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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.
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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., \geq 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

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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].

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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 upperbound 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

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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

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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 $51^{st} - 60^{th}$ and for the $61^{st} - 70^{th}$ 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

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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 costeffectiveness 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 costeffectiveness 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 Kenyaspecific 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 nterest red. 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	Diarrhe	ea	HIV		Source(s)	
	LLIN	Filters	s VCT	Condoms	LLIN	Filters	VCT / condoms
Health inputs							
Campaign participant per household			2.5			Post-campaign surv	ey
Number benefiting per campaign participant	1.563	1.840	0.950	0.361		Post-campaign surv	ey
Baseline cases per year per individual benefiting	0.057	0.542	0.004	0.009	[47, 48]	[49-51]	[8, 59-61] Post-campaign surve (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				costs	ditional \$2,300 in revi	sed filter maintenance
Discount rate	3.0%	1		1	[10]		
Health care incurred with each fatality	\$65	\$104	\$12,213	\$12,213	[61, 73]	[74]	Authors' constructio based on 22 years or 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

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IPC CEA Tables and Figures - 1

		Nigeria			Kenya		Ва	nglades	h
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

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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 AR
1	Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1,143.3	\$26	\$7	\$1,005
2	Senegal	Low er 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 12.7	4,222	445.8	\$66	\$52	\$888
8 9	Afghanistan Chad	Low Low	0.057	\$28,770 \$35,658	\$18,906 \$24,848	12.7	4,146 4,335	356.6 424.6	\$81 \$84	\$53 \$59	\$935 \$807
9 10	Lesotho	Low er middle	0.120	\$35,658	\$47,366	31.3	4,335	779.4	\$46	\$09 \$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	Low er 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	Low er middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801
18	Nigeria	Low er 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.	Low er middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756
23 24	Togo	Low Upper middle	0.075	\$29,459 \$64,586	\$32,147 \$35,794	10.4 11.5	2,849 3,268	288.7 320.8	\$102 \$201	\$111 \$112	\$864 \$674
24 25	Angola Tanzania	Low	0.088	\$33,591	\$38,453	11.5	3,200	326.9	\$201	\$112	\$935
26	Zambia	Low er middle	0.128	\$33,591	\$69,806	21.8	3,122	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	Rw anda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768
29	Malaw i	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996
30	Cameroon	Low er 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	Low er middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$955
33	Yemen	Low er middle	0.025	\$37,035	\$21,139	4.3	3,128	122.9	\$301	\$172	\$719
34	Zimbabw e	Low	0.075	\$25,326	\$76,203	17.8	1,682	428.8	\$59	\$178	\$1,731
35	Pakistan	Low er middle	0.020	\$41,856	\$19,714	3.8	2,748	108.1	\$387	\$182	\$904
36	Ghana	Low er 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 39	Eritrea Botsw ana	Low	0.033	\$27,392	\$26,438	4.3 26.8	1,942	120.5 734.1	\$227 \$187	\$219 \$253	\$1,753 \$577
40	Haiti	Upper middle Low	0.080	\$137,595 \$30,836	\$185,872 \$31,570	4.4	1,111 3,128	123.0	\$251	\$255	\$869
41	Sw aziland	Low er middle	0.150	\$58,387	\$198,392	29.1	2,230	724.2	\$81	\$274	\$632
42	Guatemala	Low er 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	Low er 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	Low er 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	Low er middle Low	0.006	\$58,387	\$42,818	1.9 0.9	1,623	54.8	\$1,066 \$1,377	\$782	\$650
53 54	Bangladesh Algeria	Upper middle	0.007	\$35,658 \$73,540	\$30,236 \$51,390	1.4	1,076 1,304	25.9 41.0	\$1,793	\$1,168 \$1,253	\$1,046 \$606
55	Uzbekistan	Low er middle	0.008	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,203	\$717
56	Ukraine	Low er middle	0.000	\$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	Low er middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793
59	Bolivia	Low er middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668
60	Vietnam	Low er 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	Low er 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 \$58,058	0.6	930	17.6	\$7,858	\$5,933 \$0,501	\$591
	Turkey	Upper middle	0.001	\$29,459	\$58,058	0.1	1,784	6.1 9.6	\$4,821 \$13,197	\$9,501	\$582
68 69	Mexico	Upper middle	0.003	\$127,264	\$134,901	0.3	0			\$13,989	\$583

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Table 4. IPC costs, DALYs averted, and cost-effectiveness compared with no intervention, and incremental costeffectiveness 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\$.

		Neto	cost	DALYs	averted	(compare	ctiveness d with no ention)	(compa	veness
Countries	Campaign cost	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	, Camp. 2	Camp. 1	Camp.
Top 10	\$583,177,366	\$397,894,640	\$468,463,768	8,047,765	5,708,048	\$49	\$82	n/a	n/a
Тор 20	\$2,387,027,516	\$2,054,199,874	\$2,067,515,989	27,062,539	16,290,756	\$76	\$127	\$87	\$151
Тор 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, <mark>421,640</mark> ,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	\$2,69
Top 70	\$51,294,946,151	\$43,498,730,679	\$46,290,783,278	78,713,520	53,217,470	\$553	\$870	\$8,340	\$19,72
			\$19,414,467,973 \$46,290,783,278						

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

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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

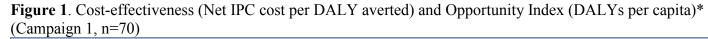
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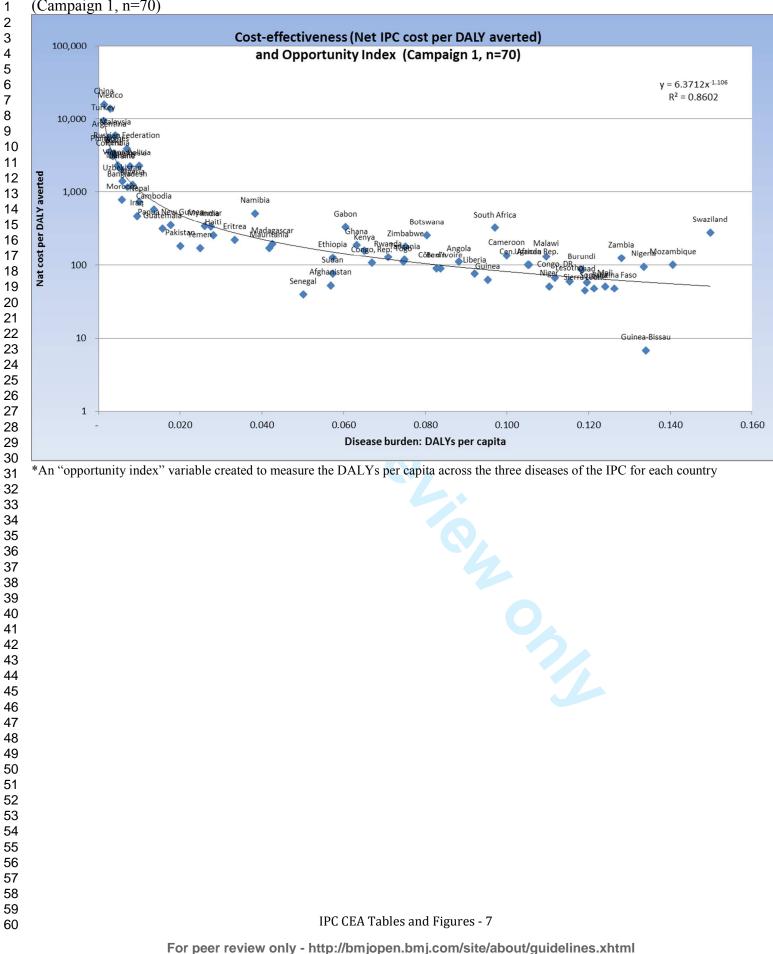
Table 6. Multiway sensitivity analysis; 20,000- trial Monte Carlo simulation, 80% confidence Interval for three IPC outcomes and cost per DALY averted by ART for HIV for Kenya, Bangladesh and Nigeria.

Outcome	Kenya	Bangladesh	Nigeria
DALYs avertee	d 206 - 407	13.1 - 45.8	228 - 564
Net Costs	\$	\$18,566 - \$41,473	\$2,241- \$61,448
Net cost per DALY averted (cost-effectivenes		\$519 - \$2,547	\$5 - \$208
Cost per DALY averted by ART for H	IIV \$883	\$1,046	\$747

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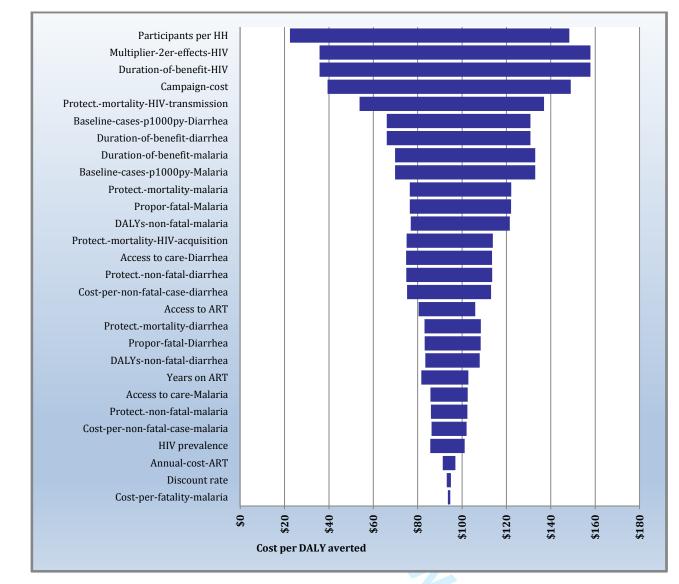


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Figure 2. Tornado Graph of Cost per DALY averted -Nigeria: Impact by Input



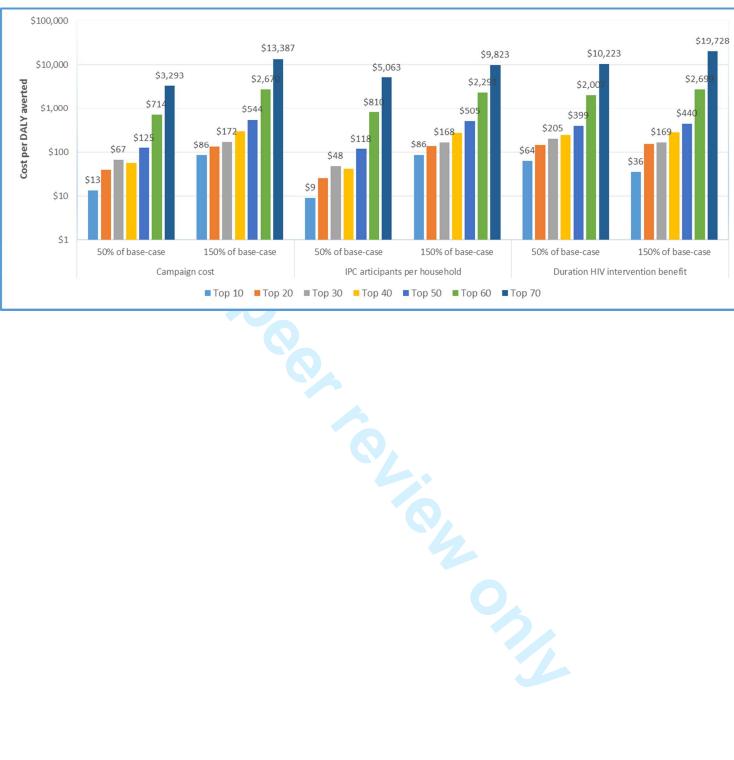


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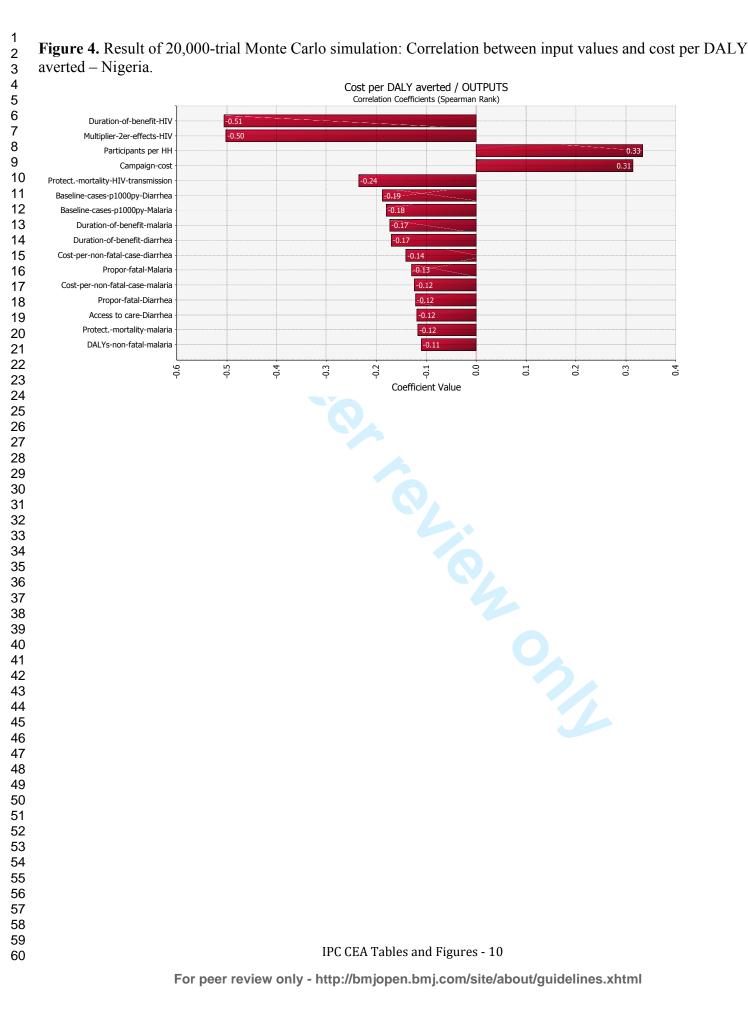
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Figure 3. One-way sensitivity analysis of incremental cost-effectiveness by three key variables in 10-country increments ranked by IPC cost-effectiveness.



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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.

11 For malaria we assume 75% as much disease incidence at years 4-6 (absent a 2nd campaign) as baseline incidence. 12 In other words, we assume that full set of LLIN distributed in the *initial* campaign, with no follow-up campaign, 13 14 would have half as much community benefit in years 4-6 as in years 1-3. Many LLIN will remain in place, and the 15 insecticide impregnation itself is stable for close to 10 years. Thus, the 50% incidence drop expected with LLIN in 16 years 1-3 will decrease but not disappear in the second 3 years. However, the second round of LLIN are likely to 17 have a relative effectiveness less than 50%, because the best LLIN users are already protected. Thus we decrease 18 the effectiveness from 50% to 33% (i.e., from 75% of baseline incidence to 50% of baseline incidence). In effect, 19 the 2nd campaign is like a booster shot that returns effectiveness to its original level. In sum, the overall benefit of 20 21 the second campaign is reduced by half -- in first campaign it was 100% of baseline incidence to 50%, and in the 22 second campaign from 75% of baseline incidence to 50%. 23

24 We note that these estimates are assembled from isolated data (e.g., LLIN physical durability) combined with a 25 logical framework and best guesses. Nonetheless, we believe that the conclusion -50% as much benefit for a 26 27 second campaign – is plausible, and is a far more realistic assumption than full benefit. Our approach is 28 conservative regarding the second campaign – if the specified durability of effect of the LLIN is larger than in 29 reality, we would be underestimating the benefit of this campaign. And our estimate of the combined effect of two 30 sequential campaigns is robust. Low estimates of durability understate benefits of the first campaign and overstate 31 benefits of the second campaign, which represent offsetting errors. Conversely, high estimates of durability 32 33 overstate the value of the first campaign and understate second campaign benefits, again offsetting. 34

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 39 40 almost all HIV-infected individuals. Thus, the effects of the second campaign depend mainly on the impact of 3 41 years of HIV incidence on (predominantly undiagnosed) HIV prevalence. This incidence has not been measured, 42 but can be estimated from HIV prevalence using simple epidemic dynamics. [1] Steady-state (pre-ART) annual 43 incidence is about 1/10th of prevalence (slightly more if prevalence above 10%, due to reduction in # of 44 susceptibles). So, if initial prevalence was 5%, then annual incidence is about 0.5%, and prevalence at 3 years will 45 be about 1.5%. 46 47

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.

⁵⁴ 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

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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 Kenva 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 Kenva. 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.

