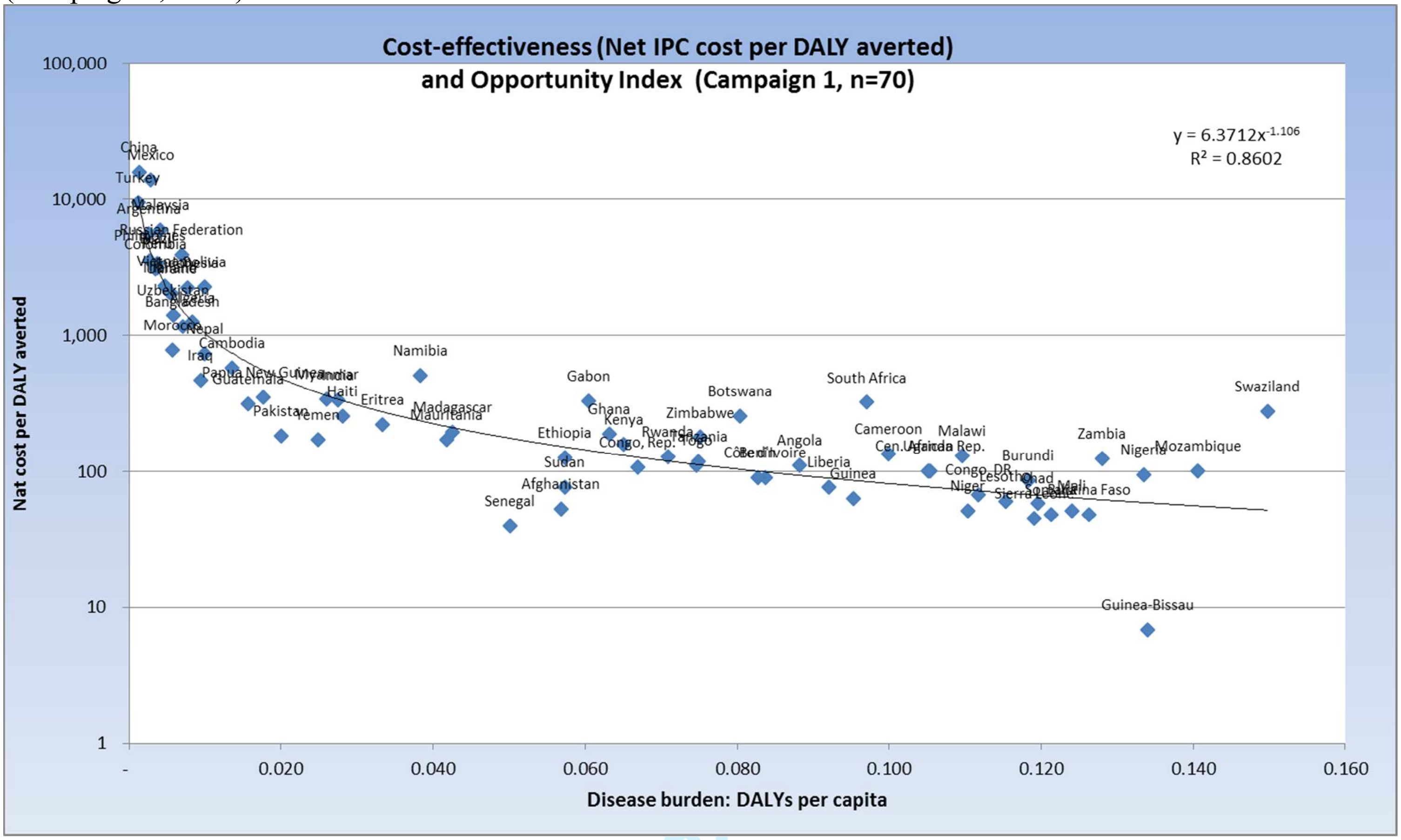
Table 5. Median cost-effectiveness (net cost per DALY averted) by 10-country increments in order of cost-effectiveness

Countries ranked by IPC cost-effectiveness	Campaign 1	Campaign 2	Antiretroviral therapy for HIV
Top 10	$50	$102	$854
11 - 20	$88	$141	$958
21 - 30	$121	$197	$797
31 - 40	$185	$318	$894
41 - 50	$335	$591	$683
51 - 60	$1,721	$3,514	$666
60 - 70	$4,774	$17,068	$587

Table 6. Multiway sensitivity analysis; 20,000- trial Monte Carlo simulation, 80% confidence Interval for three IPC outcomes and cost per DALY averted by ART for HIV for Kenya, Bangladesh and Nigeria.

Outcome	Kenya	Bangladesh	Nigeria
DALYs averted	206 - 407	13.1 - 45.8	228 - 564
Net Costs	$7,810 - $79,885	$18,566 - $41,473	$2,241- $61,448
Net cost per DALY averted (cost-effectiveness)	$23 - $304	$519 - $2,547	$5 - $208
Cost per DALY averted by ART for HIV	$883	$1,046	$747

Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (DALYs per capita)* (Campaign 1, n=70)



*An "opportunity index" variable created to measure the DALYs per capita across the three diseases of the IPC for each country

Figure 2. Tornado Graph of Cost per DALY averted –Nigeria: Impact by Input

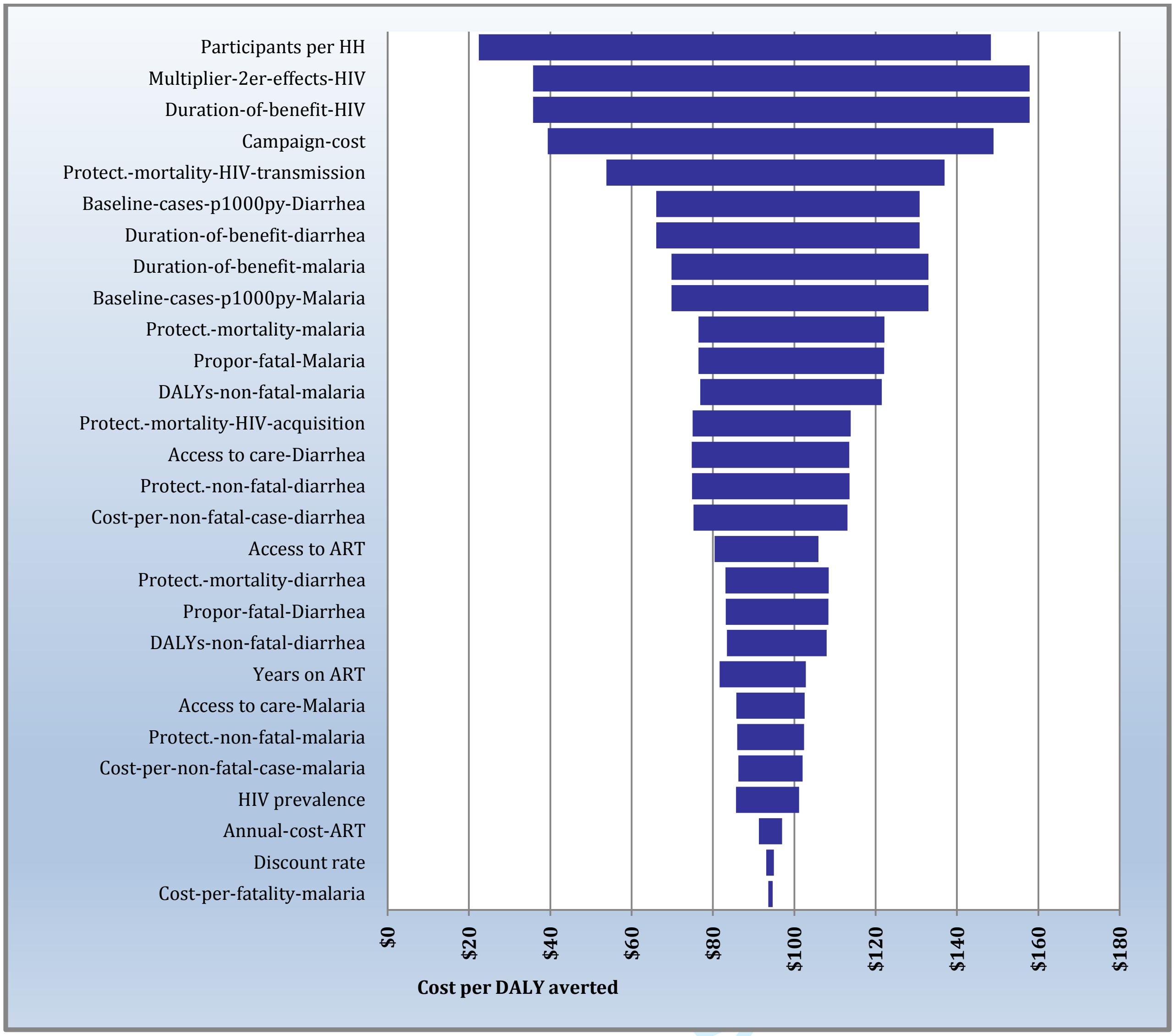


Figure 3. One-way sensitivity analysis of incremental cost-effectiveness by three key variables in 10-country increments ranked by IPC cost-effectiveness.

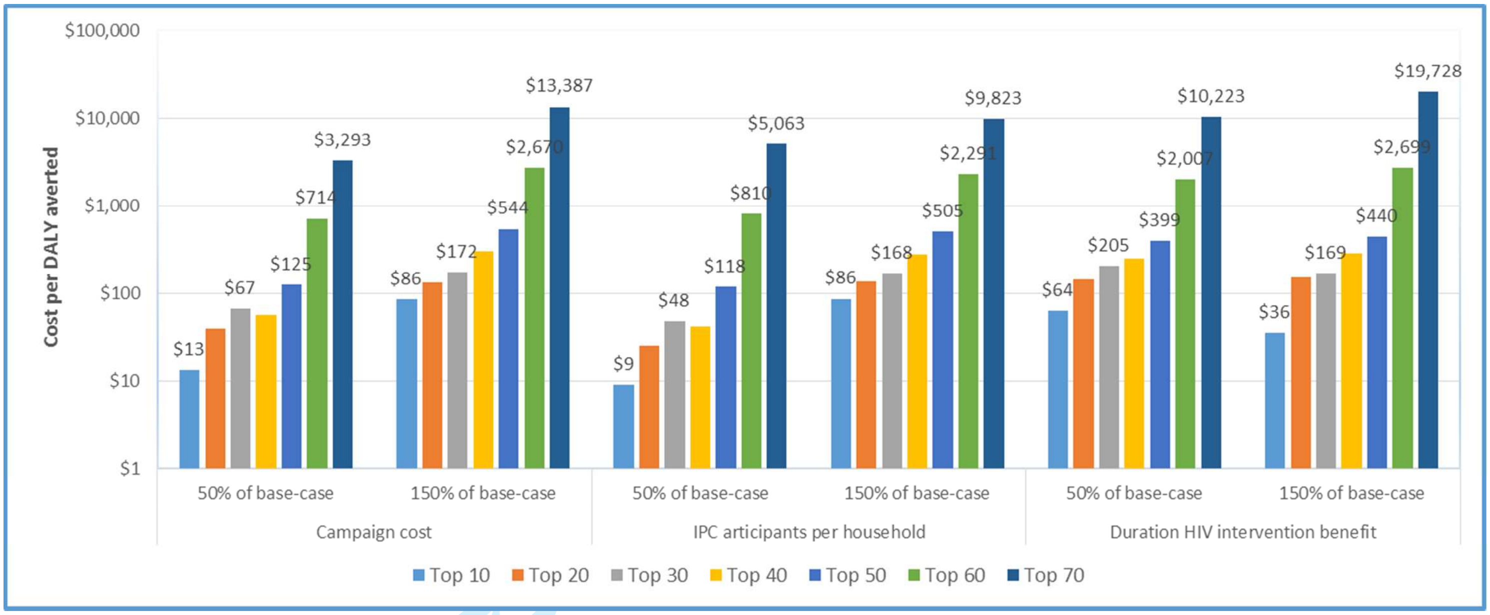
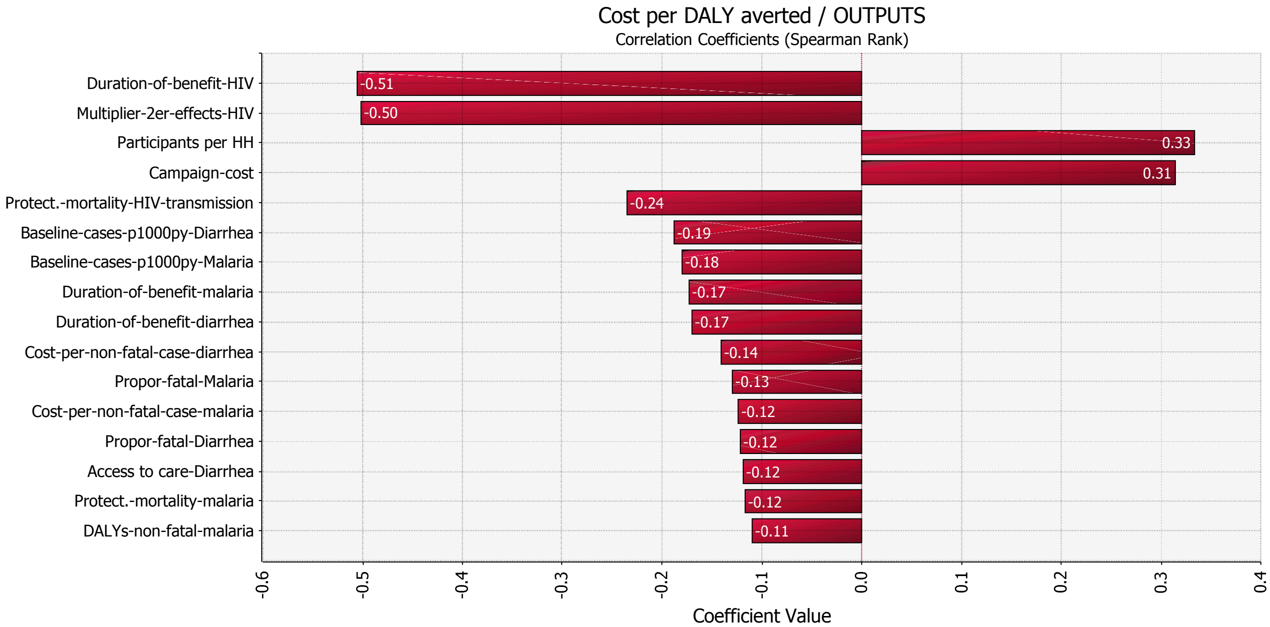


Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Nigeria.



Technical Supplement

Reduction in risk for malaria and HIV between first and second campaign

In this analysis, to explore sustainability, we examine both an initial campaign and a follow-up campaign three years later. Thus, we need to estimate the health benefit realized by the follow-up campaign, taking into account the stability of disease reduction offered initially. The more that initial protection decays over six years, and thus the larger the disease risk in years 4-6, the greater will be the benefit of a campaign at three years. This decay is a function of the physical durability of the commodities distributed, as well as maintenance of safer behaviors. The dynamics vary by disease.

For malaria we assume 75% as much disease incidence at years 4-6 (absent a 2nd campaign) as baseline incidence. In other words, we assume that full set of LLIN distributed in the *initial* campaign, with no follow-up campaign, would have half as much community benefit in years 4-6 as in years 1-3. Many LLIN will remain in place, and the insecticide impregnation itself is stable for close to 10 years. Thus, the 50% incidence drop expected with LLIN in years 1-3 will decrease but not disappear in the second 3 years. However, the second round of LLIN are likely to have a relative effectiveness less than 50%, because the best LLIN users are already protected. Thus we decrease the effectiveness from 50% to 33% (i.e., from 75% of baseline incidence to 50% of baseline incidence). In effect, the 2nd campaign is like a booster shot that returns effectiveness to its original level. In sum, the overall benefit of the second campaign is reduced by half -- in first campaign it was 100% of baseline incidence to 50%, and in the second campaign from 75% of baseline incidence to 50%.

We note that these estimates are assembled from isolated data (e.g., LLIN physical durability) combined with a logical framework and best guesses. Nonetheless, we believe that the conclusion – 50% as much benefit for a second campaign – is plausible, and is a far more realistic assumption than full benefit. Our approach is conservative regarding the second campaign – if the specified durability of effect of the LLIN is larger than in reality, we would be *under*estimating the benefit of this campaign. And our estimate of the combined effect of two sequential campaigns is robust. Low estimates of durability understate benefits of the first campaign and overstate benefits of the second campaign, which represent offsetting errors. Conversely, high estimates of durability overstate the value of the first campaign and understate second campaign benefits, again offsetting.

For diarrhea, we assume no filter benefit after three years. The filters are expected to last in good function only three years. Thus, the filter component of the second campaign is just as effective as for the first campaign.

For HIV, effects on DALYs and cost depend heavily on undiagnosed HIV prevalence. The first campaign detects almost all HIV-infected individuals. Thus, the effects of the second campaign depend mainly on the impact of 3 years of HIV incidence on (predominantly undiagnosed) HIV prevalence. This incidence has not been measured, but can be estimated from HIV prevalence using simple epidemic dynamics. [1]Steady-state (pre-ART) annual incidence is about 1/10th of prevalence (slightly more if prevalence above 10%, due to reduction in # of susceptibles). So, if initial prevalence was 5%, then annual incidence is about 0.5%, and prevalence at 3 years will be about 1.5%.

Incidence and thus prevalence could be even lower if ART reduces community viral load and also if VCT for HIV+ has substantial behavioral benefits. They could be higher if the first campaign selectively missed HIV+, eg they chose not to participate or were away in urban areas.

Diarrhea: estimation of average cases per PY and annual cases

Using data on the number of episodes per year in children under 5 [2], we estimated the average number of episodes (cases) per person-year in the overall population by weighting the incidence by the percentage of the population under five [3] and over five. We then adjusted the incidence in the >5 year-old population by the ratio of the country <5 incidence to the average global <5 incidence [4]. Multiplying each estimate by the total population [5] provided estimates of the number of cases of diarrhea in each country.

Explanation for difference between results reported in earlier analysis (Kahn, 2012) and current article. The earlier evaluation of the Integrated Prevention Campaign in Western Province, Kenya found that the 2008 campaign saved $16,015 and averted 442 DALYs per 1,000 campaign participants.[6] The current article finds a highly favorable cost-effectiveness ratio of $157 per DALY averted (net cost of $ 46,149 and 294 DALYs averted per 1,000 campaign participants), but no cost savings in the base-case analysis for Kenya. The difference can be attributed to the aggregate effect of changes in input parameter values of two types: (a) ***Geographic shift from Western Province to Kenya in general.*** The earlier analysis calculated the number of beneficiaries per household based on household size data from the campaign communities, 7.7 persons. In the current article, we used the lower national figure of 4.6, assumed to reflect fewer children per household [7]. The total benefits of the malaria and diarrheal disease interventions fell accordingly. The current article also uses lower figures for malaria and diarrhea annual incidence, 0.057 and 0.542 per individual for Kenya, respectively, versus 0.30 and 1.75 as found in the 2008 survey in Western Province. (b) ***Refined data on care seeking***. The 2012 article assumed 100% care-seeking for diarrhea and malaria. Subsequently, we obtained data on care-seeking patterns, though not specific to Kenya. The current article thus assumes 67.8% for diarrheal diseases and 68.4% for malaria. In addition, we adjusted two cost inputs. The campaign cost was updated to include a recent water filter maintenance program to $34,280 from $32,000 in the earlier paper. Based on a more complete review of the relevant literature including new findings on life expectancy for people receiving antiretroviral therapy (ART), we also increased the estimated lifetime cost of ART, from $5,092 to $12,213.

Tech. Suppl. - Table 1: Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most to least cost-effective. The grey highlighted cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the second and subsequent 3-year campaigns.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$29,459	$16,675	26.9	5,465.3	754.3	$22	$39	$1,005
2	Somalia	Low	0.121	$26,015	$23,643	11.6	2,055.1	325.2	$73	$80	$768
3	Afghanistan	Low	0.057	$28,770	$22,700	12.2	2,380.6	342.0	$66	$84	$764
4	Congo, DR	Low	0.112	$24,637	$24,258	9.3	1,851.9	259.2	$94	$95	$819
5	Niger	Low	0.110	$28,081	$24,250	10.0	2,648.0	282.6	$86	$99	$1,535
6	Mali	Low	0.124	$29,459	$25,298	10.0	2,312.1	280.1	$90	$105	$1,095
7	Burundi	Low	0.118	$26,015	$27,699	8.7	1,256.5	239.8	$116	$108	$888
8	Sierra Leone	Low	0.119	$31,525	$24,508	9.8	2,142.5	274.1	$89	$115	$935
9	Mozambique	Low	0.141	$30,147	$36,613	9.7	1,975.5	260.0	$141	$116	$807
10	Burkina Faso	Low	0.126	$31,525	$26,076	9.6	2,153.3	270.2	$96	$117	$738
11	Chad	Low	0.120	$35,658	$27,805	10.6	2,258.2	294.9	$94	$121	$928
12	Lesotho	Lower middle	0.115	$35,658	$37,171	11.7	919.3	283.6	$131	$126	$1,493
13	Malawi	Low	0.110	$28,081	$36,299	8.6	1,532.3	221.8	$164	$127	$703
14	Zambia	Lower middle	0.128	$33,591	$41,222	10.1	1,660.1	263.4	$156	$128	$1,025
15	Liberia	Low	0.092	$26,704	$25,199	6.8	1,762.6	190.4	$132	$140	$987
16	Guinea	Low	0.095	$29,459	$25,199	7.4	2,175.8	208.8	$121	$141	$910
17	Cen. African Rep.	Low	0.105	$27,392	$29,606	7.1	1,443.6	194.2	$152	$141	$801
18	Uganda	Low	0.105	$31,525	$31,104	7.9	1,841.7	214.8	$145	$147	$747
19	Zimbabwe	Low	0.075	$25,326	$40,453	6.9	905.4	165.8	$244	$153	$1,109
20	Côte d'Ivoire	Lower middle	0.084	$33,591	$31,110	7.8	2,009.7	214.9	$145	$156	$1,230
21	Ethiopia	Low	0.057	$30,147	$28,881	6.5	1,128.0	181.8	$159	$166	$749
22	Cameroon	Lower middle	0.100	$37,724	$39,507	8.1	1,620.0	223.1	$177	$169	$756
23	Senegal	Lower middle	0.050	$34,969	$22,535	6.8	2,951.7	193.6	$116	$181	$864
24	Togo	Low	0.075	$29,459	$28,877	5.5	1,466.8	153.3	$188	$192	$674
25	Rwanda	Low	0.071	$31,525	$30,620	5.9	1,248.9	163.9	$187	$192	$935
26	Tanzania	Low	0.075	$33,591	$32,273	6.1	1,636.6	167.4	$193	$201	$826
27	Benin	Low	0.083	$33,591	$28,793	5.9	1,611.1	167.1	$172	$201	$1,139
28	Swaziland	Lower middle	0.150	$58,387	$87,699	11.5	1,280.6	281.0	$312	$208	$768
29	Nigeria	Lower middle	0.133	$40,479	$34,860	6.7	1,610.1	187.0	$186	$217	$996
30	Kenya	Low	0.065	$34,280	$35,682	5.2	1,130.6	142.8	$250	$240	$741
31	Gabon	Upper middle	0.060	$29,826	$46,367	4.0	972.5	110.7	$419	$269	$883
32	Congo, Rep.	Lower middle	0.067	$54,254	$42,228	7.2	1,522.2	199.0	$212	$273	$955
33	Angola	Upper middle	0.088	$64,586	$44,239	8.5	1,758.3	236.6	$187	$273	$719
34	Sudan	Lower middle	0.057	$38,413	$24,940	4.8	2,620.5	136.6	$183	$281	$1,731
35	Mauritania	Lower middle	0.042	$36,346	$31,642	4.4	1,397.4	123.1	$257	$295	$904
36	Madagascar	Low	0.043	$28,770	$26,424	3.0	1,079.4	84.6	$312	$340	$746
37	Eritrea	Low	0.033	$27,392	$26,191	2.8	1,117.1	78.5	$334	$349	$1,025
38	Yemen	Lower middle	0.025	$37,035	$27,682	3.5	1,778.2	99.3	$279	$373	$1,753
39	Ghana	Lower middle	0.063	$44,612	$38,058	4.2	1,006.4	117.8	$323	$379	$577
40	Haiti	Low	0.028	$30,836	$29,010	2.8	1,789.6	80.4	$361	$384	$869
41	Pakistan	Lower middle	0.020	$41,856	$28,870	3.6	1,574.8	102.7	$281	$407	$632
42	South Africa	Upper middle	0.097	$99,713	$115,007	9.1	659.2	235.9	$487	$423	$627
43	Namibia	Upper middle	0.038	$75,606	$106,711	5.9	855.9	150.8	$708	$502	$582
44	India	Lower middle	0.027	$48,744	$40,648	3.4	713.2	96.2	$422	$506	$613
45	Botswana	Upper middle	0.080	$137,595	$139,112	9.9	634.1	262.4	$530	$524	$733
46	Myanmar	Low	0.026	$31,525	$29,473	1.7	672.6	48.0	$614	$657	$1,354
47	Cambodia	Low	0.014	$38,413	$33,905	1.3	758.8	37.6	$901	$1,020	$864
48	Nepal	Low	0.010	$30,836	$29,442	1.1	654.7	30.0	$982	$1,028	$758
49	Iraq	Upper middle	0.009	$53,565	$37,274	1.7	1,493.0	50.4	$740	$1,063	$606
50	Guatemala	Lower middle	0.016	$57,698	$35,999	1.8	1,812.5	51.6	$698	$1,118	$739
51	Papua New Guinea	Lower middle	0.018	$40,479	$31,703	1.2	1,488.7	35.8	$885	$1,130	$883
52	Bangladesh	Low	0.007	$35,658	$32,480	0.8	617.4	23.0	$1,413	$1,551	$650
53	Morocco	Lower middle	0.006	$58,387	$49,883	1.1	898.4	31.6	$1,577	$1,846	$1,046
54	Algeria	Upper middle	0.008	$73,540	$60,354	1.3	752.8	38.2	$1,580	$1,925	$606
55	Uzbekistan	Lower middle	0.006	$45,989	$34,086	0.5	1,357.2	14.9	$2,282	$3,079	$717
56	Indonesia	Lower middle	0.008	$56,321	$50,560	0.5	463.2	14.3	$3,545	$3,949	$600
57	Thailand	Upper middle	0.005	$90,759	$90,800	0.8	261.3	21.7	$4,177	$4,175	$622
58	Vietnam	Lower middle	0.005	$45,989	$42,516	0.3	477.7	8.2	$5,164	$5,586	$793
59	Philippines	Lower middle	0.003	$51,499	$44,213	0.3	743.4	8.8	$5,026	$5,854	$668
60	Ukraine	Lower middle	0.006	$74,228	$69,343	0.4	359.1	11.5	$6,052	$6,479	$664
61	Bolivia	Lower middle	0.010	$56,321	$41,435	0.2	1,162.3	8.2	$5,044	$6,856	$598
62	Peru	Upper middle	0.004	$95,580	$73,664	0.3	862.2	9.6	$7,650	$9,926	$613
63	Colombia	Upper middle	0.003	$95,580	$75,850	0.3	817.2	8.8	$8,575	$10,806	$581
64	Brazil	Upper middle	0.004	$104,534	$81,187	0.3	798.2	9.0	$9,029	$11,626	$724
65	Russian Federation	High: nonOECD	0.007	$143,794	$128,452	0.4	424.3	10.8	$11,898	$13,319	$579
66	Malaysia	Upper middle	0.004	$138,284	$117,395	0.2	536.0	6.6	$17,673	$20,818	$577
67	Argentina	Upper middle	0.003	$147,238	$119,687	0.2	632.8	6.8	$17,487	$21,512	$591
68	Turkey	Upper middle	0.001	$125,197	$86,272	0.1	1,029.3	3.9	$22,267	$32,314	$582
69	China	Upper middle	0.001	$84,560	$78,518	0.1	280.4	2.3	$33,785	$36,384	$583
70	Mexico	Upper middle	0.003	$127,264	$129,804	0.1	0.1	3.2	$40,371	$39,581	$638

Tech. Suppl. - Table 2. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest opportunity index score reflecting per-capita HIV, TB and malaria disease burden. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Swaziland	Lower middle	0.150	$58,387	$198,392	29.1	2,230	724.2	$81	$274	$632
2	Mozambique	Low	0.141	$30,147	$59,145	22.2	3,816	590.0	$51	$100	$1,109
3	Guinea-Bissau	Low	0.134	$29,459	$7,814	40.7	10,523	1143.3	$26	$7	$1,005
4	Nigeria	Lower middle	0.133	$40,479	$34,769	13.4	3,102	369.3	$110	$94	$747
5	Zambia	Lower middle	0.128	$33,591	$69,806	21.8	3,107	564.3	$60	$124	$826
6	Burkina Faso	Low	0.126	$31,525	$22,206	16.4	4,124	459.4	$69	$48	$819
7	Mali	Low	0.124	$29,459	$23,016	15.9	4,222	445.8	$66	$52	$888
8	Somalia	Low	0.121	$26,015	$22,754	16.8	3,682	470.5	$55	$48	$1,535
9	Chad	Low	0.120	$35,658	$24,848	15.3	4,335	424.6	$84	$59	$807
10	Sierra Leone	Low	0.119	$31,525	$20,112	16.0	4,118	446.7	$71	$45	$764
11	Burundi	Low	0.118	$26,015	$33,639	14.3	2,267	389.9	$67	$86	$987
12	Lesotho	Lower middle	0.115	$35,658	$47,366	31.3	1,756	779.4	$46	$61	$738
13	Congo, DR	Low	0.112	$24,637	$25,488	13.4	3,517	375.9	$66	$68	$1,493
14	Niger	Low	0.110	$28,081	$21,620	14.8	4,967	419.7	$67	$52	$1,095
15	Malawi	Low	0.110	$28,081	$59,745	18.3	2,965	462.2	$61	$129	$996
16	Cen. African Rep.	Low	0.105	$27,392	$37,525	13.8	2,819	373.3	$73	$101	$1,230
17	Uganda	Low	0.105	$31,525	$40,192	14.9	3,492	399.8	$79	$101	$749
18	Cameroon	Lower middle	0.100	$37,724	$52,388	14.3	3,115	388.4	$97	$135	$741
19	South Africa	Upper middle	0.097	$99,713	$180,284	21.5	1,150	561.0	$178	$321	$582
20	Guinea	Low	0.095	$29,459	$22,324	12.6	4,272	353.8	$83	$63	$928
21	Liberia	Low	0.092	$26,704	$25,526	11.9	3,401	332.6	$80	$77	$1,025
22	Angola	Upper middle	0.088	$64,586	$35,794	11.5	3,268	320.8	$201	$112	$674
23	Côte d'Ivoire	Lower middle	0.084	$33,591	$35,069	14.1	4,021	387.2	$87	$91	$801
24	Benin	Low	0.083	$33,591	$25,345	10.0	3,096	280.0	$120	$91	$910
25	Botswana	Upper middle	0.080	$137,595	$185,872	26.8	1,111	734.1	$187	$253	$577
26	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	428.8	$59	$178	$1,731
27	Tanzania	Low	0.075	$33,591	$38,453	12.1	3,122	326.9	$103	$118	$935
28	Togo	Low	0.075	$29,459	$32,147	10.4	2,849	288.7	$102	$111	$864
29	Rwanda	Low	0.071	$31,525	$34,034	9.6	2,216	266.1	$118	$128	$768
30	Congo, Rep.	Lower middle	0.067	$54,254	$33,944	11.5	2,981	318.5	$170	$107	$756
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Ghana	Lower middle	0.063	$44,612	$35,624	6.8	1,966	189.9	$235	$188	$746
33	Gabon	Upper middle	0.060	$29,826	$84,306	9.3	1,876	255.0	$117	$331	$613
34	Ethiopia	Low	0.057	$30,147	$29,630	8.6	1,986	235.7	$128	$126	$1,139
35	Sudan	Lower middle	0.057	$38,413	$15,241	6.9	4,907	198.8	$193	$77	$703
36	Afghanistan	Low	0.057	$28,770	$18,906	12.7	4,146	356.6	$81	$53	$935
37	Senegal	Lower middle	0.050	$34,969	$12,190	10.7	5,735	306.0	$114	$40	$768
38	Madagascar	Low	0.043	$28,770	$24,895	4.5	1,910	127.8	$225	$195	$1,025
39	Mauritania	Lower middle	0.042	$36,346	$28,117	5.8	2,607	164.2	$221	$171	$955
40	Namibia	Upper middle	0.038	$75,606	$204,271	15.6	1,528	402.7	$188	$507	$606
41	Eritrea	Low	0.033	$27,392	$26,438	4.3	1,942	120.5	$227	$219	$1,753
42	Haiti	Low	0.028	$30,836	$31,570	4.4	3,128	123.0	$251	$257	$869
43	India	Lower middle	0.027	$48,744	$34,973	3.7	1,255	104.9	$464	$333	$733
44	Myanmar	Low	0.026	$31,525	$28,249	2.9	1,306	83.7	$377	$337	$1,354
45	Yemen	Lower middle	0.025	$37,035	$21,139	4.3	3,128	122.9	$301	$172	$719
46	Pakistan	Lower middle	0.020	$41,856	$19,714	3.8	2,748	108.1	$387	$182	$904
47	Papua New Guinea	Lower middle	0.018	$40,479	$25,117	2.4	2,868	71.2	$568	$353	$864
48	Guatemala	Lower middle	0.016	$57,698	$22,134	2.4	3,143	70.1	$823	$316	$627
49	Cambodia	Low	0.014	$38,413	$31,172	1.9	1,341	54.3	$708	$574	$739
50	Nepal	Low	0.010	$30,836	$28,994	1.4	1,135	39.8	$776	$729	$883
51	Bolivia	Lower middle	0.010	$56,321	$30,994	0.4	2,015	13.5	$4,178	$2,299	$668
52	Iraq	Upper middle	0.009	$53,565	$25,989	1.9	2,587	55.8	$960	$466	$758
53	Algeria	Upper middle	0.008	$73,540	$51,390	1.4	1,304	41.0	$1,793	$1,253	$606
54	Indonesia	Lower middle	0.008	$56,321	$46,677	0.7	814	20.8	$2,708	$2,244	$793
55	Bangladesh	Low	0.007	$35,658	$30,236	0.9	1,076	25.9	$1,377	$1,168	$1,046
56	Russian Federation	High: nonOECD	0.007	$143,794	$121,954	1.1	735	31.2	$4,607	$3,907	$579
57	Uzbekistan	Lower middle	0.006	$45,989	$25,637	0.6	2,352	18.2	$2,523	$1,406	$717
58	Morocco	Lower middle	0.006	$58,387	$42,818	1.9	1,623	54.8	$1,066	$782	$650
59	Ukraine	Lower middle	0.006	$74,228	$68,364	1.2	623	33.6	$2,210	$2,036	$600
60	Thailand	Upper middle	0.005	$90,759	$100,377	1.8	455	48.7	$1,863	$2,061	$622
61	Vietnam	Lower middle	0.005	$45,989	$40,910	0.6	828	17.6	$2,616	$2,327	$664
62	Malaysia	Upper middle	0.004	$138,284	$104,408	0.6	930	17.6	$7,858	$5,933	$591
63	Brazil	Upper middle	0.004	$104,534	$65,501	0.6	1,385	19.2	$5,431	$3,403	$581
64	Peru	Upper middle	0.004	$95,580	$59,439	0.6	1,497	19.0	$5,026	$3,126	$613
65	Colombia	Upper middle	0.003	$95,580	$63,657	0.6	1,419	20.5	$4,652	$3,098	$598
66	Mexico	Upper middle	0.003	$127,264	$134,901	0.3	0	9.6	$13,197	$13,989	$583
67	Philippines	Lower middle	0.003	$51,499	$39,031	0.3	1,289	10.9	$4,746	$3,597	$724
68	Argentina	Upper middle	0.003	$147,238	$101,854	0.6	1,097	18.1	$8,155	$5,642	$577
69	China	Upper middle	0.001	$84,560	$74,564	0.1	486	4.7	$18,015	$15,886	$638
70	Turkey	Upper middle	0.001	$125,197	$58,058	0.1	1,784	6.1	$20,489	$9,501	$582

Tech. Suppl. - Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest opportunity index score reflecting per-capita HIV, TB and malaria disease burden. Grey highlighted cells indicate cost-effectiveness ratios less favorable than investment in ART Results shown are for the second and subsequent 3-year campaigns.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Swaziland	Lower middle	0.150	$58,387	$87,699	11.5	1,281	281.0	$312	$208	$632
2	Mozambique	Low	0.141	$30,147	$36,613	9.7	1,976	260.0	$141	$116	$1,109
3	Guinea-Bissau	Low	0.134	$29,459	$16,675	26.9	5,465	754.3	$22	$39	$1,005
4	Nigeria	Lower middle	0.133	$40,479	$34,860	6.7	1,610	187.0	$186	$217	$747
5	Zambia	Lower middle	0.128	$33,591	$41,222	10.1	1,660	263.4	$156	$128	$826
6	Burkina Faso	Low	0.126	$31,525	$26,076	9.6	2,153	270.2	$96	$117	$819
7	Mali	Low	0.124	$29,459	$25,298	10.0	2,312	280.1	$90	$105	$888
8	Somalia	Low	0.121	$26,015	$23,643	11.6	2,055	325.2	$73	$80	$1,535
9	Chad	Low	0.120	$35,658	$27,805	10.6	2,258	294.9	$94	$121	$807
10	Sierra Leone	Low	0.119	$31,525	$24,508	9.8	2,143	274.1	$89	$115	$764
11	Burundi	Low	0.118	$26,015	$27,699	8.7	1,256	239.8	$116	$108	$987
12	Lesotho	Lower middle	0.115	$35,658	$37,171	11.7	919	283.6	$131	$126	$738
13	Congo, DR	Low	0.112	$24,637	$24,258	9.3	1,852	259.2	$94	$95	$1,493
14	Niger	Low	0.110	$28,081	$24,250	10.0	2,648	282.6	$86	$99	$1,095
15	Malawi	Low	0.110	$28,081	$36,299	8.6	1,532	221.8	$164	$127	$996
16	Cen. African Rep.	Low	0.105	$27,392	$29,606	7.1	1,444	194.2	$152	$141	$1,230
17	Uganda	Low	0.105	$31,525	$31,104	7.9	1,842	214.8	$145	$147	$749
18	Cameroon	Lower middle	0.100	$37,724	$39,507	8.1	1,620	223.1	$177	$169	$741
19	South Africa	Upper middle	0.097	$99,713	$115,007	9.1	659	235.9	$487	$423	$582
20	Guinea	Low	0.095	$29,459	$25,199	7.4	2,176	208.8	$121	$141	$928
21	Liberia	Low	0.092	$26,704	$25,199	6.8	1,763	190.4	$132	$140	$1,025
22	Angola	Upper middle	0.088	$64,586	$44,239	8.5	1,758	236.6	$187	$273	$674
23	Côte d'Ivoire	Lower middle	0.084	$33,591	$31,110	7.8	2,010	214.9	$145	$156	$801
24	Benin	Low	0.083	$33,591	$28,793	5.9	1,611	167.1	$172	$201	$910
25	Botswana	Upper middle	0.080	$137,595	$139,112	9.9	634	262.4	$530	$524	$577
26	Zimbabwe	Low	0.075	$25,326	$40,453	6.9	905	165.8	$244	$153	$1,731
27	Tanzania	Low	0.075	$33,591	$32,273	6.1	1,637	167.4	$193	$201	$935
28	Togo	Low	0.075	$29,459	$28,877	5.5	1,467	153.3	$188	$192	$864
29	Rwanda	Low	0.071	$31,525	$30,620	5.9	1,249	163.9	$187	$192	$768
30	Congo, Rep.	Lower middle	0.067	$54,254	$42,228	7.2	1,522	199.0	$212	$273	$756
31	Kenya	Low	0.065	$34,280	$35,682	5.2	1,131	142.8	$250	$240	$883
32	Ghana	Lower middle	0.063	$44,612	$38,058	4.2	1,006	117.8	$323	$379	$746
33	Gabon	Upper middle	0.060	$29,826	$46,367	4.0	972	110.7	$419	$269	$613
34	Ethiopia	Low	0.057	$30,147	$28,881	6.5	1,128	181.8	$159	$166	$1,139
35	Sudan	Lower middle	0.057	$38,413	$24,940	4.8	2,620	136.6	$183	$281	$703
36	Afghanistan	Low	0.057	$28,770	$22,700	12.2	2,381	342.0	$66	$84	$935
37	Senegal	Lower middle	0.050	$34,969	$22,535	6.8	2,952	193.6	$116	$181	$768
38	Madagascar	Low	0.043	$28,770	$26,424	3.0	1,079	84.6	$312	$340	$1,025
39	Mauritania	Lower middle	0.042	$36,346	$31,642	4.4	1,397	123.1	$257	$295	$955
40	Namibia	Upper middle	0.038	$75,606	$106,711	5.9	856	150.8	$708	$502	$606
41	Eritrea	Low	0.033	$27,392	$26,191	2.8	1,117	78.5	$334	$349	$1,753
42	Haiti	Low	0.028	$30,836	$29,010	2.8	1,790	80.4	$361	$384	$869
43	India	Lower middle	0.027	$48,744	$40,648	3.4	713	96.2	$422	$506	$733
44	Myanmar	Low	0.026	$31,525	$29,473	1.7	673	48.0	$614	$657	$1,354
45	Yemen	Lower middle	0.025	$37,035	$27,682	3.5	1,778	99.3	$279	$373	$719
46	Pakistan	Lower middle	0.020	$41,856	$28,870	3.6	1,575	102.7	$281	$407	$904
47	Papua New Guinea	Lower middle	0.018	$40,479	$31,703	1.2	1,489	35.8	$885	$1,130	$864
48	Guatemala	Lower middle	0.016	$57,698	$35,999	1.8	1,813	51.6	$698	$1,118	$627
49	Cambodia	Low	0.014	$38,413	$33,905	1.3	759	37.6	$901	$1,020	$739
50	Nepal	Low	0.010	$30,836	$29,442	1.1	655	30.0	$982	$1,028	$883
51	Bolivia	Lower middle	0.010	$56,321	$41,435	0.2	1,162	8.2	$5,044	$6,856	$668
52	Iraq	Upper middle	0.009	$53,565	$37,274	1.7	1,493	50.4	$740	$1,063	$758
53	Algeria	Upper middle	0.008	$73,540	$60,354	1.3	753	38.2	$1,580	$1,925	$606
54	Indonesia	Lower middle	0.008	$56,321	$50,560	0.5	463	14.3	$3,545	$3,949	$793
55	Bangladesh	Low	0.007	$35,658	$32,480	0.8	617	23.0	$1,413	$1,551	$1,046
56	Russian Federation	High: nonOECD	0.007	$143,794	$128,452	0.4	424	10.8	$11,898	$13,319	$579
57	Uzbekistan	Lower middle	0.006	$45,989	$34,086	0.5	1,357	14.9	$2,282	$3,079	$717
58	Morocco	Lower middle	0.006	$58,387	$49,883	1.1	898	31.6	$1,577	$1,846	$650
59	Ukraine	Lower middle	0.006	$74,228	$69,343	0.4	359	11.5	$6,052	$6,479	$600
60	Thailand	Upper middle	0.005	$90,759	$90,800	0.8	261	21.7	$4,177	$4,175	$622
61	Vietnam	Lower middle	0.005	$45,989	$42,516	0.3	478	8.2	$5,164	$5,586	$664
62	Malaysia	Upper middle	0.004	$138,284	$117,395	0.2	536	6.6	$17,673	$20,818	$591
63	Brazil	Upper middle	0.004	$104,534	$81,187	0.3	798	9.0	$9,029	$11,626	$581
64	Peru	Upper middle	0.004	$95,580	$73,664	0.3	862	9.6	$7,650	$9,926	$613
65	Colombia	Upper middle	0.003	$95,580	$75,850	0.3	817	8.8	$8,575	$10,806	$598
66	Mexico	Upper middle	0.003	$127,264	$129,804	0.1	0	3.2	$40,371	$39,581	$583
67	Philippines	Lower middle	0.003	$51,499	$44,213	0.3	743	8.8	$5,026	$5,854	$724
68	Argentina	Upper middle	0.003	$147,238	$119,687	0.2	633	6.8	$17,487	$21,512	$577
69	China	Upper middle	0.001	$84,560	$78,518	0.1	280	2.3	$33,785	$36,384	$638
70	Turkey	Upper middle	0.001	$125,197	$86,272	0.1	1,029	3.9	$22,267	$32,314	$582

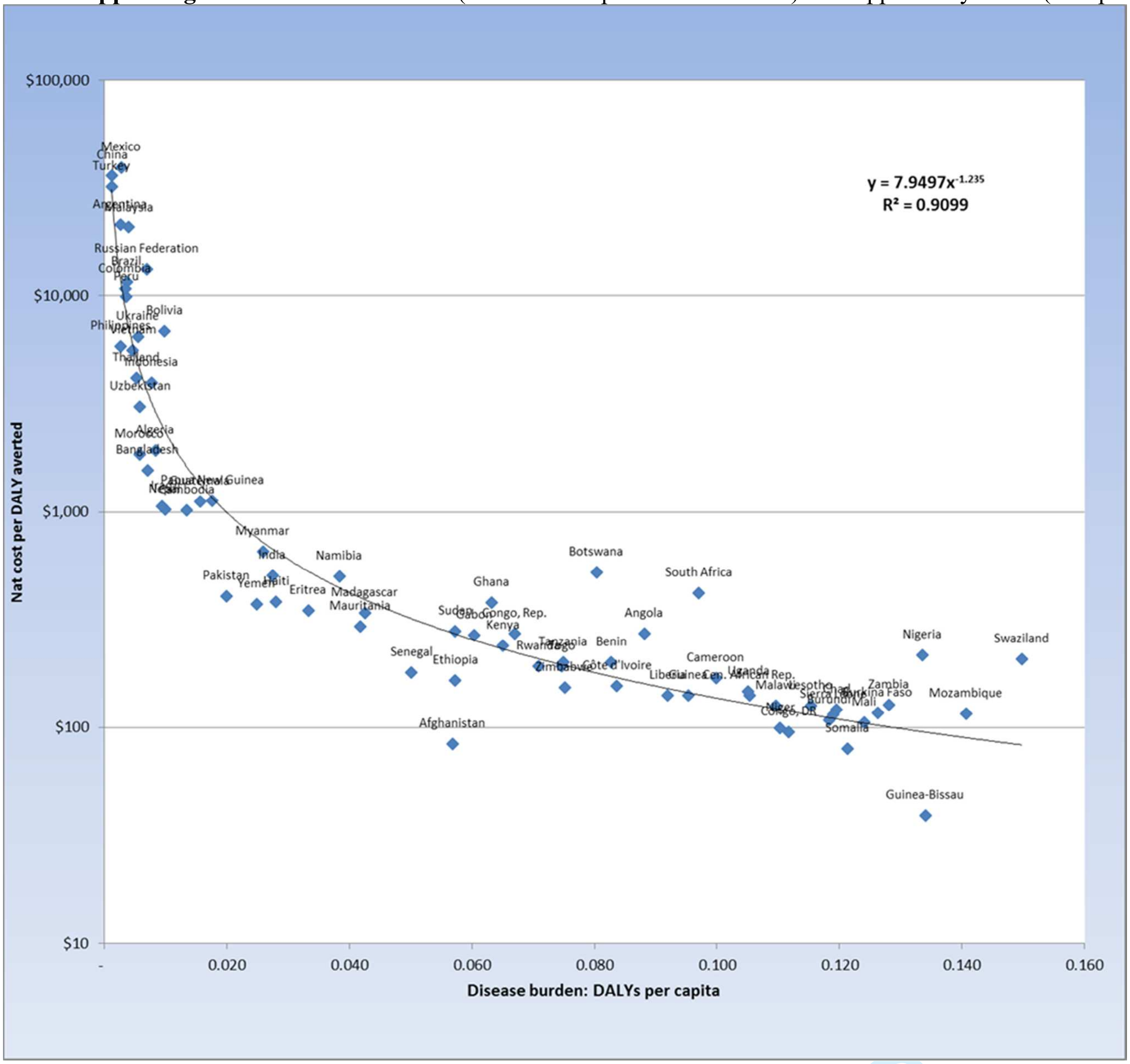
Tech. Suppl. - Table 4. Results for Kenya, Bangladesh and Nigeria, per 1000 campaign participants.

		Malaria	Diarrhea	HIV		
		LLITN	Filters	VCT	Condoms	TOTAL
Kenya						
Disease averted	Deaths	1.6	2.4	4.8	2.2	10.9
	Episodes	133.6	1,877.7	7.0		2,018.3
DALYs averted	Prevention	44.1	68.3	40.0	18.2	170.6
	Earlier HIV care			123.5		123.5
	TOTAL	44.1	68.3	181.8		294.1
Costs averted (added)	Prevention	$773	$9,068	$40,889	$18,588	$69,318
	Earlier HIV care			($81,187)		($81,187)
	TOTAL	$773	$9,068	($21,710)		-$11,869
Cost-effective ness	Campaign cost (unadjusted)					$34,280
	Net cost (savings)					$46,149
	Cost per DALY averted					$157
Bangladesh						
Disease averted	Deaths	0.1	0.8	0.0	0.0	0.9
	Episodes	14.7	1061.3	0.1		1076.1
DALYs averted	Prevention	1.7	22.4	0.4	0.2	24.7
	Earlier HIV care			1.2		1.2
	TOTAL	1.7	22.4	1.8		25.9
Costs averted (added)	Prevention	$89	$5,527	$389	$189	$6,196
	Earlier HIV care			($773)		($773)
	TOTAL	$89	$5,527	($195)		$5,422
Cost-effective ness	Campaign cost (unadjusted)					$36,658
	Net cost (savings)					$30,236
	Cost per DALY averted					$1,168
Nigeria						
Disease averted	Deaths	6.0	3.4	2.7	1.3	13.4
	Episodes	734.3	2,363.3	4.0		3,101.7
DALYs averted	Prevention	168.8	97.6	21.8	10.2	298.4
	Earlier HIV care			70.8		70.8
	TOTAL	168.8	97.6	102.9		369.3
Costs averted (added)	Prevention	$6,223	$14,300	$28,605	$13,379	$62,507
	Earlier HIV care			($55,797)		($55,797)
	TOTAL	$6,223	$14,300	($14,813)		$5,710
Cost-effective ness	Campaign cost (unadjusted)					$40,479
	Net cost (savings)					$34,769
	Cost per DALY averted					$94

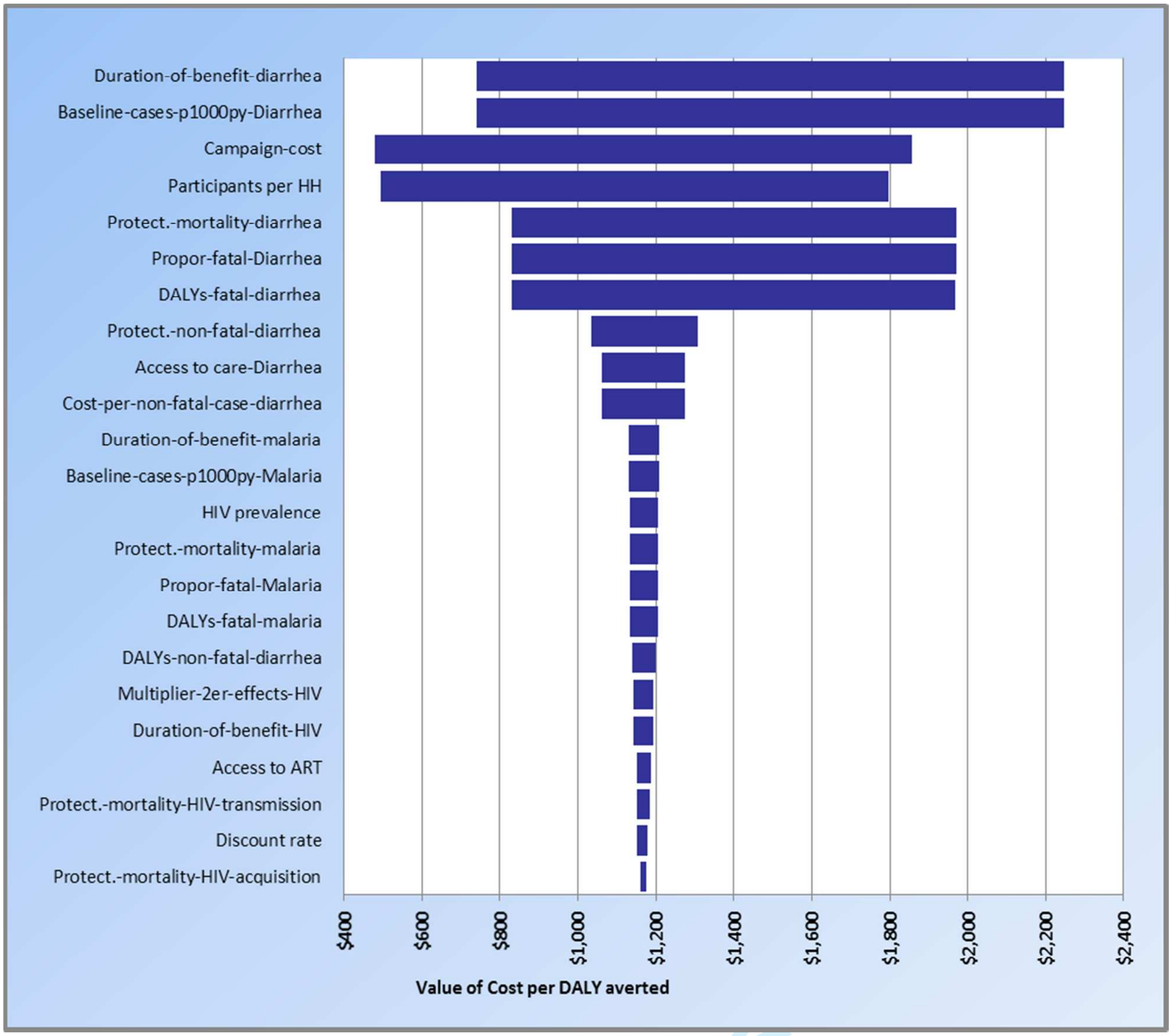
Tech. Suppl. - Table 4. Annual and cumulative results for campaigns 1 and 2 for Kenya, projected for 30 years. Assumes the second campaign starts 3 years after initial campaign. All outcomes discounted at 3% per annum.

	Annual		Cumulative			Annual DALYs averted				Cumulative DALYs averted			
Year	Net costs	Net DALYs averted	Net costs	DALYs averted	CE ($/DALY averted)	Malaria	Diarrhea	HIV	Total	Malaria	Diarrhea	HIV	Total
1	$20,151	5.2	$20,151	5.2	$3,856	1.7	3.2	0.3	5.2	1.7	3.2	0.3	5.2
2	$4,168	6.0	$24,318	11.3	$2,161	1.6	3.0	1.4	6.0	3.3	6.2	1.7	11.3
3	$2,700	7.1	$27,019	18.3	$1,475	1.6	2.9	2.6	7.1	4.9	9.1	4.3	18.3
4	$27,259	11.6	$54,278	29.9	$1,817	1.9	4.7	4.9	11.6	6.9	13.8	9.2	29.9
5	$1,996	11.5	$56,274	41.4	$1,360	1.9	4.5	5.1	11.5	8.7	18.3	14.3	41.4
6	$2,136	11.5	$58,410	52.9	$1,104	1.8	4.4	5.4	11.5	10.5	22.7	19.7	52.9
7	$1,878	11.5	$60,288	64.4	$936	1.7	3.9	5.9	11.5	12.2	26.6	25.6	64.4
8	$874	11.2	$61,162	75.6	$809	1.7	3.8	5.8	11.2	13.9	30.3	31.4	75.6
9	$1,668	10.9	$62,830	86.5	$727	1.6	3.7	5.6	10.9	15.5	34.0	37.0	86.5
10	$1,786	10.6	$64,616	97.0	$666	1.6	3.5	5.5	10.6	17.1	37.5	42.4	97.0
11	$1,896	11.3	$66,511	108.3	$614	1.5	3.4	6.3	11.3	18.6	41.0	48.7	108.3
12	$2,149	12.0	$68,661	120.3	$571	1.5	3.3	7.2	12.0	20.0	44.3	55.9	120.3
13	$2,239	12.7	$70,900	133.0	$533	1.4	3.2	8.0	12.7	21.5	47.6	63.9	133.0
14	$2,100	14.3	$73,000	147.3	$496	1.4	3.1	9.8	14.3	22.9	50.7	73.7	147.3
15	$1,967	17.4	$74,967	164.7	$455	1.3	3.1	13.0	17.4	24.2	53.8	86.7	164.7
16	$1,840	17.2	$76,807	181.9	$422	1.3	3.0	12.9	17.2	25.5	56.7	99.7	181.9
17	$1,651	16.8	$78,458	198.8	$395	1.3	2.9	12.7	16.8	26.8	59.6	112.3	198.8
18	$1,471	16.6	$79,929	215.3	$371	1.2	2.8	12.5	16.6	28.0	62.4	124.9	215.3
19	$1,301	14.7	$81,230	230.1	$353	1.2	2.7	10.8	14.7	29.2	65.1	135.7	230.1
20	$1,139	14.4	$82,368	244.5	$337	1.2	2.6	10.6	14.4	30.4	67.8	146.3	244.5
21	$985	12.7	$83,354	257.2	$324	1.1	2.6	9.0	12.7	31.5	70.3	155.3	257.2
22	$840	8.8	$84,193	266.0	$317	1.1	2.5	5.2	8.8	32.6	72.8	160.6	266.0
23	$702	8.2	$84,895	274.2	$310	1.1	2.4	4.8	8.2	33.7	75.2	165.3	274.2
24	$571	7.8	$85,466	282.1	$303	1.0	2.3	4.5	7.8	34.7	77.6	169.8	282.1
25	$2,188	6.8	$87,653	288.9	$303	1.0	2.3	3.5	6.8	35.7	79.8	173.3	288.9
26	$2,020	6.6	$89,673	295.5	$304	1.0	2.2	3.4	6.6	36.7	82.1	176.7	295.5
27	$106	6.4	$89,779	301.9	$297	0.9	2.1	3.3	6.4	37.6	84.2	180.0	301.9
28	$617	6.2	$90,396	308.1	$293	0.9	2.1	3.2	6.2	38.6	86.3	183.3	308.1
29	$575	6.0	$90,971	314.1	$290	0.9	2.0	3.1	6.0	39.4	88.3	186.4	314.1
30	$0	5.9	$90,971	320.0	$284	0.9	2.0	3.0	5.9	40.3	90.3	189.4	320.0

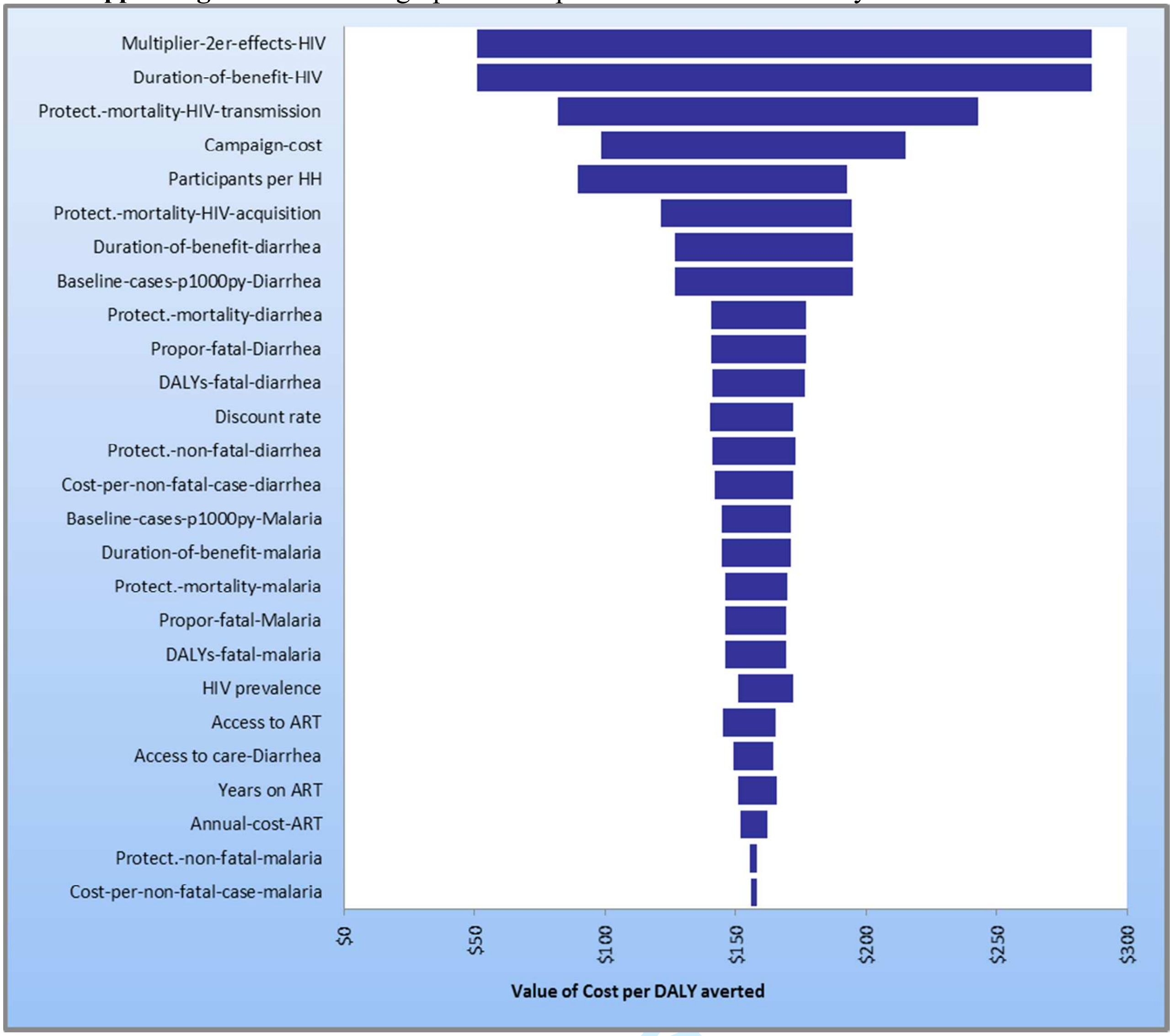
Tech. Suppl. - Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (Campaign 2, n=70)



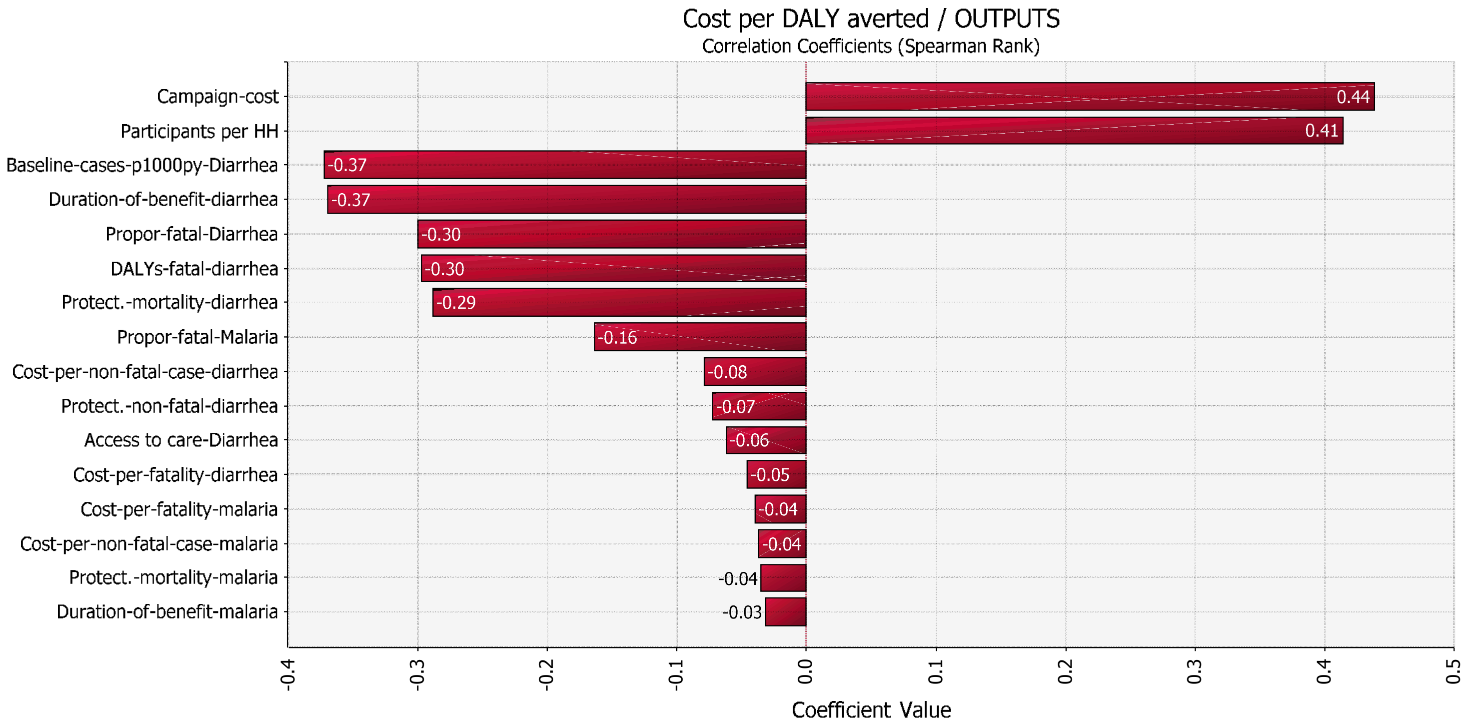
Tech. Suppl. - Figure 2. Tornado Graph of Cost per DALY averted – Bangladesh: Impact by Input



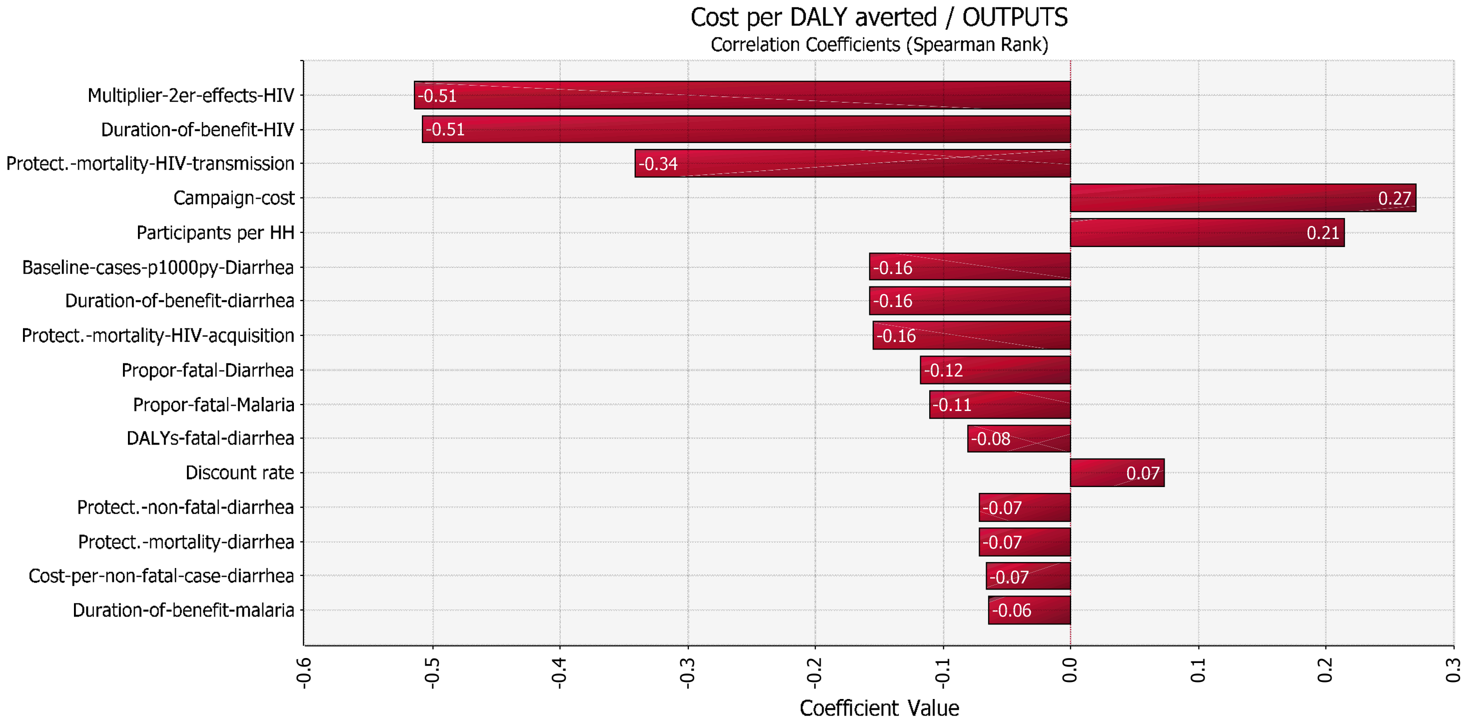
Tech. Suppl. - Figure 3. Tornado graph of cost per DALY averted – Kenya



Tech. Suppl. - Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Bangladesh.



Tech Suppl. - Figure 5. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Kenya.

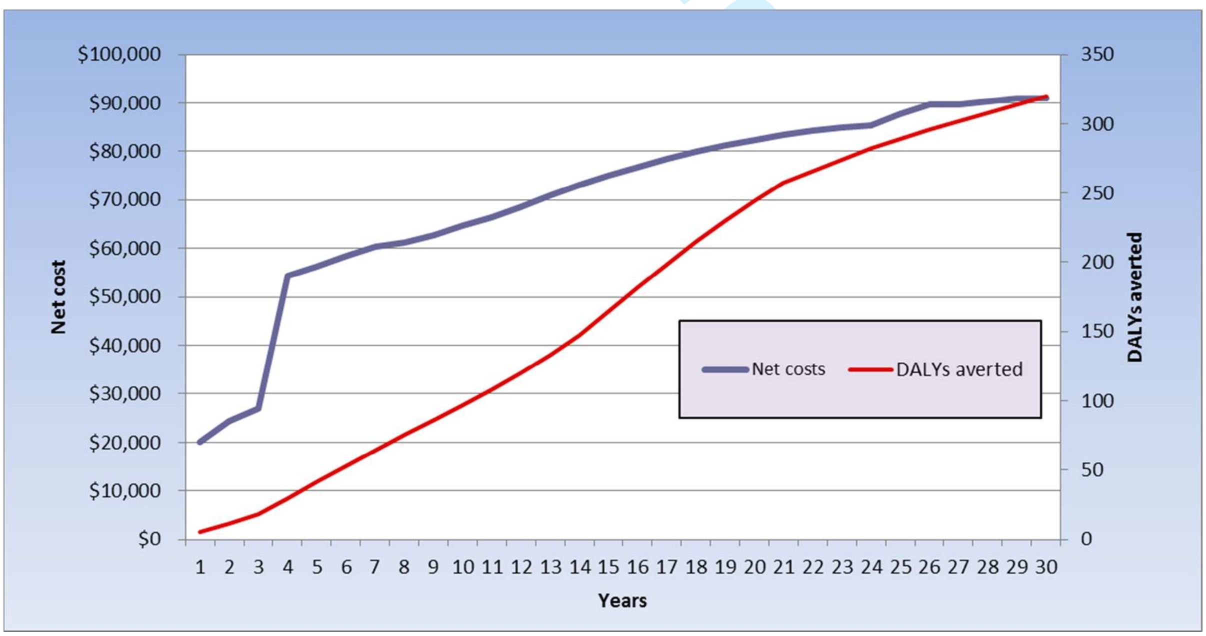


Projection of costs and outcomes to 30 years

We projected cumulative costs and outcomes of the IPC campaign in Kenya for 30 years, assuming an initial campaign and a second campaign three years later (Figure 6). Costs and benefits of the two campaigns were added and reflect the lower effectiveness of the second campaign. The large rise in costs in year 4 reflects the initiation of the second campaign, and the gradual increase in cumulative costs over time reflects the costs of additional HIV treatment. The steadily rising cumulative net DALYs averted reflects the averted morbidity during the period of bed net and water filter efficacy, but is largely determined by the distribution of saved life years due to averted mortality from all three diseases during the period of IPC benefit. Distribution of benefits were made according to the following assumptions:

- HIV deaths would occur on average 15 years after infection.
- Assumes those detected are all put on ART year of campaign.
- Earlier and more ART die to earlier detection distributed over 15 and 20 years respectively.
- HIV mortality prevention in secondary partners starts on average in year 20 after the campaign and is distributed over 20 years.
- 50% of prevented HIV mortality occurred in the index patient
- Life-expectancy at the time of the campaign was 60 years for averted mortality in malaria and diarrhea patients.
- Malaria and diarrhea morbidity reduction is confined to the campaign itself.

Tech Suppl. - Figure 6. Discounted cumulative net costs, and DALYs averted for two IPC campaigns in Kenya, projected to 30 years, per 1,000 participants.



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Scaling up integrated prevention campaigns for global health: Costs and cost-effectiveness in 70 countries

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Abstract

Objectives. This study estimated the health impact, cost, and cost-effectiveness of an integrated prevention campaign (IPC) focused on diarrhea, malaria, and HIV in 70 countries ranked by per-capita disability-adjusted life-year (DALY) burden for the three diseases.

Methods. We constructed a deterministic cost-effectiveness model portraying an IPC combining counseling and testing, cotrimoxazole prophylaxis, referral to treatment, and condom distribution for HIV prevention; bed nets for malaria prevention; and provision of household water filters for diarrhea prevention. We developed a mix of empirical and modeled cost and health impact estimates applied to all 70 countries. One-way, multi-way and scenario sensitivity analyses were conducted to document the strength of our findings. We used a health care payer's perspective, discounted costs and DALYs at 3% per year, and denominated cost in 2012 U.S. dollars.

Primary and secondary outcomes: The primary outcome was cost-effectiveness expressed as net cost per DALY averted. Other outcomes included cost of the IPC; net IPC costs adjusted for averted and additional medical costs; and DALYs averted.

Results. Implementation of the IPC in the 10 most cost-effective countries at 15% population coverage would cost $583 million over three years (adjusted costs of $398 million), averting 8.0 million DALYs. Extending IPC programs to all 70 of the identified high-burden countries at 15% coverage would cost an adjusted $51.3 billion and avert 78.7 million DALYs. Incremental cost-effectiveness ranged from $49 per DALY averted for the 10 countries with the most favourable cost-effectiveness to $119, $181, $335, $1,692 and $8,340 per DALY averted as each successive group of 10 countries is added ordered by decreasing cost-effectiveness.

Conclusion. IPC appears cost-effective in many settings, and has the potential to substantially reduce the burden of disease in resource-poor countries. This study increases confidence that IPC can be an important new approach for enhancing global health.

Strengths and limitations of this study.

Strengths

- Synthesizes a large volume of epidemiological data from disparate sources into a unified method for projecting the consequence of IPC implementation in 70 countries.
- Links the "opportunity index" concept with cost-effectiveness.
- Provides a more comprehensive assessment of intervention potential than assessment of cost-effectiveness alone.
- Methods presented here may be applied to other disease areas and facilitate more objective resource allocation decision-making for global health.

Limitations

- Incomplete availability of data relevant to the large number of countries analyzed.
- Infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered.
- Regions or urban areas within countries may have costs and health benefits that depart from the overall country assessments.

Background

For many years, vertical (disease-specific) programming has dominated the sphere of global health funding in an effort to tackle the areas of greatest need.[1] However, there is increasing recognition that, among diseases with complementary prevention strategies and overlapping populations, single-disease approaches to population health improvement create duplication of effort and miss important opportunities for synergies in health benefits and economies of scope.[2] Recent initiatives have therefore sought to integrate programs for multiple diseases, and many have demonstrated feasibility, efficiencies and success.[3 4]

A particularly promising example of integrated programming was a prevention campaign in Western Province, Kenya that targeted diarrhea, malaria, and HIV,[5] three diseases that account for a substantial portion of the total disease burden in many parts of the developing world.[6] Over the course of one week, the campaign provided general health education, condoms, insecticide-treated bed nets (ITNs), point-of-use water filters, and HIV testing and counseling to more than 80% of the target population.[5] Those testing positive for HIV were offered on-site CD4 count determination, cotrimoxazole prophylaxis, and referral to comprehensive HIV care and treatment. The campaign yielded large health benefits and net economic savings.[7 8] Large-scale expansion of this integrated prevention campaign (IPC) has the potential to deliver substantial health benefits and cost savings. In a separate study, we reviewed country-specific data for 70 low- and middle-income countries, finding that the opportunity for a diarrhea, malaria and HIV IPC is not limited to Kenya.[9] It is plausible that IPCs can have a large impact on health in many resource-limited settings.

While the cost-effectiveness of this IPC in Western Kenya has been established[8], the economic and health effects of a multi-country IPC initiative are unknown. Using data appropriate for providing an initial indication of the conditions under which IPC is likely to be cost-effective, we estimated the costs, health outcomes, and cost-effectiveness of IPC implementation in the same 70 low- and middle-income countries. To support decision-making for IPC implementation, we also estimate the increases in budgets that would be required to cover increasing numbers of countries.

Methods

Overview

We modeled the health impact, cost, and cost-effectiveness of a diarrhea, malaria, and HIV IPC in 70 countries by adapting a previously-published spreadsheet-based model that was applied to the original IPC in Western Kenya.[8] Countries were chosen for inclusion in the analysis based on two factors: they were classified as low- or middle-income as defined by the World Bank[10]; and they had a total DALY (Disability-adjusted-life-year) burden for the three diseases addressed by the IPC in the highest tertile of the 214 World Bank-defined economies (i.e., ≥ 87,000 DALYs); as described in a companion paper.[9] We refer to this ordering of countries by the combined disease burden as the “opportunity index”. For a break-down of the relative contribution by disease to each country’s total burden see Jiwani 2014 and Table 4 of the Technical Supplement). We derived incidence and case fatality rates for each country from published reports, using regional averages and other approximations when country-specific estimates were missing. We developed a mix of empirical (where available) and modeled (projected from empirical data) cost estimates applied to all 70 countries. Key outcomes examined included the cost of the IPC; net IPC costs adjusting for averted and additional medical costs; deaths and disease episodes averted; DALYs averted due to prevention, and to earlier and more HIV care; and finally, cost-effectiveness expressed as net cost per DALY averted. We used a health care payer's perspective, and discounted long-term costs and DALYs at 3% per year.[11] Costs were denominated in 2012 U.S. dollars. The time frame of the analysis is three years for the empirical data. Modeled results depend upon the age-dependent life expectancy at the time death would otherwise occurred in Kenya. This is 61 years for diarrheal diseases and malaria, and 37 years for HIV

Detailed model features

We adapted a Microsoft Excel spreadsheet that we had previously constructed to analyze the cost-effectiveness of the Kenya IPC. Details of the model have been published elsewhere.[8] The model estimates the health and cost benefits of prevention for malaria, diarrhea, and HIV separately. For HIV, it also estimates the DALYs averted and costs incurred due to earlier diagnosis and treatment arising from HIV testing. Cost-effectiveness of the IPC was compared to the cost-effectiveness of ART in each of the 70 countries. This metric was selected since, with the current aspiration of universal access to ART, [12] provision of ART is on the active policy agenda for most HIV-affected countries.

Cost estimates and projection methods. Campaign costs for the Kenya IPC were obtained from published empirical data supplemented by filter repair and replacement costs.[7 8] We estimated campaign costs for each country using the Kenya IPC as a benchmark, translating to other countries according to type of cost, as follows. Program costs were classified as commodity, personnel and other costs. Commodities were further categorized as tradable and non-tradable. Tradable commodities are those purchased on the international market and include bed nets, filters, and condoms, and required no adjustment from the dollar-denominated costs incurred by the Kenya IPC.[7] The cost of non-tradable items, primarily personnel, were adjusted according to the per-capita GDP ratio, in International dollars, between Kenya and each study country.[13] For each country, we estimated the costs of averted medical care due to the IPC by adjusting the costs for health care incurred per fatal and non-fatal case in the Kenya campaign by the ratio of GDP per capita in the target country versus Kenya. We selected per capita GDP rather than per capita health care spending as the basis for these adjustments, because the latter reflects overall access to care and our model accounts for access separately. (For a comparison of three cost adjustment methods and evidence of similar resulting cost estimates, see Technical Supplement).