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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		
_	Guinea-Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465.3	754.3	\$22	\$39	\$1,005		
_	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055.1	325.2	\$73	\$80	\$768		
	Afghanistan	Low	0.057	\$28,770 \$24,637	\$22,700 \$24,258	12.2 9.3	2,380.6 1,851.9	342.0 259.2	\$66 \$94	\$84 \$95	\$764 \$819		
5	Congo, DR Niger	Low	0.112	\$28,081	\$24,250	9.5	2,648.0	259.2	\$94 \$86	\$99	\$019		
	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312.1	280.1	\$90	\$105	\$1,095		
	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		
	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,975.5	260.0	\$141	\$116	\$807		
_	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153.3	270.2	\$96	\$117	\$738		
	Chad Lesotho	Low Low er middle	0.120	\$35,658 \$35,658	\$27,805 \$37,171	10.6 11.7	2,258.2 919.3	294.9 283.6	\$94 \$131	\$121 \$126	\$928 \$1,493		
	Malaw i	Low er middle	0.110	\$28,081	\$36,299	8.6	1,532.3	203.0	\$164	\$120	\$703		
14	Zambia	Low er middle	0.128	\$33,591	\$41,222	10.1	1,660.1	263.4	\$156	\$128	\$1,025		
	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		
	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,443.6	194.2	\$152	\$141	\$801		
	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,841.7	214.8	\$145	\$147	\$747		
	Zimbabw e	Low	0.075	\$25,326	\$40,453	6.9	905.4	165.8	\$244	\$153	\$1,109		
	Côte d'Ivoire	Low er middle	0.084 0.057	\$33,591	\$31,110 \$28,881	7.8 6.5	2,009.7 1,128.0	214.9 181.8	\$145 \$159	\$156 \$166	\$1,230 \$749		
21	Ethiopia Cameroon	Low Low er middle	0.057	\$30,147 \$37,724	\$28,881 \$39,507	6.5 8.1	1,128.0	181.8 223.1	\$159 \$177	\$166 \$169	\$749 \$756		
_	Senegal	Low er middle	0.050	\$34,969	\$22,535	6.8	2,951.7	193.6	\$177	\$189	\$864		
	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,466.8	153.3	\$188	\$192	\$674		
	Rw anda	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		
	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611.1	167.1	\$172	\$201	\$1,139		
	Sw aziland	Low er middle	0.150	\$58,387	\$87,699	11.5	1,280.6	281.0	\$312	\$208	\$768		
	Nigeria	Low er middle	0.133	\$40,479	\$34,860	6.7	1,610.1	187.0	\$186	\$217	\$996		
_	Kenya Gabon	Low	0.065	\$34,280 \$29,826	\$35,682 \$46,367	5.2 4.0	1,130.6 972.5	142.8 110.7	\$250 \$419	\$240 \$269	\$741 \$883		
	Congo, Rep.	Upper middle Low er middle	0.060	\$29,820	\$40,307 \$42,228	7.2	1,522.2	199.0	\$419 \$212	\$209 \$273	\$003 \$955		
	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5	1,758.3	236.6	\$187	\$273	\$719		
	Sudan	Low er middle	0.057	\$38,413	\$24,940	4.8	2,620.5	136.6	\$183	\$281	\$1,731		
35	Mauritania	Low er 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		
	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117.1	78.5	\$334	\$349	\$1,025		
	Yemen	Low er middle	0.025	\$37,035	\$27,682	3.5	1,778.2	99.3	\$279	\$373	\$1,753		
	Ghana	Low er middle	0.063	\$44,612	\$38,058	4.2	1,006.4	117.8	\$323	\$379	\$577		
	Haiti Pakistan	Low Low er middle	0.028	\$30,836 \$41,856	\$29,010 \$28,870	2.8 3.6	1,789.6 1,574.8	80.4 102.7	\$361 \$281	\$384 \$407	\$869 \$632		
	South Africa	Upper middle	0.020	\$99,713	\$115,007	9.1	659.2	235.9	\$487	\$423	\$627		
-	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	855.9	150.8	\$708	\$502	\$582		
	India	Low er middle	0.027	\$48,744	\$40,648	3.4	713.2	96.2	\$422	\$506	\$613		
45	Botsw ana	Upper middle	0.080	\$137,595	\$139,112	9.9	634.1	262.4	\$530	\$524	\$733		
	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	672.6	48.0	\$614	\$657	\$1,354		
	Cambodia	Low	0.014	\$38,413	\$33,905	1.3	758.8	37.6	\$901	\$1,020	\$864		
	Nepal	Low	0.010	\$30,836	\$29,442 \$37,274	1.1	654.7 1.493.0	30.0	\$982 \$740	\$1,028	\$758 \$606		
49 50	iraq Guatemala	Upper middle Low er middle	0.009	\$53,565 \$57,698	\$37,274 \$35,999	1.7 1.8	1,493.0 1,812.5	50.4 51.6	\$740 \$698	\$1,063 \$1,118	\$606 \$739		
	Papua New Guinea	Low er middle	0.018	\$40,479	\$31,703	1.0	1,488.7	35.8	\$885	\$1,130	\$883		
	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617.4	23.0	\$1,413	\$1,551	\$650		
	Morocco	Low er middle	0.006	\$58,387	\$49,883	1.1	898.4	31.6	\$1,577	\$1,846	\$1,046		
	Algeria	Upper middle	0.008	\$73,540	\$60,354	1.3	752.8	38.2	\$1,580	\$1,925	\$606		
_	Uzbekistan	Low er middle	0.006	\$45,989	\$34,086	0.5	1,357.2	14.9	\$2,282	\$3,079	\$717		
	Indonesia	Low er middle	0.008	\$56,321	\$50,560	0.5	463.2	14.3	\$3,545	\$3,949	\$600		
_	Thailand	Upper middle	0.005	\$90,759 \$45,989	\$90,800 \$42,516	0.8	261.3	21.7	\$4,177 \$5,164	\$4,175 \$5,586	\$622 \$703		
	Vietnam Philippines	Low er middle Low er middle	0.005	\$45,989 \$51,499	\$42,516 \$44,213	0.3	477.7 743.4	8.2 8.8	\$5,164 \$5,026	\$5,586 \$5,854	\$793 \$668		
	Ukraine	Low er middle	0.005	\$74,228	\$69,343	0.3	359.1	11.5	\$6,052	\$6,479	\$664		
_	Bolivia	Low er middle	0.010	\$56,321	\$41,435	0.2	1,162.3	8.2	\$5,044	\$6,856	\$598		
	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		
	Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424.3	10.8	\$11,898	\$13,319	\$579		
_	Marine and a	Upper middle	0.004	\$138,284	\$117,395	0.2	536.0	6.6	\$17,673	\$20,818	\$577		
66	Malaysia		0.677	A447	0110								
66 67	Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	632.8	6.8	\$17,487	\$21,512	\$591		
66 67 68	-		0.003 0.001 0.001	\$147,238 \$125,197 \$84,560	\$119,687 \$86,272 \$78,518	0.2 0.1 0.1	632.8 1,029.3 280.4	6.8 3.9 2.3	\$17,487 \$22,267 \$33,785	\$21,512 \$32,314 \$36,384	\$591 \$582 \$583		

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				Cost	s	Disease	averted		Cost-ef	fectiveness	(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	Sw aziland	Low er 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
	Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1143.3	\$26	\$7	\$1,005
_	Nigeria	Low er middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$747
-	Zambia Burkina Faso	Low er middle Low	0.128	\$33,591 \$31,525	\$69,806 \$22,206	21.8 16.4	3,107 4,124	564.3 459.4	\$60 \$69	\$124 \$48	\$826 \$819
·	Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$888
3	Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,535
)	Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$807
-	Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$764
1 2	Burundi Lesotho	Low Low er middle	0.118	\$26,015 \$35,658	\$33,639 \$47,366	14.3 31.3	2,267 1,756	389.9 779.4	\$67 \$46	\$86 \$61	\$987 \$738
-	Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,493
4	Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,095
-	Malawi	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996
-	Cen. African Rep. Uganda	Low	0.105	\$27,392 \$31,525	\$37,525 \$40,192	13.8 14.9	2,819 3,492	373.3 399.8	\$73 \$79	\$101 \$101	\$1,230 \$749
-	Cameroon	Low er middle	0.100	\$37,724	\$52,388	14.3	3,115	388.4	\$97	\$135	\$741
9	South Africa	Upper middle	0.097	\$99,713	\$180,284	21.5	1,150	561.0	\$178	\$321	\$582
-	Guinea Liberia	Low	0.095	\$29,459 \$26,704	\$22,324 \$25,526	12.6 11.9	4,272 3,401	353.8 332.6	\$83 \$80	\$63 \$77	\$928 \$1,025
_	Liberia Angola	Low Upper middle	0.092	\$26,704 \$64,586	\$25,526 \$35,794	11.9 11.5	3,401	332.6	\$80 \$201	\$77 \$112	\$1,025
3	Côte d'Ivoire	Low er middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801
_	Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$910
5 6	Botsw ana Zimbabw e	Upper middle Low	0.080	\$137,595 \$25,326	\$185,872 \$76,203	26.8 17.8	1,111 1,682	734.1 428.8	\$187 \$59	\$253 \$178	\$577 \$1,731
7	Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$178	\$935
в	Тодо	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864
-	Rw anda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768
-	Congo, Rep. Kenya	Low er middle Low	0.067	\$54,254 \$34,280	\$33,944 \$46,149	11.5 10.9	2,981 2,018	318.5 294.1	\$170 \$117	\$107 \$157	\$756 \$883
2	Ghana	Low er middle	0.063	\$44,612	\$35,624	6.8	1,966	189.9	\$235	\$188	\$746
3	Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613
-	Ethiopia	Low	0.057	\$30,147	\$29,630	8.6	1,986	235.7	\$128	\$126	\$1,139
5 6	Sudan Afghanistan	Low er middle Low	0.057	\$38,413 \$28,770	\$15,241 \$18,906	6.9 12.7	4,907 4,146	198.8 356.6	\$193 \$81	\$77 \$53	\$703 \$935
-	Senegal	Low er middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$768
в	Madagascar	Low	0.043	\$28,770	\$24,895	4.5	1,910	127.8	\$225	\$195	\$1,025
9	Mauritania	Low er middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$955
_	Namibia Eritrea	Upper middle Low	0.038	\$75,606 \$27,392	\$204,271 \$26,438	15.6 4.3	1,528 1,942	402.7	\$188 \$227	\$507 \$219	\$606 \$1,753
2	Haiti	Low	0.028	\$30,836	\$31,570	4.4	3,128	123.0	\$251	\$257	\$869
_	India	Low er middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$733
-	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354
5 6	Yemen Pakistan	Low er middle	0.025	\$37,035 \$41,856	\$21,139 \$19,714	4.3 3.8	3,128 2,748	122.9	\$301 \$387	\$172 \$182	\$719 \$904
_	Papua New Guinea	Low er middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$864
-	Guatemala	Low er middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$627
-	Cambodia Nepal	Low	0.014	\$38,413 \$30,836	\$31,172 \$28,994	1.9 1.4	1,341 1,135	54.3 39.8	\$708 \$776	\$574 \$729	\$739 \$883
-	Bolivia	Low Low er middle	0.010	\$30,836	\$28,994 \$30,994	0.4	2,015	13.5	\$4,178	\$729 \$2,299	\$668
2	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758
-	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
4 5	Indonesia Bangladesh	Low er middle Low	0.008	\$56,321 \$35,658	\$46,677 \$30,236	0.7	814 1,076	20.8	\$2,708 \$1,377	\$2,244 \$1,168	\$793 \$1,046
-	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,954	1.1	735	31.2	\$4,607	\$3,907	\$579
-	Uzbekistan	Low er middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717
B	Morocco	Low er middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650
-	Ukraine Thailand	Low er middle Upper middle	0.006	\$74,228 \$90,759	\$68,364 \$100,377	1.2	623 455	33.6 48.7	\$2,210 \$1,863	\$2,036 \$2,061	\$600 \$622
-	Vietnam	Low er middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664
_	Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$591
3 4	Brazil Peru	Upper middle Upper middle	0.004	\$104,534 \$95,580	\$65,501 \$59,439	0.6	1,385 1,497	19.2 19.0	\$5,431 \$5,026	\$3,403 \$3,126	\$581 \$613
-	Peru Colombia	Upper middle Upper middle	0.004	\$95,580 \$95,580	\$59,439 \$63,657	0.6	1,497	20.5	\$5,026 \$4,652	\$3,126 \$3,098	\$598
-	Mexico	Upper middle	0.003	\$127,264	\$134,901	0.3	0	9.6	\$13,197	\$13,989	\$583
-	Philippines	Low er middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$724
-	Argentina China	Upper middle Upper middle	0.003	\$147,238 \$84,560	\$101,854 \$74,564	0.6	1,097 486	18.1 4.7	\$8,155 \$18,015	\$5,642 \$15,886	\$577 \$638
~	Turkey	Upper middle	0.001	\$04,500 \$125,197	\$74,564 \$58,058	0.1	1,784	6.1	\$18,015	\$15,666	\$582

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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 1 2 cells indicate cost-effectiveness ratios less favorable than investment in ART Results shown are for the second and

3 subsequent 3-year campaigns. 4

5					Co	sts	Disease averted			Cost-effectiveness (CE)			
5		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	
3	1	Sw aziland	Low er middle	0.150	\$58,387	\$87,699	11.5	1,281	281.0	\$312	\$208	\$632	
9	2	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,976	260.0	\$141	\$116	\$1,109	
10	3	Guinea-Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465	754.3	\$22	\$39	\$1,005	
11	4	Nigeria	Low er middle	0.133	\$40,479	\$34,860	6.7	1,610	187.0	\$186	\$217	\$747	
	5	Zambia	Low er middle	0.128	\$33,591	\$41,222	10.1	1,660	263.4	\$156	\$128	\$826	
2	6 7	Burkina Faso Mali	Low	0.126	\$31,525	\$26,076	9.6	2,153	270.2 280.1	\$96	\$117	\$819 \$888	
3	8	Somalia	Low	0.124	\$29,459 \$26,015	\$25,298 \$23,643	10.0 11.6	2,312 2,055	325.2	\$90 \$73	\$105 \$80	\$000	
4	9	Chad	Low	0.120	\$35,658	\$27,805	10.6	2.258	294.9	\$94	\$121	\$807	
5	10		Low	0.119	\$31,525	\$24,508	9.8	2,143	274.1	\$89	\$115	\$764	
6	11	Burundi	Low	0.118	\$26,015	\$27,699	8.7	1,256	239.8	\$116	\$108	\$987	
			Low er middle	0.115	\$35,658	\$37,171	11.7	919	283.6	\$131	\$126	\$738	
7	13	Congo, DR	Low	0.112	\$24,637	\$24,258	9.3	1,852	259.2	\$94	\$95	\$1,493	
8	14	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648	282.6	\$86	\$99	\$1,095	
9	15		Low	0.110	\$28,081	\$36,299	8.6	1,532	221.8	\$164	\$127	\$996	
0	16 17	Cen. African Rep. Uganda	Low	0.105	\$27,392 \$31,525	\$29,606 \$31,104	7.1	1,444 1,842	194.2 214.8	\$152 \$145	\$141 \$147	\$1,230 \$749	
1	17	Cameroon	Low er middle	0.100	\$37,724	\$39,507	8.1	1,642	214.0	\$145	\$169	\$743	
	19	South Africa	Upper middle	0.097	\$99,713	\$115,007	9.1	659	235.9	\$487	\$423	\$582	
2	20	Guinea	Low	0.095	\$29,459	\$25,199	7.4	2,176	208.8	\$121	\$141	\$928	
3	21	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,763	190.4	\$132	\$140	\$1,025	
4	22	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5	1,758	236.6	\$187	\$273	\$674	
5	23 24	Côte d'Ivoire Benin	Low er middle Low	0.084	\$33,591 \$33,591	\$31,110 \$28,793	7.8	2,010	214.9 167.1	\$145 \$172	\$156 \$201	\$801 \$910	
26	24	Botsw ana	Upper middle	0.080	\$137,595	\$139,112	9.9	634	262.4	\$530	\$524	\$577	
	26	Zimbabw e	Low	0.075	\$25,326	\$40,453	6.9	905	165.8	\$244	\$153	\$1,731	
7	27	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,637	167.4	\$193	\$201	\$935	
8	28	Тодо	Low	0.075	\$29,459	\$28,877	5.5	1,467	153.3	\$188	\$192	\$864	
9	29	Rw anda	Low	0.071	\$31,525	\$30,620	5.9	1,249	163.9	\$187	\$192	\$768	
0	30 31	Congo, Rep. Kenya	Low er middle Low	0.067	\$54,254 \$34,280	\$42,228 \$35,682	7.2 5.2	1,522	199.0 142.8	\$212 \$250	\$273 \$240	\$756 \$883	
-	32	Ghana	Low er middle	0.063	\$44,612	\$38,058	4.2	1,006	142.0	\$323	\$379	\$746	
51	33	Gabon	Upper middle	0.060	\$29,826	\$46,367	4.0	972	110.7	\$419	\$269	\$613	
2	34	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128	181.8	\$159	\$166	\$1,139	
3	35	Sudan	Low er middle	0.057	\$38,413	\$24,940	4.8	2,620	136.6	\$183	\$281	\$703	
4	36	Afghanistan	Low	0.057	\$28,770	\$22,700	12.2	2,381	342.0	\$66	\$84	\$935	
5	37 38	Senegal Madagascar	Low er middle Low	0.050	\$34,969 \$28,770	\$22,535 \$26,424	6.8 3.0	2,952	193.6 84.6	\$116 \$312	\$181 \$340	\$768 \$1,025	
	39	Mauritania	Low er middle	0.043	\$36,346	\$31,642	4.4	1,397	123.1	\$312 \$257	\$295	\$955	
6	40	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	856	150.8	\$708	\$502	\$606	
7	41	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117	78.5	\$334	\$349	\$1,753	
88	42	Haiti	Low	0.028	\$30,836	\$29,010	2.8	1,790	80.4	\$361	\$384	\$869	
9	43	India	Low er middle	0.027	\$48,744	\$40,648	3.4	713	96.2	\$422	\$506	\$733	
-	44 45	Myanmar Yemen	Low Low er middle	0.026	\$31,525 \$37,035	\$29,473 \$27,682	1.7	673 1,778	48.0 99.3	\$614 \$279	\$657 \$373	\$1,354 \$719	
.0	45 46	Pakistan	Low er middle	0.025	\$41,856	\$27,082 \$28,870	3.5	1,776	99.3	\$279 \$281	\$373	\$904	
1	47	Papua New Guinea	Low er middle	0.018	\$40,479	\$31,703	1.2	1,489	35.8	\$885	\$1,130	\$864	
-2	48	Guatemala	Low er middle	0.016	\$57,698	\$35,999	1.8	1,813	51.6	\$698	\$1,118	\$627	
3	49	Cambodia	Low	0.014	\$38,413	\$33,905	1.3	759	37.6	\$901	\$1,020	\$739	
4	50 51	Nepal Bolivia	Low Low er middle	0.010	\$30,836 \$56,321	\$29,442 \$41,435	1.1 0.2	655 1,162	30.0 8.2	\$982 \$5,044	\$1,028 \$6,856	\$883 \$668	
.5		Bolivia	Low er middle Upper middle	0.010	\$56,321 \$53,565	\$41,435 \$37,274	0.2	1,162	8.2 50.4	\$5,044 \$740	\$6,856 \$1,063	\$668 \$758	
	53	Algeria	Upper middle	0.008	\$73,540	\$60,354	1.7	753	38.2	\$1,580	\$1,925	\$606	
6	54	Indonesia	Low er middle	0.008	\$56,321	\$50,560	0.5	463	14.3	\$3,545	\$3,949	\$793	
7	55	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617	23.0	\$1,413	\$1,551	\$1,046	
8	56	Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424	10.8	\$11,898	\$13,319	\$579	
9	57 58	Uzbekistan Morocco	Low er middle	0.006	\$45,989 \$58,387	\$34,086 \$49,883	0.5	1,357 898	14.9 31.6	\$2,282 \$1,577	\$3,079 \$1,846	\$717 \$650	
	50 59	Ukraine	Low er middle	0.006	\$74,228	\$69,343	0.4	359	11.5	\$6,052	\$1,646	\$600	
0	60	Thailand	Upper middle	0.005	\$90,759	\$90,800	0.4	261	21.7	\$4,177	\$4,175	\$622	
1	61	Vietnam	Low er middle	0.005	\$45,989	\$42,516	0.3	478	8.2	\$5,164	\$5,586	\$664	
2	62	Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536	6.6	\$17,673	\$20,818	\$591	
3			Upper middle	0.004	\$104,534	\$81,187	0.3	798	9.0	\$9,029	\$11,626	\$581	
4	64	Peru	Upper middle	0.004	\$95,580	\$73,664	0.3	862	9.6	\$7,650	\$9,926	\$613	
	65 66	Colombia Mexico	Upper middle Upper middle	0.003	\$95,580 \$127,264	\$75,850 \$129,804	0.3	817 0	8.8	\$8,575 \$40,371	\$10,806 \$39,581	\$598 \$583	
5	67	Philippines	Low er middle	0.003	\$51,499	\$44,213	0.3	743	8.8	\$5,026	\$5,854	\$724	
56	68	Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	633	6.8	\$17,487	\$21,512	\$577	
57	69	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280	2.3	\$33,785	\$36,384	\$638	
58	70	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029	3.9	\$22,267	\$32,314	\$582	