There are few country-specific data on access to care for malaria except for some of the more-affected countries, mostly in Africa. We therefore used global average rates of treatment access, estimated at 68.4% based on published literature.[14-19] (See Technical Appendix for the country-specific figures underlying this value). As noted in Table 2, the value of 68.4% was varied from 51.3% to 85.5% in sensitivity analyses. For access to care for diarrhea, we used country-specific estimates based on demographic and health survey data on the percent of children under five years of age with diarrhea in the two weeks preceding the survey who received any kind of treatment for diarrhea.[20] We used an average rate of access to ART of 70%. This is considerably higher than the 56% access reported for sub-Saharan Africa [21] and reflects likely increases in the context of the global commitment to access.[12]

We calculated the per person-year cost of ART for each country by using published estimates for countries where available. [22-42] The non-drug portion of each published unit cost figure was inflated to 2012 US dollars using the U.S. CPI.[43] We then derived from the set of published figures an average figure for low-income, lower middle-income excluding India, and upper-middle income countries as defined by the World Bank.[44] We applied these country income-category averages to the larger set of countries for which published ART unit cost estimates were unavailable, according to their respective income categories. ART cost-effectiveness for each country was estimated by adjusting $883 per DALY averted which is the average for 45 sites studied in Zambia.[26] To arrive at country-specific estimates we calculated the ratio of per-capita income between each country and Zambia and applied this factor to the average portion of overall ART costs for low-income countries which is non-tradable, 36.9%. This figure was derived from the ART unit cost studies described above which includes the breakdown of costs by major component.

First versus second campaign health benefits. The health benefits of a second campaign are likely to be lower than that of the initial campaign. For malaria this is due to residual benefits from nets, beyond their average functional life of three years. In the absence of a second campaign, we assume a malaria risk in years 4-6 equal to 75% of the risk at baseline (before the first campaign). For diarrheal disease the filters themselves are not expected to confer benefit after 3 years, though there may be residual benefit from the behavioral component; we assume that the risk is 87.5% of baseline. New nets and filters in a second campaign reduce disease risks to the levels expected after the first campaign. Thus the second campaign reduces the incidence of malaria from 75% to 50% of baseline (a 1/3 relative reduction). Similarly, diarrhea decreases from 87.5% to 37% of baseline (a relative drop of 58%). (Details in technical supplement)

Disease specific data and projection methods. We obtained country estimates of the prevalence of HIV in the adult (15–49 years) population.[42 45 46] For each country, we derived estimates of the baseline cases of malaria per person-year by dividing WHO-adjusted estimates of the annual number of cases [47] by the total country population [48]. For diarrhea, we estimated the average number of cases per person-year in the overall population using DHS data on the number of cases per year in children under 5[49] (details in technical supplement).[50 51] Multiplying each estimate by the total population[48] yields the estimated number of cases in each country.

We calculated country-specific case fatality rates for malaria and diarrhea as the number of deaths due to the disease[52 53] divided by the number of cases. We set an upper-bound malaria case fatality rate of 15% based on published findings of a Delphi survey of malaria experts.[54] We assumed a case fatality rate for HIV of 100%.

Using a discount rate of 3%[55], we estimated the DALYs incurred with each fatal case of malaria and diarrhea at 28 based on life expectancy at age 25 in Kenya (the estimated average age of death from malaria and diarrhea) of 61 years.[56] We derived estimates of the DALYs incurred per non-fatal case of each disease as the product of the disability weight (0.191 for malaria and 0.105 for diarrhea) [57] and the average duration of each case (7 days for malaria[58]; 4.43 days for diarrhea, a severity weighted duration for children and adults[59]; or 0.0037 and 0.0013 DALYs for each non-fatal case of malaria and diarrhea, respectively. Assuming 70% access to ART, we estimated 10.6 DALYs incurred per HIV infection, and 8.8 discounted DALYs averted per treated case of HIV, an assumption based on 22 years of antiretroviral therapy (ART), average age of ART initiation of 35 years, and a life expectancy at age 35 in Kenya of 37 years.[56] Each untreated HIV case incurs 15.1 discounted DALYs.

Household size and beneficiaries per household. Using country-specific data of rural household size as reported in the most recent Demographic and Health Survey, divided by the number of participants per household as observed in the Kenya IPC campaign, we obtained the number of beneficiaries per campaign participant. For bednets, we assumed fewer incremental beneficiaries per participant on the assumption that there was some prior access to bednets, 15.1% on average, as observed in the Kenya campaign. For HIV we assumed the same number of adult participants on average, 2.5, as the basis for calculating the number of beneficiaries per campaign participant.

For the remaining health inputs, we assumed values equal to those used in the Kenya analysis for all countries.[8] See Table 1 for base case values and sources for data inputs.

Table 1 about here

Relationship of opportunity to cost-effectiveness
In a companion article, we identified the countries in which scale-up of a diarrhea, malaria, and HIV IPC would be most beneficial, by summarizing country-specific epidemiological data related to the disease burden and shortfall in current intervention coverage (Jiwani et al, under review, 2013). We created three "opportunity indices," ranking countries by 1) DALYs per capita across the three diseases of the IPC, 2) a sum of burden ranks for each disease, and 3) a composite of burden and intervention opportunity. Here, we extend this opportunity analysis by examining the relationship between a country's opportunity rank (in DALYs per capita) and its cost-effectiveness for IPC implementation.

Sensitivity analyses. To assess the effect of uncertainty in inputs, we conducted one-way and multi-way Monte Carlo sensitivity analyses for three countries: Kenya, a low-income country where the IPC trial was performed and is at the 44th percentile for cost-effectiveness of the 70 countries analyzed; Nigeria, a lower-middle income country at the 75th percentile (relatively favorable); and Bangladesh, a low-income country at the 25th percentile. Each of 31 model inputs examined in the sensitivity analyses (Table 2) was assigned a beta distribution with alpha and beta parameters of 2, in order to ensure symmetry around the mean. Maximum and minimum values were set as 1.5 and 0.5 times the base case, except for access to malaria and diarrhea treatment (0.75 to 1.25 of base case) and access to HIV treatment (0.6 to 1.4 times base case). Figures in bold font reflect parameter values that vary by country. Finally, we examined the effect of variations in important inputs on the cost-effectiveness of IPC in all 70 countries grouped in order of cost-effectiveness.

Table 2 about here

Results

Across the 70 high opportunity countries, the cost-effectiveness of the first campaign ranges from \$7 (Guinea-Bissau) to \$15,886 (China) per DALY averted (IQR \$96 - \$1,071 per DALY averted) (Table 3). At \$182 per DALY averted, Pakistan is at the 50th percentile for cost-effectiveness. With the exception of Afghanistan, the 30 counties with the most favorable cost-effectiveness are in sub-Saharan Africa. The cost-effectiveness of IPC compares favorably to the cost-effectiveness of ART in 51 countries. The 30 countries with the lowest cost-effectiveness estimates are geographically more diverse and include only three in sub-Saharan Africa (Swaziland, South Africa, and Namibia).

As shown in Figure 1, per-capita disease burden as measured by the opportunity index is highly correlated with cost-effectiveness. See Figure 1 of the Technical Supplement for relationship between opportunity index and cost-effectiveness for campaign 2.

Table 3 and Figure 1 about here.

Table 4 displays the cumulative results, grouped in 10-country increments, assuming 15% population coverage, and moving from most to least attractive cost-effectiveness. IPC in the top 10 countries would cost \$583 million for the three-year campaign, with a net cost after adjusting for effects on health care spending of \$398 million for the first three-year campaign and \$468 million for the second and subsequent campaigns. The first and second campaigns would avert 8.0 and 5.7 million DALYs respectively with an average cost-effectiveness of \$49 and \$82 per DALY averted, respectively. As shown in the right-hand two columns, the incremental cost-effectiveness rises rapidly (becomes less favorable) after coverage of the top 50 countries. In particular, if expanding from the top 50 to 60 countries and from 60 to all 70 countries, large net incremental costs are associated with relatively modest increases in health benefits. The cost per DALY averted in expanding from 60 to 70 countries is \$8,340 and \$19,728 for campaigns 1 and 2, respectively.

For each stratum of 10 countries ranked from most to least cost-effective, Table 5 displays the median cost-effectiveness for the first three-year campaigns, for possible second campaigns, and for ART. The cost-effectiveness of the first campaign compares more favorably to ART by a wide margin for each of the 10-country strata. For the second campaign ART is more cost-effective than IPC for the 51st – 60th and for the 61st – 70th country, as ranked by IPC cost-effectiveness.

Tables 4 and 5 about here.

Results for Kenya, Bangladesh, and Nigeria illustrate reasons for variation across countries.

In Nigeria, the IPC cost-effectiveness ratio is \$94 per DALY averted, 18th of 70 countries ranked by cost-effectiveness. This result represents high health benefits for malaria and diarrhea, and modest benefits for HIV. For every 1,000 IPC participants, the first campaign averts an estimated

13.4 deaths: 6.0 due to malaria, 3.4 due to diarrhea, and 4.0 due to HIV. The campaign costs are $40,479, with net costs of $34,769 after offsetting savings from averted care needs.

In Kenya, cost-effectiveness is somewhat less attractive, at $157 per DALY averted, 31st of 70 countries. This is due to lower malaria and diarrhea benefits than in Nigeria, and more discovered HIV. For every 1,000 IPC participants, the campaign averts an estimated 10.9 deaths: 1.6 due to malaria, 2.4 to diarrhea, and 7.0 to HIV. The campaign costs $34,280. Although reduced disease creates offsetting savings in care needs, there are $81,000 in *added* HIV costs due to earlier and additional detection of HIV. The net cost of the campaign is $46,149, or $157 per DALY averted. This is less than the $883 per DALY averted for ART in Kenya.

In Bangladesh, the IPC cost-effectiveness ratio is $1,168 per DALY averted, 53rd of 70 countries. This is due to lower health benefits overall. For every 1,000 IPC participants, the campaign averts an estimated 0.9 deaths: 0.1 due to malaria, 0.8 due to diarrhea, and only 0.1 due to HIV. The campaign costs are $35,658. When adjusted for modest offsetting savings from averted care, the net cost of the campaign is $30,236. Cost-effectiveness is comparable with the estimated $1,046 per DALY averted for ART for HIV. See Table 5 of the technical supplement for detailed results for all three countries.

Sensitivity analyses

One-way sensitivity analysis. Figure 2 is a tornado graph of the sensitivity of IPC cost-effectiveness to the model inputs displayed in Table 2 for Nigeria. IPC participants per household had the greatest effect on IPC cost-effectiveness (range, $126 per DALY averted), followed by the multiplier that reflects prevention of secondary HIV transmission, the duration of the prevention benefits of HIV interventions (range, $122 per DALY averted each), cost of the IPC campaign (range, $110 per DALY averted), and the reduction in mortality due to reduced HIV transmission (range, $83 per DALY averted).

Figure 2 about here

For Bangladesh, the inputs with the greatest effect on cost-effectiveness are duration of benefits for diarrhea prevention and the baseline cases of diarrhea per 1,000 person-years (range, $1,506 per DALY averted for both), campaign cost (range, $1,377 per DALY averted), IPC participants per household (range, $1,305 per DALY averted), and protective benefit against diarrhea mortality (range, $1,140 per DALY averted). For Kenya, the variables with the most influence on cost-effectiveness are the multiplier that reflects prevention of secondary HIV transmission and the duration of the prevention benefits of HIV interventions (range, $236 per DALY averted each), the reduction in mortality due to reduced HIV transmission (range, $161 per DALY averted), cost of the IPC campaign (range, $117 per DALY averted), and the number of participants per household (range, $103 per DALY averted). See Technical Supplement Figures 2 and 3 for one-way sensitivity analysis tornado graphs for Bangladesh and Kenya respectively.

Figure 3 shows how variation in three inputs affects incremental cost-effectiveness as each successive 10 countries are added to a scaled-up IPC program. Up to 50 countries, IPC remains cost-effective compared with ART even if the least favorable end of the input estimate range is used.

Figure 3 about here

Multivariate Monte Carlo sensitivity analysis. Table 6 displays the 80% confidence interval for a 20,000-trial simulation for three outcomes: DALYs averted, net costs, and net cost per DALY averted (cost-effectiveness). For Kenya and Nigeria the least favorable end of the cost-effectiveness range is more favorable than the cost-effectiveness of ART for HIV, $304 versus $883 per DALY averted for Kenya and $208 versus $747 per DALY averted for Nigeria. For Bangladesh, the least favorable end of the cost-effectiveness range, $2,547 is *less* favorable than the estimated $1,046 per DALY averted for ART. For Nigeria the five most important variables in order of their correlation with cost-effectiveness (net cost per DALY averted) are, the duration of the HIV prevention benefits (r = -0.51); prevention of secondary HIV transmission (r = -0.50), the number of IPC participants per household (r = 0.33), cost of the IPC campaign (r = 0.31), and the reduction in mortality due to reduced HIV transmission (r = -0.24), (Figure 4). See Technical Supplement Figures 4 and 5 for multivariate sensitivity analyses correlations coefficients for Kenya and Bangladesh, for projection of IPC costs and benefits in Kenya for 30 years (Technical Supplement Figure 6).

Scenario Analysis: IPC cost-effectiveness with HIV costs and outcomes omitted. Finally, we report on the cost and cost-effectiveness of the IPC program if HIV program costs and health benefits are ignored. These results reflect the perspective of a payer who assumes responsibility for the diarrhea and malaria components only. When future HIV-related costs and benefits are disregarded, including both additional care costs due to more and earlier detection and reductions in care costs due to prevention, the cost per DALY averted decreases from $157 to $129 in Kenya; from $94 to $31 in Nigeria; and increases from $1,168 to $819 in Bangladesh.

Table 6 and Figure 4 about here.

Discussion

We examined the costs and health benefits of IPC for 70 countries with a high combined burden of diarrhea, malaria and HIV. Together these countries comprise 76% of the world population[48 50] and 98% of its disease burden.[9] If implemented with 15% population coverage in the top 40 of the 70 countries as ordered by cost-effectiveness, 47.3 million DALYs could be averted at a net cost of $4.9 billion, or $104 per DALY averted. As shown in Table 3, this compares favorably with the cost-effectiveness of ART in each of those 40 countries. The DALYs averted constitute 58% of the disease burden due to HIV, malaria and diarrheal disease in these countries. $4.9 billion is considerably less than the President's request to the United States Congress for FY 2013 for $6.4 billion for the PEPFAR program [60] and thus might be affordable from a donor's perspective, especially if the current trend of greater host country financial contribution to HIV programs continues. With the exception of Afghanistan, all 30 of the countries in which IPC was most cost-effective are in sub-Saharan Africa and in 51 countries, the cost-effectiveness of IPC compared favorably to ART.

The cost-effectiveness of IPCs varies greatly among the 70 countries we examined. This wide divergence is due primarily to differences in disease burden and therefore to the higher levels of incremental health benefit generated per incremental dollar spent for prevention. For example, Nigeria ranks 4th of the 70 countries based on DALYs per capita in the three diseases of the IPC, and Bangladesh ranks 55th. As shown in Figure 1, per-capita disease burden as measured by the opportunity index is highly correlated with cost-effectiveness. In the case of a single disease-intervention pair such a finding would be unsurprising since the cost-effectiveness of most prevention interventions depend importantly on incidence. It is more noteworthy here since the relative prevalence of the three diseases varies greatly between the countries we studied, and the effect on medical care costs of intervening also varies substantially among the three diseases. In spite of this variability, the opportunity index is a reasonably good guide to cost-effectiveness.

Costs of program delivery also matter. Swaziland, Botswana and South Africa have relatively unfavorable cost-effectiveness in relation to their disease burden. This is due primarily to their high per-capita GDP and thus the higher estimated non-commodity (mainly personnel) portion of their campaign costs. However, IPC cost-effectiveness still compares favorably to that of ART in all three countries.

Sensitivity of findings within each country reflects how the IPC interacts with local disease burden. Diarrhea is the largest contributor to the disease burden in Bangladesh, accounting for 87% of the DALYs averted by the IPC campaign. Not surprisingly, the most important determinant of cost-effectiveness was the estimated duration of the benefits of the water filter and the baseline incidence of diarrhea. Kenya has a far larger HIV epidemic, with a prevalence of 6.3% rather than 0.06% of adults as in Bangladesh. Accordingly, the largest determinants of IPC cost-effectiveness in Kenya were HIV-related in both one-way and multivariate sensitivity analyses. Nigeria's HIV prevalence of 3.6% is close to the average of 3.5% of the 70 countries examined. Nigeria's high IPC cost-effectiveness ranking is due to its high incidence of malaria and diarrhea, 252 and 765 cases per 1,000 person-years respectively, compared with median values of 52 and 521 for malaria and diarrhea respectively for the 70 countries studied.

Among the strengths of the current study are its synthesis of a large volume of epidemiological data from disparate sources into a unified method for projecting the consequence of IPC implementation in 70 countries, and the linking of the "opportunity index" concept with cost-effectiveness. This provides a more comprehensive assessment of intervention potential than assessment of cost-effectiveness alone. This data-driven process may be applied to other disease areas and facilitate more objective resource allocation decision-making.

Limitations of our approach include incomplete availability of data relevant to the large number of countries analyzed. Methods for approximation were therefore necessary. For example, the costs of the campaigns themselves were extrapolated from empirical Kenya-specific data using per-capita GDP ratios between Kenya and the other countries to estimate the non- tradable commodity portion of costs. For other variables such as the protective effects of HIV prevention, bed nets and water filters where country-specific information was absent we employed wide ranges in the sensitivity analyses to ensure that we accounted for uncertainty, and this produced wide confidence intervals around the model outcomes.

This study provides substantial evidence that IPC campaigns can be cost-effective in a large number of low and middle-income countries epidemic settings. However, it leaves unanswered important questions that need to be addressed when these broad findings are translated into programs and policies. For example, in settings with high prevalence of both HIV and malaria, as community HIV prevalence is reduced, malaria susceptibility may decline, thus reducing the benefits associated with malaria prevention. Such interactions are not accounted for in our analysis. In some countries the relative contributions of each disease to the total burden imposed by all three disease is uneven.[9] (See Table 4 of the Technical Supplement for a breakdown of the contribution of each disease to the total for all three diseases). Swaziland, for example, has a high burden of HIV and a low burden of malaria. In Swaziland and similar settings, it may be sensible to focus the IPC campaign in areas of relatively high malaria endemicity, by other means to target the malaria prevention component. Our cost projections posit relatively low IPC coverage, 15%. At this level it is reasonable to assume that in most countries, many high-prevalence areas would not be fully covered and planners need not be concerned that a point of diminishing returns would be met in which it becomes more costly to cover the next community, while the benefit of covering that community might decline. However, prior to implementation, country-specific analyses would be required to determine for which subset of countries it would be more cost-effective to scale up to higher coverage levels even if it means that some countries are excluded from implementation altogether. The current study also was not designed to consider how program costs and effectiveness might vary according to whether a more vertical or more integrated approach is adopted, or depending on the level of prior scale of existing diarrheal disease, malaria or HIV programs. These important program design considerations will depend on the organization of the health care system in each of the countries considering an IPC program.

Because we looked at a large number of countries, we could not explore specific countries in detail. It was infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered. Comparing IPC with the estimated cost-effectiveness of ART for HIV does not account for the potential intervention options that are more efficient than both IPC and ART. In addition, there may be substantial regions or urban areas within countries that have costs, health benefits that depart from the overall country assessments to which our analysis is confined. Finally, we were not able to evaluate the cost to patients of seeking care and were thus unable to adopt a full societal perspective. Since disease prevention averts the need for these expenditures, our results may under-estimate net costs and thus cost-effectiveness. The current analysis should not displace investigation of potential opportunities for efficient IPC implementation in high disease burden areas within countries.

This study increases confidence that IPC can be an important new approach for enhancing global health. IPC appears to be cost-effective compared to ART for HIV in many settings, and has the potential to substantially reduce the burden of disease in poor countries. If implemented with 15% population coverage in the top 40 of the 70 countries as ordered by cost-effectiveness, 47.3 million DALYs could be averted at a net cost of $4.9 billion, or $104 per DALY averted. The specific countries, or number of countries, a donor may want to fund will depend on resource availability, and this analysis provides substantial guidance to decision makers aiming to predict the costs and benefits of various levels of investments in IPC programs. If taken to scale, IPC can be a highly efficient strategy for improving global health.

Author contributions

EM conceived and designed the study, conducted the analyses, and drafted and revised the paper. AJ provided data for the study, helped with the analyses and drafting and revision. AR provided data for the study and revised the draft paper. SV and JW critiqued the analysis helped with specifying data inputs, and revised the draft paper. JGK helped guide design and implementation of the study, helped with specifying data inputs and edited the paper.

Data sharing

No additional data available.

Conflicts of interest

None declared.

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Figure Legends

Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (DALYs per capita) (Campaign 1, n=70)

Figure 2. Tornado Graph of Cost per DALY averted –Nigeria: Impact by Input

Figure 3. One-way sensitivity analysis of incremental cost-effectiveness by three key variables in 10-country increments ranked by IPC cost-effectiveness.

Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Nigeria.

Tech. Suppl. - Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (Campaign 2, n=70)

Tech. Suppl. - Figure 2. Tornado Graph of Cost per DALY averted – Bangladesh: Impact by Input

Tech. Suppl. - Figure 3. Tornado graph of cost per DALY averted – Kenya

Tech. Suppl. - Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Bangladesh.

Tech Suppl. - Figure 5. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Kenya.

Tech Suppl. - Figure 6. Discounted cumulative net costs, and DALYs averted for two IPC campaigns in Kenya, projected to 30 years, per 1,000 participants.

Table 1. Base case values and sources for data inputs. Bold figures represent values that change with each country.

	Malaria	Diarrhea	HIV		Source(s)		
	LLIN	Filters	VCT	Condoms	LLIN	Filters	VCT / condoms
Health in[61]puts							
Campaign participant per household	2.5				Post-campaign survey		
Number benefiting per campaign participant	**1.563**	**1.840**	0.950	0.361	Post-campaign survey		
Baseline cases per year per individual benefiting	**0.057**	**0.542**	0.004	0.009	[47, 48]	[49-51]	[8,62-64] Post-campaign survey (see text)
Proportion of cases that are fatal	**0.012**	**0.001**	1	1	[47, 52, 54]	[48, 49, 51, 59, 62]	Assumption
DALYs incurred with each fatal case	28.0	28.0	15.1	15.1	[56]	[56]	[56]
DALYs incurred with each non-fatal case	0.0037	0.0012	n/a	n/a	[57, 58]	[57, 59]	N/a
Protective effect against mortality	0.50	0.63	0.50	0.26	[65], expert opinion	[66]	[67, 68]
Protective effect against non-fatal cases	0.5	0.63	n/a	n/a	[65]	[66]	N/a
Multiplier to capture secondary benefits	n/a bit	n/a	2	2	[69]	N/a	[70] (see text)
Years of benefit	3	3	1	1	[71, 72] Adjusted to 3 years per post-campaign evaluation.	[73] Adjusted to 3 years per post-campaign evaluation.	[68]
Access to care	0.684	**0.678**	0.700	0.700	[14-19]	[20]	Assumption
Cost inputs							
Campaign cost	**$34,280**				[7] $31,980 plus additional $2,300 in revised filter maintenance costs		
Discount rate	3.0%				[10]		
Health care incurred with	**$65**	**$104**	**$12,213**	**$12,213**	[64, 74]	[75]	Authors' construction based on 22 years on ART at $766 per

each fatality							person-year discounted at 3% per annum.
Health care incurred with each non-fatal case	**$7.80**	**$7.00**	n/a	n/a	[76]	[75]	N/a

Table 2. Sensitivity analysis variables, base case, minimum and maximum values. All variables have beta distributions with alpha and beta parameters of 2. Minimum and maximum values are 0.5 and 1.5 of base case values, respectively, except for access to diarrhea disease care and malaria care which have minimum and maximums of 0.6 and 1.4, and access to HIV ART which has a minimum and maximum of 0.75 and 1.25. Bold figures represent values that change with each country.

	Nigeria			Kenya			Bangladesh		
Input parameter	**Base case**	**Min**	**Max**	**Base case**	**Min**	**Max**	**Base case**	**Min**	**Max**
Campaign cost	**$40,479**	**$20,239**	**$60,718**	**$34,280**	**$17,140**	**$51,420**	**$35,658**	**$17,829**	**$53,486**
Cost per fatality malaria	**$97.50**	**$48.75**	**$146.25**	**$65.00**	**$32.50**	**$97.50**	**$72.22**	**$36.11**	**$108.33**
Cost per fatality diarrhea	**$156.00**	**$78.00**	**$234.00**	**$104.00**	**$52.00**	**$156.00**	**$115.56**	**$57.78**	**$173.34**
Cost per non-fatal case malaria	**$11.70**	**$5.85**	**$17.55**	**$7.80**	**$3.90**	**$11.70**	**$8.67**	**$4.33**	**$13.00**
Cost per non-fatal case diarrhea	**$10.50**	**$5.25**	**$15.75**	**$7.00**	**$3.50**	**$10.50**	**$7.78**	**$3.89**	**$11.67**
Annual cost ART	**$938**	**$469**	**$1,407**	**$766**	**$383**	**$1,150**	**$766**	**$383**	**$1,150**
Discount rate	0.03	0.015	0.045	0.03	0.015	0.045	0.03	0.015	0.045
Access to care Diarrhea	**0.565**	**0.424**	**0.706**	**0.678**	**0.509**	**0.848**	**0.663**	**0.497**	**0.829**
Access to care Malaria	0.684	0.583	0.855	0.684	0.583	0.855	0.684	0.583	0.855
Access to ART	0.7	0.42	0.98	0.7	0.42	0.98	0.7	0.42	0.98
Years on ART	22	11	33	22	11	33	22	11	33
HIV prevalence	**0.036**	**0.018**	**0.054**	**0.063**	**0.032**	**0.095**	**0.0006**	**0.0003**	**0.0009**
Baseline cases p1000py Malaria	**351.6**	**175.8**	**527.5**	**57.0**	**28.5**	**85.5**	**6.13**	**3.06**	**9.19**
Baseline cases p1000py Diarrhea	**765.3**	**382.7**	**1148.0**	**542.0**	**271.0**	**813.0**	**299.81**	**149.91**	**449.72**
Propor fatal Malaria	**0.008**	**0.004**	**0.012**	**0.012**	**0.006**	**0.018**	**0.004**	**0.002**	**0.006**
Propor fatal Diarrhea	0.001	0.001	0.002	0.001	0.001	0.002	0.0007	0.0004	0.0011
Participants per HH	2.5	1.25	3.75	2.5	1.25	3.75	2.5	1.25	3.75
DALYs fatal malaria	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs fatal diarrhea	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs non-fatal malaria	0.366	0.183	0.549	0.366	0.183	0.549	0.366	0.183	0.549
DALYs non-fatal diarrhea	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191
Protect. mortality malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality diarrhea	0.630	0.315	0.945	0.630	0.315	0.945	0.630	0.315	0.945
Protect. non fatal malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. non fatal diarrhea	0.628	0.314	0.941	0.628	0.314	0.941	0.628	0.314	0.941
Protect. mortality HIV transmission	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality HIV acquisition	0.255	0.128	0.383	0.255	0.128	0.383	0.255	0.128	0.383

Multiplier: Secondary effects HIV	2	1	3	2	1	3	2	1	3
Duration of benefit malaria	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Duration of benefit diarrhea	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Duration of benefit HIV	1	0.5	1.5	1	0.5	1.5	1	0.5	1.5

Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most favorable to least favorable cost-effectiveness (net cost per DALY averted). The grey highlighted cells indicate CE ratio is less favorable than investment in ART. Results shown are for the first 3-year campaign.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$29,459	$7,814	40.7	10,523	1,143.3	$26	$7	$1,005
2	Senegal	Lower middle	0.050	$34,969	$12,190	10.7	5,735	306.0	$114	$40	$768
3	Sierra Leone	Low	0.119	$31,525	$20,112	16.0	4,118	446.7	$71	$45	$764
4	Burkina Faso	Low	0.126	$31,525	$22,206	16.4	4,124	459.4	$69	$48	$819
5	Somalia	Low	0.121	$26,015	$22,754	16.8	3,682	470.5	$55	$48	$1,535
6	Niger	Low	0.110	$28,081	$21,620	14.8	4,967	419.7	$67	$52	$1,095
7	Mali	Low	0.124	$29,459	$23,016	15.9	4,222	445.8	$66	$52	$888
8	Afghanistan	Low	0.057	$28,770	$18,906	12.7	4,146	356.6	$81	$53	$935
9	Chad	Low	0.120	$35,658	$24,848	15.3	4,335	424.6	$84	$59	$807
10	Lesotho	Lower middle	0.115	$35,658	$47,366	31.3	1,756	779.4	$46	$61	$738
11	Guinea	Low	0.095	$29,459	$22,324	12.6	4,272	353.8	$83	$63	$928
12	Congo, DR	Low	0.112	$24,637	$25,488	13.4	3,517	375.9	$66	$68	$1,493
13	Sudan	Lower middle	0.057	$38,413	$15,241	6.9	4,907	198.8	$193	$77	$703
14	Liberia	Low	0.092	$26,704	$25,526	11.9	3,401	332.6	$80	$77	$1,025
15	Burundi	Low	0.118	$26,015	$33,639	14.3	2,267	389.9	$67	$86	$987
16	Benin	Low	0.083	$33,591	$25,345	10.0	3,096	280.0	$120	$91	$910
17	Côte d'Ivoire	Lower middle	0.084	$33,591	$35,069	14.1	4,021	387.2	$87	$91	$801
18	Nigeria	Lower middle	0.133	$40,479	$34,769	13.4	3,102	369.3	$110	$94	$747
19	Mozambique	Low	0.141	$30,147	$59,145	22.2	3,816	590.0	$51	$100	$1,109
20	Cen. African Rep.	Low	0.105	$27,392	$37,525	13.8	2,819	373.3	$73	$101	$1,230
21	Uganda	Low	0.105	$31,525	$40,192	14.9	3,492	399.8	$79	$101	$749
22	Congo, Rep.	Lower middle	0.067	$54,254	$33,944	11.5	2,981	318.5	$170	$107	$756
23	Togo	Low	0.075	$29,459	$32,147	10.4	2,849	288.7	$102	$111	$864
24	Angola	Upper middle	0.088	$64,586	$35,794	11.5	3,268	320.8	$201	$112	$674
25	Tanzania	Low	0.075	$33,591	$38,453	12.1	3,122	326.9	$103	$118	$935
26	Zambia	Lower middle	0.128	$33,591	$69,806	21.8	3,107	564.3	$60	$124	$826
27	Ethiopia	Low	0.057	$30,147	$29,630	8.6	1,986	235.7	$128	$126	$1,139
28	Rwanda	Low	0.071	$31,525	$34,034	9.6	2,216	266.1	$118	$128	$768
29	Malawi	Low	0.110	$28,081	$59,745	18.3	2,965	462.2	$61	$129	$996
30	Cameroon	Lower middle	0.100	$37,724	$52,388	14.3	3,115	388.4	$97	$135	$741
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Mauritania	Lower middle	0.042	$36,346	$28,117	5.8	2,607	164.2	$221	$171	$955
33	Yemen	Lower middle	0.025	$37,035	$21,139	4.3	3,128	122.9	$301	$172	$719
34	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	428.8	$59	$178	$1,731
35	Pakistan	Lower middle	0.020	$41,856	$19,714	3.8	2,748	108.1	$387	$182	$904
36	Ghana	Lower middle	0.063	$44,612	$35,624	6.8	1,966	189.9	$235	$188	$746
37	Madagascar	Low	0.043	$28,770	$24,895	4.5	1,910	127.8	$225	$195	$1,025
38	Eritrea	Low	0.033	$27,392	$26,438	4.3	1,942	120.5	$227	$219	$1,753
39	Botswana	Upper middle	0.080	$137,595	$185,872	26.8	1,111	734.1	$187	$253	$577
40	Haiti	Low	0.028	$30,836	$31,570	4.4	3,128	123.0	$251	$257	$869
41	Swaziland	Lower middle	0.150	$58,387	$198,392	29.1	2,230	724.2	$81	$274	$632

42	Guatemala	Lower middle	0.016	$57,698	$22,134	2.4	3,143	70.1	$823	$316	$627
43	South Africa	Upper middle	0.097	$99,713	$180,284	21.5	1,150	561.0	$178	$321	$582
44	Gabon	Upper middle	0.060	$29,826	$84,306	9.3	1,876	255.0	$117	$331	$613
45	India	Lower middle	0.027	$48,744	$34,973	3.7	1,255	104.9	$464	$333	$733
46	Myanmar	Low	0.026	$31,525	$28,249	2.9	1,306	83.7	$377	$337	$1,354
47	Papua New Guinea	Lower middle	0.018	$40,479	$25,117	2.4	2,868	71.2	$568	$353	$864
48	Iraq	Upper middle	0.009	$53,565	$25,989	1.9	2,587	55.8	$960	$466	$758
49	Namibia	Upper middle	0.038	$75,606	$204,271	15.6	1,528	402.7	$188	$507	$606
50	Cambodia	Low	0.014	$38,413	$31,172	1.9	1,341	54.3	$708	$574	$739
51	Nepal	Low	0.010	$30,836	$28,994	1.4	1,135	39.8	$776	$729	$883
52	Morocco	Lower middle	0.006	$58,387	$42,818	1.9	1,623	54.8	$1,066	$782	$650
53	Bangladesh	Low	0.007	$35,658	$30,236	0.9	1,076	25.9	$1,377	$1,168	$1,046
54	Algeria	Upper middle	0.008	$73,540	$51,390	1.4	1,304	41.0	$1,793	$1,253	$606
55	Uzbekistan	Lower middle	0.006	$45,989	$25,637	0.6	2,352	18.2	$2,523	$1,406	$717
56	Ukraine	Lower middle	0.006	$74,228	$68,364	1.2	623	33.6	$2,210	$2,036	$600
57	Thailand	Upper middle	0.005	$90,759	$100,377	1.8	455	48.7	$1,863	$2,061	$622
58	Indonesia	Lower middle	0.008	$56,321	$46,677	0.7	814	20.8	$2,708	$2,244	$793
59	Bolivia	Lower middle	0.010	$56,321	$30,994	0.4	2,015	13.5	$4,178	$2,299	$668
60	Vietnam	Lower middle	0.005	$45,989	$40,910	0.6	828	17.6	$2,616	$2,327	$664
61	Colombia	Upper middle	0.003	$95,580	$63,657	0.6	1,419	20.5	$4,652	$3,098	$598
62	Peru	Upper middle	0.004	$95,580	$59,439	0.6	1,497	19.0	$5,026	$3,126	$613
63	Brazil	Upper middle	0.004	$104,534	$65,501	0.6	1,385	19.2	$5,431	$3,403	$581
64	Philippines	Lower middle	0.003	$51,499	$39,031	0.3	1,289	10.9	$4,746	$3,597	$724
65	Russian Federation	High: nonOECD	0.007	$143,794	$121,954	1.1	735	31.2	$4,607	$3,907	$579
66	Argentina	Upper middle	0.003	$147,238	$101,854	0.6	1,097	18.1	$8,155	$5,642	$577
67	Malaysia	Upper middle	0.004	$138,284	$104,408	0.6	930	17.6	$7,858	$5,933	$591
68	Turkey	Upper middle	0.001	$29,459	$58,058	0.1	1,784	6.1	$4,821	$9,501	$582
69	Mexico	Upper middle	0.003	$127,264	$134,901	0.3	0	9.6	$13,197	$13,989	$583
70	China	Upper middle	0.001	$84,560	$74,564	0.1	486	4.7	$18,015	$15,886	$638

Table 4. IPC costs, DALYs averted, and cost-effectiveness compared with no intervention, and incremental cost-effectiveness for 70 countries in increments of 10, ranked by cost-effectiveness. "Net costs" consist of IPC campaign costs adjusted for medical costs averted or added due to the campaign. Results assume 15% of population covered by IPC in each country. Costs in 2012 US$.

Countries	Campaign cost	Net cost		DALYs averted		Cost-effectiveness (compared with no intervention)		Incremental cost-effectiveness (compared with previous row)	
		Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2
Top 10	5.832E+08	3.979E+08	4.685E+08	8.048E+06	5.708E+06	$49	$82	n/a	n/a
Top 20	2.387E+09	2.054E+09	2.068E+09	2.706E+07	1.629E+07	$76	$127	$87	$151
Top 30	3.715E+09	3.554E+09	3.338E+09	3.961E+07	2.382E+07	$90	$140	$119	$169
Top 40*	5.614E+09	4.943E+09	4.858E+09	4.731E+07	2.916E+07	$104	$167	$181	$284
Top 50*	1.624E+10	1.342E+10	1.395E+10	7.265E+07	4.983E+07	$185	$280	$335	$440
Top 60	2.226E+10	1.863E+10	1.941E+10	7.573E+07	5.186E+07	$246	$374	$1,692	$2,699
Top 70	5.129E+10	4.350E+10	4.629E+10	7.871E+07	5.322E+07	$553	$870	$8,340	$19,728

Table 5. Median cost-effectiveness (net cost per DALY averted) by 10-country increments in order of cost-effectiveness

Countries ranked by IPC cost-effectiveness	Campaign 1	Campaign 2	Antiretroviral therapy for HIV
Top 10	$50	$102	$854
11 - 20	$88	$141	$958
11 - 30	$121	$197	$797
31 - 40	$185	$318	$894
41 - 50	$335	$591	$683
51 - 60	$1,721	$3,514	$666
61 - 70	$4,774	$17,068	$587

Table 6. Multiway sensitivity analysis; 20,000-trial Monte Carlo simulation, 80% confidence interval for 3 IPC outcomes and cost per DALY averted by ART for HIV in Kenya, Bangladesh, and Nigeria.

Outcomes	Kenya	Bangladesh	Nigeria
DALYs averted	206 - 407	13.1 – 45.8	228 - 564
Net costs	$7,810 - $79,885	$18,566 - $41,473	$2,241 - $61,448
Net cost per DALY averted (cost-effectiveness)	$23 - $304	$519 - $2,547	$5 - $208
Cost per DALY averted by ART for HIV	$883	$1,046	$747

Technical Supplement

Reduction in risk for malaria and HIV between first and second campaign
In this analysis, to explore sustainability, we examine both an initial campaign and a follow-up campaign three years later. Thus, we need to estimate the health benefit realized by the follow-up campaign, taking into account the stability of disease reduction offered initially. The more that initial protection decays over six years, and thus the larger the disease risk in years 4-6, the greater will be the benefit of a campaign at three years. This decay is a function of the physical durability of the commodities distributed, as well as maintenance of safer behaviors. The dynamics vary by disease.

For malaria we assume 75% as much disease incidence at years 4-6 (absent a 2nd campaign) as baseline incidence. In other words, we assume that full set of LLIN distributed in the *initial* campaign, with no follow-up campaign, would have half as much community benefit in years 4-6 as in years 1-3. Many LLIN will remain in place, and the insecticide impregnation itself is stable for close to 10 years. Thus, the 50% incidence drop expected with LLIN in years 1-3 will decrease but not disappear in the second 3 years. However, the second round of LLIN are likely to have a relative effectiveness less than 50%, because the best LLIN users are already protected. Thus we decrease the effectiveness from 50% to 33% (i.e., from 75% of baseline incidence to 50% of baseline incidence). In effect, the 2nd campaign is like a booster shot that returns effectiveness to its original level. In sum, the overall benefit of the second campaign is reduced by half -- in first campaign it was 100% of baseline incidence to 50%, and in the second campaign from 75% of baseline incidence to 50%.

We note that these estimates are assembled from isolated data (e.g., LLIN physical durability) combined with a logical framework and best guesses. Nonetheless, we believe that the conclusion – 50% as much benefit for a second campaign – is plausible, and is a far more realistic assumption than full benefit. Our approach is conservative regarding the second campaign – if the specified durability of effect of the LLIN is larger than in reality, we would be *under*estimating the benefit of this campaign. And our estimate of the combined effect of two sequential campaigns is robust. Low estimates of durability understate benefits of the first campaign and overstate benefits of the second campaign, which represent offsetting errors. Conversely, high estimates of durability overstate the value of the first campaign and understate second campaign benefits, again offsetting.

For diarrhea, we assume no filter benefit after three years. The filters are expected to last in good function only three years. Thus, the filter component of the second campaign is just as effective as for the first campaign.

For HIV, effects on DALYs and cost depend heavily on undiagnosed HIV prevalence. The first campaign detects almost all HIV-infected individuals. Thus, the effects of the second campaign depend mainly on the impact of 3 years of HIV incidence on (predominantly undiagnosed) HIV prevalence. This incidence has not been measured, but can be estimated from HIV prevalence using simple epidemic dynamics. [1]Steady-state (pre-ART) annual incidence is about 1/10th of prevalence (slightly more if prevalence above 10%, due to reduction in # of susceptible). So, if initial prevalence was 5%, then annual incidence is about 0.5%, and prevalence at 3 years will be about 1.5%.

Incidence and thus prevalence could be even lower if ART reduces community viral load and also if VCT for HIV+ has substantial behavioral benefits. They could be higher if the first campaign selectively missed HIV+, e.g. they chose not to participate or were away in urban areas.

Diarrhea: estimation of average cases per PY and annual cases
Using data on the number of episodes per year in children under 5 [2], we estimated the average number of episodes (cases) per person-year in the overall population by weighting the incidence by the percentage of the population under five [3] and over five. We then adjusted the incidence in the >5 year-old population by the ratio of the country <5 incidence to the average global <5 incidence [4]. Multiplying each estimate by the total population [5] provided estimates of the number of cases of diarrhea in each country.

Explanation for difference between results reported in earlier analysis (Kahn, 2012) and current article. The earlier evaluation of the Integrated Prevention Campaign in Western Province, Kenya found that the 2008 campaign saved $16,015 and averted 442 DALYs per 1,000 campaign participants.[6] The current article finds a highly favorable cost-effectiveness ratio of $157 per DALY averted (net cost of $ 46,149 and 294 DALYs averted per 1,000 campaign participants), but no cost savings in the base-case analysis for Kenya. The difference can be attributed to the aggregate effect of changes in input parameter values of two types: (a) ***Geographic shift from Western Province to Kenya in general.*** The earlier analysis calculated the number of beneficiaries per household based on household size data from the campaign communities, 7.7 persons. In the current article, we used the lower national figure of 4.6, assumed to reflect fewer children per household [7]. The total benefits of the malaria and diarrheal disease interventions fell accordingly. The current article also uses lower figures for malaria and diarrhea annual incidence, 0.057 and 0.542 per individual for Kenya, respectively, versus 0.30 and 1.75 as found in the 2008 survey in Western Province. (b) ***Refined data on care seeking***. The 2012 article assumed 100% care-seeking for diarrhea and malaria. Subsequently, we obtained data on care-seeking patterns, though not specific to Kenya. The current article thus assumes 67.8% for diarrheal diseases and 68.4% for malaria. In addition, we adjusted two cost inputs. The campaign cost was updated to include a recent water filter maintenance program to $34,280 from $32,000 in the earlier paper. Based on a more complete review of the relevant literature including new findings on life expectancy for people receiving antiretroviral therapy (ART), we also increased the estimated lifetime cost of ART, from $5,092 to $12,213.

Tech. Suppl. - Table 1: Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most to least cost-effective. The grey highlighted cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the second and subsequent 3-year campaigns.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$29,459	$16,675	26.9	5,465.3	754.3	$22	$39	$1,005
2	Somalia	Low	0.121	$26,015	$23,643	11.6	2,055.1	325.2	$73	$80	$768
3	Afghanistan	Low	0.057	$28,770	$22,700	12.2	2,380.6	342.0	$66	$84	$764
4	Congo, DR	Low	0.112	$24,637	$24,258	9.3	1,851.9	259.2	$94	$95	$819
5	Niger	Low	0.110	$28,081	$24,250	10.0	2,648.0	282.6	$86	$99	$1,535
6	Mali	Low	0.124	$29,459	$25,298	10.0	2,312.1	280.1	$90	$105	$1,095
7	Burundi	Low	0.118	$26,015	$27,699	8.7	1,256.5	239.8	$116	$108	$888
8	Sierra Leone	Low	0.119	$31,525	$24,508	9.8	2,142.5	274.1	$89	$115	$935
9	Mozambique	Low	0.141	$30,147	$36,613	9.7	1,975.5	260.0	$141	$116	$807
10	Burkina Faso	Low	0.126	$31,525	$26,076	9.6	2,153.3	270.2	$96	$117	$738
11	Chad	Low	0.120	$35,658	$27,805	10.6	2,258.2	294.9	$94	$121	$928
12	Lesotho	Lower middle	0.115	$35,658	$37,171	11.7	919.3	283.6	$131	$126	$1,493
13	Malawi	Low	0.110	$28,081	$36,299	8.6	1,532.3	221.8	$164	$127	$703
14	Zambia	Lower middle	0.128	$33,591	$41,222	10.1	1,660.1	263.4	$156	$128	$1,025
15	Liberia	Low	0.092	$26,704	$25,199	6.8	1,762.6	190.4	$132	$140	$987
16	Guinea	Low	0.095	$29,459	$25,199	7.4	2,175.8	208.8	$121	$141	$910
17	Cen. African Rep.	Low	0.105	$27,392	$29,606	7.1	1,443.6	194.2	$152	$141	$801
18	Uganda	Low	0.105	$31,525	$31,104	7.9	1,841.7	214.8	$145	$147	$747
19	Zimbabwe	Low	0.075	$25,326	$40,453	6.9	905.4	165.8	$244	$153	$1,109
20	Côte d'Ivoire	Lower middle	0.084	$33,591	$31,110	7.8	2,009.7	214.9	$145	$156	$1,230
21	Ethiopia	Low	0.057	$30,147	$28,881	6.5	1,128.0	181.8	$159	$166	$749
22	Cameroon	Lower middle	0.100	$37,724	$39,507	8.1	1,620.0	223.1	$177	$169	$756
23	Senegal	Lower middle	0.050	$34,969	$22,535	6.8	2,951.7	193.6	$116	$181	$864
24	Togo	Low	0.075	$29,459	$28,877	5.5	1,466.8	153.3	$188	$192	$674
25	Rwanda	Low	0.071	$31,525	$30,620	5.9	1,248.9	163.9	$187	$192	$935
26	Tanzania	Low	0.075	$33,591	$32,273	6.1	1,636.6	167.4	$193	$201	$826
27	Benin	Low	0.083	$33,591	$28,793	5.9	1,611.1	167.1	$172	$201	$1,139
28	Swaziland	Lower middle	0.150	$58,387	$87,699	11.5	1,280.6	281.0	$312	$208	$768
29	Nigeria	Lower middle	0.133	$40,479	$34,860	6.7	1,610.1	187.0	$186	$217	$996
30	Kenya	Low	0.065	$34,280	$35,682	5.2	1,130.6	142.8	$250	$240	$741
31	Gabon	Upper middle	0.060	$29,826	$46,367	4.0	972.5	110.7	$419	$269	$883
32	Congo, Rep.	Lower middle	0.067	$54,254	$42,228	7.2	1,522.2	199.0	$212	$273	$955
33	Angola	Upper middle	0.088	$64,586	$44,239	8.5	1,758.3	236.6	$187	$273	$719
34	Sudan	Lower middle	0.057	$38,413	$24,940	4.8	2,620.5	136.6	$183	$281	$1,731
35	Mauritania	Lower middle	0.042	$36,346	$31,642	4.4	1,397.4	123.1	$257	$295	$904
36	Madagascar	Low	0.043	$28,770	$26,424	3.0	1,079.4	84.6	$312	$340	$746
37	Eritrea	Low	0.033	$27,392	$26,191	2.8	1,117.1	78.5	$334	$349	$1,025
38	Yemen	Lower middle	0.025	$37,035	$27,682	3.5	1,778.2	99.3	$279	$373	$1,753
39	Ghana	Lower middle	0.063	$44,612	$38,058	4.2	1,006.4	117.8	$323	$379	$577
40	Haiti	Low	0.028	$30,836	$29,010	2.8	1,789.6	80.4	$361	$384	$869
41	Pakistan	Lower middle	0.020	$41,856	$28,870	3.6	1,574.8	102.7	$281	$407	$632
42	South Africa	Upper middle	0.097	$99,713	$115,007	9.1	659.2	235.9	$487	$423	$627

43	Namibia	Upper middle	0.038	$75,606	$106,711	5.9	855.9	150.8	$708	$502	$582
44	India	Lower middle	0.027	$48,744	$40,648	3.4	713.2	96.2	$422	$506	$613
45	Botswana	Upper middle	0.080	$137,595	$139,112	9.9	634.1	262.4	$530	$524	$733
46	Myanmar	Low	0.026	$31,525	$29,473	1.7	672.6	48.0	$614	$657	$1,354
47	Cambodia	Low	0.014	$38,413	$33,905	1.3	758.8	37.6	$901	$1,020	$864
48	Nepal	Low	0.010	$30,836	$29,442	1.1	654.7	30.0	$982	$1,028	$758
49	Iraq	Upper middle	0.009	$53,565	$37,274	1.7	1,493.0	50.4	$740	$1,063	$606
50	Guatemala	Lower middle	0.016	$57,698	$35,999	1.8	1,812.5	51.6	$698	$1,118	$739
51	Papua New Guinea	Lower middle	0.018	$40,479	$31,703	1.2	1,488.7	35.8	$885	$1,130	$883
52	Bangladesh	Low	0.007	$35,658	$32,480	0.8	617.4	23.0	$1,413	$1,551	$650
53	Morocco	Lower middle	0.006	$58,387	$49,883	1.1	898.4	31.6	$1,577	$1,846	$1,046
54	Algeria	Upper middle	0.008	$73,540	$60,354	1.3	752.8	38.2	$1,580	$1,925	$606
55	Uzbekistan	Lower middle	0.006	$45,989	$34,086	0.5	1,357.2	14.9	$2,282	$3,079	$717
56	Indonesia	Lower middle	0.008	$56,321	$50,560	0.5	463.2	14.3	$3,545	$3,949	$600
57	Thailand	Upper middle	0.005	$90,759	$90,800	0.8	261.3	21.7	$4,177	$4,175	$622
58	Vietnam	Lower middle	0.005	$45,989	$42,516	0.3	477.7	8.2	$5,164	$5,586	$793
59	Philippines	Lower middle	0.003	$51,499	$44,213	0.3	743.4	8.8	$5,026	$5,854	$668
60	Ukraine	Lower middle	0.006	$74,228	$69,343	0.4	359.1	11.5	$6,052	$6,479	$664
61	Bolivia	Lower middle	0.010	$56,321	$41,435	0.2	1,162.3	8.2	$5,044	$6,856	$598
62	Peru	Upper middle	0.004	$95,580	$73,664	0.3	862.2	9.6	$7,650	$9,926	$613
63	Colombia	Upper middle	0.003	$95,580	$75,850	0.3	817.2	8.8	$8,575	$10,806	$581
64	Brazil	Upper middle	0.004	$104,534	$81,187	0.3	798.2	9.0	$9,029	$11,626	$724
65	Russian Federation	High: nonOECD	0.007	$143,794	$128,452	0.4	424.3	10.8	$11,898	$13,319	$579
66	Malaysia	Upper middle	0.004	$138,284	$117,395	0.2	536.0	6.6	$17,673	$20,818	$577
67	Argentina	Upper middle	0.003	$147,238	$119,687	0.2	632.8	6.8	$17,487	$21,512	$591
68	Turkey	Upper middle	0.001	$125,197	$86,272	0.1	1,029.3	3.9	$22,267	$32,314	$582
69	China	Upper middle	0.001	$84,560	$78,518	0.1	280.4	2.3	$33,785	$36,384	$583
70	Mexico	Upper middle	0.003	$127,264	$129,804	0.1	0.1	3.2	$40,371	$39,581	$638

Tech. Suppl. - Table 2. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest opportunity index score reflecting per-capita HIV, TB and malaria disease burden. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Swaziland	Lower middle	0.150	$58,387	$198,392	29.1	2,230	724.2	$81	$274	$632
2	Mozambique	Low	0.141	$30,147	$59,145	22.2	3,816	590.0	$51	$100	$1,109
3	Guinea-Bissau	Low	0.134	$29,459	$7,814	40.7	10,523	1143.3	$26	$7	$1,005
4	Nigeria	Lower middle	0.133	$40,479	$34,769	13.4	3,102	369.3	$110	$94	$747
5	Zambia	Lower middle	0.128	$33,591	$69,806	21.8	3,107	564.3	$60	$124	$826
6	Burkina Faso	Low	0.126	$31,525	$22,206	16.4	4,124	459.4	$69	$48	$819
7	Mali	Low	0.124	$29,459	$23,016	15.9	4,222	445.8	$66	$52	$888
8	Somalia	Low	0.121	$26,015	$22,754	16.8	3,682	470.5	$55	$48	$1,535
9	Chad	Low	0.120	$35,658	$24,848	15.3	4,335	424.6	$84	$59	$807
10	Sierra Leone	Low	0.119	$31,525	$20,112	16.0	4,118	446.7	$71	$45	$764
11	Burundi	Low	0.118	$26,015	$33,639	14.3	2,267	389.9	$67	$86	$987
12	Lesotho	Lower middle	0.115	$35,658	$47,366	31.3	1,756	779.4	$46	$61	$738
13	Congo, DR	Low	0.112	$24,637	$25,488	13.4	3,517	375.9	$66	$68	$1,493
14	Niger	Low	0.110	$28,081	$21,620	14.8	4,967	419.7	$67	$52	$1,095
15	Malawi	Low	0.110	$28,081	$59,745	18.3	2,965	462.2	$61	$129	$996
16	Cen. African Rep.	Low	0.105	$27,392	$37,525	13.8	2,819	373.3	$73	$101	$1,230
17	Uganda	Low	0.105	$31,525	$40,192	14.9	3,492	399.8	$79	$101	$749
18	Cameroon	Lower middle	0.100	$37,724	$52,388	14.3	3,115	388.4	$97	$135	$741
19	South Africa	Upper middle	0.097	$99,713	$180,284	21.5	1,150	561.0	$178	$321	$582
20	Guinea	Low	0.095	$29,459	$22,324	12.6	4,272	353.8	$83	$63	$928
21	Liberia	Low	0.092	$26,704	$25,526	11.9	3,401	332.6	$80	$77	$1,025
22	Angola	Upper middle	0.088	$64,586	$35,794	11.5	3,268	320.8	$201	$112	$674
23	Côte d'Ivoire	Lower middle	0.084	$33,591	$35,069	14.1	4,021	387.2	$87	$91	$801
24	Benin	Low	0.083	$33,591	$25,345	10.0	3,096	280.0	$120	$91	$910
25	Botswana	Upper middle	0.080	$137,595	$185,872	26.8	1,111	734.1	$187	$253	$577
26	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	428.8	$59	$178	$1,731
27	Tanzania	Low	0.075	$33,591	$38,453	12.1	3,122	326.9	$103	$118	$935
28	Togo	Low	0.075	$29,459	$32,147	10.4	2,849	288.7	$102	$111	$864
29	Rwanda	Low	0.071	$31,525	$34,034	9.6	2,216	266.1	$118	$128	$768
30	Congo, Rep.	Lower middle	0.067	$54,254	$33,944	11.5	2,981	318.5	$170	$107	$756
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Ghana	Lower middle	0.063	$44,612	$35,624	6.8	1,966	189.9	$235	$188	$746
33	Gabon	Upper middle	0.060	$29,826	$84,306	9.3	1,876	255.0	$117	$331	$613
34	Ethiopia	Low	0.057	$30,147	$29,630	8.6	1,986	235.7	$128	$126	$1,139
35	Sudan	Lower middle	0.057	$38,413	$15,241	6.9	4,907	198.8	$193	$77	$703
36	Afghanistan	Low	0.057	$28,770	$18,906	12.7	4,146	356.6	$81	$53	$935

37	Senegal	Lower middle	0.050	$34,969	$12,190	10.7	5,735	306.0	$114	$40	$768
38	Madagascar	Low	0.043	$28,770	$24,895	4.5	1,910	127.8	$225	$195	$1,025
39	Mauritania	Lower middle	0.042	$36,346	$28,117	5.8	2,607	164.2	$221	$171	$955
40	Namibia	Upper middle	0.038	$75,606	$204,271	15.6	1,528	402.7	$188	$507	$606
41	Eritrea	Low	0.033	$27,392	$26,438	4.3	1,942	120.5	$227	$219	$1,753
42	Haiti	Low	0.028	$30,836	$31,570	4.4	3,128	123.0	$251	$257	$869
43	India	Lower middle	0.027	$48,744	$34,973	3.7	1,255	104.9	$464	$333	$733
44	Myanmar	Low	0.026	$31,525	$28,249	2.9	1,306	83.7	$377	$337	$1,354
45	Yemen	Lower middle	0.025	$37,035	$21,139	4.3	3,128	122.9	$301	$172	$719
46	Pakistan	Lower middle	0.020	$41,856	$19,714	3.8	2,748	108.1	$387	$182	$904
47	Papua New Guinea	Lower middle	0.018	$40,479	$25,117	2.4	2,868	71.2	$568	$353	$864
48	Guatemala	Lower middle	0.016	$57,698	$22,134	2.4	3,143	70.1	$823	$316	$627
49	Cambodia	Low	0.014	$38,413	$31,172	1.9	1,341	54.3	$708	$574	$739
50	Nepal	Low	0.010	$30,836	$28,994	1.4	1,135	39.8	$776	$729	$883
51	Bolivia	Lower middle	0.010	$56,321	$30,994	0.4	2,015	13.5	$4,178	$2,299	$668
52	Iraq	Upper middle	0.009	$53,565	$25,989	1.9	2,587	55.8	$960	$466	$758
53	Algeria	Upper middle	0.008	$73,540	$51,390	1.4	1,304	41.0	$1,793	$1,253	$606
54	Indonesia	Lower middle	0.008	$56,321	$46,677	0.7	814	20.8	$2,708	$2,244	$793
55	Bangladesh	Low	0.007	$35,658	$30,236	0.9	1,076	25.9	$1,377	$1,168	$1,046
56	Russian Federation	High: nonOECD	0.007	$143,794	$121,954	1.1	735	31.2	$4,607	$3,907	$579
57	Uzbekistan	Lower middle	0.006	$45,989	$25,637	0.6	2,352	18.2	$2,523	$1,406	$717
58	Morocco	Lower middle	0.006	$58,387	$42,818	1.9	1,623	54.8	$1,066	$782	$650
59	Ukraine	Lower middle	0.006	$74,228	$68,364	1.2	623	33.6	$2,210	$2,036	$600
60	Thailand	Upper middle	0.005	$90,759	$100,377	1.8	455	48.7	$1,863	$2,061	$622
61	Vietnam	Lower middle	0.005	$45,989	$40,910	0.6	828	17.6	$2,616	$2,327	$664
62	Malaysia	Upper middle	0.004	$138,284	$104,408	0.6	930	17.6	$7,858	$5,933	$591
63	Brazil	Upper middle	0.004	$104,534	$65,501	0.6	1,385	19.2	$5,431	$3,403	$581
64	Peru	Upper middle	0.004	$95,580	$59,439	0.6	1,497	19.0	$5,026	$3,126	$613
65	Colombia	Upper middle	0.003	$95,580	$63,657	0.6	1,419	20.5	$4,652	$3,098	$598
66	Mexico	Upper middle	0.003	$127,264	$134,901	0.3	0	9.6	$13,197	$13,989	$583
67	Philippines	Lower middle	0.003	$51,499	$39,031	0.3	1,289	10.9	$4,746	$3,597	$724
68	Argentina	Upper middle	0.003	$147,238	$101,854	0.6	1,097	18.1	$8,155	$5,642	$577
69	China	Upper middle	0.001	$84,560	$74,564	0.1	486	4.7	$18,015	$15,886	$638
70	Turkey	Upper middle	0.001	$125,197	$58,058	0.1	1,784	6.1	$20,489	$9,501	$582

Tech. Suppl. - Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest opportunity index score reflecting per-capita HIV, TB and malaria disease burden. Grey highlighted cells indicate cost-effectiveness ratios less favorable than investment in ART Results shown are for the second and subsequent 3-year campaigns.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Swaziland	Lower middle	0.150	$58,387	$87,699	11.5	1,281	281.0	$312	$208	$632
2	Mozambique	Low	0.141	$30,147	$36,613	9.7	1,976	260.0	$141	$116	$1,109
3	Guinea-Bissau	Low	0.134	$29,459	$16,675	26.9	5,465	754.3	$22	$39	$1,005
4	Nigeria	Lower middle	0.133	$40,479	$34,860	6.7	1,610	187.0	$186	$217	$747
5	Zambia	Lower middle	0.128	$33,591	$41,222	10.1	1,660	263.4	$156	$128	$826
6	Burkina Faso	Low	0.126	$31,525	$26,076	9.6	2,153	270.2	$96	$117	$819
7	Mali	Low	0.124	$29,459	$25,298	10.0	2,312	280.1	$90	$105	$888
8	Somalia	Low	0.121	$26,015	$23,643	11.6	2,055	325.2	$73	$80	$1,535
9	Chad	Low	0.120	$35,658	$27,805	10.6	2,258	294.9	$94	$121	$807
10	Sierra Leone	Low	0.119	$31,525	$24,508	9.8	2,143	274.1	$89	$115	$764
11	Burundi	Low	0.118	$26,015	$27,699	8.7	1,256	239.8	$116	$108	$987
12	Lesotho	Lower middle	0.115	$35,658	$37,171	11.7	919	283.6	$131	$126	$738
13	Congo, DR	Low	0.112	$24,637	$24,258	9.3	1,852	259.2	$94	$95	$1,493
14	Niger	Low	0.110	$28,081	$24,250	10.0	2,648	282.6	$86	$99	$1,095
15	Malawi	Low	0.110	$28,081	$36,299	8.6	1,532	221.8	$164	$127	$996
16	Cen. African Rep.	Low	0.105	$27,392	$29,606	7.1	1,444	194.2	$152	$141	$1,230
17	Uganda	Low	0.105	$31,525	$31,104	7.9	1,842	214.8	$145	$147	$749
18	Cameroon	Lower middle	0.100	$37,724	$39,507	8.1	1,620	223.1	$177	$169	$741
19	South Africa	Upper middle	0.097	$99,713	$115,007	9.1	659	235.9	$487	$423	$582
20	Guinea	Low	0.095	$29,459	$25,199	7.4	2,176	208.8	$121	$141	$928
21	Liberia	Low	0.092	$26,704	$25,199	6.8	1,763	190.4	$132	$140	$1,025
22	Angola	Upper middle	0.088	$64,586	$44,239	8.5	1,758	236.6	$187	$273	$674
23	Côte d'Ivoire	Lower middle	0.084	$33,591	$31,110	7.8	2,010	214.9	$145	$156	$801
24	Benin	Low	0.083	$33,591	$28,793	5.9	1,611	167.1	$172	$201	$910
25	Botswana	Upper middle	0.080	$137,595	$139,112	9.9	634	262.4	$530	$524	$577
26	Zimbabwe	Low	0.075	$25,326	$40,453	6.9	905	165.8	$244	$153	$1,731
27	Tanzania	Low	0.075	$33,591	$32,273	6.1	1,637	167.4	$193	$201	$935
28	Togo	Low	0.075	$29,459	$28,877	5.5	1,467	153.3	$188	$192	$864
29	Rwanda	Low	0.071	$31,525	$30,620	5.9	1,249	163.9	$187	$192	$768
30	Congo, Rep.	Lower middle	0.067	$54,254	$42,228	7.2	1,522	199.0	$212	$273	$756
31	Kenya	Low	0.065	$34,280	$35,682	5.2	1,131	142.8	$250	$240	$883
32	Ghana	Lower middle	0.063	$44,612	$38,058	4.2	1,006	117.8	$323	$379	$746
33	Gabon	Upper middle	0.060	$29,826	$46,367	4.0	972	110.7	$419	$269	$613

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34	Ethiopia	Low	0.057	$30,147	$28,881	6.5	1,128	181.8	$159	$166	$1,139
35	Sudan	Lower middle	0.057	$38,413	$24,940	4.8	2,620	136.6	$183	$281	$703
36	Afghanistan	Low	0.057	$28,770	$22,700	12.2	2,381	342.0	$66	$84	$935
37	Senegal	Lower middle	0.050	$34,969	$22,535	6.8	2,952	193.6	$116	$181	$768
38	Madagascar	Low	0.043	$28,770	$26,424	3.0	1,079	84.6	$312	$340	$1,025
39	Mauritania	Lower middle	0.042	$36,346	$31,642	4.4	1,397	123.1	$257	$295	$955
40	Namibia	Upper middle	0.038	$75,606	$106,711	5.9	856	150.8	$708	$502	$606
41	Eritrea	Low	0.033	$27,392	$26,191	2.8	1,117	78.5	$334	$349	$1,753
42	Haiti	Low	0.028	$30,836	$29,010	2.8	1,790	80.4	$361	$384	$869
43	India	Lower middle	0.027	$48,744	$40,648	3.4	713	96.2	$422	$506	$733
44	Myanmar	Low	0.026	$31,525	$29,473	1.7	673	48.0	$614	$657	$1,354
45	Yemen	Lower middle	0.025	$37,035	$27,682	3.5	1,778	99.3	$279	$373	$719
46	Pakistan	Lower middle	0.020	$41,856	$28,870	3.6	1,575	102.7	$281	$407	$904
47	Papua New Guinea	Lower middle	0.018	$40,479	$31,703	1.2	1,489	35.8	$885	$1,130	$864
48	Guatemala	Lower middle	0.016	$57,698	$35,999	1.8	1,813	51.6	$698	$1,118	$627
49	Cambodia	Low	0.014	$38,413	$33,905	1.3	759	37.6	$901	$1,020	$739
50	Nepal	Low	0.010	$30,836	$29,442	1.1	655	30.0	$982	$1,028	$883
51	Bolivia	Lower middle	0.010	$56,321	$41,435	0.2	1,162	8.2	$5,044	$6,856	$668
52	Iraq	Upper middle	0.009	$53,565	$37,274	1.7	1,493	50.4	$740	$1,063	$758
53	Algeria	Upper middle	0.008	$73,540	$60,354	1.3	753	38.2	$1,580	$1,925	$606
54	Indonesia	Lower middle	0.008	$56,321	$50,560	0.5	463	14.3	$3,545	$3,949	$793
55	Bangladesh	Low	0.007	$35,658	$32,480	0.8	617	23.0	$1,413	$1,551	$1,046
56	Russian Federation	High: nonOECD	0.007	$143,794	$128,452	0.4	424	10.8	$11,898	$13,319	$579
57	Uzbekistan	Lower middle	0.006	$45,989	$34,086	0.5	1,357	14.9	$2,282	$3,079	$717
58	Morocco	Lower middle	0.006	$58,387	$49,883	1.1	898	31.6	$1,577	$1,846	$650
59	Ukraine	Lower middle	0.006	$74,228	$69,343	0.4	359	11.5	$6,052	$6,479	$600
60	Thailand	Upper middle	0.005	$90,759	$90,800	0.8	261	21.7	$4,177	$4,175	$622
61	Vietnam	Lower middle	0.005	$45,989	$42,516	0.3	478	8.2	$5,164	$5,586	$664
62	Malaysia	Upper middle	0.004	$138,284	$117,395	0.2	536	6.6	$17,673	$20,818	$591
63	Brazil	Upper middle	0.004	$104,534	$81,187	0.3	798	9.0	$9,029	$11,626	$581
64	Peru	Upper middle	0.004	$95,580	$73,664	0.3	862	9.6	$7,650	$9,926	$613
65	Colombia	Upper middle	0.003	$95,580	$75,850	0.3	817	8.8	$8,575	$10,806	$598
66	Mexico	Upper middle	0.003	$127,264	$129,804	0.1	0	3.2	$40,371	$39,581	$583
67	Philippines	Lower middle	0.003	$51,499	$44,213	0.3	743	8.8	$5,026	$5,854	$724
68	Argentina	Upper middle	0.003	$147,238	$119,687	0.2	633	6.8	$17,487	$21,512	$577
69	China	Upper middle	0.001	$84,560	$78,518	0.1	280	2.3	$33,785	$36,384	$638
70	Turkey	Upper middle	0.001	$125,197	$86,272	0.1	1,029	3.9	$22,267	$32,314	$582

Tech. Suppl. - Table 4. Relative contribution of diarrhea, malaria and HIV to disease burden of each of 70 countries.

				Diarrhea		Malaria		HIV	
Country	Total DALY burden (3 diseases)	Population	DALYs per capita	Diarrhea burden	DALYs	Malaria burden	DALYs	HIV burden	DALYs
Swaziland	158,061	1,055,506	0.1497	8.4	16,523	0.03	4,338	25.9	137,200
Mozambique	3,288,897	23,390,765	0.1406	11.9	532,817	12.49	1,482,080	11.5	1,274,000
Guinea-Bissau	203,103	1,515,224	0.1340	19.1	78,434	17.65	104,089	2.5	20,580
Nigeria	21,145,996	158,423,182	0.1335	18.7	4,995,101	20.19	12,818,894	3.6	3,332,000
Zambia	1,654,717	12,926,409	0.1280	14.6	410,637	15.24	499,280	13.5	744,800
Burkina Faso	2,079,356	16,468,714	0.1263	18.9	659,064	20.39	1,353,652	1.2	66,640
Mali	1,905,686	15,369,809	0.1240	19.2	715,293	20.83	1,145,312	1	45,080
Somalia	1,131,667	9,330,872	0.1213	21.8	534,781	5.85	512,605	0.7	84,280
Chad	1,341,959	11,227,208	0.1195	21.9	652,646	18.59	400,213	3.4	289,100
Sierra Leone	698,366	5,867,536	0.1190	20.9	246,659	12.94	405,647	1.6	46,060
Burundi	991,869	8,382,849	0.1183	23.6	393,025	9.25	461,645	3.3	137,200
Lesotho	250,467	2,171,318	0.1154	9.9	25,067	0.00	Unknown	23.6	225,400
Congo, DR	7,371,699	65,965,795	0.1118	18.5	3,414,271	17.02	3,389,027	1.3	568,400
Niger	1,711,372	15,511,953	0.1103	20.3	744,317	17.95	907,275	0.8	59,780
Malawi	1,632,385	14,900,841	0.1095	10.9	431,392	16.64	485,593	11	715,400
Cen. African Rep.	463,590	4,401,051	0.1053	17.3	140,555	14.32	272,074	4.7	50,960
Uganda	3,513,177	33,424,683	0.1051	16.0	1,078,814	22.40	1,258,363	6.5	1,176,000
Cameroon	1,957,804	19,598,889	0.0999	16.2	683,514	19.05	705,891	5.3	568,400
South Africa	4,851,895	49,991,300	0.0971	8.7	1,010,490	0.07	19,404	17.8	3,822,000
Guinea	950,891	9,981,590	0.0953	13.8	305,921	23.62	584,210	1.3	60,760
Liberia	367,478	3,994,122	0.0920	17.2	112,638	15.56	231,809	1.5	23,030
Angola	1,682,066	19,081,912	0.0881	25.0	974,838	8.41	491,628	2	215,600
Côte d'Ivoire	1,651,534	19,737,800	0.0837	13.2	518,311	21.10	966,623	3.4	166,600
Benin	732,327	8,849,892	0.0827	13.0	248,863	23.34	435,445	1.2	48,020
Botswana	161,239	2,006,945	0.0803	7.0	13,221	1.04	10,818	24.8	137,200
Zimbabwe	944,891	12,571,454	0.0752	9.2	132,798	3.43	204,493	14.3	607,600
Tanzania	3,360,788	44,841,226	0.0749	11.6	1,025,316	16.43	1,355,472	5.6	980,000
Togo	450,236	6,027,798	0.0747	11.6	124,279	25.67	227,957	3.2	98,000
Rwanda	753,413	10,624,005	0.0709	22.6	357,674	5.91	309,499	2.9	86,240
Congo, Rep.	270,651	4,042,899	0.0669	14.3	81,602	23.85	125,349	3.4	63,700
Kenya	2,637,405	40,512,682	0.0651	20.5	796,738	10.94	762,667	6.3	1,078,000
Ghana	1,542,491	24,391,823	0.0632	9.5	669,521	26.25	657,370	1.8	215,600
Gabon	90,936	1,505,463	0.0604	5.9	16,740	29.32	38,915	5.2	35,280
Ethiopia	4,754,652	82,949,541	0.0573	22.8	3,507,206	6.78	1,247,446	1.5	Unknown
Sudan	1,925,260	33,603,637	0.0573	10.6	850,260	24.89	526,200	1.1	548,800
Afghanistan	1,954,973	34,385,068	0.0569	28.9	1,864,324	0.01	90,648	0.2	Unknown
Senegal	623,509	12,433,728	0.0501	14.8	229,547	18.73	335,162	0.9	58,800
Madagascar	881,807	20,713,819	0.0426	22.5	368,469	3.51	486,388	0.2	26,950
Mauritania	144,515	3,459,773	0.0418	15.7	83,866	13.33	46,929	0.7	13,720
Namibia	87,587	2,283,289	0.0384	6.3	15,072	5.11	15,675	13.1	56,840
Eritrea	175,006	5,253,676	0.0333	21.4	83,796	0.28	78,470	0.8	12,740
Haiti	280,740	9,993,247	0.0281	20.3	173,247	0.87	21,253	1.9	86,240
India	33,617,476	1,224,614,327	0.0275	13.0	30,747,070	0.34	1,498,406	0.3	1,372,000

Myanmar	1,243,928	47,963,012	0.0259	12.8	403,734	1.75	673,594	0.6	166,600
Yemen	599,468	24,052,514	0.0249	20.2	415,209	0.46	184,259	0.2	Unknown
Pakistan	3,465,577	173,593,383	0.0200	16.0	3,220,422	0.12	135,885	0.1	109,270
Papua New Guinea	121,356	6,858,266	0.0177	5.2	31,732	7.29	58,264	0.9	31,360
Guatemala	225,349	14,388,929	0.0157	19.1	152,755	0.00	1,054	0.8	71,540
Cambodia	191,054	14,138,255	0.0135	7.1	121,042	0.78	53,352	0.5	16,660
Nepal	297,240	29,959,364	0.0099	14.7	229,536	0.02	20,664	0.4	47,040
Bolivia	98,154	9,929,849	0.0099	15.2	85,256	0.02	648	0.2	12,250
Iraq	301,208	32,030,823	0.0094	11.6	301,208	0.00	Unknown	0.2	Unknown
Algeria	296,287	35,468,208	0.0084	12.8	272,766	0.00	0	0.1	23,520
Indonesia	1,849,471	239,870,937	0.0077	15.1	924,024	0.80	357,048	0.2	568,400
Bangladesh	1,057,299	148,692,131	0.0071	11.0	939,026	1.77	104,553	0.06	13,720
Russian Federation	990,798	141,920,000	0.0070	1.2	74,498	0.00	Unknown	1	916,300
Uzbekistan	166,792	28,562,400	0.0058	12.0	97,702	0.00	0	0.1	69,090
Morocco	184,114	31,951,412	0.0058	12.4	149,814	0.00	Unknown	0.1	34,300
Ukraine	255,845	45,870,700	0.0056	0.8	20,645	0.00	Unknown	1.1	235,200
Thailand	365,406	69,122,234	0.0053	1.9	237,657	0.50	10,149	1.3	117,600
Vietnam	408,534	86,927,700	0.0047	2.3	111,515	0.13	32,418	0.4	264,600
Malaysia	114,666	28,401,017	0.0040	1.0	16,176	0.17	490	0.5	98,000
Brazil	728,402	194,946,470	0.0037	5.3	292,349	0.06	4,853	0.45	431,200
Peru	106,711	29,076,512	0.0037	4.5	62,255	0.12	356	0.4	44,100
Colombia	159,217	46,294,841	0.0034	4.1	65,031	0.07	2,067	0.5	92,120
Mexico	321,228	113,423,047	0.0028	5.5	175,197	0.00	12	0.3	146,020
Philippines	255,050	93,260,798	0.0027	6.7	226,838	0.05	7,633	0.06	20,580
Argentina	106,812	40,412,376	0.0026	0.9	33,311	0.00	1	0.5	73,500
China	1,766,094	1,337,825,000	0.0013	3.1	848,167	0.00	1,627	0.1	916,300
Turkey	89,042	72,752,325	0.0012	1.3	82,672	0.00	0	0.06	6,370

Total DALY burden: Total annual DALYs for diarrhea, malaria and HIV/AIDS. Source: calculated as sum of DALYs across the 3 diseases.
Population: Total country population, 2010 data. Source: World Bank - http://data.worldbank.org/indicator/SP.POP.TOTL
DALYs per capita: DALYs per person, calculated as total DALY burden, diahrrel disease divided by population.
Diarrhea burden: percentage of childhood(<5) deaths due to diarrhea. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.
Annual deaths: Total number of deaths from diarrheal disease in children <5 yrs. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.
DALYs (Diarrhea): Total DALYs from diarrheal disease in children < 5 yrs. Source: derivation.
Malaria burden: Percentage of childhood (<5) deaths due to malaria. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.
DALYs (Malaria): Total DALYs from malaria in children < 5 yrs. Source: derivation.
HIV burden: Prevalence in 15-49 year olds. Source: AIDSInfo database, via Gapminder.org
DALYs (HIV): Total DALYs from HIV/AIDS. Source: derivation.

Tech. Suppl. - Table 5. Results for Kenya, Bangladesh and Nigeria, per 1000 campaign participants.

		Malaria	Diarrhea	HIV		
		LLITN	Filters	VCT	Condoms	TOTAL
Kenya						
Disease averted	Deaths	1.6	2.4	4.8	2.2	10.9
	Episodes	133.6	1,877.7	7.0		2,018.3
DALYs averted	Prevention	44.1	68.3	40.0	18.2	170.6
	Earlier HIV care			123.5		123.5
	TOTAL	44.1	68.3	181.8		294.1
Costs averted (added)	Prevention	$773	$9,068	$40,889	$18,588	$69,318
	Earlier HIV care			($81,187)		($81,187)
	TOTAL	$773	$9,068	($21,710)		-$11,869
Cost-effectiveness	Campaign cost (unadjusted)					$34,280
	Net cost (savings)					$46,149
	Cost per DALY averted					$157
Bangladesh						
Disease averted	Deaths	0.1	0.8	0.0	0.0	0.9
	Episodes	14.7	1061.3	0.1		1076.1
DALYs averted	Prevention	1.7	22.4	0.4	0.2	24.7
	Earlier HIV care			1.2		1.2
	TOTAL	1.7	22.4	1.8		25.9
Costs averted (added)	Prevention	$89	$5,527	$389	$189	$6,196
	Earlier HIV care			($773)		($773)
	TOTAL	$89	$5,527	($195)		$5,422
Cost-effectiveness	Campaign cost (unadjusted)					$36,658
	Net cost (savings)					$30,236
	Cost per DALY averted					$1,168
Nigeria						
Disease averted	Deaths	6.0	3.4	2.7	1.3	13.4
	Episodes	734.3	2,363.3	4.0		3,101.7
DALYs averted	Prevention	168.8	97.6	21.8	10.2	298.4

	Earlier HIV care			70.8		70.8
	TOTAL	168.8	97.6	102.9		369.3
Costs averted (added)	Prevention	$6,223	$14,300	$28,605	$13,379	$62,507
	Earlier HIV care			($55,797)		($55,797)
	TOTAL	$6,223	$14,300	($14,813)		$5,710
Cost-effectiveness	Campaign cost (unadjusted)					$40,479
	Net cost (savings)					$34,769
	Cost per DALY averted					$94

Tech. Suppl. - Table 6. Annual and cumulative results for campaigns 1 and 2 for Kenya, projected for 30 years. Assumes the second campaign starts 3 years after initial campaign. All outcomes discounted at 3% per annum.