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			Diarrhea		HIV	_	
		LLITN	Filters	VCT	Condoms	TOTAL	
		Keny	<i>v</i> a				
Disease	Deaths	1.6	2.4	4.8	2.2	10.9	
averted	Episodes	133.6	1,877.7		7.0	2,018.3	
	Prevention	44.1	68.3	40.0	18.2	170.6	
DALYs averted	Earlier HIV care			:	123.5	123.5	
uventeu	TOTAL	44.1	68.3	:	181.8	294.1	
0	Prevention	\$773	\$9,068	\$40,889	\$18,588	\$69,318	
Costs averted	Earlier HIV care				31,187)	(\$81,187)	
(added)	TOTAL	\$773	\$9,068		21,710)	-\$11,869	
	Campaign cost (unadjusted)		. ,		-	\$34,280	
Cost- effective	Net cost (savings)					\$46,149	
ness	Cost per DALY averted					\$157	
		Banglad	loch			7157	
Disease	Deaths	0.1	0.8	0.0	0.0	0.9	
averted	Episodes	14.7	1061.3	0.0	0.0	1076.1	
	Prevention	1.7	22.4	0.4	0.2	24.7	
DALYs	Earlier HIV care				1.2	1.2	
averted	TOTAL	1.7	22.4		1.8	25.9	
Costs	Prevention	\$89	\$5,527	\$389	\$189	\$6,196	
averted	Earlier HIV care		. ,		\$773)	(\$773)	
(added)	TOTAL	\$89	\$5,527		\$195)	\$5,422	
Cost-	Campaign cost (unadjusted)		. ,			\$36,658	
effective	Net cost (savings)					\$30,236	
ness	Cost per DALY averted					\$1,168	
		Niger	ria				
Disease	Deaths	6.0	3.4	2.7	1.3	13.4	
averted	Episodes	734.3	2,363.3		4.0	3,101.7	
	Prevention	168.8	97.6	21.8	10.2	298.4	
DALYs averted	Earlier HIV care				70.8	70.8	
aventeu	TOTAL	168.8	97.6	:	102.9	369.3	
Costs	Prevention	\$6,223	\$14,300	\$28,605	\$13,379	\$62,507	
averted	Earlier HIV care				55,797)	(\$55,797)	
(added)	TOTAL	\$6,223	\$14,300		14,813)	\$5,710	
Cost-	Campaign cost (unadjusted)					\$40,479	
effective	Net cost (savings)					\$34,769	
	Cost per DALY averted			ر ب د کې			

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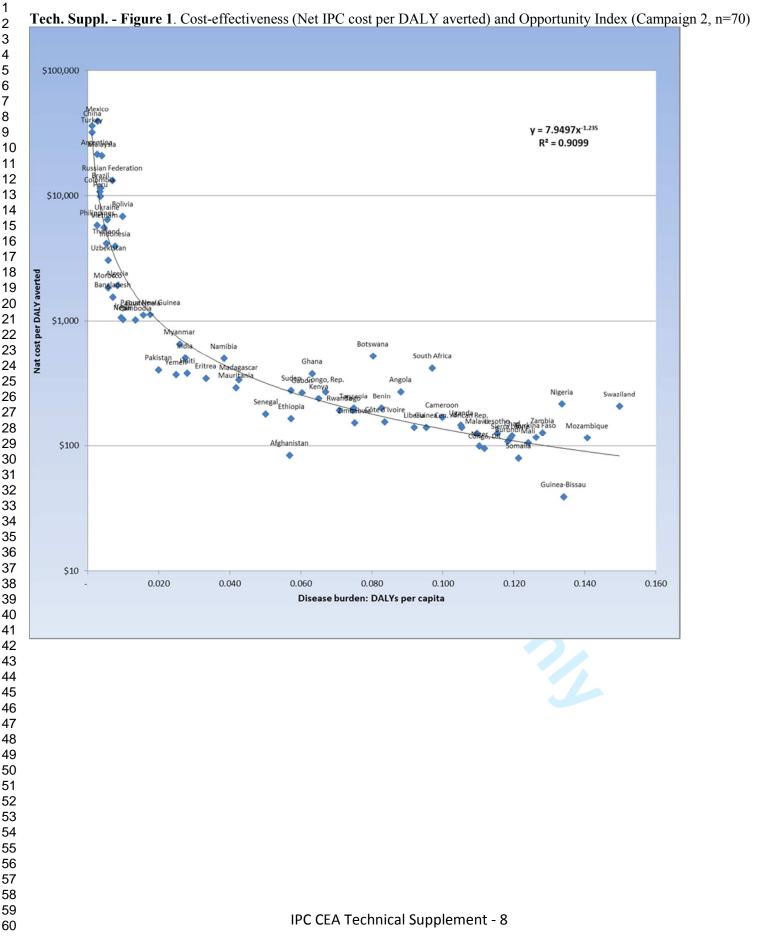
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Tech. Suppl. - Table 4. Annual and cumulative results for campaigns 1 and 2 for Kenya, projected for 30 years. Assumes the second campaign starts 3 years after initial campaign. All outcomes discounted at 3% per annum.

1	the se	econd camp	aign starts	s 3 years aft	er initial ca	ampaign. A	All outcomes discounted at 3% per annum.								
2		Annual		al Cumulative				Annual DAL	Ys averted	ł	Cumulative DALYs averted				
3			Net DALYs		DALYs	CE (\$/DALY									
4	Year	Net costs	averted	Net costs	averted	averted)	Malaria	Diarrhea	HIV	Total	Malaria	Diarrhea	HIV	Total	
5	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	
6	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	
7	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	
8	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	
9	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	
10	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	
11	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	
12	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	
13	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	
14	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	
15	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	
16	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	
17	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	
18	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	
19	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	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	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	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	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	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	
25	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	
26	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	
27	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	
28	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	
29															

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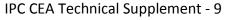


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Tech. Suppl. - Figure 2. Tornado Graph of Cost per DALY averted – Bangladesh: Impact by Input

Duration-of-benefit-diarrhea				1			1				
Baseline-cases-p1000py-Diarrhea						1					
Campaign-cost					1	Ĩ					
Participants per HH				-					_		
Protectmortality-diarrhea											
Propor-fatal-Diarrhea											
DALYs-fatal-diarrhea											
Protectnon-fatal-diarrhea											
Access to care-Diarrhea											
Cost-per-non-fatal-case-diarrhea											
Duration-of-benefit-malaria											
Baseline-cases-p1000py-Malaria											
HIV prevalence											
Protectmortality-malaria											
Propor-fatal-Malaria											
DALYs-fatal-malaria											
DALYs-non-fatal-diarrhea											
Multiplier-2er-effects-HIV											
Duration-of-benefit-HIV											
Access to ART											
Protectmortality-HIV-transmission											
Discount rate											
Protectmortality-HIV-acquisition											
	8	8	8	8	8	8	8	8	8	8	
	\$400	\$600	\$800	\$1,000	\$1,200	\$1,400	\$1,600	\$1,800	\$2,000	\$2,200	

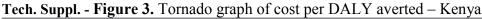


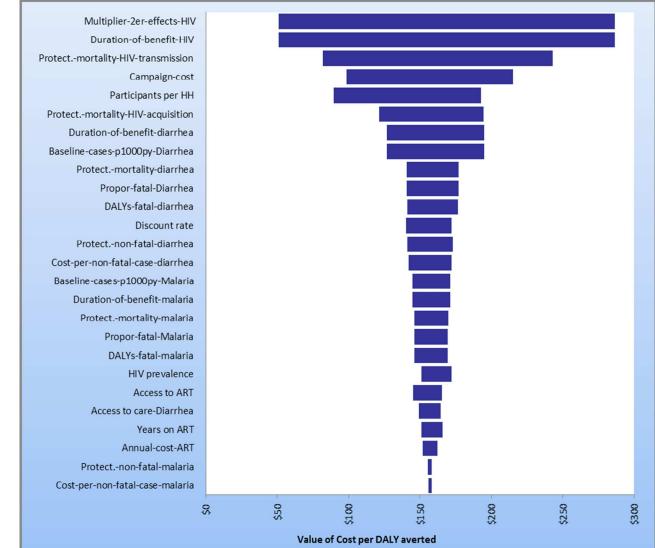


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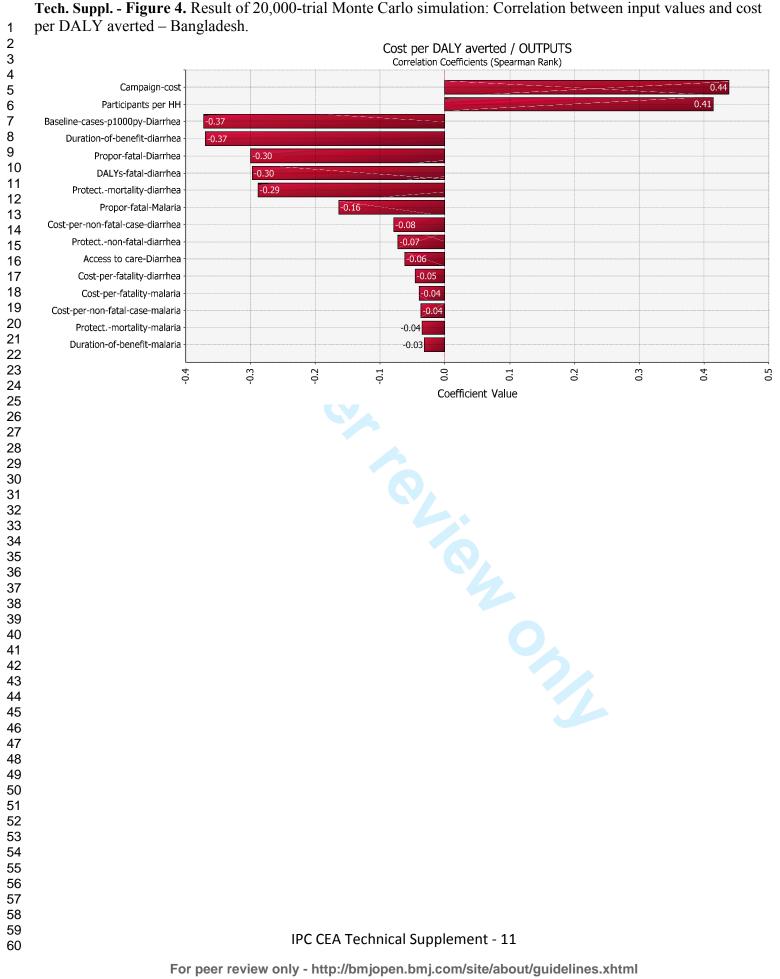


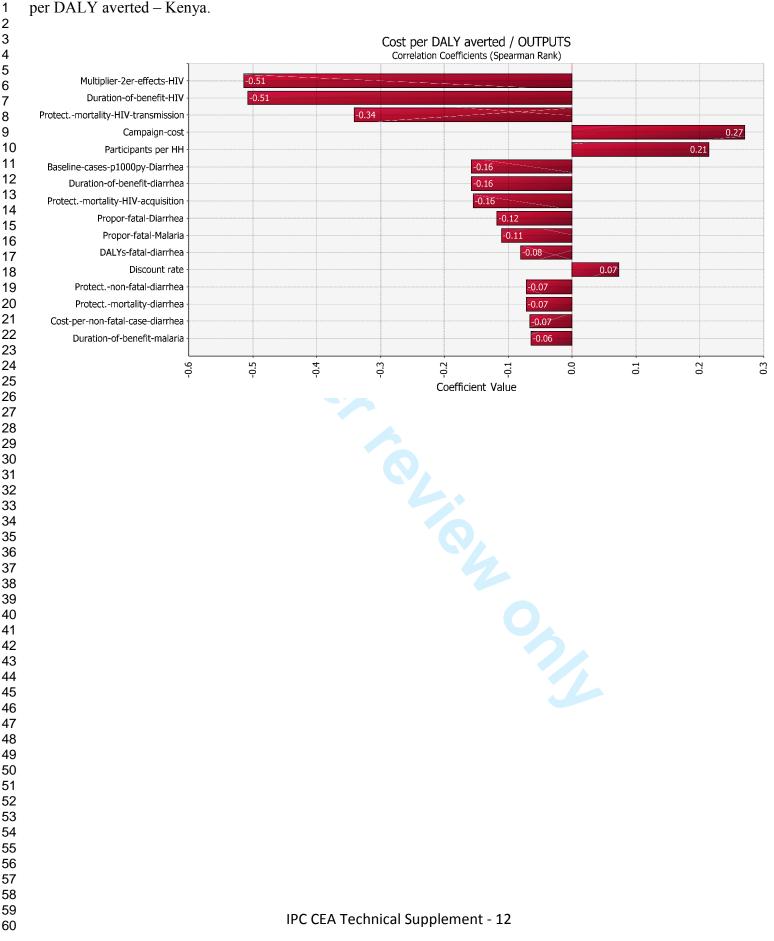




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Projection of costs and outcomes to 30 years

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 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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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.

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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.³⁴

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 established⁸, 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 Bank¹⁰; 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., \geq 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.⁷⁸ 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 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 moreaffected 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 countryspecific 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 Africa²¹ 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 5⁴⁹ (details in technical supplement).^{50 51} Multiplying each estimate by the total population⁴⁸ 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 malaria⁵⁸; 4.43 days for

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diarrhea, a severity weighted duration for children and adults⁵⁹; 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 $51^{st} - 60^{th}$ and for the $61^{st} - 70^{th}$ 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 costeffectiveness 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.

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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 population⁴⁸ 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.

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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 highprevalence 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.

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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.

Data sharing

le. 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

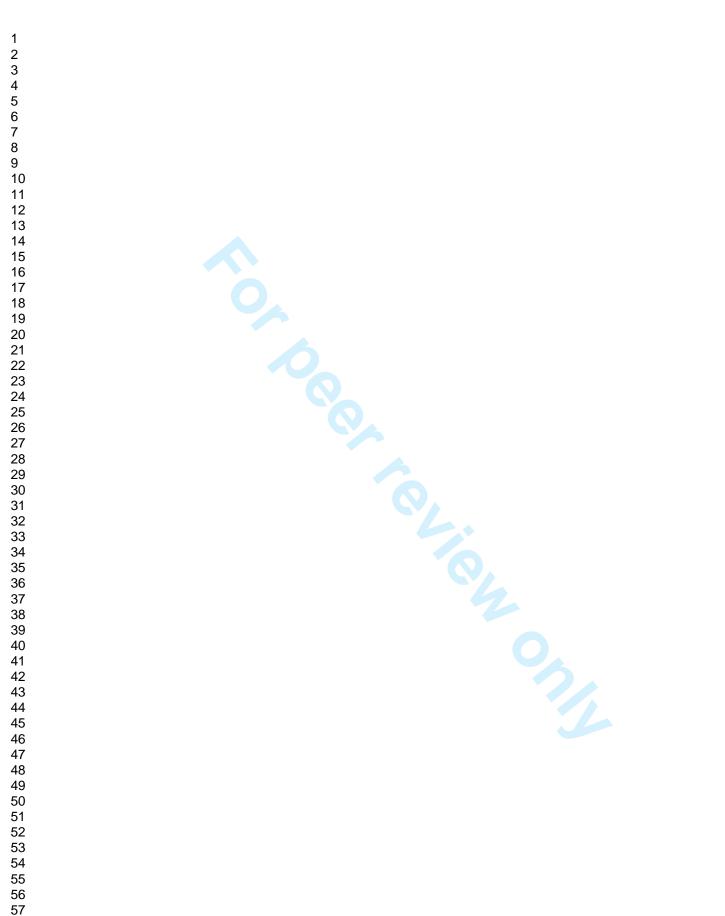
Tech. Suppl. - Figure 3. Tornado graph of cost per DALY averted – Kenya

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.





	Malari a	Diarrhe a	!	HIV		Source(s)				
	LLIN	Filters	VCT	Condom s	LLIN	Filters	VCT / condoms			
Health in ⁶¹ puts										
Campaign			2.5			Post-campaign sur	vey			
participant per										
household										
Number	1.563	1.840	0.95	0.361		Post-campaign sur	vey			
benefiting per			0							
campaign										
participant										
Baseline cases per	0.057	0.542	0.00	0.009	[47, 48]	[49-51]	[8,62-64]			
year per individual			4				Post-campaign surve			
benefiting							(see text)			
Proportion of	0.012	0.001	1	1	[47, 52, 54]	[48, 49, 51, 59,	Assumption			
cases that are						62]				
fatal										
DALYs incurred	28.0	28.0	15.1	15.1	[56]	[56]	[56]			
with each fatal										
case										
DALYs incurred	0.0037	0.0012	n/a	n/a	[57, 58]	[57, 59]	N/a			
with each non-										
fatal case										
Protective effect	0.50	0.63	0.50	0.26	[65], expert	[66]	[67, 68]			
against mortality					opinion					
Protective effect	0.5	0.63	n/a	n/a	[65]	[66]	N/a			
against non-fatal										
cases										
Multiplier to	n/a bit	n/a	2	2	[69]	N/a	[70] (see text)			
capture secondary										
benefits										
Years of benefit	3	3	1	1	[71, 72] Adjusted	[73] Adjusted to	[68]			
					to 3 years per post-campaign	3 years per post- campaign				
					evaluation.	evaluation.				
Access to care	0.684	0.678	0.70	0.700	[14-19]	[20]	Assumption			
			0							
Cost inputs										
Campaign cost	\$34,280					ditional \$2,300 in rev	vised filter maintenance			
	2.09/				costs					
Discount rate	3.0%	6405	<u> </u>	643.242						
Health care	\$65	\$104	\$12,213	\$12,213	[64, 74]	[75]	Authors' construction based on 22 years or			
incurred with				1			ART at \$766 per			

ach fatality							person-year discounted at 3% pe
							annum.
lealth care ncurred with ach non-fatal ase	\$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		Ba	nglades	h
Input parameter	Base case	Min	Max	Base case	Min	Мах	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
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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	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5
diarrhea Duration of benefit HIV	1	0.5	1.5	1	0.5	1.5	1	0.5	1.5

icsa	s lavorable tila	n investment in	AKI. K	Cos			s-year cam	paign.	Cost-off	ectivenes	
				00	515	Diseas	e averteu		Cost-en	ectivenes	5 (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	\$185,87 2	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

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1	42	Guatemala	Lower middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$627
2 3	43	South Africa	Upper middle	0.097	\$99,713	\$180,28 4	21.5	1,150	561.0	\$178	\$321	\$582
4	44	Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613
5	45	India	Lower middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$733
6	46	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354
7 8	47	Papua New Guinea	Lower middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$864
9	48	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758
10 11	49	Namibia	Upper middle	0.038	\$75,606	\$204,27 1	15.6	1,528	402.7	\$188	\$507	\$606
12	50	Cambodia	Low	0.014	\$38,413	\$31,172	1.9	1,341	54.3	\$708	\$574	\$739
13	51	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883
14	52	Morocco	Lower middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650
15	53	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046
16	54	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
17 18	55	Uzbekistan	Lower middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717
19	56	Ukraine	Lower middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$600
20	57	Thailand	Upper middle	0.005	\$90,759	\$100,37 7	1.8	455	48.7	\$1,863	\$2,061	\$622
21	58	Indonesia	Lower middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793
22	59	Bolivia	Lower middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668
23 24	60	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664
24 25	61	Colombia	Upper middle	0.003	\$95,580	\$63,657	0.6	1,419	20.5	\$4,652	\$3,098	\$598
26	62	Peru	Upper middle	0.004	\$95,580	\$59,439	0.6	1,497	19.0	\$5,026	\$3,126	\$613
27	63	Brazil	Upper middle	0.004	\$104,534	\$65,501	0.6	1,385	19.2	\$5,431	\$3,403	\$581
28	64	Philippines	Lower middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$724
29 30	65	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,95 4	1.1	735	31.2	\$4,607	\$3,907	\$579
31	66	Argentina	Upper middle	0.003	\$147,238	\$101,85 4	0.6	1,097	18.1	\$8,155	\$5,642	\$577
32 33	67	Malaysia	Upper middle	0.004	\$138,284	\$104,40 8	0.6	930	17.6	\$7,858	\$5,933	\$591
34	68	Turkey	Upper middle	0.001	\$29,459	\$58,058	0.1	1,784	6.1	\$4,821	\$9,501	\$582
35 36	69	Mexico	Upper middle	0.003	\$127,264	\$134,90 1	0.3	0	9.6	\$13,197	\$13,989	\$583
37	70	China	Upper middle	0.001	\$84,560	\$74,564	0.1	486	4.7	\$18,015	\$15,886	\$638
38 39 40 41 42 43 44 45												
46 47												

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\$.

		Net	cost	DALYs	averted	Cost- effectiveness (compared with no intervention)		co effecti (compa	mental ost- veness red with us row)
Countrie s	Campaig n cost	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2
Тор 10	5.832E+08	3.979E+0 8	4.685E+0 8	8.048E+0 6	5.708E+0 6	\$49	\$82	n/a	n/a
Тор 20	2.387E+09	2.054E+0 9	2.068E+0 9	2.706E+0 7	1.629E+0 7	\$76	\$127	\$87	\$151
Тор 30	3.715E+09	3.554E+0 9	3.338E+0 9	3.961E+0 7	2.382E+0 7	\$90	\$140	\$119	\$169
Top 40*	5.614E+09	4.943E+0 9	4.858E+0 9	4.731E+0 7	2.916E+0 7	\$104	\$167	\$181	\$284
Top 50*	1.624E+10	1.342E+1 0	1.395E+1 0	7.265E+0 7	4.983E+0 7	\$185	\$280	\$335	\$440
Тор 60	2.226E+10	1.863E+1 0	1.941E+1 0	7.573E+0 7	5.186E+0 7	\$246	\$374	\$1,692	\$2,699
Тор 70	5.129E+10	4.350E+1 0	4.629E+1 0	7.871E+0 7	5.322E+0 7	\$553	\$870	\$8,340	\$19,728

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

Countries ranked by IPC cost- effectiveness	Campaign 1	Campaign 2	Antiretrovira therapy for HIV
Тор 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

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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

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10

Technical Supplement

Reduction in risk for malaria and HIV between first and second campaign 11

In this analysis, to explore sustainability, we examine both an initial campaign and a follow-up campaign three 12 years later. Thus, we need to estimate the health benefit realized by the follow-up campaign, taking into account 13 the stability of disease reduction offered initially. The more that initial protection decays over six years, and thus 14 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 15 function of the physical durability of the commodities distributed, as well as maintenance of safer behaviors. The 16 dynamics vary by disease.

17 For malaria we assume 75% as much disease incidence at years 4-6 (absent a 2^{nd} campaign) as baseline incidence. 18 In other words, we assume that full set of LLIN distributed in the *initial* campaign, with no follow-up campaign, 19 would have half as much community benefit in years 4-6 as in years 1-3. Many LLIN will remain in place, and the 20 insecticide impregnation itself is stable for close to 10 years. Thus, the 50% incidence drop expected with LLIN in 21 years 1-3 will decrease but not disappear in the second 3 years. However, the second round of LLIN are likely to 22 have a relative effectiveness less than 50%, because the best LLIN users are already protected. Thus we decrease 23 the effectiveness from 50% to 33% (i.e., from 75% of baseline incidence to 50% of baseline incidence). In effect, 24 the 2nd campaign is like a booster shot that returns effectiveness to its original level. In sum, the overall benefit of 25 the second campaign is reduced by half -- in first campaign it was 100% of baseline incidence to 50%, and in the 26 second campaign from 75% of baseline incidence to 50%.

27

We note that these estimates are assembled from isolated data (e.g., LLIN physical durability) combined with a 28 logical framework and best guesses. Nonetheless, we believe that the conclusion -50% as much benefit for a 29 second campaign – is plausible, and is a far more realistic assumption than full benefit. Our approach is 30 conservative regarding the second campaign – if the specified durability of effect of the LLIN is larger than in 31 reality, we would be *under*estimating the benefit of this campaign. And our estimate of the combined effect of two 32 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 33 overstate the value of the first campaign and understate second campaign benefits, again offsetting. 34 35

For diarrhea, we assume no filter benefit after three years. The filters are expected to last in good function only 36 three years. Thus, the filter component of the second campaign is just as effective as for the first campaign. 37

38 For HIV, effects on DALYs and cost depend heavily on undiagnosed HIV prevalence. The first campaign detects 39 almost all HIV-infected individuals. Thus, the effects of the second campaign depend mainly on the impact of 3 40 years of HIV incidence on (predominantly undiagnosed) HIV prevalence. This incidence has not been measured, 41 but can be estimated from HIV prevalence using simple epidemic dynamics. ¹Steady-state (pre-ART) annual 42 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 43 be about 1.5%. 44

45 Incidence and thus prevalence could be even lower if ART reduces community viral load and also if VCT for 46 HIV+ has substantial behavioral benefits. They could be higher if the first campaign selectively missed HIV+, e.g. 47 they chose not to participate or were away in urban areas.

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9 Diarrhea: estimation of average cases per PY and annual cases

Using data on the number of episodes per year in children under 5², 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 12 c5 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 22 based on household size data from the campaign communities, 7.7 persons. In the current article, we used the 23 lower national figure of 4.6, assumed to reflect fewer children per household 7 . The total benefits of the malaria 24 and diarrheal disease interventions fell accordingly. The current article also uses lower figures for malaria and 25 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 30 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.

- 6

10 Tech. Suppl. - Table 1: Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered 11 from most to least cost-effective. The grey highlighted cells indicate cost-effectiveness ratios less favorable than investment 12 in ART. Results shown are for the second and subsequent 3-year campaigns.

		its snown are			osts		averted		Cost-effectiveness (CE)			
13 14 15 16	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	
17	Guinea- Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465.3	754.3	\$22	\$39	\$1,005	
18 19	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055.1	325.2	\$73	\$80	\$768	
19	Afghanistan	Low	0.057	\$28,770	\$22,700	12.2	2,380.6	342.0	\$66	\$84	\$764	
20	Congo, DR	Low	0.112	\$24,637	\$24,258	9.3	1,851.9	259.2	\$94	\$95	\$819	
21	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648.0	282.6	\$86	\$99	\$1,535	
	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312.1	280.1	\$90	\$105	\$1,095	
22 23	Burundi	Low	0.118	\$26,015	\$27,699	8.7	1,256.5	239.8	\$116	\$108	\$888	
	Sierra Leone	Low	0.119	\$31,525	\$24,508	9.8	2,142.5	274.1	\$89	\$115	\$935	
24	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,975.5	260.0	\$141	\$116	\$807	
215	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153.3	270.2	\$96	\$117	\$738	
218	Chad	Low	0.120	\$35,658	\$27,805	10.6	2,258.2	294.9	\$94	\$121	\$928	
2^{12}_{13}	Lesotho	Lower middle	0.115	\$35,658	\$37,171	11.7	919.3	283.6	\$131	\$126	\$1,493	
	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532.3	221.8	\$164	\$127	\$703	
28	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660.1	263.4	\$156	\$128	\$1,025	
29	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,762.6	190.4	\$132	\$140	\$987	
319	Guinea	Low	0.095	\$29,459	\$25,199	7.4	2,175.8	208.8	\$121	\$141	\$910	
<u>31</u>	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,443.6	194.2	\$152	\$141	\$801	
3½	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,841.7	214.8	\$145	\$147	\$747	
33 323	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	
34	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128.0	181.8	\$159	\$166	\$749	
35	Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620.0	223.1	\$177	\$169	\$756	
36	Senegal	Lower middle	0.050	\$34,969	\$22,535	6.8	2,951.7	193.6	\$116	\$181	\$864	
3^{24}_{25}	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,466.8	153.3	\$188	\$192	\$674	
-25 328	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,248.9	163.9	\$187	\$192	\$935	
	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,636.6	167.4	\$193	\$201	\$826	
39	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611.1	167.1	\$172	\$201	\$1,139	
40	Swaziland	Lower middle	0.150	\$58,387 \$40,470	\$87,699	11.5 6.7	1,280.6 1,610.1	281.0	\$312 \$186	\$208 \$217	\$768 \$006	
4 <u>3</u> 9	Nigeria	Lower middle Low	0.133	\$40,479 \$34,280	\$34,860 \$35,682	5.2	1,610.1	187.0 142.8	\$186	\$217 \$240	\$996 \$741	
432	Kenya Gabon	Upper middle	0.065	\$34,280 \$29,826	\$35,662 \$46,367	5.2 4.0	972.5	142.8	\$250 \$419	\$240	\$883	
433	Congo, Rep.	Lower middle	0.067	\$29,820	\$40,307	7.2	1,522.2	199.0	\$419 \$212	\$209	\$955	
	Angola	Upper middle	0.087	\$64,586	\$42,228	8.5	1,522.2	236.6	\$212	\$273	\$955	
434 34	Sudan	Lower middle	0.088	\$38,413	\$44,239 \$24,940	4.8	2,620.5	136.6	\$187	\$273	\$1,731	
435	Mauritania	Lower middle	0.042	\$36,346	\$24,940 \$31,642	4.0	1,397.4	123.1	\$103	\$295	\$904	
4 <u>6</u>	Madagascar	Low	0.042	\$28,770	\$26,424	3.0	1,079.4	84.6	\$312	\$340	\$746	
437	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117.1	78.5	\$334	\$349	\$1,025	
4 8 8	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778.2	99.3	\$279	\$373	\$1,753	
40 39	Ghana	Lower middle	0.063	\$44,612	\$38,058	4.2	1,006.4	117.8	\$323	\$379	\$577	
4 <u>9</u>	Haiti	Low	0.028	\$30,836	\$29,010	2.8	1,789.6	80.4	\$361	\$384	\$869	
5 <u>0</u>	Pakistan	Lower middle	0.020	\$41,856	\$28,870	3.6	1,574.8	102.7	\$281	\$407	\$632	
542	South Africa	Upper middle	0.097	\$99,713	\$115,007	9.1	659.2	235.9	\$487	\$423	\$627	
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B 43 [Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	855.9	150.8	\$708	\$502	\$582
9 ⁴³ 149 149	India	Lower middle	0.038	\$48,744	\$40,648	3.4	713.2	96.2	\$422	\$502	\$613
1.0	Botswana	Upper middle	0.027	\$137,595	\$139,112	9.9	634.1	262.4	\$530	\$524	\$733
46 146	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	672.6	48.0	\$614	\$657	\$1,354
1472	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
148 149	Iraq	Upper middle	0.009	\$53,565	\$37,274	1.7	1,493.0	50.4	\$740	\$1,063	\$606
158	Guatemala	Lower middle	0.016	\$57,698	\$35,999	1.8	1,812.5	51.6	\$698	\$1,118	\$739
15	Papua New	Lower middle	0.018	\$40,479	\$31,703	1.2	1,488.7	35.8	\$885	\$1,130	\$883
1 <u>6</u>	Guinea		0.007	605.050	600 100	0.0	047.4	00.0	64 , 110	¢4 554	#050
1512 1516	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617.4	23.0	\$1,413	\$1,551	\$650 \$1.046
	Morocco	Lower middle	0.006	\$58,387 \$72,540	\$49,883	1.1	898.4 752.8	31.6 38.2	\$1,577	\$1,846	\$1,046 \$606
18	Algeria Uzbekistan	Upper middle Lower middle	0.008	\$73,540 \$45,989	\$60,354 \$34,086	1.3 0.5	752.8 1,357.2	38.2	\$1,580 \$2,282	\$1,925 \$3,079	\$606
19 56	Indonesia	Lower middle	0.006	\$45,989 \$56,321	\$34,086 \$50,560	0.5	463.2	14.9	\$2,282 \$3,545	\$3,079 \$3,949	\$717
159 56 20	Thailand	Upper middle	0.008	\$90,759	\$90,800	0.5	463.2 261.3	21.7	\$3,545 \$4,177	\$3,949 \$4,175	\$600
258	Vietnam	Lower middle	0.005	\$45,989	\$42,516	0.3	477.7	8.2	\$5,164	\$5,586	\$793
282	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
61 61 62	Peru	Upper middle	0.004	\$95,580	\$73,664	0.3	862.2	9.6	\$7,650	\$9,926	\$613
75	Colombia	Upper middle	0.003	\$95,580	\$75,850	0.3	817.2	8.8	\$8,575	\$10,806	\$581
8	Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798.2	9.0	\$9,029	\$11,626	\$724
<u>65</u>	Russian	High:	0.007	\$143,794	\$128,452	0.4	424.3	10.8	\$11,898	\$13,319	\$579
	Federation	nonOECD	0.004	¢400.004	¢447.005	0.2	500.0	0.0	¢47.070	\$00.040	\$577
288	Malaysia	Upper middle Upper middle	0.004	\$138,284 \$147,238	\$117,395 \$119,687	0.2	536.0 632.8	6.6 6.8	\$17,673 \$17,487	\$20,818 \$21,512	\$577
20	Argentina Turkey	Upper middle	0.003	\$125,197	\$86,272	0.2	1,029.3	3.9	\$17,487 \$22,267	\$21,512 \$32,314	\$582
<u>ko</u> 800 800 800 800	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280.4	2.3	\$33,785	\$36,384	\$583
376	Mexico	Upper middle	0.003	\$127,264	\$129,804	0.1	0.1	3.2	\$40,371	\$39,581	\$638
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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.