	Annual		Cumulative			Annual DALYs averted				Cumulative DALYs averted			
Year	Net costs	Net DALYs averted	Net costs	DALYs averted	CE ($/DALY averted)	Malaria	Diarrhea	HIV	Total	Malaria	Diarrhea	HIV	Total
1	$20,151	5.2	$20,151	5.2	$3,856	1.7	3.2	0.3	5.2	1.7	3.2	0.3	5.2
2	$4,168	6.0	$24,318	11.3	$2,161	1.6	3.0	1.4	6.0	3.3	6.2	1.7	11.3
3	$2,700	7.1	$27,019	18.3	$1,475	1.6	2.9	2.6	7.1	4.9	9.1	4.3	18.3
4	$27,259	11.6	$54,278	29.9	$1,817	1.9	4.7	4.9	11.6	6.9	13.8	9.2	29.9
5	$1,996	11.5	$56,274	41.4	$1,360	1.9	4.5	5.1	11.5	8.7	18.3	14.3	41.4
6	$2,136	11.5	$58,410	52.9	$1,104	1.8	4.4	5.4	11.5	10.5	22.7	19.7	52.9
7	$1,878	11.5	$60,288	64.4	$936	1.7	3.9	5.9	11.5	12.2	26.6	25.6	64.4
8	$874	11.2	$61,162	75.6	$809	1.7	3.8	5.8	11.2	13.9	30.3	31.4	75.6
9	$1,668	10.9	$62,830	86.5	$727	1.6	3.7	5.6	10.9	15.5	34.0	37.0	86.5
10	$1,786	10.6	$64,616	97.0	$666	1.6	3.5	5.5	10.6	17.1	37.5	42.4	97.0
11	$1,896	11.3	$66,511	108.3	$614	1.5	3.4	6.3	11.3	18.6	41.0	48.7	108.3
12	$2,149	12.0	$68,661	120.3	$571	1.5	3.3	7.2	12.0	20.0	44.3	55.9	120.3
13	$2,239	12.7	$70,900	133.0	$533	1.4	3.2	8.0	12.7	21.5	47.6	63.9	133.0
14	$2,100	14.3	$73,000	147.3	$496	1.4	3.1	9.8	14.3	22.9	50.7	73.7	147.3
15	$1,967	17.4	$74,967	164.7	$455	1.3	3.1	13.0	17.4	24.2	53.8	86.7	164.7
16	$1,840	17.2	$76,807	181.9	$422	1.3	3.0	12.9	17.2	25.5	56.7	99.7	181.9
17	$1,651	16.8	$78,458	198.8	$395	1.3	2.9	12.7	16.8	26.8	59.6	112.3	198.8
18	$1,471	16.6	$79,929	215.3	$371	1.2	2.8	12.5	16.6	28.0	62.4	124.9	215.3
19	$1,301	14.7	$81,230	230.1	$353	1.2	2.7	10.8	14.7	29.2	65.1	135.7	230.1
20	$1,139	14.4	$82,368	244.5	$337	1.2	2.6	10.6	14.4	30.4	67.8	146.3	244.5
21	$985	12.7	$83,354	257.2	$324	1.1	2.6	9.0	12.7	31.5	70.3	155.3	257.2
22	$840	8.8	$84,193	266.0	$317	1.1	2.5	5.2	8.8	32.6	72.8	160.6	266.0
23	$702	8.2	$84,895	274.2	$310	1.1	2.4	4.8	8.2	33.7	75.2	165.3	274.2
24	$571	7.8	$85,466	282.1	$303	1.0	2.3	4.5	7.8	34.7	77.6	169.8	282.1
25	$2,188	6.8	$87,653	288.9	$303	1.0	2.3	3.5	6.8	35.7	79.8	173.3	288.9
26	$2,020	6.6	$89,673	295.5	$304	1.0	2.2	3.4	6.6	36.7	82.1	176.7	295.5
27	$106	6.4	$89,779	301.9	$297	0.9	2.1	3.3	6.4	37.6	84.2	180.0	301.9
28	$617	6.2	$90,396	308.1	$293	0.9	2.1	3.2	6.2	38.6	86.3	183.3	308.1
29	$575	6.0	$90,971	314.1	$290	0.9	2.0	3.1	6.0	39.4	88.3	186.4	314.1
30	$0	5.9	$90,971	320.0	$284	0.9	2.0	3.0	5.9	40.3	90.3	189.4	320.0

Tech. Suppl. - Table 7. Country-specific estimates for unit costs of antiretroviral therapy for HIV adjusted to 2012 US$. In countries with multiple estimate, the mean is shown.

ART UNIT COSTS		
Country	**ART per person-year** (2012 US$)	**Sources**
Benin	$701	Hounton et al. 2008
Botswana	$703	Menzies, 2011
Brazil	$1,786	Acurcio, 2006 (Cited in Galarraga 2011)
Ethiopia	$610	Menzies 2011; Bikilla et al. 2009;
Haiti	$1,120	Koenig 2008
India	$230	Gupta 2009
Lesotho	$165	Cleary 2006
Mexico	$5,990	Bautista 2003; Bautista 2008; Aracena-Genao
Morocco	$1,102	Loubiere 2008 (Cited in Galarraga 2011)
Nigeria	$938	Menzies, 2011; Kombe 2004
South Africa	$1,260	Cleary 2006; Kevany 2009; Deghaye 2006; Martinson 2009; Rosen 2008
Thailand	$3,994	Kitajima 2003
Uganda	$805	Marseille 2009; Jaffar 2009
Zambia	$794	Marseille 2012
Vietnam	$964	Menzies, 2011

Methods for estimating health care and campaign costs.

There is no recognized 'gold standard' for adjusting program and health care costs by country setting. While per-capita GDP may reflects overall ability to pay it assumes that health care is a normal good in which consumption increases monotonically with income. It also lacks the specificity to capture both the unit cost and the relevant quantity utilized of various health inputs, such as inpatient days or outpatient visits. These utilization patterns can vary by country partially independently of income. An alternative index is per-capita spending on health care. This is a more direct measure of overall health care spending, but also fails to capture the detailed inputs cost and utilization mix. Finally, WHO-CHOICE provides country-specific costs for inpatient days and outpatient visits at various levels of facilities (e.g. primary, secondary, and teaching hospitals). By comparing the WHO-CHOICE-derived costs for Kenya against the other 69 countries, yet a third index can be created. However, this WHO-CHOICE based index has its own short-comings. In addition to not reflecting the specific mix of inputs needed for the present analysis, the methods used to derive the costs are somewhat opaque. The regression model used to predict country health care costs includes per-capita GDP, and thus may be similar to using a per-capita GDP-based index.

The variation in the results yielded by each method is modest. Table 8 shows the base-case results using the per-capita health care spending approach; Table 9 uses the index derived from WHO-CHOICE. These show very little difference in the cost-effectiveness results by country rankings when compared with the per-capita GDP approach (Table 3 in the main paper).

Table 8. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign. Non-tradable portion of costs imputed from Kenya trial data based on per-capita health care spending. Sources: WHO, World Health Statistics 2012, Http://apps.who.int/gho/data/node.main.78?lang=en. Definitions: Health Expenditure per-capita (PPP; International $): The sum of public and private health expenditure (in PPP, International $) divided by population. Health expenditure includes the provision of health services, family planning activities, nutrition activities and emergency aid designated for heath, but excludes the provision of water and sanitation.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes		Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$31,652	$2,286	40.7	10,523	1,145.2	$28	$2	$1,005
2	Sierra Leone	Low	0.119	$52,305	$4,927	16.0	4,118	447.9	$117	$11	$764
3	Senegal	Lower middle	0.050	$36,210	$11,527	10.7	5,735	305.4	$119	$38	$768
4	Burkina Faso	Low	0.126	$35,260	$20,805	16.4	4,124	459.8	$77	$45	$819
5	Somalia	Low	0.121	$26,015	$22,924	16.8	3,682	470.8	$55	$49	$1,535
6	Mali	Low	0.124	$32,840	$22,058	15.9	4,222	445.4	$74	$50	$888
7	Niger	Low	0.110	$28,445	$21,450	14.8	4,967	419.1	$68	$51	$1,095
8	Afghanistan	Low	0.057	$28,905	$18,828	12.7	4,146	356.9	$81	$53	$935
9	Sudan	Lower middle	0.057	$45,505	$10,906	6.9	4,907	198.4	$229	$55	$703
10	Guinea	Low	0.095	$31,875	$21,102	12.6	4,272	355.2	$90	$59	$928
11	Lesotho	Lower middle	0.115	$55,557	$54,805	31.3	1,756	859.0	$65	$64	$738
12	Congo, DR	Low	0.112	$25,386	$25,306	13.4	3,517	376.8	$67	$67	$1,493
13	Chad	Low	0.120	$28,103	$29,728	15.3	4,335	427.1	$66	$70	$807
14	Liberia	Low	0.092	$36,982	$23,225	11.9	3,401	333.2	$111	$70	$1,025
15	Côte d'Ivoire	Lower middle	0.084	$43,278	$30,730	14.1	4,021	393.7	$110	$78	$801
16	Burundi	Low	0.118	$28,504	$34,224	14.3	2,267	393.6	$72	$87	$987
17	Uganda	Low	0.105	$37,888	$36,726	14.9	3,492	409.5	$93	$90	$749
18	Benin	Low	0.083	$32,216	$25,362	10.0	3,096	280.0	$115	$91	$910
19	Nigeria	Lower middle	0.133	$45,846	$34,213	13.4	3,102	370.6	$124	$92	$747
20	Mozambique	Low	0.141	$31,652	$58,371	22.2	3,816	606.8	$52	$96	$1,109
21	Cen. African Rep.	Low	0.105	$26,663	$37,686	13.8	2,819	380.3	$70	$99	$1,230
22	Congo, Rep.	Lower middle	0.067	$42,684	$33,709	11.5	2,981	319.7	$134	$105	$756
23	Togo	Low	0.075	$32,973	$32,220	10.4	2,849	287.6	$115	$112	$864
24	Zambia	Lower middle	0.128	$38,512	$68,361	21.8	3,107	594.6	$65	$115	$826
25	Malawi	Low	0.110	$34,146	$58,110	18.3	2,965	496.4	$69	$117	$996
26	Tanzania	Low	0.075	$30,345	$39,174	12.1	3,122	331.0	$92	$118	$935
27	Ethiopia	Low	0.057	$28,371	$28,810	8.6	1,986	237.4	$120	$121	$1,139

28	Angola	Upper middle	0.088	$53,374	$39,069	11.5	3,268	321.5	$166	$122	$674
29	Cameroon	Lower middle	0.100	$39,729	$52,377	14.3	3,115	394.2	$101	$133	$741
30	Rwanda	Low	0.071	$43,307	$37,051	9.6	2,216	265.0	$163	$140	$768
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	478.9	$53	$159	$1,731
33	Yemen	Lower middle	0.025	$39,388	$20,853	4.3	3,128	122.6	$321	$170	$719
34	Mauritania	Lower middle	0.042	$39,952	$29,100	5.8	2,607	164.0	$244	$177	$955
35	Ghana	Lower middle	0.063	$37,606	$34,488	6.8	1,966	189.9	$198	$182	$746
36	Pakistan	Lower middle	0.020	$35,334	$20,601	3.8	2,748	108.0	$327	$191	$904
37	Madagascar	Low	0.043	$27,806	$24,564	4.5	1,910	127.6	$218	$192	$1,025
38	Eritrea	Low	0.033	$24,332	$25,362	4.3	1,942	119.5	$204	$212	$1,753
39	Swaziland	Lower middle	0.150	$88,325	$197,225	29.1	2,230	800.0	$110	$247	$632
40	Haiti	Low	0.028	$34,310	$31,765	4.4	3,128	121.7	$282	$261	$869
41	Botswana	Upper middle	0.080	$151,324	$196,117	26.8	1,111	734.1	$206	$267	$577
42	Guatemala	Lower middle	0.016	$76,551	$19,936	2.4	3,143	68.3	$1,121	$292	$627
43	Myanmar	Low	0.026	$25,550	$25,518	2.9	1,306	83.1	$307	$307	$1,354
44	India	Lower middle	0.027	$45,178	$33,274	3.7	1,255	104.6	$432	$318	$733
45	Papua New Guinea	Lower middle	0.018	$44,272	$24,760	2.4	2,868	70.6	$627	$351	$864
46	South Africa	Upper middle	0.097	$167,731	$223,292	21.5	1,150	579.7	$289	$385	$582
47	Gabon	Upper middle	0.060	$104,762	$107,288	9.3	1,876	251.5	$417	$427	$613
48	Iraq	Upper middle	0.009	$43,990	$25,081	1.9	2,587	55.5	$792	$452	$758
49	Namibia	Upper middle	0.038	$113,745	$218,642	15.6	1,528	416.7	$273	$525	$606
50	Cambodia	Low	0.014	$41,971	$32,821	1.9	1,341	53.9	$779	$609	$739
51	Nepal	Low	0.010	$33,760	$30,891	1.4	1,135	39.2	$861	$788	$883
52	Morocco	Lower middle	0.006	$72,424	$50,688	1.9	1,623	54.5	$1,329	$930	$650
53	Bangladesh	Low	0.007	$31,949	$28,039	0.9	1,076	25.8	$1,237	$1,086	$1,046
54	Algeria	Upper middle	0.008	$87,063	$59,839	1.4	1,304	40.8	$2,136	$1,468	$606
55	Uzbekistan	Lower middle	0.006	$54,666	$26,791	0.6	2,352	18.1	$3,021	$1,481	$717
56	Indonesia	Lower middle	0.008	$44,169	$38,316	0.7	814	20.5	$2,158	$1,872	$793
57	Thailand	Upper middle	0.005	$79,120	$90,878	1.8	455	46.5	$1,700	$1,952	$622
58	Bolivia	Lower middle	0.010	$67,123	$33,507	0.4	2,015	13.1	$5,105	$2,549	$668
59	Vietnam	Lower middle	0.005	$51,726	$44,913	0.6	828	16.7	$3,102	$2,694	$664
60	Ukraine	Lower middle	0.006	$105,326	$92,351	1.2	623	32.8	$3,209	$2,814	$600
61	Peru	Upper middle	0.004	$104,227	$63,328	0.6	1,497	17.8	$5,864	$3,563	$613
62	Philippines	Lower middle	0.003	$51,949	$39,286	0.3	1,289	10.8	$4,832	$3,654	$724

63	Colombia	Upper middle	0.003	$129,275	$80,234	0.6	1,419	18.7	$6,900	$4,283	$598
64	Malaysia	Upper middle	0.004	$122,297	$93,832	0.6	930	16.5	$7,428	$5,699	$591
65	Brazil	Upper middle	0.004	$186,498	$105,365	0.6	1,385	18.1	$10,306	$5,822	$581
66	Russian Federation	High: nonOECD	0.007	$240,707	$192,690	1.1	735	30.2	$7,975	$6,384	$579
67	Argentina	Upper middle	0.003	$252,229	$164,213	0.6	1,097	16.6	$15,161	$9,871	$577
68	Turkey	Upper middle	0.001	$191,725	$80,928	0.1	1,784	5.9	$32,276	$13,624	$582
69	China	Upper middle	0.001	$93,151	$81,634	0.1	486	4.4	$20,990	$18,395	$638
70	Mexico	Upper middle	0.003	$179,550	$187,187	0.3	0	8.7	$20,612	$21,489	$583

Tech. Suppl. - Table 9. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign. Non-tradable portion of costs imputed from Kenya trial data based on WHO-CHOICE data on costs for inpatient day and outpatient visit assuming 75% of costs are for outpatient; 25% for inpatient. Source: WHO–CHOICE: http://www.who.int/choice/cost-effectiveness/inputs/health_service/en/

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				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$26,373	$17,367	40.7	10,523	1,145.2	$23	$15	$1,005
2	Senegal	Lower middle	0.050	$36,106	$11,638	10.7	5,735	305.4	$118	$38	$768
3	Burkina Faso	Low	0.126	$33,007	$21,650	16.4	4,124	459.8	$72	$47	$819
4	Sierra Leone	Low	0.119	$28,338	$22,441	16.0	4,118	447.9	$63	$50	#N/A
5	Mali	Low	0.124	$31,186	$22,527	15.9	4,222	445.4	$70	$51	$888
6	Niger	Low	0.110	$27,560	$21,862	14.8	4,967	419.1	$66	$52	$1,095
7	Afghanistan	Low	0.057	$28,280	$19,188	12.7	4,146	356.9	$79	$54	$935
8	Lesotho	Lower middle	0.115	$34,378	$46,888	31.3	1,756	859.0	$40	$55	$738
9	Guinea	Low	0.095	$30,485	$21,805	12.6	4,272	355.2	$86	$61	$928
10	Chad	Low	0.120	$32,650	$27,127	15.3	4,335	427.1	$76	$64	$807
11	Congo, DR	Low	0.112	$24,540	$25,512	13.4	3,517	376.8	$65	$68	$1,493
12	Liberia	Low	0.092	$25,154	$26,045	11.9	3,401	333.2	$75	$78	$1,025
13	Sudan	Lower middle	0.057	$38,572	$15,919	6.9	4,907	198.4	$194	$80	$703
14	Burundi	Low	0.118	$25,095	$33,564	14.3	2,267	393.6	$64	$85	$987
15	Côte d'Ivoire	Lower middle	0.084	$34,943	$34,796	14.1	4,021	393.7	$89	$88	$801
16	Benin	Low	0.083	$33,846	$25,342	10.0	3,096	280.0	$121	$91	$910
17	Nigeria	Lower middle	0.133	$38,931	$34,929	13.4	3,102	370.6	$105	$94	$747
18	Uganda	Low	0.105	$32,646	$39,581	14.9	3,492	409.5	$80	$97	$749
19	Mozambique	Low	0.141	$28,771	$59,852	22.2	3,816	606.8	$47	$99	$1,109
20	Cen. African Rep.	Low	0.105	$28,010	$37,642	13.8	2,819	380.3	$74	$99	$1,230
21	Congo, Rep.	Lower middle	0.067	$51,672	$33,891	11.5	2,981	319.7	$162	$106	#N/A
22	Togo	Low	0.075	$31,613	$32,267	10.4	2,849	287.6	$110	$112	$864
23	Angola	Upper middle	0.088	$62,105	$37,627	11.5	3,268	321.5	$193	$117	$674
24	Tanzania	Low	0.075	$32,091	$38,786	12.1	3,122	331.0	$97	$117	$935
25	Zambia	Lower middle	0.128	$32,785	$70,043	21.8	3,107	594.6	$55	$118	$826
26	Malawi	Low	0.110	$28,219	$59,708	18.3	2,965	496.4	$57	$120	$996
27	Ethiopia	Low	0.057	$29,008	$29,104	8.6	1,986	237.4	$122	$123	$1,139
28	Rwanda	Low	0.071	$30,681	$33,818	9.6	2,216	265.0	$116	$128	$768
29	Cameroon	Lower middle	0.100	$39,111	$52,380	14.3	3,115	394.2	$99	$133	$741
30	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
31	Yemen	Lower middle	0.025	$41,823	$20,557	4.3	3,128	122.6	$341	$168	$719
32	Mauritania	Lower middle	0.042	$38,314	$28,653	5.8	2,607	164.0	$234	$175	$955
33	Ghana	Lower middle	0.063	$33,612	$33,841	6.8	1,966	189.9	$177	$178	$746
34	Pakistan	Lower middle	0.020	$40,398	$19,912	3.8	2,748	108.0	$374	$184	$904
35	Madagascar	Low	0.043	$30,438	$25,467	4.5	1,910	127.6	$239	$200	$1,025
36	Eritrea	Low	0.033	$26,867	$26,253	4.3	1,942	119.5	$225	$220	$1,753

37	Botswana	Upper middle	0.080	$116,424	$173,837	26.8	1,111	734.1	$159	$237	$577
38	Swaziland	Lower middle	0.150	$58,455	$198,389	29.1	2,230	800.0	$73	$248	$632
39	Haiti	Low	0.028	$30,962	$31,577	4.4	3,128	121.7	$254	$260	$869
40	South Africa	Upper middle	0.097	$93,433	$177,476	21.5	1,150	579.7	$161	$306	$582
41	India	Lower middle	0.027	$44,370	$32,889	3.7	1,255	104.6	$424	$314	$733
42	Guatemala	Lower middle	0.016	$57,311	$22,179	2.4	3,143	68.3	$839	$325	$627
43	Myanmar	Low	0.026	$31,316	$28,153	2.9	1,306	83.1	$377	$339	$1,354
44	Papua New Guinea	Lower middle	0.018	$39,103	$25,246	2.4	2,868	70.6	$554	$358	$864
45	Gabon	Upper middle	0.060	$56,344	$92,439	9.3	1,876	251.5	$224	$368	$613
46	Iraq	Upper middle	0.009	$47,126	$25,378	1.9	2,587	55.5	$848	$457	$758
47	Namibia	Upper middle	0.038	$68,440	$201,570	15.6	1,528	416.7	$164	$484	$606
48	Cambodia	Low	0.014	$38,523	$31,223	1.9	1,341	53.9	$715	$579	$739
49	Nepal	Low	0.010	$30,887	$29,027	1.4	1,135	39.2	$788	$740	$883
50	Morocco	Lower middle	0.006	$54,334	$40,545	1.9	1,623	54.5	$997	$744	$650
51	Bangladesh	Low	0.007	$32,639	$28,448	0.9	1,076	25.8	$1,264	$1,101	$1,046
52	Algeria	Upper middle	0.008	$80,074	$55,887	1.4	1,304	40.8	$1,965	$1,371	$606
53	Uzbekistan	Lower middle	0.006	$43,037	$25,245	0.6	2,352	18.1	$2,379	$1,395	$717
54	Brazil	Upper middle	0.004	$34,045	$31,218	0.6	1,385	18.1	$1,881	$1,725	$581
55	Thailand	Upper middle	0.005	$79,636	$91,299	1.8	455	46.5	$1,711	$1,961	$622
56	Ukraine	Lower middle	0.006	$74,578	$68,634	1.2	623	32.8	$2,272	$2,091	$600
57	Indonesia	Lower middle	0.008	$51,988	$43,696	0.7	814	20.5	$2,540	$2,135	$793
58	Bolivia	Lower middle	0.010	$53,963	$30,445	0.4	2,015	13.1	$4,105	$2,316	$668
59	Vietnam	Lower middle	0.005	$43,303	$39,035	0.6	828	16.7	$2,597	$2,341	$664
60	Peru	Upper middle	0.004	$82,397	$53,509	0.6	1,497	17.8	$4,636	$3,011	$613
61	Philippines	Lower middle	0.003	$48,596	$37,382	0.3	1,289	10.8	$4,520	$3,477	$724
62	Colombia	Upper middle	0.003	$124,448	$77,859	0.6	1,419	18.7	$6,643	$4,156	$598
63	Russian Federation	High: nonOECD	0.007	$156,317	$131,095	1.1	735	30.2	$5,179	$4,343	$579
64	Argentina	Upper middle	0.003	$119,219	$85,212	0.6	1,097	16.6	$7,166	$5,122	$577
65	Malaysia	Upper middle	0.004	$118,529	$91,339	0.6	930	16.5	$7,199	$5,548	$591
66	Turkey	Upper middle	0.001	$116,707	$55,139	0.1	1,784	5.9	$19,647	$9,283	$582
67	China	Upper middle	0.001	$66,612	$59,793	0.1	486	4.4	$15,010	$13,474	$638
68	Mexico	Upper middle	0.003	$120,196	$127,833	0.3	0	8.7	$13,799	$14,675	$583

Tech. Suppl. - Table 10. Estimates of rates of care seeking for malaria.

Source	Location	Care-seeking rate
ScientificWorldJournal. 2003 Aug 19;3:721-30. Prevalence of childhood illnesses and care-seeking practices in rural Uganda. Mbonye AK.	Rural Uganda	44.7%
Malar J. 2010 Nov 22;9:333. From fever to anti-malarial: the treatment-seeking process in rural Senegal. Smith LA, Bruce J, Gueye L, Helou A, Diallo R, Gueye B, Jones C, Webster J.	Rural Senegal	61.6%
BMC Pub Health. 2008. Obstacles to prompt and effective malaria treatment lead to low community-coverage in two rural districts of Tanzania. Hetzel MW, Obrist B, Lengeler C, Msechu JJ, Nathan R, Dillip A, Makemba AM, Mshana C, Schulze A, Mshinda H.	South-eastern Tanzania (rural, high malaria transmission)	76.3% (caretakers bringing children to HF); 56.1% (adults attending health facility for own symptoms)
Malar J. 2011 Oct 31;10:327. Monitoring fever treatment behaviour and equitable access to effective medicines in the context of initiatives to improve ACT access: baseline results and implications for programming in six African countries. Littrell M, Gatakaa H, Evance I, et al	Benin, DRC, Madagascar, Nigeria, Uganda, Zambia	Treatment-seeking outside of home: Benin - 50.3%; DRC - 73%; Madagascar - 78%; Nigeria - 73%; Uganda - 72%; Zambia - 77%
Malar J. 2010 Dec 30;9:377. Factors affecting treatment-seeking for febrile illness in a malaria endemic block in Boudh district, Orissa, India: policy implications for malaria control. Das A, Ravindran TS.	Orissa, India (high malaria transmission area)	Treatment-seeking: 94%
Malar J. 2010 Jun 15;9:163. Improvements in access to malaria treatment in Tanzania following community, retail sector and health facility interventions -- a user perspective. Alba S, Dillip A, Hetzel MW, et al	Ifakara, Tanzania	Health facility attendance:52%

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Tech-Suppl - Figure 1.

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Tech-Suppl - Figure 2.

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Projection of costs and outcomes to 30 years

We projected cumulative costs and outcomes of the IPC campaign in Kenya for 30 years, assuming an initial campaign and a second campaign three years later (Figure 6). Costs and benefits of the two campaigns were added and reflect the lower effectiveness of the second campaign. The large rise in costs in year 4 reflects the initiation of the second campaign, and the gradual increase in cumulative costs over time reflects the costs of additional HIV treatment. The steadily rising cumulative net DALYs averted reflects the averted morbidity during the period of bed net and water filter efficacy, but is largely determined by the distribution of saved life years due to averted mortality from all three diseases during the period of IPC benefit. Distribution of benefits were made according to the following assumptions:

- HIV deaths would occur on average 15 years after infection.
- Assumes those detected are all put on ART at year of campaign.
- Earlier and more ART die to earlier detection distributed over 15 and 20 years respectively.
- HIV mortality prevention in secondary partners starts on average in year 20 after the campaign and is distributed over 20 years.
- 50% of prevented HIV mortality occurred in the index patient
- Life-expectancy at the time of the campaign was 60 years for averted mortality in malaria and diarrhea patients.
- Malaria and diarrhea morbidity reduction is confined to the campaign itself.

Tech Suppl. - Figure 6.

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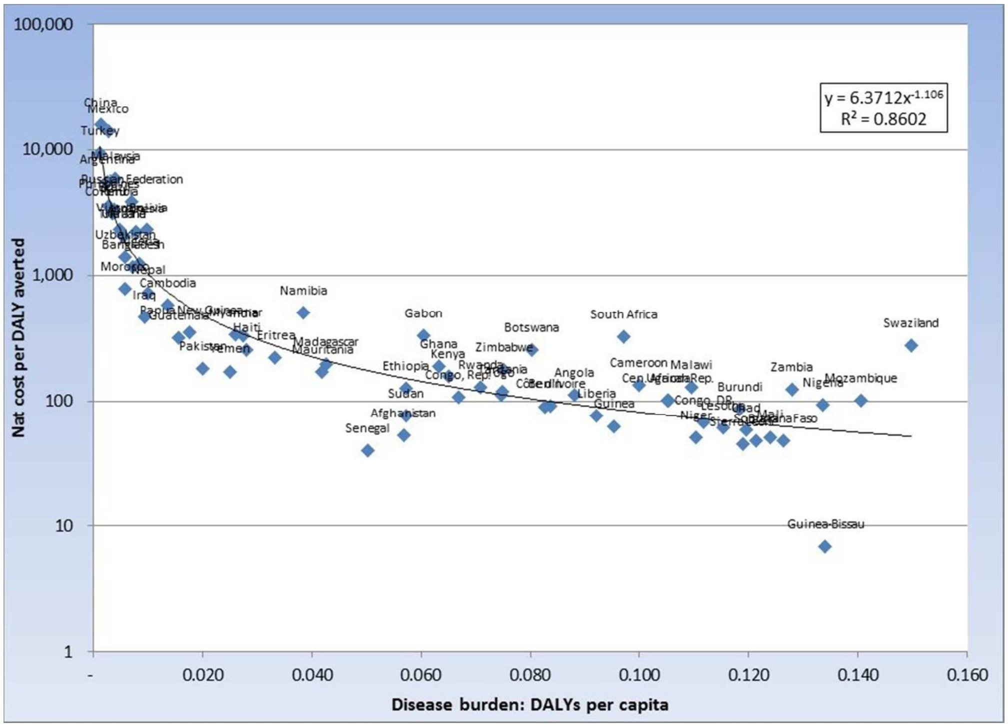

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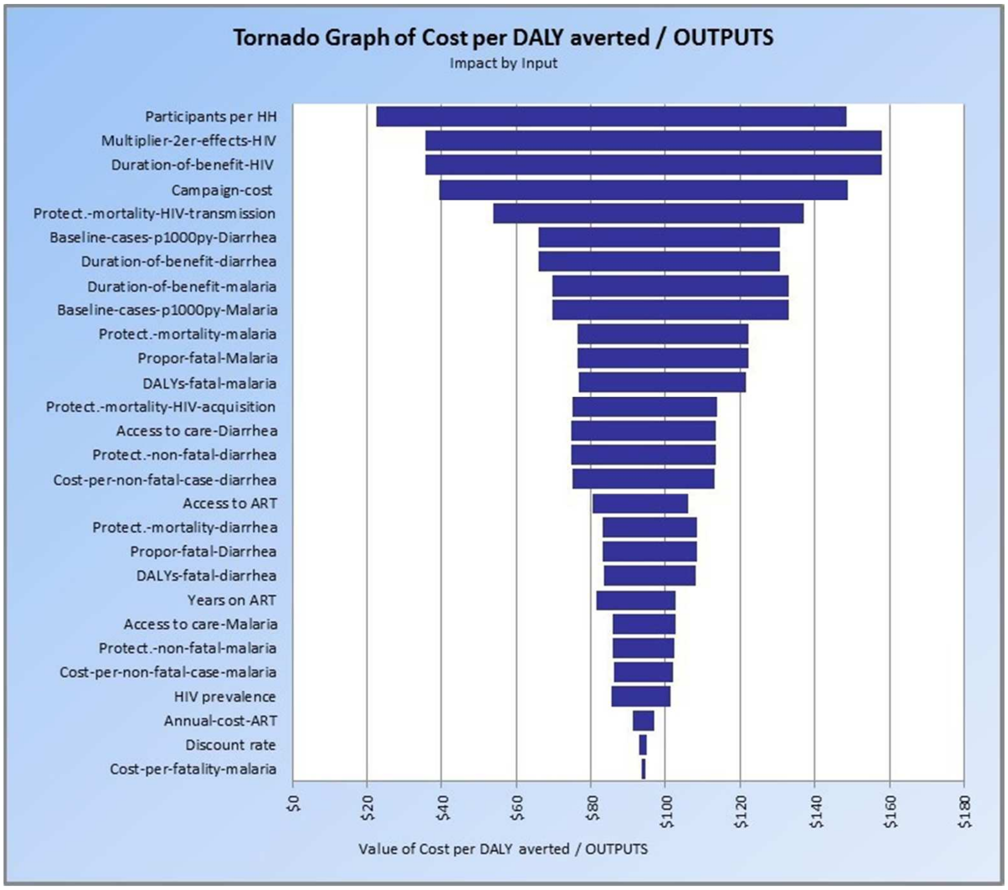

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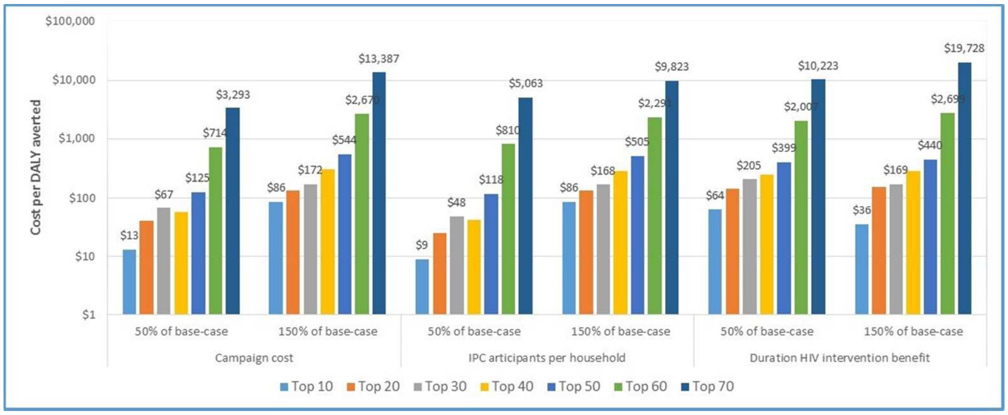

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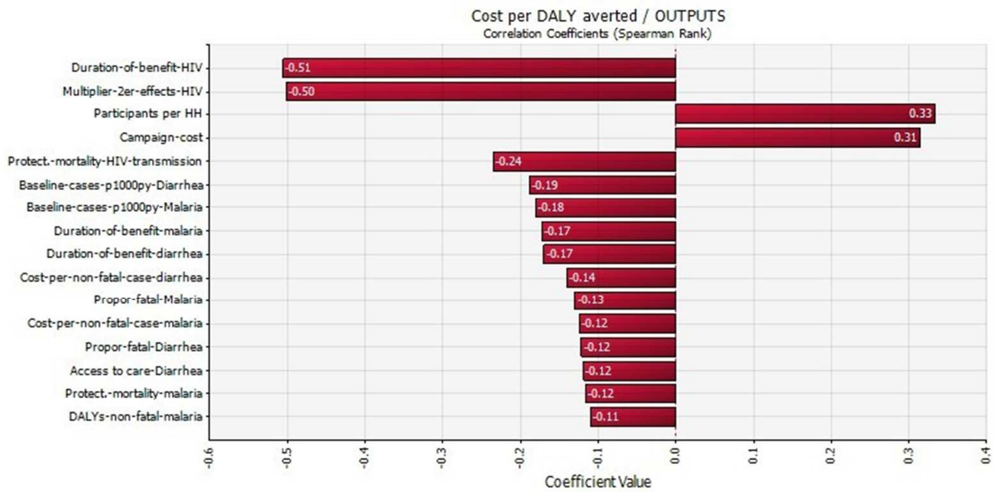

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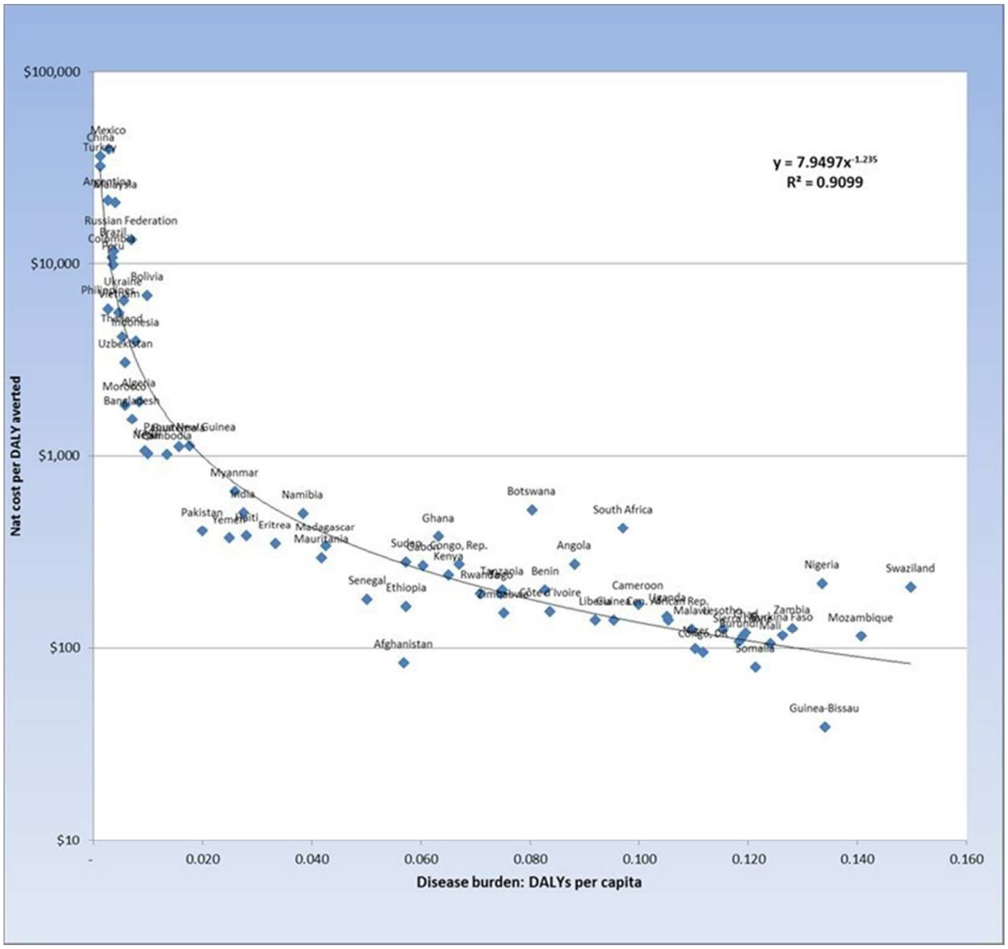

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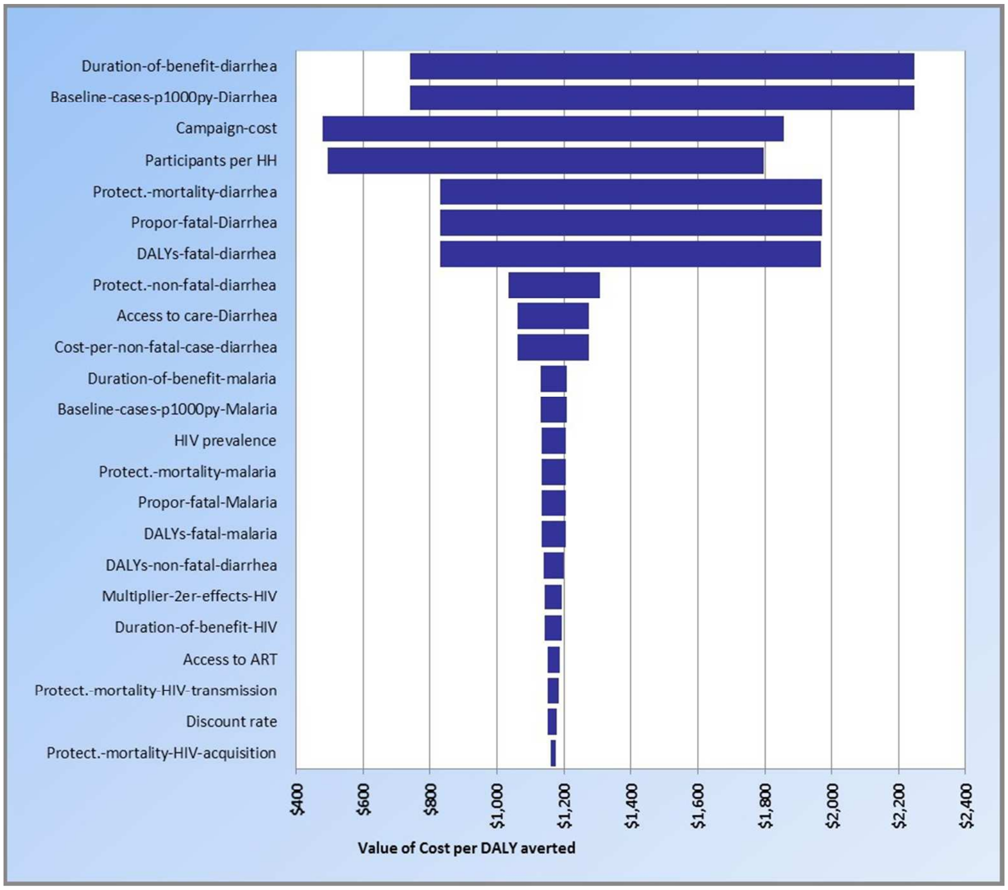

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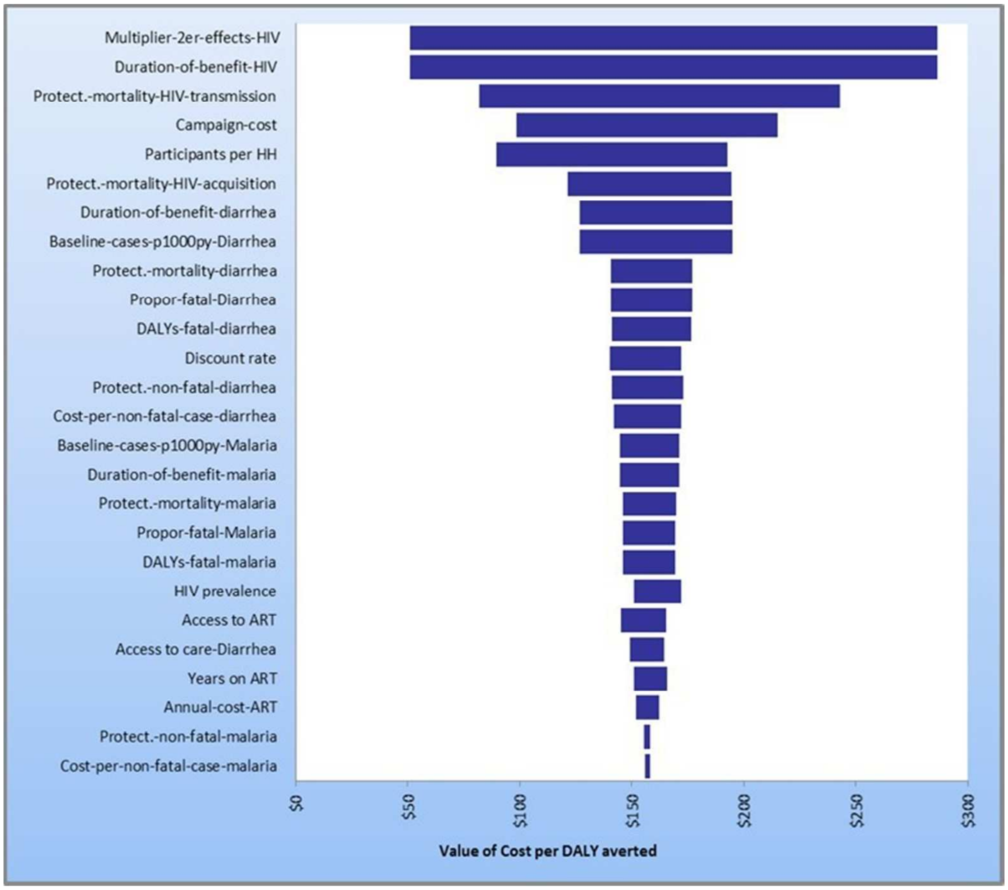

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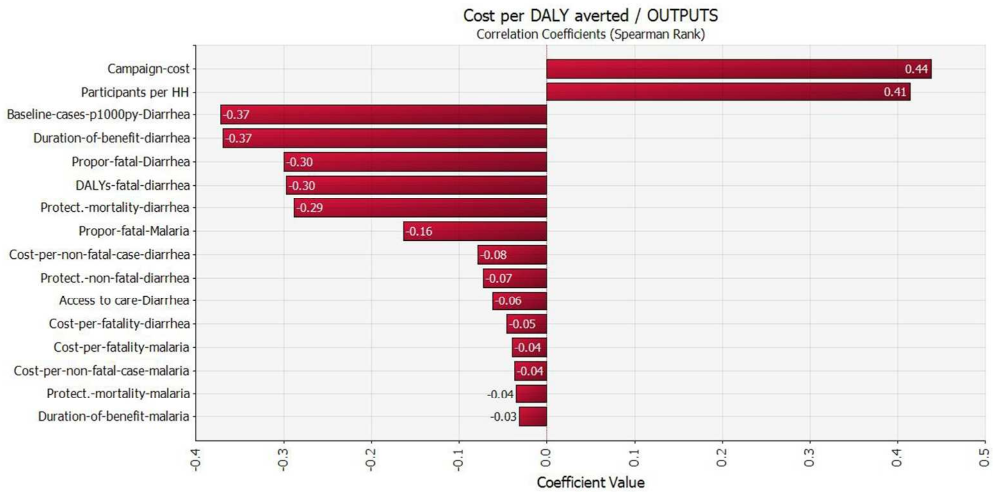

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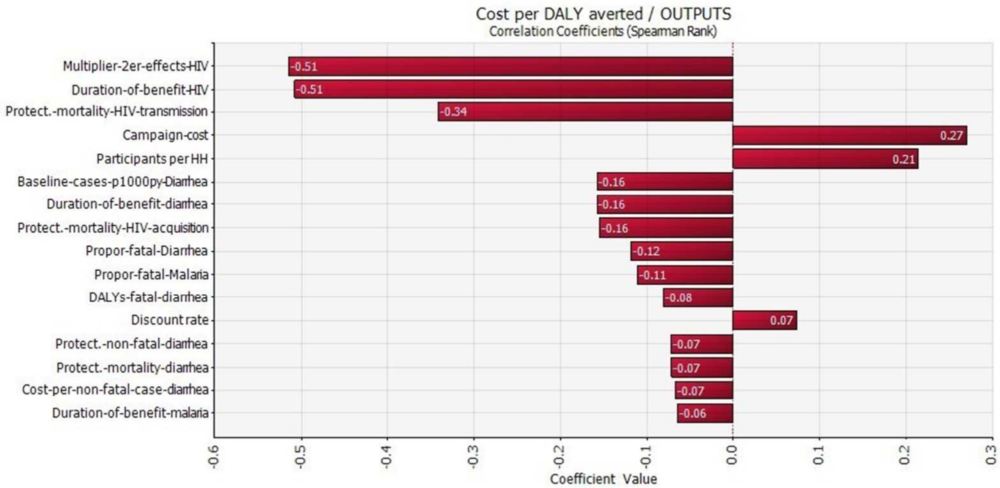

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Technical Supplement

Reduction in risk for malaria and HIV between first and second campaign
In this analysis, to explore sustainability, we examine both an initial campaign and a follow-up campaign three years later. Thus, we need to estimate the health benefit realized by the follow-up campaign, taking into account the stability of disease reduction offered initially. The more that initial protection decays over six years, and thus the larger the disease risk in years 4-6, the greater will be the benefit of a campaign at three years. This decay is a function of the physical durability of the commodities distributed, as well as maintenance of safer behaviors. The dynamics vary by disease.