12				Costs		Disease averted			Cost-eff	ectivene	ss (CE)
13 14 15	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
15 16	Swaziland	Lower middle	0.150	\$58,387	\$198,392	29.1	2,230	724.2	\$81	\$274	\$632
1^{2}	Mozambique	Low	0.141	\$30,147	\$59,145	22.2	3,816	590.0	\$51	\$100	\$1,109
18	Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1143.3	\$26	\$7	\$1,005
19	Nigeria	Lower middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$747
20	Zambia	Lower middle	0.128	\$33,591	\$69,806	21.8	3,107	564.3	\$60	\$124	\$826
21	Burkina Faso	Low	0.126	\$31,525	\$22,206	16.4	4,124	459.4	\$69	\$48	\$819
22	Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$888
23	Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,535
24	Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$807
25	Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$764
26	Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$987
21/2	Lesotho	Lower middle	0.115	\$35,658	\$47,366	31.3	1,756	779.4	\$46	\$61	\$738
28	Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,493
29	Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,095
30	Malawi	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996
31¢	Cen. African Rep.	Low	0.105	\$27,392	\$37,525	13.8	2,819	373.3	\$73	\$101	\$1,230
32	Uganda	Low	0.105	\$31,525	\$40,192	14.9	3,492	399.8	\$79	\$101	\$749
33	Cameroon	Lower middle	0.100	\$37,724	\$52,388	14.3	3,115	388.4	\$97	\$135	\$741
34	South Africa	Upper middle	0.097	\$99,713	\$180,284	21.5	1,150	561.0	\$178	\$321	\$582
350	Guinea	Low	0.095	\$29,459	\$22,324	12.6	4,272	353.8	\$83	\$63	\$928
36	Liberia	Low	0.092	\$26,704	\$25,526	11.9	3,401	332.6	\$80	\$77	\$1,025
372	Angola	Upper middle	0.088	\$64,586	\$35,794	11.5	3,268	320.8	\$201	\$112	\$674
3 8	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801
3 9	Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$910
4Ð	Botswana	Upper middle	0.080	\$137,595	\$185,872	26.8	1,111	734.1	\$187	\$253	\$577
426	Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	428.8	\$59	\$178	\$1,731
427	Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$935
4 3 8	Тодо	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864
428	Rwanda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768
43	Congo, Rep.	Lower middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756
121	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
1 37	Ghana	Lower middle	0.063	\$44,612	\$35,624	6.8	1,966	189.9	\$235	\$188	\$746
4^{33}_{8}	Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613
$\frac{47}{48}$ $\frac{49}{50}$	Ethiopia	Low	0.057	\$30,147	\$29,630	8.6	1,986	235.7	\$128	\$126	\$1,139
50^{35}	Sudan	Lower middle	0.057	\$38,413	\$15,241	6.9	4,907	198.8	\$193	\$77	\$703
51 51	Afghanistan	Low	0.057	\$28,770	\$18,906	12.7	4,146	356.6	\$81	\$53	\$935

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	Senegal	Lower middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$76
	Madagascar	Low	0.043	\$28,770	\$24,895	4.5	1,910	127.8	\$225	\$195	\$1,0
	Mauritania	Lower middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$95
	Namibia	Upper middle	0.038	\$75,606	\$204,271	15.6	1,528	402.7	\$188	\$507	\$60
	Eritrea	Low	0.033	\$27,392	\$26,438	4.3	1,942	120.5	\$227	\$219	\$1,7
	Haiti	Low	0.028	\$30,836	\$31,570	4.4	3,128	123.0	\$251	\$257	\$86
	India	Lower middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$73
	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,3
	Yemen	Lower middle	0.025	\$37,035	\$21,139	4.3	3,128	122.9	\$301	\$172	\$71
	Pakistan	Lower middle	0.020	\$41,856	\$19,714	3.8	2,748	108.1	\$387	\$182	\$90
	Papua New Guinea	Lower middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$86
	Guatemala	Lower middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$62
	Cambodia	Low	0.014	\$38,413	\$31,172	1.9	1,341	54.3	\$708	\$574	\$73
	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$88
	Bolivia	Lower middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$66
	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$75
	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$60
	Indonesia	Lower middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$79
	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,0
	Russian	High: nonOECD	0.007	\$143,794	\$121,954	1.1	735	31.2	\$4,607	\$3,907	\$57
-	Federation Uzbekistan	Lower middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$7 [.]
-	Morocco	Lower middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$65
_	Ukraine	Lower middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$60
-	Thailand	Upper middle	0.005	\$90,759	\$100,377	1.8	455	48.7	\$1,863	\$2,061	\$62
_	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$66
	Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$59
	Brazil	Upper middle	0.004	\$104,534	\$65,501	0.6	1,385	19.2	\$5,431	\$3,403	\$58
	Peru	Upper middle	0.004	\$95,580	\$59,439	0.6	1,497	19.0	\$5,026	\$3,126	\$61
	Colombia	Upper middle	0.003	\$95,580	\$63,657	0.6	1,419	20.5	\$4,652	\$3,098	\$59
	Mexico	Upper middle	0.003	\$127,264	\$134,901	0.3	0	9.6	\$13,197	\$13,989	\$58
	Philippines	Lower middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$72
	Argentina	Upper middle	0.003	\$147,238	\$101,854	0.6	1,097	18.1	\$8,155	\$5,642	\$57
_	China	Upper middle	0.001	\$84,560	\$74,564	0.1	486	4.7	\$18,015	\$15,886	\$63
	Turkey	Upper middle	0.001	\$125,197	\$58,058	0.1	1,784	6.1	\$20,489	\$9,501	\$58

3				Co	osts	Disease	e averted		Cost-effectiveness (CE)			
4	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	
7 ¹	Swaziland	Lower middle	0.150	\$58,387	\$87,699	11.5	1,281	281.0	\$312	\$208	\$632	
3 2	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,976	260.0	\$141	\$116	\$1,109	
3 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	
2 ⁵	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660	263.4	\$156	\$128	\$826	
3 ⁶	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153	270.2	\$96	\$117	\$819	
	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312	280.1	\$90	\$105	\$888	
5 ⁸	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055	325.2	\$73	\$80	\$1,535	
5 ⁹	Chad	Low	0.120	\$35,658	\$27,805	10.6	2,258	294.9	\$94	\$121	\$807	
	Sierra Leone	Low	0.119	\$31,525	\$24,508	9.8	2,143	274.1	\$89	\$115	\$764	
	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	
1 ₁₄	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648	282.6	\$86	\$99	\$1,095	
`	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532	221.8	\$164	\$127	\$996	
5 16 1	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,444	194.2	\$152	\$141	\$1,230	
17 0	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,842	214.8	\$145	\$147	\$749	
3 ¹⁸	Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620	223.1	\$177	\$169	\$741	
7 ¹⁹	South Africa	Upper middle	0.097	\$99,713	\$115,007	9.1	659	235.9	\$487	\$423	\$582	
3 ²⁰	Guinea	Low	0.095	\$29,459	\$25,199	7.4	2,176	208.8	\$121	\$141	\$928	
f ¹	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,763	190.4	\$132	\$140	\$1,025	
	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5	1,758	236.6	\$187	\$273	\$674	
	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$31,110	7.8	2,010	214.9	\$145	\$156	\$801	
<u> </u>	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611	167.1	\$172	\$201	\$910	
,	Botswana	Upper middle	0.080	\$137,595	\$139,112	9.9	634	262.4	\$530	\$524	\$577	
т	Zimbabwe	Low	0.075	\$25,326	\$40,453	6.9	905	165.8	\$244	\$153	\$1,731	
3 77	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,637	167.4	\$193	\$201	\$935	
3 28	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,467	153.3	\$188	\$192	\$864	
	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,249	163.9	\$187	\$192	\$768	
-	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522	199.0	\$212	\$273	\$756	
-	Kenya	Low	0.065	\$34,280	\$35,682	5.2	1,131	142.8	\$250	\$240	\$883	
B 2	Ghana	Lower middle	0.063	\$44,612	\$38,058	4.2	1,006	117.8	\$323	\$379	\$746	

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

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	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128	181.8	\$159	\$166	\$1,139
5	Sudan	Lower middle	0.057	\$38,413	\$24,940	4.8	2,620	136.6	\$183	\$281	\$703
86	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
	Madagascar	Low	0.043	\$28,770	\$26,424	3.0	1,079	84.6	\$312	\$340	\$1,025
9	Mauritania	Lower middle	0.042	\$36,346	\$31,642	4.4	1,397	123.1	\$257	\$295	\$955
0	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	856	150.8	\$708	\$502	\$606
	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
13	India	Lower middle	0.027	\$48,744	\$40,648	3.4	713	96.2	\$422	\$506	\$733
	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	673	48.0	\$614	\$657	\$1,354
15	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778	99.3	\$279	\$373	\$719
	Pakistan	Lower middle	0.020	\$41,856	\$28,870	3.6	1,575	102.7	\$281	\$407	\$904
	Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,489	35.8	\$885	\$1,130	\$864
	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
	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
	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
	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 58	Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898	31.6	\$1,577	\$1,846	\$650
r 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
6 1	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
_	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
7 0	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029	3.9	\$22,267	\$32,314	\$582

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9 Tech. Suppl. - Table 4. Relative contribution of diarrhea, malaria and 10 HIV to disease burden of each of 70 countries.

					Diar	rhea	ivia	laria		IIV
3	Country	Total DALY burden (3	Population	DALYs per capita	Diarrhea burden	DALYs	Malaria burden	DALYs	HIV burden	DALYs
		diseases)								
į	Swaziland	158,061	1,055,506	0.1497	8.4	16,523	0.03	4,338	25.9	137,200
ľ	Mozambique	3,288,897	23,390,765	0.1406	11.9	532,817	12.49	1,482,080	11.5	1,274,00
	Guinea-Bissau	203,103	1,515,224	0.1340	19.1	78,434	17.65	104,089	2.5	20,580
Γ	Nigeria	21,145,996	158,423,182	0.1335	18.7	4,995,101	20.19	12,818,894	3.6	3,332,00
Γ	Zambia	1,654,717	12,926,409	0.1280	14.6	410,637	15.24	499,280	13.5	744,800
ľ	Burkina Faso	2,079,356	16,468,714	0.1263	18.9	659,064	20.39	1,353,652	1.2	66,640
Γ	Mali	1,905,686	15,369,809	0.1240	19.2	715,293	20.83	1,145,312	1	45,080
Γ	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
ſ	Burundi	991,869	8,382,849	0.1183	23.6	393,025	9.25	461,645	3.3	137,200
L	Lesotho	250,467	2,171,318	0.1154	9.9	25,067	0.00	Unknown	23.6	225,400
Γ	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
Γ	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
Γ	Uganda	3,513,177	33,424,683	0.1051	16.0	1,078,814	22.40	1,258,363	6.5	1,176,00
	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	3,822,00
	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
L	Botswana	161,239	2,006,945	0.0803	7.0	13,221	1.04	10,818	24.8	137,200
L	Zimbabwe	944,891	12,571,454	0.0752	9.2	132,798	3.43	204,493	14.3	607,600
L	Tanzania	3,360,788	44,841,226	0.0749	11.6	1,025,316	16.43	1,355,472	5.6	980,000
L	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
L	Congo, Rep.	270,651	4,042,899	0.0669	14.3	81,602	23.85	125,349	3.4	63,700
L	Kenya	2,637,405	40,512,682	0.0651	20.5	796,738	10.94	762,667	6.3	1,078,00
L	Ghana	1,542,491	24,391,823	0.0632	9.5	669,521	26.25	657,370	1.8	215,600
L	Gabon	90,936	1,505,463	0.0604	5.9	16,740	29.32	38,915	5.2	35,280
L	Ethiopia	4,754,652	82,949,541	0.0573	22.8	3,507,206	6.78	1,247,446	1.5	Unknow
L	Sudan	1,925,260	33,603,637	0.0573	10.6	850,260	24.89	526,200	1.1	548,800
L	Afghanistan	1,954,973	34,385,068	0.0569	28.9	1,864,324	0.01	90,648	0.2	Unknow
L	Senegal	623,509	12,433,728	0.0501	14.8	229,547	18.73	335,162	0.9	58,800
L	Madagascar	881,807	20,713,819	0.0426	22.5	368,469	3.51	486,388	0.2	26,950
L	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
L	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
L	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

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Ī	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
0	Pakistan	3,465,577	173,593,383	0.0200	16.0	3,220,422	0.12	135,885	0.1	109,270
1 2	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
3	Cambodia	191,054	14,138,255	0.0135	7.1	121,042	0.78	53,352	0.5	16,660
4	Nepal	297,240	29,959,364	0.0099	14.7	229,536	0.02	20,664	0.4	47,040
5	Bolivia	98,154	9,929,849	0.0099	15.2	85,256	0.02	648	0.2	12,250
6	Iraq	301,208	32,030,823	0.0094	11.6	301,208	0.00	Unknown	0.2	Unknown
7	Algeria	296,287	35,468,208	0.0084	12.8	272,766	0.00	0	0.1	23,520
8	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
9 0	Russian Federation	990,798	141,920,000	0.0070	1.2	74,498	0.00	Unknown	1	916,300
1	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
2	Ukraine	255,845	45,870,700	0.0056	0.8	20,645	0.00	Unknown	1.1	235,200
3	Thailand	365,406	69,122,234	0.0053	1.9	237,657	0.50	10,149	1.3	117,600
4	Vietnam	408,534	86,927,700	0.0047	2.3	111,515	0.13	32,418	0.4	264,600
5	Malaysia	114,666	28,401,017	0.0040	1.0	16,176	0.17	490	0.5	98,000
5	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
7	Colombia	159,217	46,294,841	0.0034	4.1	65,031	0.07	2,067	0.5	92,120
3	Mexico	321,228	113,423,047	0.0028	5.5	175,197	0.00	12	0.3	146,020
9	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
1	China	1,766,094	1,337,825,000	0.0013	3.1	848,167	0.00	1,627	0.1	916,300
2	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.

Total DALY burden: Total annual DALYs for diarhea, 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, diahred lisease divided by population. Diarrhea burden: percentage of childhood(<5) deaths due to diarhea. 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 diarheal 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 (piarhea): Total DALYS form diarheal 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 (piarhea): Total DALYS form diarheal 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 (Diarhea): Total DALYS form diarheal 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 (Diarhea): Total DALYS form diarheal 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 (Malaria): Total DALYS form malaria in children <5 yrs. Source: derivation. HV hurden: Drevalenze in 16-40 ware rule: Cource: MUSING database yris darminder org

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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 K	enva. Bangladesh and Nigeria.	per 1000 campaign participants.

		Malaria	Diarrhea		Ormalian	TOTA
		LLITN	Filters	VCT	Condoms	TOTAL
 .	.	Keny	<i>v</i> a			
Disease averted	Deaths		2.4	4.0	2.2	10.0
avontou	Episodes	1.6	2.4	4.8 7.0	2.2	10.9
	Epidoded	133.6	1,877.7	7.0		2,018.3
DALYs	Prevention	44.1	68.3	40.0	18.2	170.6
averted	Earlier LIV (eare			400 5		400 5
	Earlier HIV care			123.5		123.5
	TOTAL	44.1	68.3	181.8		294.1
Costs	Prevention	\$773	\$9,068	\$40,889	\$18,588	\$69,318
averted						
(added)	Earlier HIV care			(\$81,187		(\$81,187)
)		(+ , ,)
	TOTAL	\$773	\$9,068	(\$21,710		-\$11,869
Cost- effectiveness	Campaign cost (unadjusted)					\$34,280
chectiveness	Net cost (savings)					\$46,149
	Cost per DALY averted					\$157
						, CI Ç
		Banglad	desh			
Disease	Deaths	0.1	0.8	0.0	0.0	0.9
averted	Episodes	14.7	1061.3	0.1		1076.1
DALYs	Prevention	1.7	22.4	0.4	0.2	24.7
averted						
	Earlier HIV care TOTAL		22.4	1.2		1.2
Costs	Prevention	1.7	22.4	1.8	¢100	25.9
averted	Flevention	\$89	\$5,527	\$389	\$189	\$6,196
(added)						
	Earlier HIV care	ćao	65 50 7	(\$773)		(\$773)
Cost-	TOTAL Campaign cost	\$89	\$5,527	(\$195)		\$5,422 \$36,658
effectiveness	(unadjusted)					φ30,030
	Net cost (savings)					\$30,236
	Cost per DALY averted					\$1,168
		Niger	'ia			
Disease	Deaths	6.0	3.4	2.7	1.3	13.4
averted	Enicodoo					
	Episodes	734.3	2,363.3	4.0		3,101.7
DALYs	Prevention	168.8	97.6	21.8	10.2	298.4
averted				_1.0	- 212	
			echnical Sup	nlement	11	
		II C CLA IE	.crimical Sup	piement -	T T	

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Page	42	of	126
		~ .	

1 2 3 4 5 6 7								
8 9 10	Costs	Earlier HIV care TOTAL Prevention	168.8 \$6,223	97.6 \$14,300	70.8 102.9 \$28,605	\$13,379	70.8 369.3 \$62,507	
11 12 13	averted (added)	Earlier HIV care	<i>φ</i> 0,223	Ş14,300	(\$55,797	<i>ξ</i> τ3,375	(\$55,797)	
14 15		TOTAL	\$6,223	\$14,300) (\$14,813		\$5,710	
16 17 18 19	Cost- effectiveness	Campaign cost (unadjusted) Net cost (savings) Cost per DALY averted	Ö				\$40,479 \$34,769 \$94	
20 21 22 32 25 26 27 28 29 31 23 34 35 36 37 89 04 12 43 44 56 27 28 29 31 23 34 35 36 37 89 04 12 43 44 56 57 55 55 57 58 59 60			IPC CEA Te	echnical Sup	oplement - 1	2		

11		Ann	iual		Cumulativ		An	nual DAL	Ys aver	ted	Cum	lative D	Cumulative DALYs averted			
12 13	Year	Net costs	Net DALYs averted	Net costs	DALYs averted	CE (\$/DALY averted)	Malari a	Diarrhea	HIV	Total	Malari a	Diarrh ea	HIV	Total		
14	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		
15	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		
16	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		
17	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		
8	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		
9	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		
20	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		
21	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		
22	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		
23	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		
24	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		
25	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		
26	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		
27	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		
28	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		
29	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		
30	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		
31	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		
32	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		
33	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		
34	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		
35	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		
86	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		
37	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		
38	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		
39	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		
40	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		
11 12 13 14 15 16																

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

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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.

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 pereapita 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-CHOICEderived 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 GDPbased index.

The variation in the results yielded by each method is modest. Table 8 shows the base case results using the percapita 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 makings when compared with the per-capita GDP approach (Table 3 in the main paper).

8
9 Table 8. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to
10 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:
12 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.

15			-			D					1
16				Costs		Dise ave			Cos effectiven		
17 18 19 20	Country	World Bank income classificat ion	DALY s per capit a	IPC campaig n cost	Net cost	Deaths	Episod es		Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
21 1	Guinea-	Low	0.134	\$31,652	\$2,286	40.7	10,523	1,145.2	\$28	\$2	\$1,005
22 2	Bissau Sierra Leone	Low	0.119	\$52,305	\$4,927	16.0	4,118	447.9	\$117	\$11	\$764
23 ³	Senegal	Lower middle	0.050	\$36,210	\$11,527	10.7	5,735	305.4	\$119	\$38	\$768
24 4	Burkina Faso	Low	0.126	\$35,260	\$20,805	16.4	4,124	459.8	\$77	\$45	\$819
25 5	Somalia	Low	0.121	\$26,015	\$22,924	16.8	3,682	470.8	\$55	\$49	\$1,535
26 6	Mali	Low	0.124	\$32,840	\$22,058	15.9	4,222	445.4	\$74	\$50	\$888
27 7	Niger	Low	0.110	\$28,445	\$21,450	14.8	4,967	419.1	\$68	\$51	\$1,095
28 8	Afghanistan	Low	0.057	\$28,905	\$18,828	12.7	4,146	356.9	\$81	\$53	\$935
29	Sudan	Lower middle	0.057	\$45,505	\$10,906	6.9	4,907	198.4	\$229	\$55	\$703
30 ¹ ₀	Guinea	Low	0.095	\$31,875	\$21,102	12.6	4,272	355.2	\$90	\$59	\$928
31 ¹	Lesotho	Lower middle	0.115	\$55,557	\$54,805	31.3	1,756	859.0	\$65	\$64	\$738
32 1 33 2	Congo, DR	Low	0.112	\$25,386	\$25,306	13.4	3,517	376.8	\$67	\$67	\$1,493
34 ³	Chad	Low	0.120	\$28,103	\$29,728	15.3	4,335	427.1	\$66	\$70	\$807
35 ¹ ₄	Liberia	Low	0.092	\$36,982	\$23,225	11.9	3,401	333.2	\$111	\$70	\$1,025
36 ¹ ₅	Côte d'Ivoire	Lower middle	0.084	\$43,278	\$30,730	14.1	4,021	393.7	\$110	\$78	\$801
37 1 20 ⁶	Burundi	Low	0.118	\$28,504	\$34,224	14.3	2,267	393.6	\$72	\$87	\$987
38 ⁶ 39 ⁷	Uganda	Low	0.105	\$37,888	\$36,726	14.9	3,492	409.5	\$93	\$90	\$749
40 ¹ / ₈	Benin	Low	0.083	\$32,216	\$25,362	10.0	3,096	280.0	\$115	\$91	\$910
41 ¹ ₉	Nigeria	Lower middle	0.133	\$45,846	\$34,213	13.4	3,102	370.6	\$124	\$92	\$747
42 ²	Mozambique	Low	0.141	\$31,652	\$58,371	22.2	3,816	606.8	\$52	\$96	\$1,109
43 ⁰ ₂ 44 ¹	Cen. African Rep.	Low	0.105	\$26,663	\$37,686	13.8	2,819	380.3	\$70	\$99	\$1,230
45 ² / ₂	Congo, Rep.	Lower middle	0.067	\$42,684	\$33,709	11.5	2,981	319.7	\$134	\$105	\$756
46 ² ₃	Тодо	Low	0.075	\$32,973	\$32,220	10.4	2,849	287.6	\$115	\$112	\$864
47 ²	Zambia	Lower middle	0.128	\$38,512	\$68,361	21.8	3,107	594.6	\$65	\$115	\$826
48 ⁴ 49 ⁵	Malawi	Low	0.110	\$34,146	\$58,110	18.3	2,965	496.4	\$69	\$117	\$996
49 ² 50 ⁶	Tanzania	Low	0.075	\$30,345	\$39,174	12.1	3,122	331.0	\$92	\$118	\$935
51 ² / ₇	Ethiopia	Low	0.057	\$28,371	\$28,810	8.6	1,986	237.4	\$120	\$121	\$1,139
52		1			L					I	

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\$247 \$632 \$261 \$869 \$267 \$577 \$292 \$627 \$307 \$1,354 \$318 \$733 \$351 \$864 \$385 \$582 \$427 \$613 \$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$192	\$1,025
\$261 \$869 \$267 \$577 \$292 \$627 \$307 \$1,354 \$318 \$733 \$351 \$864 \$385 \$582 \$427 \$613 \$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,481 \$717 \$1,872 \$793 \$1,952 \$668 \$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$212	\$1,753
\$267 \$577 \$292 \$627 \$307 \$1,354 \$318 \$733 \$351 \$864 \$385 \$582 \$427 \$613 \$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$247	\$632
\$292 \$627 \$307 \$1,354 \$318 \$733 \$351 \$864 \$385 \$582 \$427 \$613 \$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,481 \$717 \$1,872 \$793 \$1,952 \$668 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$261	\$869
\$307 \$1,354 \$318 \$733 \$351 \$864 \$385 \$582 \$427 \$613 \$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,481 \$717 \$1,872 \$793 \$1,952 \$668 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$267	\$577
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\$427 \$613 \$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,481 \$717 \$1,872 \$793 \$1,952 \$668 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$351	\$864
\$452 \$758 \$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,468 \$606 \$1,468 \$606 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$385	\$582
\$525 \$606 \$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,468 \$606 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$427	\$613
\$609 \$739 \$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,468 \$606 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$452	\$758
\$788 \$883 \$930 \$650 \$1,086 \$1,046 \$1,468 \$606 \$1,481 \$717 \$1,872 \$793 \$1,952 \$668 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$525	\$606
\$930 \$650 \$1,086 \$1,046 \$1,468 \$606 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$609	\$739
\$1,086 \$1,046 \$1,468 \$606 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$788	\$883
\$1,468 \$606 \$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,814 \$600 \$3,563 \$613	\$930	\$650
\$1,481 \$717 \$1,872 \$793 \$1,952 \$662 \$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$1,086	\$1,046
\$1,872 \$793 \$1,952 \$622 \$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$1,468	\$606
\$1,952 \$622 \$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$1,481	\$717
\$2,549 \$668 \$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$1,872	\$793
\$2,694 \$664 \$2,814 \$600 \$3,563 \$613	\$1,952	\$622
\$2,814 \$600 \$3,563 \$613	\$2,549	\$668
\$3,563 \$613	\$2,694	\$664
	\$2,814	\$600
\$3,654 \$724	\$3,563	\$613
	\$3,654	\$724

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0 7												
8 9 2		Angola	Upper	0.088	\$53,374	\$39,069	11.5	3,268	321.5	\$166	\$122	\$674
10		Cameroon	middle Lower	0.100	\$39,729	\$52,377	14.3	3,115	394.2	\$101	\$133	\$741
11 3		Rwanda	middle Low	0.071	\$43,307	\$37,051	9.6	2,216	265.0	\$163	\$140	\$768
	3	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
	3	Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	478.9	\$53	\$159	\$1,731
	3	Yemen	Lower middle	0.025	\$39,388	\$20,853	4.3	3,128	122.6	\$321	\$170	\$719
16 3		Mauritania	Lower middle	0.042	\$39,952	\$29,100	5.8	2,607	164.0	\$244	\$177	\$955
	3 5	Ghana	Lower middle	0.063	\$37,606	\$34,488	6.8	1,966	189.9	\$198	\$182	\$746
19 e		Pakistan	Lower middle	0.020	\$35,334	\$20,601	3.8	2,748	108.0	\$327	\$191	\$904
20 7	7	Madagascar	Low	0.043	\$27,806	\$24,564	4.5	1,910	127.6	\$218	\$192	\$1,025
21 3 22 3	В	Eritrea	Low	0.033	\$24,332	\$25,362	4.3	1,942	119.5	\$204	\$212	\$1,753
23	9	Swaziland	Lower middle	0.150	\$88,325	\$197,22 5	29.1	2,230	800.0	\$110	\$247	\$632
24 o	0	Haiti	Low	0.028	\$34,310	\$31,765	4.4	3,128	121.7	\$282	\$261	\$869
20 ₁	1	Botswana	Upper middle	0.080	\$151,324	\$196,11 7	26.8	1,111	734.1	\$206	\$267	\$577
272	2	Guatemala	Lower middle	0.016	\$76,551	\$19,936	2.4	3,143	68.3	\$1,121	\$292	\$627
28	3	Myanmar	Low	0.026	\$25,550	\$25,518	2.9	1,306	83.1 104.6	\$307	\$307	\$1,354
29 4	4	India	Lower middle		\$45,178	\$33,274	3.7	1,255	70.6	\$432 \$627	\$318	\$733
30 g	5	Papua New Guinea South Africa	Lower middle Upper	0.018	\$44,272 \$167.731	\$24,760 \$223,29	2.4 21.5	2,868	579.7	\$027	\$351 \$385	\$864 \$582
	6	Gabon	middle Upper	0.097	\$104,762	\$223,29 2 \$107,28	9.3	1,876	251.5	\$289 \$417	\$385	\$582
33 4	7	Iraq	middle Upper	0.000	\$43,990	\$107,28 8 \$25,081	9.5	2,587	55.5	\$792	\$452	\$758
<u>34</u>	В	Namibia	middle Upper	0.009	\$113,745	\$218,64	1.9	1,528	416.7	\$273	\$525	\$606
35 g	9	Cambodia	middle	0.030	\$41,971	\$210,04 2 \$32,821	1.9	1,341	53.9	\$779	\$609	\$739
30 g	0	Nepal	Low	0.014	\$33,760	\$30,891	1.4	1,135	39.2	\$861	\$788	\$883
38 1	1	Morocco	Lower	0.006	\$72,424	\$50,688	1.9	1,623	54.5	\$1,329	\$930	\$650
39 2	2	Bangladesh	Low	0.007	\$31,949	\$28,039	0.9	1,076	25.8	\$1,237	\$1,086	\$1,046
40 3	3	Algeria	Upper	0.008	\$87,063	\$59,839	1.4	1,304	40.8	\$2,136	\$1,468	\$606
414	4	Uzbekistan	middle Lower	0.006	\$54,666	\$26,791	0.6	2,352	18.1	\$3,021	\$1,481	\$717
13	5	Indonesia	middle Lower	0.008	\$44,169	\$38,316	0.7	814	20.5	\$2,158	\$1,872	\$793
44	6 5	Thailand	middle Upper	0.005	\$79,120	\$90,878	1.8	455	46.5	\$1,700	\$1,952	\$622
	7 5	Bolivia	middle Lower	0.010	\$67,123	\$33,507	0.4	2,015	13.1	\$5,105	\$2,549	\$668
	8 5	Vietnam	middle Lower	0.005	\$51,726	\$44,913	0.6	828	16.7	\$3,102	\$2,694	\$664
48 e		Ukraine	middle Lower	0.006	\$105,326	\$92,351	1.2	623	32.8	\$3,209	\$2,814	\$600
43		Peru	middle Upper	0.004	\$104,227	\$63,328	0.6	1,497	17.8	\$5,864	\$3,563	\$613
51 6		Philippines	middle Lower	0.003	\$51,949	\$39,286	0.3	1,289	10.8	\$4,832	\$3,654	\$724
52	2		middle		100 1		at and Co		17			
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0 Josephia	Unan	0.003	\$400 0 7 5	\$80,234	0.0	4 440	18.7	* C 000	¢4.000	\$598
6 Colombia 3 6 Malaysia	Upper middle Upper	0.003	\$129,275 \$122,297	\$93,832	0.6	1,419 930	16.7	\$6,900 \$7,428	\$4,283 \$5,699	\$598
6 Malaysia 4 6 Brazil	middle Upper	0.004	\$122,297	\$93,832	0.6	1,385	18.1	\$10,306	\$5,822	\$591
5 Russian	middle High:	0.004	\$240,707	\$103,30 5 \$192,69	1.1	735	30.2	\$7,975	\$6,384	\$579
Federation	nonOECD Upper	0.003	\$252,229	0 \$164,21	0.6	1,097	16.6	\$15,161	\$9,871	\$577
7	middle Upper	0.000	\$191,725	3 \$80,928	0.0	1,784	5.9	\$32,276	\$13,624	\$582
В	middle Upper	0.001								
6 China 9 7 Mexico	middle Upper	0.003	\$179,550	\$187,18	0.3	0	8.7	\$20,612	\$21,489	\$583
	middle	0.000	¢3,000	7	0.0			420,012	¢21,100	<i>4000</i>
								\$20,990 \$20,612		

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Tech. Suppl. - Table 9. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered 11 from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART.

12 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.

14 Source: WHO–CHOICE: http://www.who.int/choice/cost-effectiveness/inputs/health_service/en/

14								•					
15					Costs Disease					Cost-effectiveness (CE)			
16		_					ave	rted					
17 18		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	
19 20	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	
21 22	3	Burkina Faso	Low	0.126	\$33,007	\$21,650	16.4	4,124	459.8	\$72	\$47	\$819	
23	4	Sierra Leone	Low	0.119	\$28,338	\$22,441	16.0	4,118	447.9	\$63	\$50	#N/A	
24	5	Mali	Low	0.124	\$31,186	\$22,527	15.9	4,222	445.4	\$70	\$51	\$888	
25	6	Niger	Low	0.110	\$27,560	\$21,862	14.8	4,967	419.1	\$66	\$52	\$1,095	
26	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	
27	9	Guinea	Low	0.095	\$30,485	\$21,805	12.6	4,272	355.2	\$86	\$61	\$928	
28	10	Chad	Low	0.120	\$32,650	\$27,127	15.3	4,335	427.1	\$76	\$64	\$807	
29	11	Congo, DR	Low	0.112	\$24,540	\$25,512	13.4	3,517	376.8	\$65	\$68	\$1,493	
30	12	Liberia	Low	0.092	\$25,154	\$26,045	11.9	3,401	333.2	\$75	\$78	\$1,025	
31	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	
32	15	Côte d'Ivoire	Lower middle	0.084	\$34,943	\$34,796	14.1	4,021	393.7	\$89	\$88	\$801	
33	16	Benin	Low	0.083	\$33,846	\$25,342	10.0	3,096	280.0	\$121	\$91	\$910	
34	17	Nigeria	Lower middle	0.133	\$38,931	\$34,929	13.4	3,102	370.6	\$105	\$94	\$747	
35	18	Uganda	Low	0.105	\$32,646	\$39,581	14.9	3,492	409.5	\$80	\$97	\$749	
36	19	Mozambiqu e	Low	0.141	\$28,771	\$59,852	22.2	3,816	606.8	\$47	\$99	\$1,109	
37	20	Cen. African Rep.	Low	0.105	\$28,010	\$37,642	13.8	2,819	380.3	\$74	\$99	\$1,230	
38 39	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	
40	23	Angola	Upper middle	0.088	\$62,105	\$37,627	11.5	3,268	321.5	\$193	\$117	\$674	
41	24	Tanzania	Low	0.075	\$32,091	\$38,786	12.1	3,122	331.0	\$97	\$117	\$935	
42	25	Zambia	Lower middle	0.128	\$32,785	\$70,043	21.8	3,107	594.6	\$55	\$118	\$826	
43	26	Malawi	Low	0.110	\$28,219	\$59,708	18.3	2,965	496.4	\$57	\$120	\$996	
44	27	Ethiopia	Low	0.057	\$29,008	\$29,104	8.6	1,986	237.4	\$122	\$123	\$1,139	
45	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	
46	30	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883	
47	31	Yemen	Lower middle	0.025	\$41,823	\$20,557	4.3	3,128	122.6	\$341	\$168	\$719	
48	32	Mauritania	Lower middle	0.042	\$38,314	\$28,653	5.8	2,607	164.0	\$234	\$175	\$955	
49	33	Ghana	Lower middle	0.063	\$33,612	\$33,841	6.8	1,966	189.9	\$177	\$178	\$746	
50	34	Pakistan	Lower middle	0.020	\$40,398	\$19,912	3.8	2,748	108.0	\$374	\$184	\$904	
51	35	Madagascar	Low	0.043	\$30,438	\$25,467	4.5	1,910	127.6	\$239	\$200	\$1,025	
51 52	36	Eritrea	Low	0.033	\$26,867	\$26,253	4.3	1,942	119.5	\$225	\$220	\$1,753	
52					IPC CEA	Technica	l Supplen	nent - 19					