For malaria we assume 75% as much disease incidence at years 4-6 (absent a 2nd campaign) as baseline incidence. In other words, we assume that full set of LLIN distributed in the *initial* campaign, with no follow-up campaign, would have half as much community benefit in years 4-6 as in years 1-3. Many LLIN will remain in place, and the insecticide impregnation itself is stable for close to 10 years. Thus, the 50% incidence drop expected with LLIN in years 1-3 will decrease but not disappear in the second 3 years. However, the second round of LLIN are likely to have a relative effectiveness less than 50%, because the best LLIN users are already protected. Thus we decrease the effectiveness from 50% to 33% (i.e., from 75% of baseline incidence to 50% of baseline incidence). In effect, the 2nd campaign is like a booster shot that returns effectiveness to its original level. In sum, the overall benefit of the second campaign is reduced by half -- in first campaign it was 100% of baseline incidence to 50%, and in the second campaign from 75% of baseline incidence to 50%.

We note that these estimates are assembled from isolated data (e.g., LLIN physical durability) combined with a logical framework and best guesses. Nonetheless, we believe that the conclusion – 50% as much benefit for a second campaign – is plausible, and is a far more realistic assumption than full benefit. Our approach is conservative regarding the second campaign – if the specified durability of effect of the LLIN is larger than in reality, we would be *under*estimating the benefit of this campaign. And our estimate of the combined effect of two sequential campaigns is robust. Low estimates of durability understate benefits of the first campaign and overstate benefits of the second campaign, which represent offsetting errors. Conversely, high estimates of durability overstate the value of the first campaign and understate second campaign benefits, again offsetting.

For diarrhea, we assume no filter benefit after three years. The filters are expected to last in good function only three years. Thus, the filter component of the second campaign is just as effective as for the first campaign.

For HIV, effects on DALYs and cost depend heavily on undiagnosed HIV prevalence. The first campaign detects almost all HIV-infected individuals. Thus, the effects of the second campaign depend mainly on the impact of 3 years of HIV incidence on (predominantly undiagnosed) HIV prevalence. This incidence has not been measured, but can be estimated from HIV prevalence using simple epidemic dynamics. [1]Steady-state (pre-ART) annual incidence is about 1/10th of prevalence (slightly more if prevalence above 10%, due to reduction in # of susceptible). So, if initial prevalence was 5%, then annual incidence is about 0.5%, and prevalence at 3 years will be about 1.5%.

Incidence and thus prevalence could be even lower if ART reduces community viral load and also if VCT for HIV+ has substantial behavioral benefits. They could be higher if the first campaign selectively missed HIV+, e.g. they chose not to participate or were away in urban areas.

Diarrhea: estimation of average cases per PY and annual cases
Using data on the number of episodes per year in children under 5 [2], we estimated the average number of episodes (cases) per person-year in the overall population by weighting the incidence by the percentage of the population under five [3] and over five. We then adjusted the incidence in the >5 year-old population by the ratio of the country <5 incidence to the average global <5 incidence [4]. Multiplying each estimate by the total population [5] provided estimates of the number of cases of diarrhea in each country.

Explanation for difference between results reported in earlier analysis (Kahn, 2012) and current article. The earlier evaluation of the Integrated Prevention Campaign in Western Province, Kenya found that the 2008 campaign saved $16,015 and averted 442 DALYs per 1,000 campaign participants.[6] The current article finds a highly favorable cost-effectiveness ratio of $157 per DALY averted (net cost of $ 46,149 and 294 DALYs averted per 1,000 campaign participants), but no cost savings in the base-case analysis for Kenya. The difference can be attributed to the aggregate effect of changes in input parameter values of two types: (a) ***Geographic shift from Western Province to Kenya in general.*** The earlier analysis calculated the number of beneficiaries per household based on household size data from the campaign communities, 7.7 persons. In the current article, we used the lower national figure of 4.6, assumed to reflect fewer children per household [7]. The total benefits of the malaria and diarrheal disease interventions fell accordingly. The current article also uses lower figures for malaria and diarrhea annual incidence, 0.057 and 0.542 per individual for Kenya, respectively, versus 0.30 and 1.75 as found in the 2008 survey in Western Province. (b) ***Refined data on care seeking***. The 2012 article assumed 100% care-seeking for diarrhea and malaria. Subsequently, we obtained data on care-seeking patterns, though not specific to Kenya. The current article thus assumes 67.8% for diarrheal diseases and 68.4% for malaria. In addition, we adjusted two cost inputs. The campaign cost was updated to include a recent water filter maintenance program to $34,280 from $32,000 in the earlier paper. Based on a more complete review of the relevant literature including new findings on life expectancy for people receiving antiretroviral therapy (ART), we also increased the estimated lifetime cost of ART, from $5,092 to $12,213.

Tech. Suppl. - Table 1: Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most to least cost-effective. The grey highlighted cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the <u>second and subsequent 3-year campaigns</u>.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$29,459	$16,675	26.9	5,465.3	754.3	$22	$39	$1,005
2	Somalia	Low	0.121	$26,015	$23,643	11.6	2,055.1	325.2	$73	$80	$768
3	Afghanistan	Low	0.057	$28,770	$22,700	12.2	2,380.6	342.0	$66	$84	$764
4	Congo, DR	Low	0.112	$24,637	$24,258	9.3	1,851.9	259.2	$94	$95	$819
5	Niger	Low	0.110	$28,081	$24,250	10.0	2,648.0	282.6	$86	$99	$1,535
6	Mali	Low	0.124	$29,459	$25,298	10.0	2,312.1	280.1	$90	$105	$1,095
7	Burundi	Low	0.118	$26,015	$27,699	8.7	1,256.5	239.8	$116	$108	$888
8	Sierra Leone	Low	0.119	$31,525	$24,508	9.8	2,142.5	274.1	$89	$115	$935
9	Mozambique	Low	0.141	$30,147	$36,613	9.7	1,975.5	260.0	$141	$116	$807
10	Burkina Faso	Low	0.126	$31,525	$26,076	9.6	2,153.3	270.2	$96	$117	$738
11	Chad	Low	0.120	$35,658	$27,805	10.6	2,258.2	294.9	$94	$121	$928
12	Lesotho	Lower middle	0.115	$35,658	$37,171	11.7	919.3	283.6	$131	$126	$1,493
13	Malawi	Low	0.110	$28,081	$36,299	8.6	1,532.3	221.8	$164	$127	$703
14	Zambia	Lower middle	0.128	$33,591	$41,222	10.1	1,660.1	263.4	$156	$128	$1,025
15	Liberia	Low	0.092	$26,704	$25,199	6.8	1,762.6	190.4	$132	$140	$987
16	Guinea	Low	0.095	$29,459	$25,199	7.4	2,175.8	208.8	$121	$141	$910
17	Cen. African Rep.	Low	0.105	$27,392	$29,606	7.1	1,443.6	194.2	$152	$141	$801
18	Uganda	Low	0.105	$31,525	$31,104	7.9	1,841.7	214.8	$145	$147	$747
19	Zimbabwe	Low	0.075	$25,326	$40,453	6.9	905.4	165.8	$244	$153	$1,109
20	Côte d'Ivoire	Lower middle	0.084	$33,591	$31,110	7.8	2,009.7	214.9	$145	$156	$1,230
21	Ethiopia	Low	0.057	$30,147	$28,881	6.5	1,128.0	181.8	$159	$166	$749
22	Cameroon	Lower middle	0.100	$37,724	$39,507	8.1	1,620.0	223.1	$177	$169	$756
23	Senegal	Lower middle	0.050	$34,969	$22,535	6.8	2,951.7	193.6	$116	$181	$864
24	Togo	Low	0.075	$29,459	$28,877	5.5	1,466.8	153.3	$188	$192	$674
25	Rwanda	Low	0.071	$31,525	$30,620	5.9	1,248.9	163.9	$187	$192	$935
26	Tanzania	Low	0.075	$33,591	$32,273	6.1	1,636.6	167.4	$193	$201	$826
27	Benin	Low	0.083	$33,591	$28,793	5.9	1,611.1	167.1	$172	$201	$1,139
28	Swaziland	Lower middle	0.150	$58,387	$87,699	11.5	1,280.6	281.0	$312	$208	$768
29	Nigeria	Lower middle	0.133	$40,479	$34,860	6.7	1,610.1	187.0	$186	$217	$996
30	Kenya	Low	0.065	$34,280	$35,682	5.2	1,130.6	142.8	$250	$240	$741
31	Gabon	Upper middle	0.060	$29,826	$46,367	4.0	972.5	110.7	$419	$269	$883
32	Congo, Rep.	Lower middle	0.067	$54,254	$42,228	7.2	1,522.2	199.0	$212	$273	$955
33	Angola	Upper middle	0.088	$64,586	$44,239	8.5	1,758.3	236.6	$187	$273	$719
34	Sudan	Lower middle	0.057	$38,413	$24,940	4.8	2,620.5	136.6	$183	$281	$1,731
35	Mauritania	Lower middle	0.042	$36,346	$31,642	4.4	1,397.4	123.1	$257	$295	$904
36	Madagascar	Low	0.043	$28,770	$26,424	3.0	1,079.4	84.6	$312	$340	$746
37	Eritrea	Low	0.033	$27,392	$26,191	2.8	1,117.1	78.5	$334	$349	$1,025
38	Yemen	Lower middle	0.025	$37,035	$27,682	3.5	1,778.2	99.3	$279	$373	$1,753
39	Ghana	Lower middle	0.063	$44,612	$38,058	4.2	1,006.4	117.8	$323	$379	$577
40	Haiti	Low	0.028	$30,836	$29,010	2.8	1,789.6	80.4	$361	$384	$869
41	Pakistan	Lower middle	0.020	$41,856	$28,870	3.6	1,574.8	102.7	$281	$407	$632
42	South Africa	Upper middle	0.097	$99,713	$115,007	9.1	659.2	235.9	$487	$423	$627

43	Namibia	Upper middle	0.038	$75,606	$106,711	5.9	855.9	150.8	$708	$502	$582
44	India	Lower middle	0.027	$48,744	$40,648	3.4	713.2	96.2	$422	$506	$613
45	Botswana	Upper middle	0.080	$137,595	$139,112	9.9	634.1	262.4	$530	$524	$733
46	Myanmar	Low	0.026	$31,525	$29,473	1.7	672.6	48.0	$614	$657	$1,354
47	Cambodia	Low	0.014	$38,413	$33,905	1.3	758.8	37.6	$901	$1,020	$864
48	Nepal	Low	0.010	$30,836	$29,442	1.1	654.7	30.0	$982	$1,028	$758
49	Iraq	Upper middle	0.009	$53,565	$37,274	1.7	1,493.0	50.4	$740	$1,063	$606
50	Guatemala	Lower middle	0.016	$57,698	$35,999	1.8	1,812.5	51.6	$698	$1,118	$739
51	Papua New Guinea	Lower middle	0.018	$40,479	$31,703	1.2	1,488.7	35.8	$885	$1,130	$883
52	Bangladesh	Low	0.007	$35,658	$32,480	0.8	617.4	23.0	$1,413	$1,551	$650
53	Morocco	Lower middle	0.006	$58,387	$49,883	1.1	898.4	31.6	$1,577	$1,846	$1,046
54	Algeria	Upper middle	0.008	$73,540	$60,354	1.3	752.8	38.2	$1,580	$1,925	$606
55	Uzbekistan	Lower middle	0.006	$45,989	$34,086	0.5	1,357.2	14.9	$2,282	$3,079	$717
56	Indonesia	Lower middle	0.008	$56,321	$50,560	0.5	463.2	14.3	$3,545	$3,949	$600
57	Thailand	Upper middle	0.005	$90,759	$90,800	0.8	261.3	21.7	$4,177	$4,175	$622
58	Vietnam	Lower middle	0.005	$45,989	$42,516	0.3	477.7	8.2	$5,164	$5,586	$793
59	Philippines	Lower middle	0.003	$51,499	$44,213	0.3	743.4	8.8	$5,026	$5,854	$668
60	Ukraine	Lower middle	0.006	$74,228	$69,343	0.4	359.1	11.5	$6,052	$6,479	$664
61	Bolivia	Lower middle	0.010	$56,321	$41,435	0.2	1,162.3	8.2	$5,044	$6,856	$598
62	Peru	Upper middle	0.004	$95,580	$73,664	0.3	862.2	9.6	$7,650	$9,926	$613
63	Colombia	Upper middle	0.003	$95,580	$75,850	0.3	817.2	8.8	$8,575	$10,806	$581
64	Brazil	Upper middle	0.004	$104,534	$81,187	0.3	798.2	9.0	$9,029	$11,626	$724
65	Russian Federation	High: nonOECD	0.007	$143,794	$128,452	0.4	424.3	10.8	$11,898	$13,319	$579
66	Malaysia	Upper middle	0.004	$138,284	$117,395	0.2	536.0	6.6	$17,673	$20,818	$577
67	Argentina	Upper middle	0.003	$147,238	$119,687	0.2	632.8	6.8	$17,487	$21,512	$591
68	Turkey	Upper middle	0.001	$125,197	$86,272	0.1	1,029.3	3.9	$22,267	$32,314	$582
69	China	Upper middle	0.001	$84,560	$78,518	0.1	280.4	2.3	$33,785	$36,384	$583
70	Mexico	Upper middle	0.003	$127,264	$129,804	0.1	0.1	3.2	$40,371	$39,581	$638

Tech. Suppl. - Table 2. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest opportunity index score reflecting per-capita HIV, TB and malaria disease burden. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Swaziland	Lower middle	0.150	$58,387	$198,392	29.1	2,230	724.2	$81	$274	$632
2	Mozambique	Low	0.141	$30,147	$59,145	22.2	3,816	590.0	$51	$100	$1,109
3	Guinea-Bissau	Low	0.134	$29,459	$7,814	40.7	10,523	1143.3	$26	$7	$1,005
4	Nigeria	Lower middle	0.133	$40,479	$34,769	13.4	3,102	369.3	$110	$94	$747
5	Zambia	Lower middle	0.128	$33,591	$69,806	21.8	3,107	564.3	$60	$124	$826
6	Burkina Faso	Low	0.126	$31,525	$22,206	16.4	4,124	459.4	$69	$48	$819
7	Mali	Low	0.124	$29,459	$23,016	15.9	4,222	445.8	$66	$52	$888
8	Somalia	Low	0.121	$26,015	$22,754	16.8	3,682	470.5	$55	$48	$1,535
9	Chad	Low	0.120	$35,658	$24,848	15.3	4,335	424.6	$84	$59	$807
10	Sierra Leone	Low	0.119	$31,525	$20,112	16.0	4,118	446.7	$71	$45	$764
11	Burundi	Low	0.118	$26,015	$33,639	14.3	2,267	389.9	$67	$86	$987
12	Lesotho	Lower middle	0.115	$35,658	$47,366	31.3	1,756	779.4	$46	$61	$738
13	Congo, DR	Low	0.112	$24,637	$25,488	13.4	3,517	375.9	$66	$68	$1,493
14	Niger	Low	0.110	$28,081	$21,620	14.8	4,967	419.7	$67	$52	$1,095
15	Malawi	Low	0.110	$28,081	$59,745	18.3	2,965	462.2	$61	$129	$996
16	Cen. African Rep.	Low	0.105	$27,392	$37,525	13.8	2,819	373.3	$73	$101	$1,230
17	Uganda	Low	0.105	$31,525	$40,192	14.9	3,492	399.8	$79	$101	$749
18	Cameroon	Lower middle	0.100	$37,724	$52,388	14.3	3,115	388.4	$97	$135	$741
19	South Africa	Upper middle	0.097	$99,713	$180,284	21.5	1,150	561.0	$178	$321	$582
20	Guinea	Low	0.095	$29,459	$22,324	12.6	4,272	353.8	$83	$63	$928
21	Liberia	Low	0.092	$26,704	$25,526	11.9	3,401	332.6	$80	$77	$1,025
22	Angola	Upper middle	0.088	$64,586	$35,794	11.5	3,268	320.8	$201	$112	$674
23	Côte d'Ivoire	Lower middle	0.084	$33,591	$35,069	14.1	4,021	387.2	$87	$91	$801
24	Benin	Low	0.083	$33,591	$25,345	10.0	3,096	280.0	$120	$91	$910
25	Botswana	Upper middle	0.080	$137,595	$185,872	26.8	1,111	734.1	$187	$253	$577
26	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	428.8	$59	$178	$1,731
27	Tanzania	Low	0.075	$33,591	$38,453	12.1	3,122	326.9	$103	$118	$935
28	Togo	Low	0.075	$29,459	$32,147	10.4	2,849	288.7	$102	$111	$864
29	Rwanda	Low	0.071	$31,525	$34,034	9.6	2,216	266.1	$118	$128	$768
30	Congo, Rep.	Lower middle	0.067	$54,254	$33,944	11.5	2,981	318.5	$170	$107	$756
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Ghana	Lower middle	0.063	$44,612	$35,624	6.8	1,966	189.9	$235	$188	$746
33	Gabon	Upper middle	0.060	$29,826	$84,306	9.3	1,876	255.0	$117	$331	$613
34	Ethiopia	Low	0.057	$30,147	$29,630	8.6	1,986	235.7	$128	$126	$1,139
35	Sudan	Lower middle	0.057	$38,413	$15,241	6.9	4,907	198.8	$193	$77	$703
36	Afghanistan	Low	0.057	$28,770	$18,906	12.7	4,146	356.6	$81	$53	$935

37	Senegal	Lower middle	0.050	$34,969	$12,190	10.7	5,735	306.0	$114	$40	$768
38	Madagascar	Low	0.043	$28,770	$24,895	4.5	1,910	127.8	$225	$195	$1,025
39	Mauritania	Lower middle	0.042	$36,346	$28,117	5.8	2,607	164.2	$221	$171	$955
40	Namibia	Upper middle	0.038	$75,606	$204,271	15.6	1,528	402.7	$188	$507	$606
41	Eritrea	Low	0.033	$27,392	$26,438	4.3	1,942	120.5	$227	$219	$1,753
42	Haiti	Low	0.028	$30,836	$31,570	4.4	3,128	123.0	$251	$257	$869
43	India	Lower middle	0.027	$48,744	$34,973	3.7	1,255	104.9	$464	$333	$733
44	Myanmar	Low	0.026	$31,525	$28,249	2.9	1,306	83.7	$377	$337	$1,354
45	Yemen	Lower middle	0.025	$37,035	$21,139	4.3	3,128	122.9	$301	$172	$719
46	Pakistan	Lower middle	0.020	$41,856	$19,714	3.8	2,748	108.1	$387	$182	$904
47	Papua New Guinea	Lower middle	0.018	$40,479	$25,117	2.4	2,868	71.2	$568	$353	$864
48	Guatemala	Lower middle	0.016	$57,698	$22,134	2.4	3,143	70.1	$823	$316	$627
49	Cambodia	Low	0.014	$38,413	$31,172	1.9	1,341	54.3	$708	$574	$739
50	Nepal	Low	0.010	$30,836	$28,994	1.4	1,135	39.8	$776	$729	$883
51	Bolivia	Lower middle	0.010	$56,321	$30,994	0.4	2,015	13.5	$4,178	$2,299	$668
52	Iraq	Upper middle	0.009	$53,565	$25,989	1.9	2,587	55.8	$960	$466	$758
53	Algeria	Upper middle	0.008	$73,540	$51,390	1.4	1,304	41.0	$1,793	$1,253	$606
54	Indonesia	Lower middle	0.008	$56,321	$46,677	0.7	814	20.8	$2,708	$2,244	$793
55	Bangladesh	Low	0.007	$35,658	$30,236	0.9	1,076	25.9	$1,377	$1,168	$1,046
56	Russian Federation	High: nonOECD	0.007	$143,794	$121,954	1.1	735	31.2	$4,607	$3,907	$579
57	Uzbekistan	Lower middle	0.006	$45,989	$25,637	0.6	2,352	18.2	$2,523	$1,406	$717
58	Morocco	Lower middle	0.006	$58,387	$42,818	1.9	1,623	54.8	$1,066	$782	$650
59	Ukraine	Lower middle	0.006	$74,228	$68,364	1.2	623	33.6	$2,210	$2,036	$600
60	Thailand	Upper middle	0.005	$90,759	$100,377	1.8	455	48.7	$1,863	$2,061	$622
61	Vietnam	Lower middle	0.005	$45,989	$40,910	0.6	828	17.6	$2,616	$2,327	$664
62	Malaysia	Upper middle	0.004	$138,284	$104,408	0.6	930	17.6	$7,858	$5,933	$591
63	Brazil	Upper middle	0.004	$104,534	$65,501	0.6	1,385	19.2	$5,431	$3,403	$581
64	Peru	Upper middle	0.004	$95,580	$59,439	0.6	1,497	19.0	$5,026	$3,126	$613
65	Colombia	Upper middle	0.003	$95,580	$63,657	0.6	1,419	20.5	$4,652	$3,098	$598
66	Mexico	Upper middle	0.003	$127,264	$134,901	0.3	0	9.6	$13,197	$13,989	$583
67	Philippines	Lower middle	0.003	$51,499	$39,031	0.3	1,289	10.9	$4,746	$3,597	$724
68	Argentina	Upper middle	0.003	$147,238	$101,854	0.6	1,097	18.1	$8,155	$5,642	$577
69	China	Upper middle	0.001	$84,560	$74,564	0.1	486	4.7	$18,015	$15,886	$638
70	Turkey	Upper middle	0.001	$125,197	$58,058	0.1	1,784	6.1	$20,489	$9,501	$582

Tech. Suppl. - Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest opportunity index score reflecting per-capita HIV, TB and malaria disease burden. Grey highlighted cells indicate cost-effectiveness ratios less favorable than investment in ART Results shown are for the second and subsequent 3-year campaigns.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Swaziland	Lower middle	0.150	$58,387	$87,699	11.5	1,281	281.0	$312	$208	$632
2	Mozambique	Low	0.141	$30,147	$36,613	9.7	1,976	260.0	$141	$116	$1,109
3	Guinea-Bissau	Low	0.134	$29,459	$16,675	26.9	5,465	754.3	$22	$39	$1,005
4	Nigeria	Lower middle	0.133	$40,479	$34,860	6.7	1,610	187.0	$186	$217	$747
5	Zambia	Lower middle	0.128	$33,591	$41,222	10.1	1,660	263.4	$156	$128	$826
6	Burkina Faso	Low	0.126	$31,525	$26,076	9.6	2,153	270.2	$96	$117	$819
7	Mali	Low	0.124	$29,459	$25,298	10.0	2,312	280.1	$90	$105	$888
8	Somalia	Low	0.121	$26,015	$23,643	11.6	2,055	325.2	$73	$80	$1,535
9	Chad	Low	0.120	$35,658	$27,805	10.6	2,258	294.9	$94	$121	$807
10	Sierra Leone	Low	0.119	$31,525	$24,508	9.8	2,143	274.1	$89	$115	$764
11	Burundi	Low	0.118	$26,015	$27,699	8.7	1,256	239.8	$116	$108	$987
12	Lesotho	Lower middle	0.115	$35,658	$37,171	11.7	919	283.6	$131	$126	$738
13	Congo, DR	Low	0.112	$24,637	$24,258	9.3	1,852	259.2	$94	$95	$1,493
14	Niger	Low	0.110	$28,081	$24,250	10.0	2,648	282.6	$86	$99	$1,095
15	Malawi	Low	0.110	$28,081	$36,299	8.6	1,532	221.8	$164	$127	$996
16	Cen. African Rep.	Low	0.105	$27,392	$29,606	7.1	1,444	194.2	$152	$141	$1,230
17	Uganda	Low	0.105	$31,525	$31,104	7.9	1,842	214.8	$145	$147	$749
18	Cameroon	Lower middle	0.100	$37,724	$39,507	8.1	1,620	223.1	$177	$169	$741
19	South Africa	Upper middle	0.097	$99,713	$115,007	9.1	659	235.9	$487	$423	$582
20	Guinea	Low	0.095	$29,459	$25,199	7.4	2,176	208.8	$121	$141	$928
21	Liberia	Low	0.092	$26,704	$25,199	6.8	1,763	190.4	$132	$140	$1,025
22	Angola	Upper middle	0.088	$64,586	$44,239	8.5	1,758	236.6	$187	$273	$674
23	Côte d'Ivoire	Lower middle	0.084	$33,591	$31,110	7.8	2,010	214.9	$145	$156	$801
24	Benin	Low	0.083	$33,591	$28,793	5.9	1,611	167.1	$172	$201	$910
25	Botswana	Upper middle	0.080	$137,595	$139,112	9.9	634	262.4	$530	$524	$577
26	Zimbabwe	Low	0.075	$25,326	$40,453	6.9	905	165.8	$244	$153	$1,731
27	Tanzania	Low	0.075	$33,591	$32,273	6.1	1,637	167.4	$193	$201	$935
28	Togo	Low	0.075	$29,459	$28,877	5.5	1,467	153.3	$188	$192	$864
29	Rwanda	Low	0.071	$31,525	$30,620	5.9	1,249	163.9	$187	$192	$768
30	Congo, Rep.	Lower middle	0.067	$54,254	$42,228	7.2	1,522	199.0	$212	$273	$756
31	Kenya	Low	0.065	$34,280	$35,682	5.2	1,131	142.8	$250	$240	$883
32	Ghana	Lower middle	0.063	$44,612	$38,058	4.2	1,006	117.8	$323	$379	$746
33	Gabon	Upper middle	0.060	$29,826	$46,367	4.0	972	110.7	$419	$269	$613

34 Ethiopia	Low	0.057	$30,147	$28,881	6.5	1,128	181.8	$159	$166	$1,139
35 Sudan	Lower middle	0.057	$38,413	$24,940	4.8	2,620	136.6	$183	$281	$703
36 Afghanistan	Low	0.057	$28,770	$22,700	12.2	2,381	342.0	$66	$84	$935
37 Senegal	Lower middle	0.050	$34,969	$22,535	6.8	2,952	193.6	$116	$181	$768
38 Madagascar	Low	0.043	$28,770	$26,424	3.0	1,079	84.6	$312	$340	$1,025
39 Mauritania	Lower middle	0.042	$36,346	$31,642	4.4	1,397	123.1	$257	$295	$955
40 Namibia	Upper middle	0.038	$75,606	$106,711	5.9	856	150.8	$708	$502	$606
41 Eritrea	Low	0.033	$27,392	$26,191	2.8	1,117	78.5	$334	$349	$1,753
42 Haiti	Low	0.028	$30,836	$29,010	2.8	1,790	80.4	$361	$384	$869
43 India	Lower middle	0.027	$48,744	$40,648	3.4	713	96.2	$422	$506	$733
44 Myanmar	Low	0.026	$31,525	$29,473	1.7	673	48.0	$614	$657	$1,354
45 Yemen	Lower middle	0.025	$37,035	$27,682	3.5	1,778	99.3	$279	$373	$719
46 Pakistan	Lower middle	0.020	$41,856	$28,870	3.6	1,575	102.7	$281	$407	$904
47 Papua New Guinea	Lower middle	0.018	$40,479	$31,703	1.2	1,489	35.8	$885	$1,130	$864
48 Guatemala	Lower middle	0.016	$57,698	$35,999	1.8	1,813	51.6	$698	$1,118	$627
49 Cambodia	Low	0.014	$38,413	$33,905	1.3	759	37.6	$901	$1,020	$739
50 Nepal	Low	0.010	$30,836	$29,442	1.1	655	30.0	$982	$1,028	$883
51 Bolivia	Lower middle	0.010	$56,321	$41,435	0.2	1,162	8.2	$5,044	$6,856	$668
52 Iraq	Upper middle	0.009	$53,565	$37,274	1.7	1,493	50.4	$740	$1,063	$758
53 Algeria	Upper middle	0.008	$73,540	$60,354	1.3	753	38.2	$1,580	$1,925	$606
54 Indonesia	Lower middle	0.008	$56,321	$50,560	0.5	463	14.3	$3,545	$3,949	$793
55 Bangladesh	Low	0.007	$35,658	$32,480	0.8	617	23.0	$1,413	$1,551	$1,046
56 Russian Federation	High: nonOECD	0.007	$143,794	$128,452	0.4	424	10.8	$11,898	$13,319	$579
57 Uzbekistan	Lower middle	0.006	$45,989	$34,086	0.5	1,357	14.9	$2,282	$3,079	$717
58 Morocco	Lower middle	0.006	$58,387	$49,883	1.1	898	31.6	$1,577	$1,846	$650
59 Ukraine	Lower middle	0.006	$74,228	$69,343	0.4	359	11.5	$6,052	$6,479	$600
60 Thailand	Upper middle	0.005	$90,759	$90,800	0.8	261	21.7	$4,177	$4,175	$622
61 Vietnam	Lower middle	0.005	$45,989	$42,516	0.3	478	8.2	$5,164	$5,586	$664
62 Malaysia	Upper middle	0.004	$138,284	$117,395	0.2	536	6.6	$17,673	$20,818	$591
63 Brazil	Upper middle	0.004	$104,534	$81,187	0.3	798	9.0	$9,029	$11,626	$581
64 Peru	Upper middle	0.004	$95,580	$73,664	0.3	862	9.6	$7,650	$9,926	$613
65 Colombia	Upper middle	0.003	$95,580	$75,850	0.3	817	8.8	$8,575	$10,806	$598
66 Mexico	Upper middle	0.003	$127,264	$129,804	0.1	0	3.2	$40,371	$39,581	$583
67 Philippines	Lower middle	0.003	$51,499	$44,213	0.3	743	8.8	$5,026	$5,854	$724
68 Argentina	Upper middle	0.003	$147,238	$119,687	0.2	633	6.8	$17,487	$21,512	$577
69 China	Upper middle	0.001	$84,560	$78,518	0.1	280	2.3	$33,785	$36,384	$638
70 Turkey	Upper middle	0.001	$125,197	$86,272	0.1	1,029	3.9	$22,267	$32,314	$582

Tech. Suppl. - Table 4. Relative contribution of diarrhea, malaria and HIV to disease burden of each of 70 countries.

Country	Total DALY burden (3 diseases)	Population	DALYs per capita	Diarrhea		Malaria		HIV	
				Diarrhea burden	DALYs	Malaria burden	DALYs	HIV burden	DALYs
Swaziland	158,061	1,055,506	0.1497	8.4	16,523	0.03	4,338	25.9	137,200
Mozambique	3,288,897	23,390,765	0.1406	11.9	532,817	12.49	1,482,080	11.5	1,274,000
Guinea-Bissau	203,103	1,515,224	0.1340	19.1	78,434	17.65	104,089	2.5	20,580
Nigeria	21,145,996	158,423,182	0.1335	18.7	4,995,101	20.19	12,818,894	3.6	3,332,000
Zambia	1,654,717	12,926,409	0.1280	14.6	410,637	15.24	499,280	13.5	744,800
Burkina Faso	2,079,356	16,468,714	0.1263	18.9	659,064	20.39	1,353,652	1.2	66,640
Mali	1,905,686	15,369,809	0.1240	19.2	715,293	20.83	1,145,312	1	45,080
Somalia	1,131,667	9,330,872	0.1213	21.8	534,781	5.85	512,605	0.7	84,280
Chad	1,341,959	11,227,208	0.1195	21.9	652,646	18.59	400,213	3.4	289,100
Sierra Leone	698,366	5,867,536	0.1190	20.9	246,659	12.94	405,647	1.6	46,060
Burundi	991,869	8,382,849	0.1183	23.6	393,025	9.25	461,645	3.3	137,200
Lesotho	250,467	2,171,318	0.1154	9.9	25,067	0.00	Unknown	23.6	225,400
Congo, DR	7,371,699	65,965,795	0.1118	18.5	3,414,271	17.02	3,389,027	1.3	568,400
Niger	1,711,372	15,511,953	0.1103	20.3	744,317	17.95	907,275	0.8	59,780
Malawi	1,632,385	14,900,841	0.1095	10.9	431,392	16.64	485,593	11	715,400
Cen. African Rep.	463,590	4,401,051	0.1053	17.3	140,555	14.32	272,074	4.7	50,960
Uganda	3,513,177	33,424,683	0.1051	16.0	1,078,814	22.40	1,258,363	6.5	1,176,000
Cameroon	1,957,804	19,598,889	0.0999	16.2	683,514	19.05	705,891	5.3	568,400
South Africa	4,851,895	49,991,300	0.0971	8.7	1,010,490	0.07	19,404	17.8	3,822,000
Guinea	950,891	9,981,590	0.0953	13.8	305,921	23.62	584,210	1.3	60,760
Liberia	367,478	3,994,122	0.0920	17.2	112,638	15.56	231,809	1.5	23,030
Angola	1,682,066	19,081,912	0.0881	25.0	974,838	8.41	491,628	2	215,600
Côte d'Ivoire	1,651,534	19,737,800	0.0837	13.2	518,311	21.10	966,623	3.4	166,600
Benin	732,327	8,849,892	0.0827	13.0	248,863	23.34	435,445	1.2	48,020
Botswana	161,239	2,006,945	0.0803	7.0	13,221	1.04	10,818	24.8	137,200
Zimbabwe	944,891	12,571,454	0.0752	9.2	132,798	3.43	204,493	14.3	607,600
Tanzania	3,360,788	44,841,226	0.0749	11.6	1,025,316	16.43	1,355,472	5.6	980,000
Togo	450,236	6,027,798	0.0747	11.6	124,279	25.67	227,957	3.2	98,000
Rwanda	753,413	10,624,005	0.0709	22.6	357,674	5.91	309,499	2.9	86,240
Congo, Rep.	270,651	4,042,899	0.0669	14.3	81,602	23.85	125,349	3.4	63,700
Kenya	2,637,405	40,512,682	0.0651	20.5	796,738	10.94	762,667	6.3	1,078,000
Ghana	1,542,491	24,391,823	0.0632	9.5	669,521	26.25	657,370	1.8	215,600
Gabon	90,936	1,505,463	0.0604	5.9	16,740	29.32	38,915	5.2	35,280
Ethiopia	4,754,652	82,949,541	0.0573	22.8	3,507,206	6.78	1,247,446	1.5	Unknown
Sudan	1,925,260	33,603,637	0.0573	10.6	850,260	24.89	526,200	1.1	548,800
Afghanistan	1,954,973	34,385,068	0.0569	28.9	1,864,324	0.01	90,648	0.2	Unknown
Senegal	623,509	12,433,728	0.0501	14.8	229,547	18.73	335,162	0.9	58,800
Madagascar	881,807	20,713,819	0.0426	22.5	368,469	3.51	486,388	0.2	26,950
Mauritania	144,515	3,459,773	0.0418	15.7	83,866	13.33	46,929	0.7	13,720
Namibia	87,587	2,283,289	0.0384	6.3	15,072	5.11	15,675	13.1	56,840
Eritrea	175,006	5,253,676	0.0333	21.4	83,796	0.28	78,470	0.8	12,740
Haiti	280,740	9,993,247	0.0281	20.3	173,247	0.87	21,253	1.9	86,240
India	33,617,476	1,224,614,327	0.0275	13.0	30,747,070	0.34	1,498,406	0.3	1,372,000

Myanmar	1,243,928	47,963,012	0.0259	12.8	403,734	1.75	673,594	0.6	166,600
Yemen	599,468	24,052,514	0.0249	20.2	415,209	0.46	184,259	0.2	Unknown
Pakistan	3,465,577	173,593,383	0.0200	16.0	3,220,422	0.12	135,885	0.1	109,270
Papua New Guinea	121,356	6,858,266	0.0177	5.2	31,732	7.29	58,264	0.9	31,360
Guatemala	225,349	14,388,929	0.0157	19.1	152,755	0.00	1,054	0.8	71,540
Cambodia	191,054	14,138,255	0.0135	7.1	121,042	0.78	53,352	0.5	16,660
Nepal	297,240	29,959,364	0.0099	14.7	229,536	0.02	20,664	0.4	47,040
Bolivia	98,154	9,929,849	0.0099	15.2	85,256	0.02	648	0.2	12,250
Iraq	301,208	32,030,823	0.0094	11.6	301,208	0.00	Unknown	0.2	Unknown
Algeria	296,287	35,468,208	0.0084	12.8	272,766	0.00	0	0.1	23,520
Indonesia	1,849,471	239,870,937	0.0077	15.1	924,024	0.80	357,048	0.2	568,400
Bangladesh	1,057,299	148,692,131	0.0071	11.0	939,026	1.77	104,553	0.06	13,720
Russian Federation	990,798	141,920,000	0.0070	1.2	74,498	0.00	Unknown	1	916,300
Uzbekistan	166,792	28,562,400	0.0058	12.0	97,702	0.00	0	0.1	69,090
Morocco	184,114	31,951,412	0.0058	12.4	149,814	0.00	Unknown	0.1	34,300
Ukraine	255,845	45,870,700	0.0056	0.8	20,645	0.00	Unknown	1.1	235,200
Thailand	365,406	69,122,234	0.0053	1.9	237,657	0.50	10,149	1.3	117,600
Vietnam	408,534	86,927,700	0.0047	2.3	111,515	0.13	32,418	0.4	264,600
Malaysia	114,666	28,401,017	0.0040	1.0	16,176	0.17	490	0.5	98,000
Brazil	728,402	194,946,470	0.0037	5.3	292,349	0.06	4,853	0.45	431,200
Peru	106,711	29,076,512	0.0037	4.5	62,255	0.12	356	0.4	44,100
Colombia	159,217	46,294,841	0.0034	4.1	65,031	0.07	2,067	0.5	92,120
Mexico	321,228	113,423,047	0.0028	5.5	175,197	0.00	12	0.3	146,020
Philippines	255,050	93,260,798	0.0027	6.7	226,838	0.05	7,633	0.06	20,580
Argentina	106,812	40,412,376	0.0026	0.9	33,311	0.00	1	0.5	73,500
China	1,766,094	1,337,825,000	0.0013	3.1	848,167	0.00	1,627	0.1	916,300
Turkey	89,042	72,752,325	0.0012	1.3	82,672	0.00	0	0.06	6,370

Total DALY burden: Total annual DALYs for diarrhea, malaria and HIV/AIDS. Source: calculated as sum of DALYs across the 3 diseases.
Population: Total country population, 2010 data. Source: World Bank - http://data.worldbank.org/indicator/SP.POP.TOTL
DALYs per capita: DALYs per person, calculated as total DALY burden, diahrrel disease divided by population.
Diarrhea burden: percentage of childhood(<5) deaths due to diarrhea. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.
Annual deaths: Total number of deaths from diarrheal disease in children <5 yrs. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.
DALYs (Diarrhea): Total DALYs from diarrheal disease in children < 5 yrs. Source: derivation.
Malaria burden: Percentage of childhood (<5) deaths due to malaria. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.
DALYs (Malaria): Total DALYs from malaria in children < 5 yrs. Source: derivation.
HIV burden: Prevalence in 15-49 year olds. Source: AIDSInfo database, via Gapminder.org
DALYs (HIV): Total DALYs from HIV/AIDS. Source: derivation.