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8	37	Botswana	Upper middle	0.080	\$116,424	\$173,837	26.8	1,111	734.1	\$159	\$237	\$577
9	38	Swaziland	Lower middle	0.000	\$58,455	\$198,389	20.0	2,230	800.0	\$73	\$248	\$632
10	39	Haiti	Low	0.028	\$30,962	\$31,577	4.4	3,128	121.7	\$254	\$260	\$869
11	40	South Africa	Upper middle	0.097	\$93,433	\$177,476	21.5	1,150	579.7	\$161	\$306	\$582
12	41	India	Lower middle	0.027	\$44,370	\$32,889	3.7	1,166	104.6	\$424	\$314	\$733
13	42	Guatemala	Lower middle	0.016	\$57,311	\$22,179	2.4	3,143	68.3	\$839	\$325	\$627
14	43	Myanmar	Low	0.026	\$31,316	\$28,153	2.9	1,306	83.1	\$377	\$339	\$1,354
14	44	Papua New Guinea	Lower middle	0.018	\$39,103	\$25,246	2.4	2,868	70.6	\$554	\$358	\$864
16	45	Gabon	Upper middle	0.060	\$56,344	\$92,439	9.3	1,876	251.5	\$224	\$368	\$613
17	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
18	48	Cambodia	Low	0.014	\$38,523	\$31,223	1.9	1,341	53.9	\$715	\$579	\$739
19	49	Nepal	Low	0.010	\$30,887	\$29,027	1.4	1,135	39.2	\$788	\$740	\$883
20	50	Morocco	Lower middle	0.006	\$54,334	\$40,545	1.9	1,623	54.5	\$997	\$744	\$650
21	51	Bangladesh	Low	0.007	\$32,639	\$28,448	0.9	1,076	25.8	\$1,264	\$1,101	\$1,046
22	52	Algeria	Upper middle	0.008	\$80,074	\$55,887	1.4	1,304	40.8	\$1,965	\$1,371	\$606
23	53	Uzbekistan	Lower middle	0.006	\$43,037	\$25,245	0.6	2,352	18.1	\$2,379	\$1,395	\$717
24	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
25	56	Ukraine	Lower middle	0.006	\$74,578	\$68,634	1.2	623	32.8	\$2,272	\$2,091	\$600
26	57	Indonesia	Lower middle	0.008	\$51,988	\$43,696	0.7	814	20.5	\$2,540	\$2,135	\$793
27	58	Bolivia	Lower middle	0.010	\$53,963	\$30,445	0.4	2,015	13.1	\$4,105	\$2,316	\$668
28	59	Vietnam	Lower middle	0.005	\$43,303	\$39,035	0.6	828	16.7	\$2,597	\$2,341	\$664
29	60	Peru	Upper middle	0.004	\$82,397	\$53,509	0.6	1,497	17.8	\$4,636	\$3,011	\$613
30	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
31 32	63	Russian Federation	High: nonOECD	0.007	\$156,317	\$131,095	1.1	735	30.2	\$5,179	\$4,343	\$579
33	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
34	66	Turkey	Upper middle	0.001	\$116,707	\$55,139	0.1	1,784	5.9	\$19,647	\$9,283	\$582
35	67	China	Upper middle	0.001	\$66,612	\$59,793	0.1	486	4.4	\$15,010	\$13,474	\$638
36	68	Mexico	Upper middle	0.003	\$120,196	\$127,833	0.3	0	8.7	\$13,799	\$14,675	\$583
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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.	<u>Rural Uganda</u>	<u>44.7%</u>
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	<u>61.6%</u>
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.	<u>South-eastern Tanzania</u> (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.	<u>Orissa, India (high</u> 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	<u>Ifakara, Tanzania</u>	Health facility attendance:52%

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Tech-Suppl - Figure 1.

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Tech-Suppl - Figure 2.

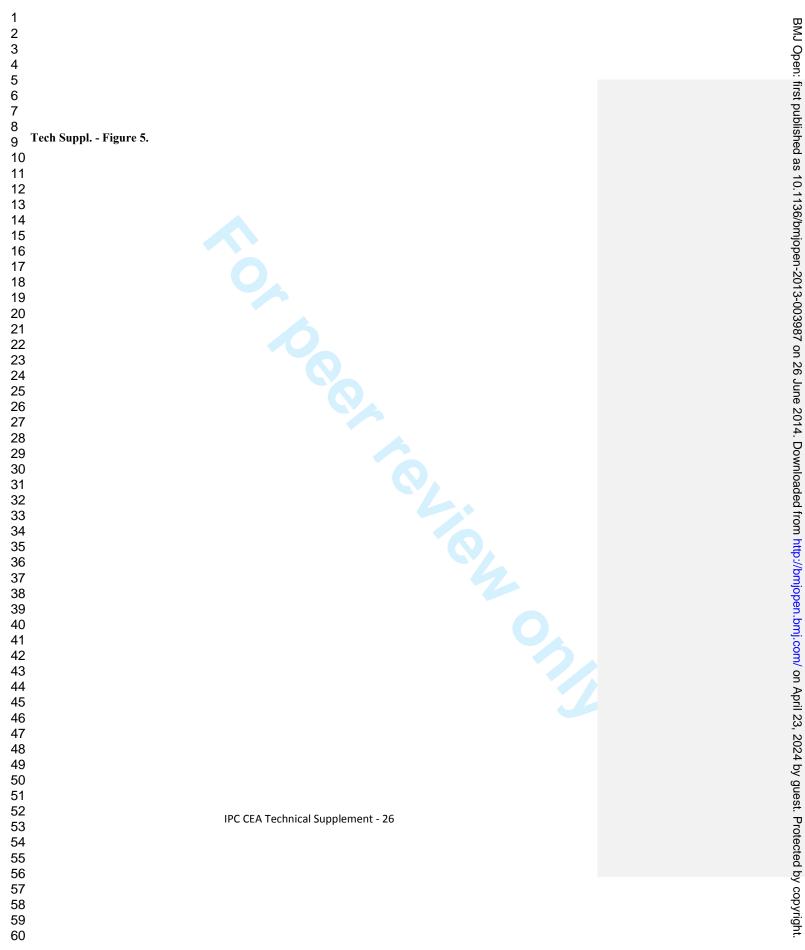
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Tech-Suppl - Figure 3.

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Projection of costs and outcomes to 30 years 9

10 We projected cumulative costs and outcomes of the IPC campaign in Kenya for 30 years, assuming an initial 11 campaign and a second campaign three years later (Figure 6). Costs and benefits of the two campaigns were added 12 and reflect the lower effectiveness of the second campaign. The large rise in costs in year 4 reflects the initiation of 13 the second campaign, and the gradual increase in cumulative costs over time reflects the costs of additional HIV 14 treatment. The steadily rising cumulative net DALYs averted reflects the averted morbidity during the period of 15 bed net and water filter efficacy, but is largely determined by the distribution of saved life years due to averted 16 mortality from all three diseases during the period of IPC benefit. Distribution of benefits were made according to the following assumptions: 17

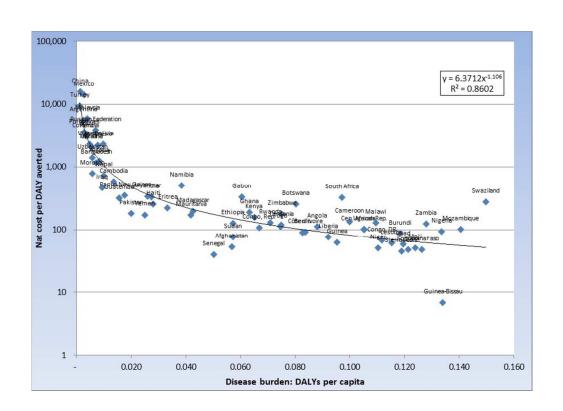
- 18 HIV deaths would occur on average 15 years after infection. . 19
- Assumes those detected are all put on ART at year of campaign. • 20
 - Earlier and more ART die to earlier detection distributed over 15 and 20 years respectively. ٠
- 21 HIV mortality prevention in secondary partners starts on average in year 20 after the campaign and is 22 distributed over 20 years. 23
 - 50% of prevented HIV mortality occurred in the index patient
- 24 Life-expectancy at the time of the campaign was 60 years for averted mortality in malaria and diarrhea 25 patients. 26
 - Malaria and diarrhea morbidity reduction is confined to the campaign itself.

29 Tech Suppl. - Figure 6. 30

patients.	
 Malaria and diarrhea morbidity reduction is confined to the campaign itself. 	
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29 30 Tech Suppl Figure 6.	
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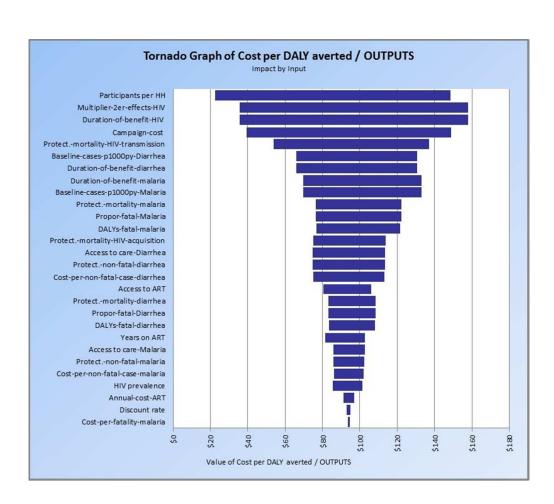
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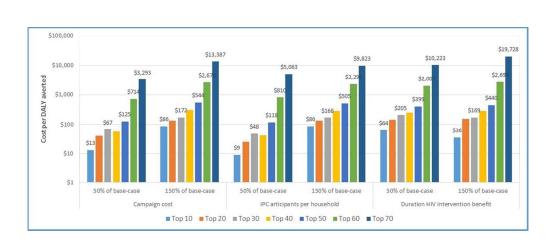
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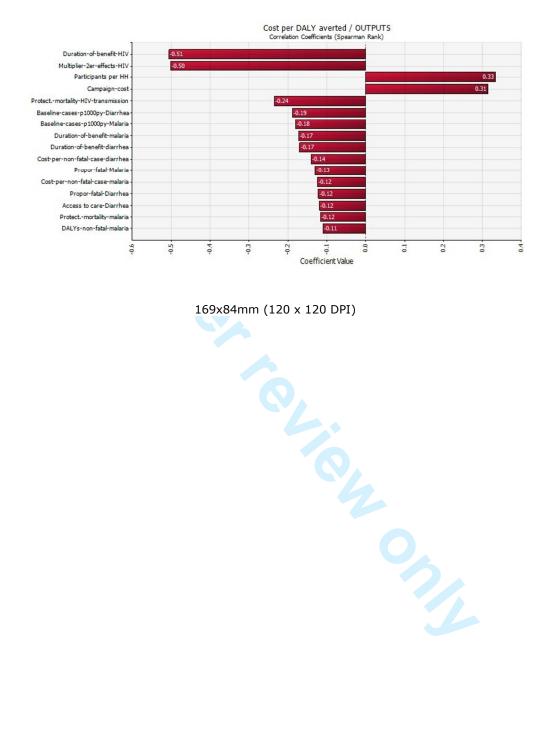
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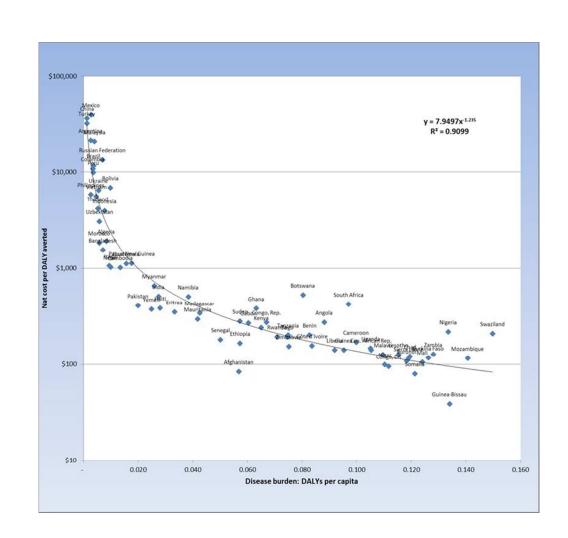
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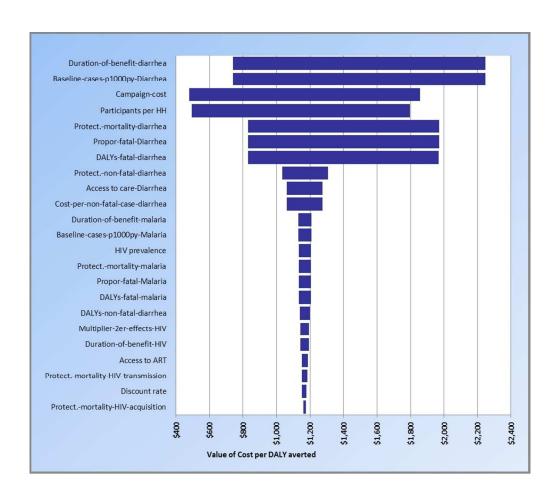
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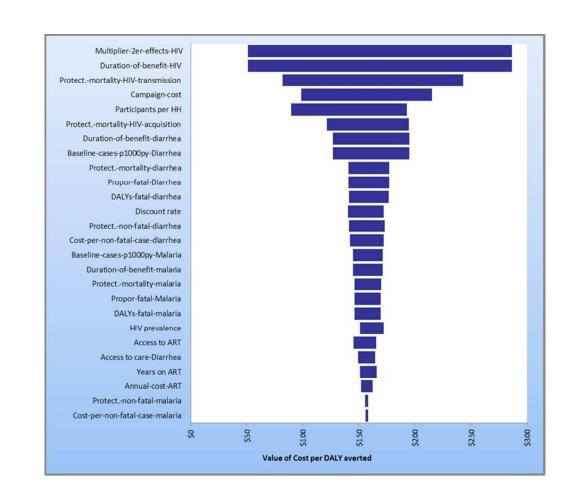
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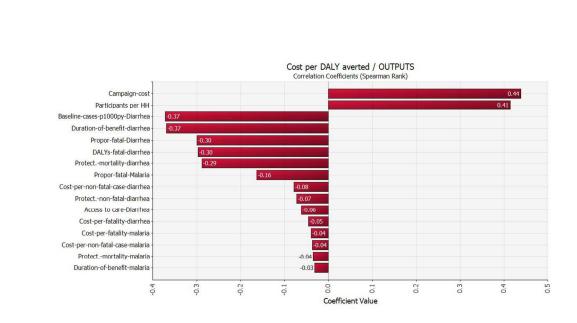
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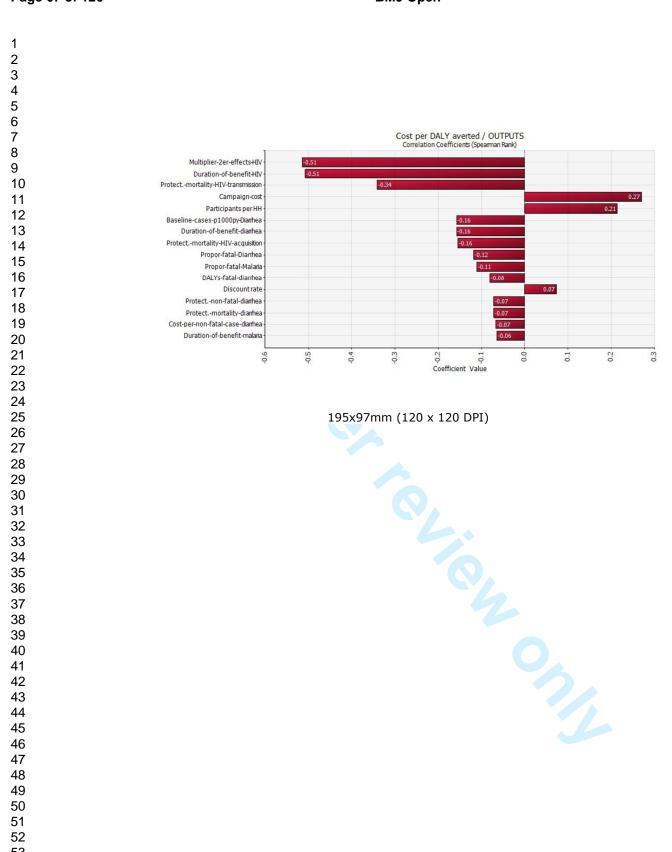
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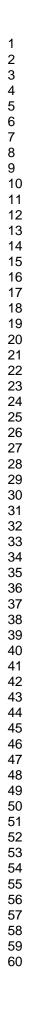


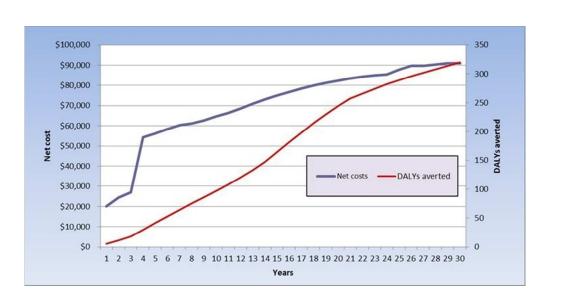
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4 Reduction in risk for malaria and HIV between first and second campaign

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.

13 For malaria we assume 75% as much disease incidence at years 4-6 (absent a 2nd campaign) as baseline incidence. 14 In other words, we assume that full set of LLIN distributed in the *initial* campaign, with no follow-up campaign, 15 would have half as much community benefit in years 4-6 as in years 1-3. Many LLIN will remain in place, and the 16 17 insecticide impregnation itself is stable for close to 10 years. Thus, the 50% incidence drop expected with LLIN in 18 years 1-3 will decrease but not disappear in the second 3 years. However, the second round of LLIN are likely to 19 have a relative effectiveness less than 50%, because the best LLIN users are already protected. Thus we decrease 20 the effectiveness from 50% to 33% (i.e., from 75% of baseline incidence to 50% of baseline incidence). In effect, 21 the 2nd campaign is like a booster shot that returns effectiveness to its original level. In sum, the overall benefit of 22 the second campaign is reduced by half -- in first campaign it was 100% of baseline incidence to 50%, and in the 23 24 second campaign from 75% of baseline incidence to 50%. 25

26 We note that these estimates are assembled from isolated data (e.g., LLIN physical durability) combined with a 27 logical framework and best guesses. Nonetheless, we believe that the conclusion -50% as much benefit for a 28 second campaign – is plausible, and is a far more realistic assumption than full benefit. Our approach is 29 30 conservative regarding the second campaign – if the specified durability of effect of the LLIN is larger than in 31 reality, we would be *under*estimating the benefit of this campaign. And our estimate of the combined effect of two 32 sequential campaigns is robust. Low estimates of durability understate benefits of the first campaign and overstate 33 benefits of the second campaign, which represent offsetting errors. Conversely, high estimates of durability 34 overstate the value of the first campaign and understate second campaign benefits, again offsetting. 35 36

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.