Tech. Suppl. - Table 5. Results for Kenya, Bangladesh and Nigeria, per 1000 campaign participants.

		Malaria	Diarrhea	HIV		
		LLITN	Filters	VCT	Condoms	TOTAL
Kenya						
Disease averted	Deaths	1.6	2.4	4.8	2.2	10.9
	Episodes	133.6	1,877.7	7.0		2,018.3
DALYs averted	Prevention	44.1	68.3	40.0	18.2	170.6
	Earlier HIV care			123.5		123.5
	TOTAL	44.1	68.3	181.8		294.1
Costs averted (added)	Prevention	$773	$9,068	$40,889	$18,588	$69,318
	Earlier HIV care			($81,187)		($81,187)
	TOTAL	$773	$9,068	($21,710)		-$11,869
Cost-effectiveness	Campaign cost (unadjusted)					$34,280
	Net cost (savings)					$46,149
	Cost per DALY averted					$157
Bangladesh						
Disease averted	Deaths	0.1	0.8	0.0	0.0	0.9
	Episodes	14.7	1061.3	0.1		1076.1
DALYs averted	Prevention	1.7	22.4	0.4	0.2	24.7
	Earlier HIV care			1.2		1.2
	TOTAL	1.7	22.4	1.8		25.9
Costs averted (added)	Prevention	$89	$5,527	$389	$189	$6,196
	Earlier HIV care			($773)		($773)
	TOTAL	$89	$5,527	($195)		$5,422
Cost-effectiveness	Campaign cost (unadjusted)					$36,658
	Net cost (savings)					$30,236
	Cost per DALY averted					$1,168
Nigeria						
Disease averted	Deaths	6.0	3.4	2.7	1.3	13.4
	Episodes	734.3	2,363.3	4.0		3,101.7
DALYs averted	Prevention	168.8	97.6	21.8	10.2	298.4

	Earlier HIV care			70.8		70.8
	TOTAL	168.8	97.6	102.9		369.3
Costs averted (added)	Prevention	$6,223	$14,300	$28,605	$13,379	$62,507
	Earlier HIV care			($55,797)		($55,797)
	TOTAL	$6,223	$14,300	($14,813)		$5,710
Cost-effectiveness	Campaign cost (unadjusted)					$40,479
	Net cost (savings)					$34,769
	Cost per DALY averted					$94

Tech. Suppl. - Table 6. Annual and cumulative results for campaigns 1 and 2 for Kenya, projected for 30 years. Assumes the second campaign starts 3 years after initial campaign. All outcomes discounted at 3% per annum.

	Annual		Cumulative			Annual DALYs averted				Cumulative DALYs averted			
Year	Net costs	Net DALYs averted	Net costs	DALYs averted	CE ($/DALY averted)	Malaria	Diarrhea	HIV	Total	Malaria	Diarrhea	HIV	Total
1	$20,151	5.2	$20,151	5.2	$3,856	1.7	3.2	0.3	5.2	1.7	3.2	0.3	5.2
2	$4,168	6.0	$24,318	11.3	$2,161	1.6	3.0	1.4	6.0	3.3	6.2	1.7	11.3
3	$2,700	7.1	$27,019	18.3	$1,475	1.6	2.9	2.6	7.1	4.9	9.1	4.3	18.3
4	$27,259	11.6	$54,278	29.9	$1,817	1.9	4.7	4.9	11.6	6.9	13.8	9.2	29.9
5	$1,996	11.5	$56,274	41.4	$1,360	1.9	4.5	5.1	11.5	8.7	18.3	14.3	41.4
6	$2,136	11.5	$58,410	52.9	$1,104	1.8	4.4	5.4	11.5	10.5	22.7	19.7	52.9
7	$1,878	11.5	$60,288	64.4	$936	1.7	3.9	5.9	11.5	12.2	26.6	25.6	64.4
8	$874	11.2	$61,162	75.6	$809	1.7	3.8	5.8	11.2	13.9	30.3	31.4	75.6
9	$1,668	10.9	$62,830	86.5	$727	1.6	3.7	5.6	10.9	15.5	34.0	37.0	86.5
10	$1,786	10.6	$64,616	97.0	$666	1.6	3.5	5.5	10.6	17.1	37.5	42.4	97.0
11	$1,896	11.3	$66,511	108.3	$614	1.5	3.4	6.3	11.3	18.6	41.0	48.7	108.3
12	$2,149	12.0	$68,661	120.3	$571	1.5	3.3	7.2	12.0	20.0	44.3	55.9	120.3
13	$2,239	12.7	$70,900	133.0	$533	1.4	3.2	8.0	12.7	21.5	47.6	63.9	133.0
14	$2,100	14.3	$73,000	147.3	$496	1.4	3.1	9.8	14.3	22.9	50.7	73.7	147.3
15	$1,967	17.4	$74,967	164.7	$455	1.3	3.1	13.0	17.4	24.2	53.8	86.7	164.7
16	$1,840	17.2	$76,807	181.9	$422	1.3	3.0	12.9	17.2	25.5	56.7	99.7	181.9
17	$1,651	16.8	$78,458	198.8	$395	1.3	2.9	12.7	16.8	26.8	59.6	112.3	198.8
18	$1,471	16.6	$79,929	215.3	$371	1.2	2.8	12.5	16.6	28.0	62.4	124.9	215.3
19	$1,301	14.7	$81,230	230.1	$353	1.2	2.7	10.8	14.7	29.2	65.1	135.7	230.1
20	$1,139	14.4	$82,368	244.5	$337	1.2	2.6	10.6	14.4	30.4	67.8	146.3	244.5
21	$985	12.7	$83,354	257.2	$324	1.1	2.6	9.0	12.7	31.5	70.3	155.3	257.2
22	$840	8.8	$84,193	266.0	$317	1.1	2.5	5.2	8.8	32.6	72.8	160.6	266.0
23	$702	8.2	$84,895	274.2	$310	1.1	2.4	4.8	8.2	33.7	75.2	165.3	274.2
24	$571	7.8	$85,466	282.1	$303	1.0	2.3	4.5	7.8	34.7	77.6	169.8	282.1
25	$2,188	6.8	$87,653	288.9	$303	1.0	2.3	3.5	6.8	35.7	79.8	173.3	288.9
26	$2,020	6.6	$89,673	295.5	$304	1.0	2.2	3.4	6.6	36.7	82.1	176.7	295.5
27	$106	6.4	$89,779	301.9	$297	0.9	2.1	3.3	6.4	37.6	84.2	180.0	301.9
28	$617	6.2	$90,396	308.1	$293	0.9	2.1	3.2	6.2	38.6	86.3	183.3	308.1
29	$575	6.0	$90,971	314.1	$290	0.9	2.0	3.1	6.0	39.4	88.3	186.4	314.1
30	$0	5.9	$90,971	320.0	$284	0.9	2.0	3.0	5.9	40.3	90.3	189.4	320.0

Tech. Suppl. - Table 7. Country-specific estimates for unit costs of antiretroviral therapy for HIV adjusted to 2012 US$. In countries with multiple estimate, the mean is shown.

ART UNIT COSTS		
Country	**ART per person-year** (2012 US$)	**Sources**
Benin	$701	Hounton et al. 2008
Botswana	$703	Menzies, 2011
Brazil	$1,786	Acurcio, 2006 (Cited in Galarraga 2011)
Ethiopia	$610	Menzies 2011; Bikilla et al. 2009;
Haiti	$1,120	Koenig 2008
India	$230	Gupta 2009
Lesotho	$165	Cleary 2006
Mexico	$5,990	Bautista 2003; Bautista 2008; Aracena-Genao
Morocco	$1,102	Loubiere 2008 (Cited in Galarraga 2011)
Nigeria	$938	Menzies, 2011; Kombe 2004
South Africa	$1,260	Cleary 2006; Kevany 2009; Deghaye 2006; Martinson 2009; Rosen 2008
Thailand	$3,994	Kitajima 2003
Uganda	$805	Marseille 2009; Jaffar 2009
Zambia	$794	Marseille 2012
Vietnam	$964	Menzies, 2011

Methods for estimating health care and campaign costs.

There is no recognized "gold standard" for adjusting program and health care costs by country. While per-capita GDP reflects overall ability to pay, it assumes that health care is a normal good in which consumption increases monotonically with income. A per-capita GDP-based index also lacks the specificity to capture both the unit cost and the relevant quantity utilized of various health inputs, such as inpatient days or outpatient visits. These utilization patterns can vary by country partially independently of income. An alternative index is per-capita spending on health care. This is a more direct measure of overall health care spending, but also fails to capture the detailed inputs cost and utilization mix. Finally, WHO-CHOICE provides country-specific costs for inpatient days and outpatient visits at various levels of facilities (e.g. primary, secondary, and teaching hospitals). By comparing the WHO-CHOICE-derived costs for Kenya against the other 69 countries, yet a third index can be created.[8] However, the WHO-CHOICE-based index has its own short-comings. In addition to not reflecting the specific mix of inputs needed for the present analysis, the methods used to derive the costs are somewhat opaque. The regression model used to predict country health care costs includes per-capita GDP and may thus be similar to using a per-capita GDP-based index. Table 8 shows the base-case results using the per-capita health care spending approach; and Table 9 uses the index derived from WHO-CHOICE. These show very little difference in the cost-effectiveness results by country rankings when compared with the per-capita GDP approach shown in Table 3 in the main paper.

Table 8. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign. Non-tradable portion of costs imputed from Kenya trial data based on per-capita health care spending. Sources: WHO, World Health Statistics 2012, Http://apps.who.int/gho/data/node.main.78?lang=en. Definitions: Health Expenditure per-capita (PPP; International $): The sum of public and private health expenditure (in PPP, International $) divided by population. Health expenditure includes the provision of health services, family planning activities, nutrition activities and emergency aid designated for heath, but excludes the provision of water and sanitation.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes		Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$31,652	$2,286	40.7	10,523	1,145.2	$28	$2	$1,005
2	Sierra Leone	Low	0.119	$52,305	$4,927	16.0	4,118	447.9	$117	$11	$764
3	Senegal	Lower middle	0.050	$36,210	$11,527	10.7	5,735	305.4	$119	$38	$768
4	Burkina Faso	Low	0.126	$35,260	$20,805	16.4	4,124	459.8	$77	$45	$819
5	Somalia	Low	0.121	$26,015	$22,924	16.8	3,682	470.8	$55	$49	$1,535
6	Mali	Low	0.124	$32,840	$22,058	15.9	4,222	445.4	$74	$50	$888
7	Niger	Low	0.110	$28,445	$21,450	14.8	4,967	419.1	$68	$51	$1,095
8	Afghanistan	Low	0.057	$28,905	$18,828	12.7	4,146	356.9	$81	$53	$935
9	Sudan	Lower middle	0.057	$45,505	$10,906	6.9	4,907	198.4	$229	$55	$703
10	Guinea	Low	0.095	$31,875	$21,102	12.6	4,272	355.2	$90	$59	$928
11	Lesotho	Lower middle	0.115	$55,557	$54,805	31.3	1,756	859.0	$65	$64	$738
12	Congo, DR	Low	0.112	$25,386	$25,306	13.4	3,517	376.8	$67	$67	$1,493
13	Chad	Low	0.120	$28,103	$29,728	15.3	4,335	427.1	$66	$70	$807
14	Liberia	Low	0.092	$36,982	$23,225	11.9	3,401	333.2	$111	$70	$1,025
15	Côte d'Ivoire	Lower middle	0.084	$43,278	$30,730	14.1	4,021	393.7	$110	$78	$801
16	Burundi	Low	0.118	$28,504	$34,224	14.3	2,267	393.6	$72	$87	$987
17	Uganda	Low	0.105	$37,888	$36,726	14.9	3,492	409.5	$93	$90	$749
18	Benin	Low	0.083	$32,216	$25,362	10.0	3,096	280.0	$115	$91	$910
19	Nigeria	Lower middle	0.133	$45,846	$34,213	13.4	3,102	370.6	$124	$92	$747
20	Mozambique	Low	0.141	$31,652	$58,371	22.2	3,816	606.8	$52	$96	$1,109
21	Cen. African Rep.	Low	0.105	$26,663	$37,686	13.8	2,819	380.3	$70	$99	$1,230
22	Congo, Rep.	Lower middle	0.067	$42,684	$33,709	11.5	2,981	319.7	$134	$105	$756
23	Togo	Low	0.075	$32,973	$32,220	10.4	2,849	287.6	$115	$112	$864
24	Zambia	Lower middle	0.128	$38,512	$68,361	21.8	3,107	594.6	$65	$115	$826
25	Malawi	Low	0.110	$34,146	$58,110	18.3	2,965	496.4	$69	$117	$996
26	Tanzania	Low	0.075	$30,345	$39,174	12.1	3,122	331.0	$92	$118	$935
27	Ethiopia	Low	0.057	$28,371	$28,810	8.6	1,986	237.4	$120	$121	$1,139

28	Angola	Upper middle	0.088	$53,374	$39,069	11.5	3,268	321.5	$166	$122	$674
29	Cameroon	Lower middle	0.100	$39,729	$52,377	14.3	3,115	394.2	$101	$133	$741
30	Rwanda	Low	0.071	$43,307	$37,051	9.6	2,216	265.0	$163	$140	$768
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	478.9	$53	$159	$1,731
33	Yemen	Lower middle	0.025	$39,388	$20,853	4.3	3,128	122.6	$321	$170	$719
34	Mauritania	Lower middle	0.042	$39,952	$29,100	5.8	2,607	164.0	$244	$177	$955
35	Ghana	Lower middle	0.063	$37,606	$34,488	6.8	1,966	189.9	$198	$182	$746
36	Pakistan	Lower middle	0.020	$35,334	$20,601	3.8	2,748	108.0	$327	$191	$904
37	Madagascar	Low	0.043	$27,806	$24,564	4.5	1,910	127.6	$218	$192	$1,025
38	Eritrea	Low	0.033	$24,332	$25,362	4.3	1,942	119.5	$204	$212	$1,753
39	Swaziland	Lower middle	0.150	$88,325	$197,225	29.1	2,230	800.0	$110	$247	$632
40	Haiti	Low	0.028	$34,310	$31,765	4.4	3,128	121.7	$282	$261	$869
41	Botswana	Upper middle	0.080	$151,324	$196,117	26.8	1,111	734.1	$206	$267	$577
42	Guatemala	Lower middle	0.016	$76,551	$19,936	2.4	3,143	68.3	$1,121	$292	$627
43	Myanmar	Low	0.026	$25,550	$25,518	2.9	1,306	83.1	$307	$307	$1,354
44	India	Lower middle	0.027	$45,178	$33,274	3.7	1,255	104.6	$432	$318	$733
45	Papua New Guinea	Lower middle	0.018	$44,272	$24,760	2.4	2,868	70.6	$627	$351	$864
46	South Africa	Upper middle	0.097	$167,731	$223,292	21.5	1,150	579.7	$289	$385	$582
47	Gabon	Upper middle	0.060	$104,762	$107,288	9.3	1,876	251.5	$417	$427	$613
48	Iraq	Upper middle	0.009	$43,990	$25,081	1.9	2,587	55.5	$792	$452	$758
49	Namibia	Upper middle	0.038	$113,745	$218,642	15.6	1,528	416.7	$273	$525	$606
50	Cambodia	Low	0.014	$41,971	$32,821	1.9	1,341	53.9	$779	$609	$739
51	Nepal	Low	0.010	$33,760	$30,891	1.4	1,135	39.2	$861	$788	$883
52	Morocco	Lower middle	0.006	$72,424	$50,688	1.9	1,623	54.5	$1,329	$930	$650
53	Bangladesh	Low	0.007	$31,949	$28,039	0.9	1,076	25.8	$1,237	$1,086	$1,046
54	Algeria	Upper middle	0.008	$87,063	$59,839	1.4	1,304	40.8	$2,136	$1,468	$606
55	Uzbekistan	Lower middle	0.006	$54,666	$26,791	0.6	2,352	18.1	$3,021	$1,481	$717
56	Indonesia	Lower middle	0.008	$44,169	$38,316	0.7	814	20.5	$2,158	$1,872	$793
57	Thailand	Upper middle	0.005	$79,120	$90,878	1.8	455	46.5	$1,700	$1,952	$622
58	Bolivia	Lower middle	0.010	$67,123	$33,507	0.4	2,015	13.1	$5,105	$2,549	$668
59	Vietnam	Lower middle	0.005	$51,726	$44,913	0.6	828	16.7	$3,102	$2,694	$664
60	Ukraine	Lower middle	0.006	$105,326	$92,351	1.2	623	32.8	$3,209	$2,814	$600
61	Peru	Upper middle	0.004	$104,227	$63,328	0.6	1,497	17.8	$5,864	$3,563	$613
62	Philippines	Lower middle	0.003	$51,949	$39,286	0.3	1,289	10.8	$4,832	$3,654	$724

63	Colombia	Upper middle	0.003	$129,275	$80,234	0.6	1,419	18.7	$6,900	$4,283	$598
64	Malaysia	Upper middle	0.004	$122,297	$93,832	0.6	930	16.5	$7,428	$5,699	$591
65	Brazil	Upper middle	0.004	$186,498	$105,365	0.6	1,385	18.1	$10,306	$5,822	$581
66	Russian Federation	High: nonOECD	0.007	$240,707	$192,690	1.1	735	30.2	$7,975	$6,384	$579
67	Argentina	Upper middle	0.003	$252,229	$164,213	0.6	1,097	16.6	$15,161	$9,871	$577
68	Turkey	Upper middle	0.001	$191,725	$80,928	0.1	1,784	5.9	$32,276	$13,624	$582
69	China	Upper middle	0.001	$93,151	$81,634	0.1	486	4.4	$20,990	$18,395	$638
70	Mexico	Upper middle	0.003	$179,550	$187,187	0.3	0	8.7	$20,612	$21,489	$583

Tech. Suppl. - Table 9. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the first 3-year campaign. Non-tradable portion of costs imputed from Kenya trial data based on WHO-CHOICE data on costs for inpatient day and outpatient visit assuming 75% of costs are for outpatient; 25% for inpatient. Source: WHO–CHOICE: http://www.who.int/choice/cost-effectiveness/inputs/health_service/en/

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$26,373	$17,367	40.7	10,523	1,145.2	$23	$15	$1,005
2	Senegal	Lower middle	0.050	$36,106	$11,638	10.7	5,735	305.4	$118	$38	$768
3	Burkina Faso	Low	0.126	$33,007	$21,650	16.4	4,124	459.8	$72	$47	$819
4	Sierra Leone	Low	0.119	$28,338	$22,441	16.0	4,118	447.9	$63	$50	#N/A
5	Mali	Low	0.124	$31,186	$22,527	15.9	4,222	445.4	$70	$51	$888
6	Niger	Low	0.110	$27,560	$21,862	14.8	4,967	419.1	$66	$52	$1,095
7	Afghanistan	Low	0.057	$28,280	$19,188	12.7	4,146	356.9	$79	$54	$935
8	Lesotho	Lower middle	0.115	$34,378	$46,888	31.3	1,756	859.0	$40	$55	$738
9	Guinea	Low	0.095	$30,485	$21,805	12.6	4,272	355.2	$86	$61	$928
10	Chad	Low	0.120	$32,650	$27,127	15.3	4,335	427.1	$76	$64	$807
11	Congo, DR	Low	0.112	$24,540	$25,512	13.4	3,517	376.8	$65	$68	$1,493
12	Liberia	Low	0.092	$25,154	$26,045	11.9	3,401	333.2	$75	$78	$1,025
13	Sudan	Lower middle	0.057	$38,572	$15,919	6.9	4,907	198.4	$194	$80	$703
14	Burundi	Low	0.118	$25,095	$33,564	14.3	2,267	393.6	$64	$85	$987
15	Côte d'Ivoire	Lower middle	0.084	$34,943	$34,796	14.1	4,021	393.7	$89	$88	$801
16	Benin	Low	0.083	$33,846	$25,342	10.0	3,096	280.0	$121	$91	$910
17	Nigeria	Lower middle	0.133	$38,931	$34,929	13.4	3,102	370.6	$105	$94	$747
18	Uganda	Low	0.105	$32,646	$39,581	14.9	3,492	409.5	$80	$97	$749
19	Mozambique	Low	0.141	$28,771	$59,852	22.2	3,816	606.8	$47	$99	$1,109
20	Cen. African Rep.	Low	0.105	$28,010	$37,642	13.8	2,819	380.3	$74	$99	$1,230
21	Congo, Rep.	Lower middle	0.067	$51,672	$33,891	11.5	2,981	319.7	$162	$106	#N/A
22	Togo	Low	0.075	$31,613	$32,267	10.4	2,849	287.6	$110	$112	$864
23	Angola	Upper middle	0.088	$62,105	$37,627	11.5	3,268	321.5	$193	$117	$674
24	Tanzania	Low	0.075	$32,091	$38,786	12.1	3,122	331.0	$97	$117	$935
25	Zambia	Lower middle	0.128	$32,785	$70,043	21.8	3,107	594.6	$55	$118	$826
26	Malawi	Low	0.110	$28,219	$59,708	18.3	2,965	496.4	$57	$120	$996
27	Ethiopia	Low	0.057	$29,008	$29,104	8.6	1,986	237.4	$122	$123	$1,139
28	Rwanda	Low	0.071	$30,681	$33,818	9.6	2,216	265.0	$116	$128	$768
29	Cameroon	Lower middle	0.100	$39,111	$52,380	14.3	3,115	394.2	$99	$133	$741
30	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
31	Yemen	Lower middle	0.025	$41,823	$20,557	4.3	3,128	122.6	$341	$168	$719
32	Mauritania	Lower middle	0.042	$38,314	$28,653	5.8	2,607	164.0	$234	$175	$955
33	Ghana	Lower middle	0.063	$33,612	$33,841	6.8	1,966	189.9	$177	$178	$746
34	Pakistan	Lower middle	0.020	$40,398	$19,912	3.8	2,748	108.0	$374	$184	$904
35	Madagascar	Low	0.043	$30,438	$25,467	4.5	1,910	127.6	$239	$200	$1,025
36	Eritrea	Low	0.033	$26,867	$26,253	4.3	1,942	119.5	$225	$220	$1,753

37	Botswana	Upper middle	0.080	$116,424	$173,837	26.8	1,111	734.1	$159	$237	$577
38	Swaziland	Lower middle	0.150	$58,455	$198,389	29.1	2,230	800.0	$73	$248	$632
39	Haiti	Low	0.028	$30,962	$31,577	4.4	3,128	121.7	$254	$260	$869
40	South Africa	Upper middle	0.097	$93,433	$177,476	21.5	1,150	579.7	$161	$306	$582
41	India	Lower middle	0.027	$44,370	$32,889	3.7	1,255	104.6	$424	$314	$733
42	Guatemala	Lower middle	0.016	$57,311	$22,179	2.4	3,143	68.3	$839	$325	$627
43	Myanmar	Low	0.026	$31,316	$28,153	2.9	1,306	83.1	$377	$339	$1,354
44	Papua New Guinea	Lower middle	0.018	$39,103	$25,246	2.4	2,868	70.6	$554	$358	$864
45	Gabon	Upper middle	0.060	$56,344	$92,439	9.3	1,876	251.5	$224	$368	$613
46	Iraq	Upper middle	0.009	$47,126	$25,378	1.9	2,587	55.5	$848	$457	$758
47	Namibia	Upper middle	0.038	$68,440	$201,570	15.6	1,528	416.7	$164	$484	$606
48	Cambodia	Low	0.014	$38,523	$31,223	1.9	1,341	53.9	$715	$579	$739
49	Nepal	Low	0.010	$30,887	$29,027	1.4	1,135	39.2	$788	$740	$883
50	Morocco	Lower middle	0.006	$54,334	$40,545	1.9	1,623	54.5	$997	$744	$650
51	Bangladesh	Low	0.007	$32,639	$28,448	0.9	1,076	25.8	$1,264	$1,101	$1,046
52	Algeria	Upper middle	0.008	$80,074	$55,887	1.4	1,304	40.8	$1,965	$1,371	$606
53	Uzbekistan	Lower middle	0.006	$43,037	$25,245	0.6	2,352	18.1	$2,379	$1,395	$717
54	Brazil	Upper middle	0.004	$34,045	$31,218	0.6	1,385	18.1	$1,881	$1,725	$581
55	Thailand	Upper middle	0.005	$79,636	$91,299	1.8	455	46.5	$1,711	$1,961	$622
56	Ukraine	Lower middle	0.006	$74,578	$68,634	1.2	623	32.8	$2,272	$2,091	$600
57	Indonesia	Lower middle	0.008	$51,988	$43,696	0.7	814	20.5	$2,540	$2,135	$793
58	Bolivia	Lower middle	0.010	$53,963	$30,445	0.4	2,015	13.1	$4,105	$2,316	$668
59	Vietnam	Lower middle	0.005	$43,303	$39,035	0.6	828	16.7	$2,597	$2,341	$664
60	Peru	Upper middle	0.004	$82,397	$53,509	0.6	1,497	17.8	$4,636	$3,011	$613
61	Philippines	Lower middle	0.003	$48,596	$37,382	0.3	1,289	10.8	$4,520	$3,477	$724
62	Colombia	Upper middle	0.003	$124,448	$77,859	0.6	1,419	18.7	$6,643	$4,156	$598
63	Russian Federation	High: nonOECD	0.007	$156,317	$131,095	1.1	735	30.2	$5,179	$4,343	$579
64	Argentina	Upper middle	0.003	$119,219	$85,212	0.6	1,097	16.6	$7,166	$5,122	$577
65	Malaysia	Upper middle	0.004	$118,529	$91,339	0.6	930	16.5	$7,199	$5,548	$591
66	Turkey	Upper middle	0.001	$116,707	$55,139	0.1	1,784	5.9	$19,647	$9,283	$582
67	China	Upper middle	0.001	$66,612	$59,793	0.1	486	4.4	$15,010	$13,474	$638
68	Mexico	Upper middle	0.003	$120,196	$127,833	0.3	0	8.7	$13,799	$14,675	$583

Tech. Suppl. - Table 10. Estimates of rates of care seeking for malaria.

Source	Location	Care-seeking rate
ScientificWorldJournal. 2003 Aug 19;3:721-30. Prevalence of childhood illnesses and care-seeking practices in rural Uganda. Mbonye AK.	Rural Uganda	44.7%
Malar J. 2010 Nov 22;9:333. From fever to anti-malarial: the treatment-seeking process in rural Senegal. Smith LA, Bruce J, Gueye L, Helou A, Diallo R, Gueye B, Jones C, Webster J.	Rural Senegal	61.6%
BMC Pub Health. 2008. Obstacles to prompt and effective malaria treatment lead to low community-coverage in two rural districts of Tanzania. Hetzel MW, Obrist B, Lengeler C, Msechu JJ, Nathan R, Dillip A, Makemba AM, Mshana C, Schulze A, Mshinda H.	South-eastern Tanzania (rural, high malaria transmission)	76.3% (caretakers bringing children to HF); 56.1% (adults attending health facility for own symptoms)
Malar J. 2011 Oct 31;10:327. Monitoring fever treatment behaviour and equitable access to effective medicines in the context of initiatives to improve ACT access: baseline results and implications for programming in six African countries. Littrell M, Gatakaa H, Evance I, et al	Benin, DRC, Madagascar, Nigeria, Uganda, Zambia	Treatment-seeking outside of home: Benin - 50.3%; DRC - 73%; Madagascar - 78%; Nigeria - 73%; Uganda - 72%; Zambia - 77%
Malar J. 2010 Dec 30;9:377. Factors affecting treatment-seeking for febrile illness in a malaria endemic block in Boudh district, Orissa, India: policy implications for malaria control. Das A, Ravindran TS.	Orissa, India (high malaria transmission area)	Treatment-seeking: 94%
Malar J. 2010 Jun 15;9:163. Improvements in access to malaria treatment in Tanzania following community, retail sector and health facility interventions -- a user perspective. Alba S, Dillip A, Hetzel MW, et al	Ifakara, Tanzania	Health facility attendance:52%

Tech-Suppl - Figure 1.

Tech-Suppl - Figure 2.

Tech-Suppl - Figure 3.

Tech. Suppl. - Figure 4.

Tech Suppl. - Figure 5.

Projection of costs and outcomes to 30 years

We projected cumulative costs and outcomes of the IPC campaign in Kenya for 30 years, assuming an initial campaign and a second campaign three years later (Figure 6). Costs and benefits of the two campaigns were added and reflect the lower effectiveness of the second campaign. The large rise in costs in year 4 reflects the initiation of the second campaign, and the gradual increase in cumulative costs over time reflects the costs of additional HIV treatment. The steadily rising cumulative net DALYs averted reflects the averted morbidity during the period of bed net and water filter efficacy, but is largely determined by the distribution of saved life years due to averted mortality from all three diseases during the period of IPC benefit. Distribution of benefits were made according to the following assumptions:

- HIV deaths would occur on average 15 years after infection.
- Assumes those detected are all put on ART at year of campaign.
- Earlier and more ART die to earlier detection distributed over 15 and 20 years respectively.
- HIV mortality prevention in secondary partners starts on average in year 20 after the campaign and is distributed over 20 years.
- 50% of prevented HIV mortality occurred in the index patient
- Life-expectancy at the time of the campaign was 60 years for averted mortality in malaria and diarrhea patients.
- Malaria and diarrhea morbidity reduction is confined to the campaign itself.

Tech Suppl. - Figure 6.

References

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Scaling up integrated prevention campaigns for global health: Costs and cost-effectiveness in 70 countries

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Abstract

Objectives. This study estimated the health impact, cost, and cost-effectiveness of an integrated prevention campaign (IPC) focused on diarrhea, malaria, and HIV in 70 countries ranked by per-capita disability-adjusted life-year (DALY) burden for the three diseases.

Methods. We constructed a deterministic cost-effectiveness model portraying an IPC combining counseling and testing, cotrimoxazole prophylaxis, referral to treatment, and condom distribution for HIV prevention; bed nets for malaria prevention; and provision of household water filters for diarrhea prevention. We developed a mix of empirical and modeled cost and health impact estimates applied to all 70 countries. One-way, multi-way and scenario sensitivity analyses were conducted to document the strength of our findings. We used a health care payer's perspective, discounted costs and DALYs at 3% per year, and denominated cost in 2012 U.S. dollars.

Primary and secondary outcomes: The primary outcome was cost-effectiveness expressed as net cost per DALY averted. Other outcomes included cost of the IPC; net IPC costs adjusted for averted and additional medical costs; and DALYs averted.

Results. Implementation of the IPC in the 10 most cost-effective countries at 15% population coverage would cost $583 million over three years (adjusted costs of $398 million), averting 8.0 million DALYs. Extending IPC programs to all 70 of the identified high-burden countries at 15% coverage would cost an adjusted $51.3 billion and avert 78.7 million DALYs. Incremental cost-effectiveness ranged from $49 per DALY averted for the 10 countries with the most favourable cost-effectiveness to $119, $181, $335, $1,692 and $8,340 per DALY averted as each successive group of 10 countries is added ordered by decreasing cost-effectiveness.

Conclusion. IPC appears cost-effective in many settings, and has the potential to substantially reduce the burden of disease in resource-poor countries. This study increases confidence that IPC can be an important new approach for enhancing global health.

Strengths and limitations of this study.

Strengths

- Synthesizes a large volume of epidemiological data from disparate sources into a unified method for projecting the consequence of IPC implementation in 70 countries.
- Links the "opportunity index" concept with cost-effectiveness.
- Provides a more comprehensive assessment of intervention potential than assessment of cost-effectiveness alone.
- Methods presented here may be applied to other disease areas and facilitate more objective resource allocation decision-making for global health.

Limitations

- Incomplete availability of data relevant to the large number of countries analyzed.
- Infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered.
- Regions or urban areas within countries may have costs and health benefits that depart from the overall country assessments.

Background

For many years, vertical (disease-specific) programming has dominated the sphere of global health funding in an effort to tackle the areas of greatest need.[1] However, there is increasing recognition that, among diseases with complementary prevention strategies and overlapping populations, single-disease approaches to population health improvement create duplication of effort and miss important opportunities for synergies in health benefits and economies of scope.[2] Recent initiatives have therefore sought to integrate programs for multiple diseases, and many have demonstrated feasibility, efficiencies and success.[3,4]

A particularly promising example of integrated programming was a prevention campaign in Western Province, Kenya that targeted diarrhea, malaria, and HIV,[5] three diseases that account for a substantial portion of the total disease burden in many parts of the developing world.[6] Over the course of one week, the campaign provided general health education, condoms, insecticide-treated bed nets (ITNs), point-of-use water filters, and HIV testing and counseling to more than 80% of the target population.[5] Those testing positive for HIV were offered on-site CD4 count determination, cotrimoxazole prophylaxis, and referral to comprehensive HIV care and treatment. The campaign yielded large health benefits and net economic savings.[7,8] Large-scale expansion of this integrated prevention campaign (IPC) has the potential to deliver substantial health benefits and cost savings. In a separate study, we reviewed country-specific data for 70 low- and middle-income countries, finding that the opportunity for a diarrhea, malaria and HIV IPC is not limited to Kenya.[9] It is plausible that IPCs can have a large impact on health in many resource-limited settings.

While the cost-effectiveness of this IPC in Western Kenya has been established[8], the economic and health effects of a multi-country IPC initiative are unknown. Using data appropriate for providing an initial indication of the conditions under which IPC is likely to be cost-effective, we estimated the costs, health outcomes, and cost-effectiveness of IPC implementation in the same 70 low- and middle-income countries. To support decision-making for IPC implementation, we also estimate the increases in budgets that would be required to cover increasing numbers of countries.

Methods

Overview

We modeled the health impact, cost, and cost-effectiveness of a diarrhea, malaria, and HIV IPC in 70 countries by adapting a previously-published spreadsheet-based model that was applied to the original IPC in Western Kenya.[8] Countries were chosen for inclusion in the analysis based on two factors: they were classified as low- or middle-income as defined by the World Bank[10]; and they had a total DALY (Disability-adjusted-life-year) burden for the three diseases addressed by the IPC in the highest tertile of the 214 World Bank-defined economies (i.e., ≥ 87,000 DALYs); as described in a companion paper.[9] We refer to this ordering of countries by the combined disease burden as the "opportunity index". For a break-down of the relative contribution by disease to each country's total burden see Jiwani 2014 and Table 4 of the Technical Supplement). We derived incidence and case fatality rates for each country from published reports, using regional averages and other approximations when country-specific estimates were missing. We developed a mix of empirical (where available) and modeled (projected from empirical data) cost estimates applied to all 70 countries. Key outcomes examined included the cost of the IPC; net IPC costs adjusting for averted and additional medical costs; deaths and disease episodes averted; DALYs averted due to prevention, and to earlier and more HIV care; and finally, cost-effectiveness expressed as net cost per DALY averted. We used a health care payer's perspective, and discounted long-term costs and DALYs at 3% per year.[11] Costs were denominated in 2012 U.S. dollars. The time frame of the analysis is three years for the empirical data. Modeled results depend upon the age-dependent life expectancy at the time death would otherwise occurred in Kenya. This is 61 years for diarrheal diseases and malaria, and 37 years for HIV

Detailed model features

We adapted a Microsoft Excel spreadsheet that we had previously constructed to analyze the cost-effectiveness of the Kenya IPC. Details of the model have been published elsewhere.[8] The model estimates the health and cost benefits of prevention for malaria, diarrhea, and HIV separately. For HIV, it also estimates the DALYs averted and costs incurred due to earlier diagnosis and treatment arising from HIV testing. Cost-effectiveness of the IPC was compared to the cost-effectiveness of ART in each of the 70 countries. This metric was selected since, with the current aspiration of universal access to ART, [12] provision of ART is on the active policy agenda for most HIV-affected countries.

Cost estimates and projection methods. Campaign costs for the Kenya IPC were obtained from published empirical data supplemented by filter repair and replacement costs.[7 8] We estimated campaign costs for each country using the Kenya IPC as a benchmark, translating to other countries according to type of cost, as follows. Program costs were classified as commodity, personnel and other costs. Commodities were further categorized as tradable and non-tradable. Tradable commodities are those purchased on the international market and include bed nets, filters, and condoms, and required no adjustment from the dollar-denominated costs incurred by the Kenya IPC.[7] -The cost of non-tradable items, primarily personnel, were adjusted according to the per-capita GDP ratio, in International dollars, between Kenya and each study country.[13] For each country, we estimated the costs of averted medical care due to the IPC by adjusting the costs for health care incurred per fatal and non-fatal case in the Kenya campaign by the ratio of GDP per capita in the target country versus Kenya. We selected per capita GDP rather than per capita health care spending as the basis for these adjustments, because the latter reflects overall access to care and our model accounts for access separately.

It is worth noting that there is no recognized "gold standard" for adjusting program and health care costs by country. While per-capita GDP reflects overall ability to pay, it assumes that health care is a normal good in which consumption increases monotonically with income. A per-capita GDP-based index also lacks the specificity to capture both the unit cost and the relevant quantity utilized of various health inputs, such as inpatient days or outpatient visits. These utilization patterns can vary by country partially independently of income. An alternative index is per-capita spending on health care. This is a more direct measure of overall health care spending, but also fails to capture the detailed inputs cost and utilization mix. Finally, WHO-CHOICE provides country-specific costs for inpatient days and outpatient visits at various levels of facilities (e.g.

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primary, secondary, and teaching hospitals). By comparing the WHO-CHOICE-derived costs for Kenya against the other 69 countries, yet a third index can be created. However, the WHO-CHOICE-based index has its own short-comings. In addition to not reflecting the specific mix of inputs needed for the present analysis, the methods used to derive the costs are somewhat opaque. In any case, the regression model used to predict country health care costs includes per-capita GDP and may thus be similar to using a per-capita GDP-based index. Table 8 of the Technical Supplement shows the base-case results using the per-capita health care spending approach; and Table 9 of the Technical Supplement uses the index derived from WHO-CHOICE. These show very little difference in the cost-effectiveness results by country rankings when compared with the per-capita GDP approach shown in Table 3.

~~For each country, we estimated the costs of averted medical care due to the IPC by adjusting the costs for health care incurred per fatal and non-fatal case in the Kenya campaign by the ratio of GDP per capita in the target country versus Kenya. We selected per capita GDP rather than per capita health care spending as the basis for these adjustments, because the latter reflects overall access to care and our model accounts for access separately. (For a comparison of cost adjustment methods, see Technical Supplement). For malaria,~~ There are few country-specific data on access to care for malaria except for some of the more-affected countries, mostly in Africa. W~~w~~e therefore used global average rates of treatment access, estimated at 68.4% based on published literature.[14-~~19~~19] (See Technical Appendix for the country-specific figures underlying this value).

As noted in Table 2, the value of 68.4% was varied from 51.3% to 85.5% in sensitivity analyses.

For access to care for diarrhea, we used country-specific estimates based on demographic and health survey data on the percent of children under five years of age with diarrhea in the two weeks preceding the survey who received any kind of treatment for diarrhea.[20] We used an average rate of access to ART of 70%. This is considerably higher than the 56% access reported for sub-Saharan Africa [21] and reflects likely increases in access in the context of the global commitment to access.[12]

We calculated the per person-year cost of ART for each country by using published estimates for countries where available. [22-42] The non-drug portion of each published unit cost figure was inflated to 2012 US dollars using the U.S. CPI.[43] We then derived from the set of published figures an average figure for low-income, lower middle-income excluding India, and upper-middle income countries as defined by the World Bank.[44] We applied these country income-category averages to the larger set of countries for which published ART unit cost estimates were unavailable, according to their respective income categories. ART cost-effectiveness for each country was estimated by adjusting $883 per DALY averted which is the average for 45 sites studied in Zambia.[26] To arrive at country-specific estimates we calculated the ratio of per-capita income between each country and Zambia and applied this factor to the average portion of overall ART costs for low-income countries which is non-tradable, 36.9%. This figure was derived from the ART unit cost studies described above which includes the breakdown of costs by major component.

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First versus second campaign health benefits. The health benefits of a second campaign are likely to be lower than that of the initial campaign. For malaria this is due to residual benefits from nets, beyond their average functional life of three years. In the absence of a second campaign, we assume a malaria risk in years 4-6 equal to 75% of the risk at baseline (before the first campaign). For diarrheal disease the filters themselves are not expected to confer benefit after 3 years, though there may be residual benefit from the behavioral component; we assume that the risk is 87.5% of baseline. New nets and filters in a second campaign reduce disease risks to the levels expected after the first campaign. Thus the second campaign reduces the incidence of malaria from 75% to 50% of baseline (a 1/3 relative reduction). Similarly, diarrhea decreases from 87.5% to 37% of baseline (a relative drop of 58%). (Details in technical supplement)

Disease specific data and projection methods. We obtained country estimates of the prevalence of HIV in the adult (15–49 years) population.[42 45 46] For each country, we derived estimates of the baseline cases of malaria per person-year by dividing WHO-adjusted estimates of the annual number of cases [47] by the total country population [48]. For diarrhea, we estimated the average number of cases per person-year in the overall population using DHS data on the number of cases per year in children under 5[49] (details in technical supplement).[50 51] Multiplying each estimate by the total population[48] yields the estimated number of cases in each country.

We calculated country-specific case fatality rates for malaria and diarrhea as the number of deaths due to the disease[52 53] divided by the number of cases. We set an upper-bound malaria case fatality rate of 15% based on published findings of a Delphi survey of malaria experts.[54] We assumed a case fatality rate for HIV of 100%.

Using a discount rate of 3%[55], we estimated the DALYs incurred with each fatal case of malaria and diarrhea at 28 based on life expectancy at age 25 in Kenya (the estimated average age of death from malaria and diarrhea) of 61 years.[56] We derived estimates of the DALYs incurred per non-fatal case of each disease as the product of the disability weight (0.191 for malaria and 0.105 for diarrhea) [57] and the average duration of each case (7 days for malaria[58]; 4.43 days for diarrhea, a severity weighted duration for children and adults[59]; or 0.0037 and 0.0013 DALYs for each non-fatal case of malaria and diarrhea, respectively. Assuming 70% access to ART, we estimated 10.6 DALYs incurred per HIV infection, and 8.8 discounted DALYs averted per treated case of HIV, an assumption based on 22 years of antiretroviral therapy (ART), average age of ART initiation of 35 years, and a life expectancy at age 35 in Kenya of 37 years.[56] Each untreated HIV case incurs 15.1 discounted DALYs.

Household size and beneficiaries per household. Using country-specific data of rural household size as reported in the most recent Demographic and Health Survey, divided by the number of participants per household as observed in the Kenya IPC campaign, we obtained the number of beneficiaries per campaign participant. For bednets, we assumed fewer incremental beneficiaries per participant on the assumption that there was some prior access to bednets, 15.1% on average, as observed in the Kenya campaign. For HIV we assumed the same number of adult participants on average, 2.5, as the basis for calculating the number of beneficiaries per campaign participant.

For the remaining health inputs, we assumed values equal to those used in the Kenya analysis for all countries.[8] See Table 1 for base case values and sources for data inputs.

Table 1 about here

Relationship of opportunity to cost-effectiveness

In a companion article, we identified the countries in which scale-up of a diarrhea, malaria, and HIV IPC would be most beneficial, by summarizing country-specific epidemiological data related to the disease burden and shortfall in current intervention coverage (Jiwani et al, under review, 2013). We created three "opportunity indices," ranking countries by 1) DALYs per capita across the three diseases of the IPC, 2) a sum of burden ranks for each disease, and 3) a composite of burden and intervention opportunity. Here, we extend this opportunity analysis by examining the relationship between a country's opportunity rank (in DALYs per capita) and its cost-effectiveness for IPC implementation.

Sensitivity analyses. To assess the effect of uncertainty in inputs, we conducted one-way and multi-way Monte Carlo sensitivity analyses for three countries: Kenya, a low-income country where the IPC trial was performed and is at the 44^{th} percentile for cost-effectiveness of the 70 countries analyzed; Nigeria, a lower-middle income country at the 75^{th} percentile (relatively favorable); and Bangladesh, a low-income country at the 25^{th} percentile. Each of 31 model inputs examined in the sensitivity analyses (Table 2) was assigned a beta distribution with alpha and beta parameters of 2, in order to ensure symmetry around the mean. Maximum and minimum values were set as 1.5 and 0.5 times the base case, except for access to malaria and diarrhea treatment (0.75 to 1.25 of base case) and access to HIV treatment (0.6 to 1.4 times base case). Figures in bold font reflect parameter values that vary by country. Finally, we examined the effect of variations in important inputs on the cost-effectiveness of IPC in all 70 countries grouped in order of cost-effectiveness.

Table 2 about here

Results

Across the 70 high opportunity countries, the cost-effectiveness of the first campaign ranges from $7 (Guinea-Bissau) to $15,886 (China) per DALY averted (IQR $96 - $1,071 per DALY averted) (Table 3). At $182 per DALY averted, Pakistan is at the 50^{th} percentile for cost-effectiveness. With the exception of Afghanistan, the 30 counties with the most favorable cost-effectiveness are in sub-Saharan Africa. The cost-effectiveness of IPC compares favorably to the cost-effectiveness of ART in 51 countries. The 30 countries with the lowest cost-effectiveness estimates are geographically more diverse and include only three in sub-Saharan Africa (Swaziland, South Africa, and Namibia).

As shown in Figure 1, per-capita disease burden as measured by the opportunity index is highly correlated with cost-effectiveness. See Figure 1 of the Technical Supplement for relationship between opportunity index and cost-effectiveness for campaign 2.

Table 3 and Figure 1 about here.

Table 4 displays the cumulative results, grouped in 10-country increments, assuming 15% population coverage, and moving from most to least attractive cost-effectiveness. IPC in the top 10 countries would cost $583 million for the three-year campaign, with a net cost after adjusting for effects on health care spending of $398 million for the first three-year campaign and $468 million for the second and subsequent campaigns. The first and second campaigns would avert 8.0 and 5.7 million DALYs respectively with an average cost-effectiveness of $49 and $82 per DALY averted, respectively. As shown in the right-hand two columns, the incremental cost-effectiveness rises rapidly (becomes less favorable) after coverage of the top 50 countries. In particular, if expanding from the top 50 to 60 countries and from 60 to all 70 countries, large net incremental costs are associated with relatively modest increases in health benefits. The cost per DALY averted in expanding from 60 to 70 countries is $8,340 and $19,728 for campaigns 1 and 2, respectively.

For each stratum of 10 countries ranked from most to least cost-effective, Table 5 displays the median cost-effectiveness for the first three-year campaigns, for possible second campaigns, and for ART. The cost-effectiveness of the first campaign compares more favorably to ART by a wide margin for each of the 10-country strata. For the second campaign ART is more cost-effective than IPC for the 51st – 60th and for the 61st – 70th country, as ranked by IPC cost-effectiveness.

Tables 4 and 5 about here.

Results for Kenya, Bangladesh, and Nigeria illustrate reasons for variation across countries.

In Nigeria, the IPC cost-effectiveness ratio is $94 per DALY averted, 18th of 70 countries ranked by cost-effectiveness. This result represents high health benefits for malaria and diarrhea, and modest benefits for HIV. For every 1,000 IPC participants, the first campaign averts an estimated 13.4 deaths: 6.0 due to malaria, 3.4 due to diarrhea, and 4.0 due to HIV. The campaign costs are $40,479, with net costs of $34,769 after offsetting savings from averted care needs.

In Kenya, cost-effectiveness is somewhat less attractive, at $157 per DALY averted, 31st of 70 countries. This is due to lower malaria and diarrhea benefits than in Nigeria, and more discovered HIV. For every 1,000 IPC participants, the campaign averts an estimated 10.9 deaths: 1.6 due to malaria, 2.4 to diarrhea, and 7.0 to HIV. The campaign costs $34,280. Although reduced disease creates offsetting savings in care needs, there are $81,000 in *added* HIV costs due to earlier and additional detection of HIV. The net cost of the campaign is $46,149, or $157 per DALY averted. This is less than the $883 per DALY averted for ART in Kenya.

In Bangladesh, the IPC cost-effectiveness ratio is $1,168 per DALY averted, 53rd of 70 countries. This is due to lower health benefits overall. For every 1,000 IPC participants, the campaign averts an estimated 0.9 deaths: 0.1 due to malaria, 0.8 due to diarrhea, and only 0.1 due to HIV. The campaign costs are $35,658. When adjusted for modest offsetting savings from averted care, the net cost of the campaign is $30,236. Cost-effectiveness is comparable with the estimated $1,046 per DALY averted for ART for HIV. See Table 5 of the technical supplement for detailed results for all three countries.

Sensitivity analyses

One-way sensitivity analysis. Figure 2 is a tornado graph of the sensitivity of IPC cost-effectiveness to the model inputs displayed in Table 2 for Nigeria. IPC participants per household had the greatest effect on IPC cost-effectiveness (range, $126 per DALY averted), followed by the multiplier that reflects prevention of secondary HIV transmission, the duration of the prevention benefits of HIV interventions (range, $122 per DALY averted each), cost of the IPC campaign (range, $110 per DALY averted), and the reduction in mortality due to reduced HIV transmission (range, $83 per DALY averted).

Figure 2 about here

For Bangladesh, the inputs with the greatest effect on cost-effectiveness are duration of benefits for diarrhea prevention and the baseline cases of diarrhea per 1,000 person-years (range, $1,506 per DALY averted for both), campaign cost (range, $1,377 per DALY averted), IPC participants per household (range, $1,305 per DALY averted), and protective benefit against diarrhea mortality (range, $1,140 per DALY averted). For Kenya, the variables with the most influence on cost-effectiveness are the multiplier that reflects prevention of secondary HIV transmission and the duration of the prevention benefits of HIV interventions (range, $236 per DALY averted each), the reduction in mortality due to reduced HIV transmission (range, $161 per DALY averted), cost of the IPC campaign (range, $117 per DALY averted), and the number of participants per household (range, $103 per DALY averted). See Technical Supplement Figures 2 and 3 for one-way sensitivity analysis tornado graphs for Bangladesh and Kenya respectively.

Figure 3 shows how variation in three inputs affects incremental cost-effectiveness as each successive 10 countries are added to a scaled-up IPC program. Up to 50 countries, IPC remains cost-effective compared with ART even if the least favorable end of the input estimate range is used.

Figure 3 about here

Multivariate Monte Carlo sensitivity analysis. Table 6 displays the 80% confidence interval for a 20,000-trial simulation for three outcomes: DALYs averted, net costs, and net cost per DALY averted (cost-effectiveness). For Kenya and Nigeria the least favorable end of the cost-effectiveness range is more favorable than the cost-effectiveness of ART for HIV, $304 versus $883 per DALY averted for Kenya and $208 versus $747 per DALY averted for Nigeria. For Bangladesh, the least favorable end of the cost-effectiveness range, $2,547 is *less* favorable than the estimated $1,046 per DALY averted for ART. For Nigeria the five most important variables in order of their correlation with cost-effectiveness (net cost per DALY averted) are, the duration of the HIV prevention benefits ($r = -0.51$); prevention of secondary HIV transmission ($r = -0.50$), the number of IPC participants per household ($r = 0.33$), cost of the IPC campaign ($r = 0.31$), and the reduction in mortality due to reduced HIV transmission ($r = -0.24$), (Figure 4). See Technical Supplement Figures 4 and 5 for multivariate sensitivity analyses correlations coefficients for Kenya and Bangladesh, for projection of IPC costs and benefits in Kenya for 30 years (Technical Supplement Figure 6).

Scenario Analysis: IPC cost-effectiveness with HIV costs and outcomes omitted. Finally, we report on the cost and cost-effectiveness of the IPC program if HIV program costs and health benefits are ignored. These results reflect the perspective of a payer who assumes responsibility for the diarrhea and malaria components only. When future HIV-related costs and benefits are disregarded, including both additional care costs due to more and earlier detection and reductions in care costs due to prevention, the cost per DALY averted decreases from $157 to $129 in Kenya; from $94 to $31 in Nigeria; and increases from $1,168 to $819 in Bangladesh.

Table 6 and Figure 4 about here.

Discussion

We examined the costs and health benefits of IPC for 70 countries with a high combined burden of diarrhea, malaria and HIV. Together these countries comprise 76% of the world population[48-50] and 98% of its disease burden.[9] If implemented with 15% population coverage in the top 40 of the 70 countries as ordered by cost-effectiveness, 47.3 million DALYs could be averted at a net cost of $4.9 billion, or $104 per DALY averted. As shown in Table 3, this compares favorably with the cost-effectiveness of ART in each of those 40 countries. The DALYs averted constitute 58% of the disease burden due to HIV, malaria and diarrheal disease in these countries. $4.9 billion is considerably less than the President's request to the United States Congress for FY 2013 for $6.4 billion for the PEPFAR program [60] and thus might be affordable from a donor's perspective, especially if the current trend of greater host country financial contribution to HIV programs continues. With the exception of Afghanistan, all 30 of the countries in which IPC was most cost-effective are in sub-Saharan Africa and in 51 countries, the cost-effectiveness of IPC compared favorably to ART.

The cost-effectiveness of IPCs varies greatly among the 70 countries we examined. This wide divergence is due primarily to differences in disease burden and therefore to the higher levels of incremental health benefit generated per incremental dollar spent for prevention. For example, Nigeria ranks 4th of the 70 countries based on DALYs per capita in the three diseases of the IPC, and Bangladesh ranks 55th. As shown in Figure 1, per-capita disease burden as measured by the opportunity index is highly correlated with cost-effectiveness. In the case of a single disease-intervention pair such a finding would be unsurprising since the cost-effectiveness of most prevention interventions depend importantly on incidence. It is more noteworthy here since the relative prevalence of the three diseases varies greatly between the countries we studied, and the effect on medical care costs of intervening also varies substantially among the three diseases. In spite of this variability, the opportunity index is a reasonably good guide to cost-effectiveness.

Costs of program delivery also matter. Swaziland, Botswana and South Africa have relatively unfavorable cost-effectiveness in relation to their disease burden. This is due primarily to their high per-capita GDP and thus the higher estimated non-commodity (mainly personnel) portion of their campaign costs. However, IPC cost-effectiveness still compares favorably to that of ART in all three countries.

Sensitivity of findings within each country reflects how the IPC interacts with local disease burden. Diarrhea is the largest contributor to the disease burden in Bangladesh, accounting for 87% of the DALYs averted by the IPC campaign. Not surprisingly, the most important determinant of cost-effectiveness was the estimated duration of the benefits of the water filter and the baseline incidence of diarrhea. Kenya has a far larger HIV epidemic, with a prevalence of 6.3% rather than 0.06% of adults as in Bangladesh. Accordingly, the largest determinants of IPC cost-effectiveness in Kenya were HIV-related in both one-way and multivariate sensitivity analyses. Nigeria's HIV prevalence of 3.6% is close to the average of 3.5% of the 70 countries examined. Nigeria's high IPC cost-effectiveness ranking is due to its high incidence of malaria and diarrhea, 252 and 765 cases per 1,000 person-years respectively, compared with median values of 52 and 521 for malaria and diarrhea respectively for the 70 countries studied.

Among the strengths of the current study are its synthesis of a large volume of epidemiological data from disparate sources into a unified method for projecting the consequence of IPC implementation in 70 countries, and the linking of the "opportunity index" concept with cost-effectiveness. This provides a more comprehensive assessment of intervention potential than assessment of cost-effectiveness alone. This data-driven process may be applied to other disease areas and facilitate more objective resource allocation decision-making.

Limitations of our approach include incomplete availability of data relevant to the large number of countries analyzed. Methods for approximation were therefore necessary. For example, the costs of the campaigns themselves were extrapolated from empirical Kenya-specific data using per-capita GDP ratios between Kenya and the other countries to estimate the non- tradable commodity portion of costs. For other variables such as the protective effects of HIV prevention, bed nets and water filters where country-specific information was absent we employed wide ranges in the sensitivity analyses to ensure that we accounted for uncertainty, and this produced wide confidence intervals around the model outcomes.

This study provides substantial evidence that IPC campaigns can be cost-effective in a large number of low and middle-income countries epidemic settings. However, it leaves unanswered important questions that need to be addressed when these broad findings are translated into programs and policies. For example, in settings with high prevalence of both HIV and malaria, as community HIV prevalence is reduced, malaria susceptibility may decline, thus reducing the benefits associated with malaria prevention. Such interactions are not accounted for in our analysis. In some countries the relative contributions of each disease to the total burden imposed by all three disease is uneven.[9] (See Table 4 of the Technical Supplement for a breakdown of the contribution of each disease to the total for all three diseases). Swaziland, for example, has a high burden of HIV and a low burden of malaria. In Swaziland and similar settings, it may be sensible to focus the IPC campaign in areas of relatively high malaria endemicity, by other means to target the malaria prevention component. Our cost projections posit relatively low IPC coverage, 15%. At this level it is reasonable to assume that in most countries, many high-prevalence areas would not be fully covered and planners need not be concerned that a point of diminishing returns would be met in which it becomes more costly to cover the next community, while the benefit of covering that community might decline. However, prior to implementation, country-specific analyses would be required to determine for which subset of countries it would be more cost-effective to scale up to higher coverage levels even if it means that some countries are excluded from implementation altogether. The current study also was not designed to consider how program costs and effectiveness might vary according to whether a more vertical or more integrated approach is adopted, or depending on the level of prior scale of existing diarrheal disease, malaria or HIV programs. These important program design considerations will depend on the organization of the health care system in each of the countries considering an IPC program.

Because we looked at a large number of countries, we could not explore specific countries in detail. It was infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered. Comparing IPC with the estimated cost-effectiveness of ART for HIV does not account for the potential intervention options that are more efficient than both IPC and ART. In addition, there may be substantial regions or urban areas within countries that have costs, health benefits that depart from the overall country assessments to which our analysis is confined. Finally, we were not able to evaluate the cost to patients of seeking care and were thus unable to adopt a full societal perspective. Since disease prevention averts the need for these expenditures, our results may under-estimate net costs and thus cost-effectiveness. The current analysis should not displace investigation of potential opportunities for efficient IPC implementation in high disease burden areas within countries.

This study increases confidence that IPC can be an important new approach for enhancing global health. IPC appears to be cost-effective compared to ART for HIV in many settings, and has the potential to substantially reduce the burden of disease in poor countries. If implemented with 15% population coverage in the top 40 of the 70 countries as ordered by cost-effectiveness, 47.3 million DALYs could be averted at a net cost of $4.9 billion, or $104 per DALY averted. The specific countries, or number of countries, a donor may want to fund will depend on resource availability, and this analysis provides substantial guidance to decision makers aiming to predict the costs and benefits of various levels of investments in IPC programs. If taken to scale, IPC can be a highly efficient strategy for improving global health.

Author contributions

EM conceived and designed the study, conducted the analyses, and drafted and revised the paper. AJ provided data for the study, helped with the analyses and drafting and revision. AR provided data for the study and revised the draft paper. SV and JW critiqued the analysis helped with specifying data inputs, and revised the draft paper. JGK helped guide design and implementation of the study, helped with specifying data inputs and edited the paper.

Conflicts of interest

None declared.

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Figure Legends

Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (DALYs per capita) (Campaign 1, n=70)

Figure 2. Tornado Graph of Cost per DALY averted –Nigeria: Impact by Input

Figure 3. One-way sensitivity analysis of incremental cost-effectiveness by three key variables in 10-country increments ranked by IPC cost-effectiveness.

Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Nigeria.

Tech. Suppl. - Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (Campaign 2, n=70)

Tech. Suppl. - Figure 2. Tornado Graph of Cost per DALY averted – Bangladesh: Impact by Input

Tech. Suppl. - Figure 3. Tornado graph of cost per DALY averted – Kenya

Tech. Suppl. - Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Bangladesh.

Tech Suppl. - Figure 5. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Kenya.

Tech Suppl. - Figure 6. Discounted cumulative net costs, and DALYs averted for two IPC campaigns in Kenya, projected to 30 years, per 1,000 participants.

Table 1. Base case values and sources for data inputs. Bold figures represent values that change with each country.

	Malaria	Diarrhea	HIV		Source(s)		
	LLIN	Filters	VCT	Condoms	LLIN	Filters	VCT / condoms
Health inputs							
Campaign participant per household	2.5				Post-campaign survey		
Number benefiting per campaign participant	**1.563**	**1.840**	0.950	0.361	Post-campaign survey		
Baseline cases per year per individual benefiting	**0.057**	**0.542**	0.004	0.009	[47, 48]	[49-51]	[8,62-64] Post-campaign survey (see text)
Proportion of cases that are fatal	**0.012**	**0.001**	1	1	[47, 52, 54]	[48, 49, 51, 59, 62]	Assumption
DALYs incurred with each fatal case	28.0	28.0	15.1	15.1	[56]	[56]	[56]
DALYs incurred with each non-fatal case	0.0037	0.0012	n/a	n/a	[57, 58]	[57, 59]	N/a
Protective effect against mortality	0.50	0.63	0.50	0.26	[65], expert opinion	[66]	[67, 68]
Protective effect against non-fatal cases	0.5	0.63	n/a	n/a	[65]	[66]	N/a
Multiplier to capture secondary benefits	n/a bit	n/a	2	2	[69]	N/a	[70] (see text)
Years of benefit	3	3	1	1	[71, 72] Adjusted to 3 years per post-campaign evaluation.	[73] Adjusted to 3 years per post-campaign evaluation.	[68]
Access to care	0.684	**0.678**	0.700	0.700	[14-19]	[20]	Assumption
Cost inputs							
Campaign cost	**$34,280**				[7] $31,980 plus additional $2,300 in revised filter maintenance costs		
Discount rate	3.0%				[10]		
Health care incurred with	**$65**	**$104**	**$12,213**	**$12,213**	[64, 74]	[75]	Authors' construction based on 22 years on ART at $766 per

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each fatality							person-year discounted at 3% per annum.
Health care incurred with each non-fatal case	**$7.80**	**$7.00**	n/a	n/a	[76]	[75]	N/a

Table 2. Sensitivity analysis variables, base case, minimum and maximum values. All variables have beta distributions with alpha and beta parameters of 2. Minimum and maximum values are 0.5 and 1.5 of base case values, respectively, except for access to diarrhea disease care and malaria care which have minimum and maximums of 0.6 and 1.4, and access to HIV ART which has a minimum and maximum of 0.75 and 1.25. Bold figures represent values that change with each country.

	Nigeria			Kenya			Bangladesh		
Input parameter	**Base case**	**Min**	**Max**	**Base case**	**Min**	**Max**	**Base case**	**Min**	**Max**
Campaign cost	**$40,479**	**$20,239**	**$60,718**	**$34,280**	**$17,140**	**$51,420**	**$35,658**	**$17,829**	**$53,486**
Cost per fatality malaria	**$97.50**	**$48.75**	**$146.25**	**$65.00**	**$32.50**	**$97.50**	**$72.22**	**$36.11**	**$108.33**
Cost per fatality diarrhea	**$156.00**	**$78.00**	**$234.00**	**$104.00**	**$52.00**	**$156.00**	**$115.56**	**$57.78**	**$173.34**
Cost per non-fatal case malaria	**$11.70**	**$5.85**	**$17.55**	**$7.80**	**$3.90**	**$11.70**	**$8.67**	**$4.33**	**$13.00**
Cost per non-fatal case diarrhea	**$10.50**	**$5.25**	**$15.75**	**$7.00**	**$3.50**	**$10.50**	**$7.78**	**$3.89**	**$11.67**
Annual cost ART	**$938**	**$469**	**$1,407**	**$766**	**$383**	**$1,150**	**$766**	**$383**	**$1,150**
Discount rate	0.03	0.015	0.045	0.03	0.015	0.045	0.03	0.015	0.045
Access to care Diarrhea	**0.565**	**0.424**	**0.706**	**0.678**	**0.509**	**0.848**	**0.663**	**0.497**	**0.829**
Access to care Malaria	0.684	0.583	0.855	0.684	0.583	0.855	0.684	0.583	0.855
Access to ART	0.7	0.42	0.98	0.7	0.42	0.98	0.7	0.42	0.98
Years on ART	22	11	33	22	11	33	22	11	33
HIV prevalence	**0.036**	**0.018**	**0.054**	**0.063**	**0.032**	**0.095**	**0.0006**	**0.0003**	**0.0009**
Baseline cases p1000py Malaria	**351.6**	**175.8**	**527.5**	**57.0**	**28.5**	**85.5**	**6.13**	**3.06**	**9.19**
Baseline cases p1000py Diarrhea	**765.3**	**382.7**	**1148.0**	**542.0**	**271.0**	**813.0**	**299.81**	**149.91**	**449.72**
Propor fatal Malaria	**0.008**	**0.004**	**0.012**	**0.012**	**0.006**	**0.018**	**0.004**	**0.002**	**0.006**
Propor fatal Diarrhea	0.001	0.001	0.002	0.001	0.001	0.002	0.0007	0.0004	0.0011
Participants per HH	2.5	1.25	3.75	2.5	1.25	3.75	2.5	1.25	3.75
DALYs fatal malaria	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs fatal diarrhea	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs non-fatal malaria	0.366	0.183	0.549	0.366	0.183	0.549	0.366	0.183	0.549
DALYs non-fatal diarrhea	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191
Protect. mortality malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality diarrhea	0.630	0.315	0.945	0.630	0.315	0.945	0.630	0.315	0.945
Protect. non fatal malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. non fatal diarrhea	0.628	0.314	0.941	0.628	0.314	0.941	0.628	0.314	0.941
Protect. mortality HIV transmission	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality HIV acquisition	0.255	0.128	0.383	0.255	0.128	0.383	0.255	0.128	0.383

Multiplier: Secondary effects HIV	2	1	3	2	1	3	2	1	3
Duration of benefit malaria	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Duration of benefit diarrhea	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
Duration of benefit HIV	1	0.5	1.5	1	0.5	1.5	1	0.5	1.5

Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most favorable to least favorable cost-effectiveness (net cost per DALY averted). The grey highlighted cells indicate CE ratio is less favorable than investment in ART. Results shown are for the first 3-year campaign.

				Costs		Disease averted			Cost-effectiveness (CE)		
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	$29,459	$7,814	40.7	10,523	1,143.3	$26	$7	$1,005
2	Senegal	Lower middle	0.050	$34,969	$12,190	10.7	5,735	306.0	$114	$40	$768
3	Sierra Leone	Low	0.119	$31,525	$20,112	16.0	4,118	446.7	$71	$45	$764
4	Burkina Faso	Low	0.126	$31,525	$22,206	16.4	4,124	459.4	$69	$48	$819
5	Somalia	Low	0.121	$26,015	$22,754	16.8	3,682	470.5	$55	$48	$1,535
6	Niger	Low	0.110	$28,081	$21,620	14.8	4,967	419.7	$67	$52	$1,095
7	Mali	Low	0.124	$29,459	$23,016	15.9	4,222	445.8	$66	$52	$888
8	Afghanistan	Low	0.057	$28,770	$18,906	12.7	4,146	356.6	$81	$53	$935
9	Chad	Low	0.120	$35,658	$24,848	15.3	4,335	424.6	$84	$59	$807
10	Lesotho	Lower middle	0.115	$35,658	$47,366	31.3	1,756	779.4	$46	$61	$738
11	Guinea	Low	0.095	$29,459	$22,324	12.6	4,272	353.8	$83	$63	$928
12	Congo, DR	Low	0.112	$24,637	$25,488	13.4	3,517	375.9	$66	$68	$1,493
13	Sudan	Lower middle	0.057	$38,413	$15,241	6.9	4,907	198.8	$193	$77	$703
14	Liberia	Low	0.092	$26,704	$25,526	11.9	3,401	332.6	$80	$77	$1,025
15	Burundi	Low	0.118	$26,015	$33,639	14.3	2,267	389.9	$67	$86	$987
16	Benin	Low	0.083	$33,591	$25,345	10.0	3,096	280.0	$120	$91	$910
17	Côte d'Ivoire	Lower middle	0.084	$33,591	$35,069	14.1	4,021	387.2	$87	$91	$801
18	Nigeria	Lower middle	0.133	$40,479	$34,769	13.4	3,102	369.3	$110	$94	$747
19	Mozambique	Low	0.141	$30,147	$59,145	22.2	3,816	590.0	$51	$100	$1,109
20	Cen. African Rep.	Low	0.105	$27,392	$37,525	13.8	2,819	373.3	$73	$101	$1,230
21	Uganda	Low	0.105	$31,525	$40,192	14.9	3,492	399.8	$79	$101	$749
22	Congo, Rep.	Lower middle	0.067	$54,254	$33,944	11.5	2,981	318.5	$170	$107	$756
23	Togo	Low	0.075	$29,459	$32,147	10.4	2,849	288.7	$102	$111	$864
24	Angola	Upper middle	0.088	$64,586	$35,794	11.5	3,268	320.8	$201	$112	$674
25	Tanzania	Low	0.075	$33,591	$38,453	12.1	3,122	326.9	$103	$118	$935
26	Zambia	Lower middle	0.128	$33,591	$69,806	21.8	3,107	564.3	$60	$124	$826
27	Ethiopia	Low	0.057	$30,147	$29,630	8.6	1,986	235.7	$128	$126	$1,139
28	Rwanda	Low	0.071	$31,525	$34,034	9.6	2,216	266.1	$118	$128	$768
29	Malawi	Low	0.110	$28,081	$59,745	18.3	2,965	462.2	$61	$129	$996
30	Cameroon	Lower middle	0.100	$37,724	$52,388	14.3	3,115	388.4	$97	$135	$741
31	Kenya	Low	0.065	$34,280	$46,149	10.9	2,018	294.1	$117	$157	$883
32	Mauritania	Lower middle	0.042	$36,346	$28,117	5.8	2,607	164.2	$221	$171	$955
33	Yemen	Lower middle	0.025	$37,035	$21,139	4.3	3,128	122.9	$301	$172	$719
34	Zimbabwe	Low	0.075	$25,326	$76,203	17.8	1,682	428.8	$59	$178	$1,731
35	Pakistan	Lower middle	0.020	$41,856	$19,714	3.8	2,748	108.1	$387	$182	$904
36	Ghana	Lower middle	0.063	$44,612	$35,624	6.8	1,966	189.9	$235	$188	$746
37	Madagascar	Low	0.043	$28,770	$24,895	4.5	1,910	127.8	$225	$195	$1,025
38	Eritrea	Low	0.033	$27,392	$26,438	4.3	1,942	120.5	$227	$219	$1,753
39	Botswana	Upper middle	0.080	$137,595	$185,872	26.8	1,111	734.1	$187	$253	$577
40	Haiti	Low	0.028	$30,836	$31,570	4.4	3,128	123.0	$251	$257	$869
41	Swaziland	Lower middle	0.150	$58,387	$198,392	29.1	2,230	724.2	$81	$274	$632

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42	Guatemala	Lower middle	0.016	$57,698	$22,134	2.4	3,143	70.1	$823	$316	$627
43	South Africa	Upper middle	0.097	$99,713	$180,284	21.5	1,150	561.0	$178	$321	$582
44	Gabon	Upper middle	0.060	$29,826	$84,306	9.3	1,876	255.0	$117	$331	$613
45	India	Lower middle	0.027	$48,744	$34,973	3.7	1,255	104.9	$464	$333	$733
46	Myanmar	Low	0.026	$31,525	$28,249	2.9	1,306	83.7	$377	$337	$1,354
47	Papua New Guinea	Lower middle	0.018	$40,479	$25,117	2.4	2,868	71.2	$568	$353	$864
48	Iraq	Upper middle	0.009	$53,565	$25,989	1.9	2,587	55.8	$960	$466	$758
49	Namibia	Upper middle	0.038	$75,606	$204,271	15.6	1,528	402.7	$188	$507	$606
50	Cambodia	Low	0.014	$38,413	$31,172	1.9	1,341	54.3	$708	$574	$739
51	Nepal	Low	0.010	$30,836	$28,994	1.4	1,135	39.8	$776	$729	$883
52	Morocco	Lower middle	0.006	$58,387	$42,818	1.9	1,623	54.8	$1,066	$782	$650
53	Bangladesh	Low	0.007	$35,658	$30,236	0.9	1,076	25.9	$1,377	$1,168	$1,046
54	Algeria	Upper middle	0.008	$73,540	$51,390	1.4	1,304	41.0	$1,793	$1,253	$606
55	Uzbekistan	Lower middle	0.006	$45,989	$25,637	0.6	2,352	18.2	$2,523	$1,406	$717
56	Ukraine	Lower middle	0.006	$74,228	$68,364	1.2	623	33.6	$2,210	$2,036	$600
57	Thailand	Upper middle	0.005	$90,759	$100,377	1.8	455	48.7	$1,863	$2,061	$622
58	Indonesia	Lower middle	0.008	$56,321	$46,677	0.7	814	20.8	$2,708	$2,244	$793
59	Bolivia	Lower middle	0.010	$56,321	$30,994	0.4	2,015	13.5	$4,178	$2,299	$668
60	Vietnam	Lower middle	0.005	$45,989	$40,910	0.6	828	17.6	$2,616	$2,327	$664
61	Colombia	Upper middle	0.003	$95,580	$63,657	0.6	1,419	20.5	$4,652	$3,098	$598
62	Peru	Upper middle	0.004	$95,580	$59,439	0.6	1,497	19.0	$5,026	$3,126	$613
63	Brazil	Upper middle	0.004	$104,534	$65,501	0.6	1,385	19.2	$5,431	$3,403	$581
64	Philippines	Lower middle	0.003	$51,499	$39,031	0.3	1,289	10.9	$4,746	$3,597	$724
65	Russian Federation	High: nonOECD	0.007	$143,794	$121,954	1.1	735	31.2	$4,607	$3,907	$579
66	Argentina	Upper middle	0.003	$147,238	$101,854	0.6	1,097	18.1	$8,155	$5,642	$577
67	Malaysia	Upper middle	0.004	$138,284	$104,408	0.6	930	17.6	$7,858	$5,933	$591
68	Turkey	Upper middle	0.001	$29,459	$58,058	0.1	1,784	6.1	$4,821	$9,501	$582
69	Mexico	Upper middle	0.003	$127,264	$134,901	0.3	0	9.6	$13,197	$13,989	$583
70	China	Upper middle	0.001	$84,560	$74,564	0.1	486	4.7	$18,015	$15,886	$638

Table 4. IPC costs, DALYs averted, and cost-effectiveness compared with no intervention, and incremental cost-effectiveness for 70 countries in increments of 10, ranked by cost-effectiveness. "Net costs" consist of IPC campaign costs adjusted for medical costs averted or added due to the campaign. Results assume 15% of population covered by IPC in each country. Costs in 2012 US$.

Countries	Campaign cost	Net cost		DALYs averted		Cost-effectiveness (compared with no intervention)		Incremental cost-effectiveness (compared with previous row)	
		Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2
Top 10	5.832E+08	3.979E+08	4.685E+08	8.048E+06	5.708E+06	$49	$82	n/a	n/a
Top 20	2.387E+09	2.054E+09	2.068E+09	2.706E+07	1.629E+07	$76	$127	$87	$151
Top 30	3.715E+09	3.554E+09	3.338E+09	3.961E+07	2.382E+07	$90	$140	$119	$169
Top 40*	5.614E+09	4.943E+09	4.858E+09	4.731E+07	2.916E+07	$104	$167	$181	$284
Top 50*	1.624E+10	1.342E+10	1.395E+10	7.265E+07	4.983E+07	$185	$280	$335	$440
Top 60	2.226E+10	1.863E+10	1.941E+10	7.573E+07	5.186E+07	$246	$374	$1,692	$2,699
Top 70	5.129E+10	4.350E+10	4.629E+10	7.871E+07	5.322E+07	$553	$870	$8,340	$19,728

Table 5. Median cost-effectiveness (net cost per DALY averted) by 10-country increments in order of cost-effectiveness

Countries ranked by IPC cost-effectiveness	Campaign 1	Campaign 2	Antiretroviral therapy for HIV
Top 10	$50	$102	$854
11 - 20	$88	$141	$958
11 - 30	$121	$197	$797
31 - 40	$185	$318	$894
41 - 50	$335	$591	$683
51 - 60	$1,721	$3,514	$666
61 - 70	$4,774	$17,068	$587

Table 6. Multiway sensitivity analysis; 20,000-trial Monte Carlo simulation, 80% confidence interval for 3 IPC outcomes and cost per DALY averted by ART for HIV in Kenya, Bangladesh, and Nigeria.

Outcomes	Kenya	Bangladesh	Nigeria
DALYs averted	206 - 407	13.1 – 45.8	228 - 564
Net costs	$7,810 - $79,885	$18,566 - $41,473	$2,241 - $61,448
Net cost per DALY averted (cost-effectiveness)	$23 - $304	$519 - $2,547	$5 - $208
Cost per DALY averted by ART for HIV	$883	$1,046	$747