40 For HIV, effects on DALYs and cost depend heavily on undiagnosed HIV prevalence. The first campaign detects 41 42 almost all HIV-infected individuals. Thus, the effects of the second campaign depend mainly on the impact of 3 43 years of HIV incidence on (predominantly undiagnosed) HIV prevalence. This incidence has not been measured, 44 but can be estimated from HIV prevalence using simple epidemic dynamics. ¹Steady-state (pre-ART) annual 45 incidence is about 1/10th of prevalence (slightly more if prevalence above 10%, due to reduction in # of 46 susceptible). So, if initial prevalence was 5%, then annual incidence is about 0.5%, and prevalence at 3 years will 47 be about 1.5%. 48 49

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.

¹ Diarrhea: estimation of average cases per PY and annual cases

Using data on the number of episodes per year in children under 5², 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.

11 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 Kenva. 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.

		least cost-effect			•			veness ranc	5 1055 10001		estiment
1	in ART. Resu	Its shown are	tor the <u>se</u>		subsequent :		averted		Cost-	effectivenes	s (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
	Guinea-	Low	0.134	\$29,459	\$16,675	26.9	5,465.3	754.3	\$22	\$39	\$1,005
2	Bissau	Low	0.121	¢26.015	¢02 642	11.6	2.055.1	225.2	¢72	0.02	\$760
2	Somalia	Low	0.121	\$26,015 \$28,770	\$23,643 \$22,700	11.6 12.2	2,055.1 2,380.6	325.2 342.0	\$73 \$66	\$80 \$84	\$768 \$764
3	Afghanistan Congo, DR	Low Low	0.057	\$28,770 \$24,637	\$22,700 \$24,258	9.3	2,380.6	259.2	\$66 \$94	\$84 \$95	\$764
ł	•		0.112	\$24,637 \$28,081	\$24,250 \$24,250	9.3	2,648.0	259.2	\$94 \$86	\$95 \$99	\$019
	Niger Mali	Low	0.110	\$29,459	\$24,250 \$25,298	10.0	2,040.0	280.1	\$00 \$90	\$99 \$105	\$1,535
) ,	Burundi	Low	0.124	\$29,459 \$26,015	\$25,298 \$27,699	10.0 8.7	1,256.5	280.1	\$90 \$116	\$105	\$1,095
2	Sierra Leone	Low	0.118			8.7 9.8		239.8	\$116		\$888
3		Low		\$31,525 \$30,147	\$24,508 \$36,613		2,142.5	274.1	•	\$115 \$116	\$935
, 0	Mozambique Burkina Faso	Low	0.141		\$36,613	9.7	1,975.5 2,153.3	260.0	\$141 \$06	\$116 \$117	\$807
0 1	Burkina Faso Chad	Low	0.126	\$31,525 \$35,658	\$26,076 \$27,805	9.6 10.6		270.2	\$96 \$04	\$117 \$121	\$738
1	Lesotho	Low Lower middle	0.120	\$35,658	\$27,805	10.6	2,258.2 919.3		\$94 \$121		•
2 3				\$35,658	\$37,171			283.6	\$131 \$104	\$126	\$1,493
3 4	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532.3	221.8	\$164 \$150	\$127 ©120	\$703
4 5	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660.1	263.4	\$156	\$128	\$1,025
5 6	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,762.6	190.4	\$132	\$140	\$987
ь 7	Guinea	Low	0.095	\$29,459	\$25,199	7.4	2,175.8	208.8	\$121	\$141	\$910
1	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,443.6	194.2	\$152	\$141	\$801
8	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,841.7	214.8	\$145	\$147	\$747
9	Zimbabwe	Low	0.075	\$25,326	\$40,453	6.9	905.4	165.8	\$244	\$153	\$1,109
0	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$31,110	7.8	2,009.7	214.9	\$145	\$156	\$1,230
1	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128.0	181.8	\$159	\$166	\$749
2	Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620.0	223.1	\$177	\$169	\$756
0 1 2 3	Senegal	Lower middle	0.050	\$34,969	\$22,535	6.8	2,951.7	193.6	\$116	\$181	\$864
4	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,466.8	153.3	\$188	\$192	\$674
5	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,248.9	163.9	\$187	\$192	\$935
5 6	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,636.6	167.4	\$193	\$201	\$826
7	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611.1	167.1	\$172	\$201	\$1,139
8	Swaziland	Lower middle	0.150	\$58,387	\$87,699	11.5	1,280.6	281.0	\$312	\$208	\$768
9	Nigeria	Lower middle	0.133	\$40,479	\$34,860	6.7	1,610.1	187.0	\$186	\$217	\$996
0	Kenya	Low	0.065	\$34,280	\$35,682	5.2	1,130.6	142.8	\$250	\$240	\$741
1	Gabon	Upper middle	0.060	\$29,826	\$46,367	4.0	972.5	110.7	\$419	\$269	\$883
2	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522.2	199.0	\$212	\$273	\$955
3	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5	1,758.3	236.6	\$187	\$273	\$719
4	Sudan	Lower middle	0.057	\$38,413	\$24,940	4.8	2,620.5	136.6	\$183	\$281	\$1,731
5	Mauritania	Lower middle	0.042	\$36,346	\$31,642	4.4	1,397.4	123.1	\$257	\$295	\$904
6	Madagascar	Low	0.043	\$28,770	\$26,424	3.0	1,079.4	84.6	\$312	\$340	\$746
	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117.1	78.5	\$334	\$349	\$1,025
8	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778.2	99.3	\$279	\$373	\$1,753
7 8 9 0 1	Ghana	Lower middle	0.063	\$44,612	\$38,058	4.2	1,006.4	117.8	\$323	\$379	\$577
0	Haiti	Low	0.028	\$30,836	\$29,010	2.8	1,789.6	80.4	\$361	\$384	\$869
- 1	Pakistan	Lower middle	0.020	\$41,856	\$29,010	3.6	1,789.0	102.7	\$281	\$407	\$632
2	South Africa	Upper middle	0.020	\$99,713	\$20,870	9.1	659.2	235.9	\$487	\$423	\$627

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3 Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	855.9	150.8	\$708	\$502	\$582
4 India	Lower middle	0.030	\$48,744	\$40,648	3.4	713.2	96.2	\$422	\$506	\$613
5 Botswana	Upper middle	0.027	\$137,595	\$139,112	9.9	634.1	262.4	\$530	\$500	\$733
6 Myanmar	Low	0.080	\$31,525	\$29,473	9.9 1.7	672.6	48.0	\$550 \$614	\$657	\$1,354
7 Cambodia	Low	0.020	\$38,413	\$29,473	1.7	758.8	37.6	\$9014	\$057	\$864
					1.1	654.7	30.0			\$758
8 Nepal	Low	0.010	\$30,836	\$29,442	1.1		50.0	\$982 \$740	\$1,028	\$756
9 Iraq	Upper middle	0.009	\$53,565	\$37,274		1,493.0			\$1,063	
0 Guatemala	Lower middle	0.016	\$57,698	\$35,999	1.8	1,812.5	51.6	\$698	\$1,118	\$739
1 Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,488.7	35.8	\$885	\$1,130	\$883
Guinea 2 Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617.4	23.0	\$1,413	\$1,551	\$650
3 Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898.4	31.6	\$1,577	\$1,846	\$1,046
4 Algena	Upper middle	0.008	\$73,540	\$60,354	1.3	752.8	38.2	\$1,580	\$1,925	\$606
5 Uzbekistan	Lower middle	0.006	\$45,989	\$34,086	0.5	1,357.2	14.9	\$2,282	\$3,079	\$717
6 Indonesia	Lower middle	0.008	\$56,321	\$50,560	0.5	463.2	14.3	\$3,545	\$3,949	\$600
7 Thailand	Upper middle	0.005	\$90,759	\$90,800	0.8	261.3	21.7	\$4,177	\$4,175	\$622
8 Vietnam	Lower middle	0.005	\$45,989	\$42,516	0.3	477.7	8.2	\$5,164	\$5,586	\$793
9 Philippines	Lower middle	0.003	\$51,499	\$44,213	0.3	743.4	8.8	\$5,026	\$5,854	\$668
0 Ukraine	Lower middle	0.006	\$74,228	\$69,343	0.4	359.1	11.5	\$6,052	\$6,479	\$664
1 Bolivia	Lower middle	0.010	\$56,321	\$41,435	0.2	1,162.3	8.2	\$5,044	\$6,856	\$598
2 Peru	Upper middle	0.004	\$95,580	\$73,664	0.3	862.2	9.6	\$7,650	\$9,926	\$613
3 Colombia	Upper middle	0.003	\$95,580	\$75,850	0.3	817.2	8.8	\$8,575	\$10,806	\$581
4 Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798.2	9.0	\$9,029	\$11,626	\$724
5 Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424.3	10.8	\$11,898	\$13,319	\$579
6 Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536.0	6.6	\$17,673	\$20,818	\$577
7 Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	632.8	6.8	\$17,487	\$21,512	\$591
8 Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029.3	3.9	\$22,267	\$32,314	\$582
9 China	Upper middle	0.001	\$84,560	\$78,518	0.1	280.4	2.3	\$33,785	\$36,384	\$583
0 Mexico	Upper middle	0.003	\$127,264	\$129,804	0.1	0.1	3.2	\$40,371	\$39,581	\$638

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			<u> </u>	sts	Diccoc	e averted	1	Cost-eff	ootivono	<u> </u>
Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Disease	Episodes	DALYs averted	Cost-en Campaign cost per DALY averted	Net cost per DALY averted	CE (AR
Swaziland	Lower middle	0.150	\$58,387	\$198,392	29.1	2,230	724.2	\$81	\$274	\$63
Mozambique	Low	0.141	\$30,147	\$59,145	22.2	3,816	590.0	\$51	\$100	\$1,1
Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1143.3	\$26	\$7	\$1,0
Nigeria	Lower middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$74
Zambia	Lower middle	0.128	\$33,591	\$69,806	21.8	3,107	564.3	\$60	\$124	\$82
Burkina Faso	Low	0.126	\$31,525	\$22,206	16.4	4,124	459.4	\$69	\$48	\$81
Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$88
Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,5
Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$80
Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$76
Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$98
Lesotho	Lower middle	0.115	\$35,658	\$47,366	31.3	1,756	779.4	\$46	\$61	\$73
Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,4
Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,0
Malawi	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$99
Cen. African Rep.	Low	0.105	\$27,392	\$37,525	13.8	2,819	373.3	\$73	\$101	\$1,2
Uganda	Low	0.105	\$31,525	\$40,192	14.9	3,492	399.8	\$79	\$101	\$74
Cameroon	Lower middle	0.100	\$37,724	\$52,388	14.3	3,115	388.4	\$97	\$135	\$74
South Africa	Upper middle	0.097	\$99,713	\$180,284	21.5	1,150	561.0	\$178	\$321	\$58
Guinea	Low	0.095	\$29,459	\$22,324	12.6	4,272	353.8	\$83	\$63	\$92
Liberia	Low	0.092	\$26,704	\$25,526	11.9	3,401	332.6	\$80	\$77	\$1,0
Angola	Upper middle	0.088	\$64,586	\$35,794	11.5	3,268	320.8	\$201	\$112	\$67
Côte d'Ivoire	Lower middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$80
Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$91
Botswana	Upper middle	0.080	\$137,595	\$185,872	26.8	1,111	734.1	\$187	\$253	\$57
Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	428.8	\$59	\$178	\$1,73
Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$93
Togo	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$86
Rwanda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118 \$170	\$128 \$107	\$76
Congo, Rep.	Lower middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170 \$117	\$107 \$157	\$75 ¢00
Kenya	Low	0.065	\$34,280 \$44,612	\$46,149 \$35,624	10.9	2,018	294.1 189.9	\$117 \$235	\$157 \$188	\$88 \$74
Ghana Gabon	Lower middle Upper middle	0.063	\$44,612 \$29,826	\$35,624 \$84,306	6.8 9.3	1,966 1,876	255.0	\$235 \$117	\$188	\$74
	Low	0.060	\$29,826	\$84,306 \$29,630	9.3 8.6	1,876	235.0	\$117	\$331 \$126	\$01 \$1,1
Ethiopia Sudan	Low Lower middle	0.057	\$30,147	\$29,630	6.9	4,907	198.8	\$128	\$126 \$77	\$1,1
Afghanistan	Lower middle	0.057	\$38,413	\$15,241 \$18,906	12.7	4,907	356.6	\$81	\$77	\$70

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2 ³⁷	Senegal	Lower middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$768
3 ³⁸	Madagascar	Low	0.043	\$28,770	\$24,895	4.5	1,910	127.8	\$225	\$195	\$1,025
4 39	Mauritania	Lower middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$955
5 ₄₀	Namibia	Upper middle	0.038	\$75,606	\$204,271	15.6	1,528	402.7	\$188	\$507	\$606
ө 7 ⁴¹	Eritrea	Low	0.033	\$27,392	\$26,438	4.3	1,942	120.5	\$227	\$219	\$1,753
8 ⁴²	Haiti	Low	0.028	\$30,836	\$31,570	4.4	3,128	123.0	\$251	\$257	\$869
9 43	India	Lower middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$733
10 44 11	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354
12 ⁴⁵	Yemen	Lower middle	0.025	\$37,035	\$21,139	4.3	3,128	122.9	\$301	\$172	\$719
1 3 46	Pakistan	Lower middle	0.020	\$41,856	\$19,714	3.8	2,748	108.1	\$387	\$182	\$904
14 ₄₇ 15	Papua New Guinea	Lower middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$864
1 6 98	Guatemala	Lower middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$627
1749	Cambodia	Low	0.014	\$38,413	\$31,172	1.9	1,341	54.3	\$708	\$574	\$739
1850 19	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883
20 ⁵¹	Bolivia	Lower middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668
2152	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758
22 ₃	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
23 24	Indonesia	Lower middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793
25 ⁵	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046
2 6 56 27	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,954	1.1	735	31.2	\$4,607	\$3,907	\$579 r
28් ⁷	Uzbekistan	Lower middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717 :
29 58	Morocco	Lower middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650
30 3 9 21	Ukraine	Lower middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$600
31 32 ⁶⁰	Thailand	Upper middle	0.005	\$90,759	\$100,377	1.8	455	48.7	\$1,863	\$2,061	\$622
33 ⁶¹	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664
3462	Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$591
35 ₆₃ 36	Brazil	Upper middle	0.004	\$104,534	\$65,501	0.6	1,385	19.2	\$5,431	\$3,403	\$581
37 ⁶⁴	Peru	Upper middle	0.004	\$95,580	\$59,439	0.6	1,497	19.0	\$5,026	\$3,126	\$613
3865	Colombia	Upper middle	0.003	\$95,580	\$63,657	0.6	1,419	20.5	\$4,652	\$3,098	\$598
39 ₆	Mexico	Upper middle	0.003	\$127,264	\$134,901	0.3	0	9.6	\$13,197	\$13,989	\$583
40. 67 41	Philippines	Lower middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$724
41 42 ⁹⁸	Argentina	Upper middle	0.003	\$147,238	\$101,854	0.6	1,097	18.1	\$8,155	\$5,642	\$577
436 9	China	Upper middle	0.001	\$84,560	\$74,564	0.1	486	4.7	\$18,015	\$15,886	\$638
44 ₇₀ 45	Turkey	Upper middle	0.001	\$125,197	\$58,058	0.1	1,784	6.1	\$20,489	\$9,501	\$582
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	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 A
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	\$1,10
3	Guinea-	Low	0.134	\$29,459	\$16,675	26.9	5,465	754.3	\$22	\$39	\$1,00
4	Bissau 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	\$1,53
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 \$1,49 \$1,09
13	Congo, DR	Low	0.112	\$24,637	\$24,258	9.3	1,852	259.2	\$94	\$95	\$1,49
14	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648	282.6	\$86	\$99	\$1,09
15	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532	221.8	\$164	\$127	\$996
16	Cen. African	Low	0.105	\$27,392	\$29,606	7.1	1,444	194.2	\$152	\$141	\$1,23
17	Rep. 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
	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	\$1,02 \$674
	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	\$674 \$801 \$910 \$577
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	\$577 \$1,73
27	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,637	167.4	\$193	\$201	\$035
28	Тодо	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	\$864 \$768 \$756 \$883
30	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522	199.0	\$212	\$273	\$756
	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
1 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
	Papua New	Lower middle	0.018	\$40,479	\$31,703	1.2	1,489	35.8	\$885	\$1,130	\$864
48	Guinea 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
	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	\$1,040
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
	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
	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
	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
	Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	633	6.8	\$17,487	\$21,512	\$577
9 69	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280	2.3	\$33,785	\$36,384	\$638
	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029	3.9	\$22,267	\$32,314	\$582

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				Diar	rhea	Ma	laria	ŀ	IIV
Country	Total DALY burden (3 diseases)	Population	DALYs per capita	Diarrhea burden	DALYs	Malaria burden	DALYs	HIV burden	DALY
Swaziland	158,061	1,055,506	0.1497	8.4	16,523	0.03	4,338	25.9	137,20
Mozambique	3,288,897	23,390,765	0.1406	11.9	532,817	12.49	1,482,080	11.5	1,274,0
Guinea-Bissau	203,103	1,515,224	0.1340	19.1	78,434	17.65	104,089	2.5	20,58
Nigeria	21,145,996	158,423,182	0.1335	18.7	4,995,101	20.19	12,818,894	3.6	3,332,0
Zambia	1,654,717	12,926,409	0.1280	14.6	410,637	15.24	499,280	13.5	744,80
Burkina Faso	2,079,356	16,468,714	0.1263	18.9	659,064	20.39	1,353,652	1.2	66,64
Mali	1,905,686	15,369,809	0.1240	19.2	715,293	20.83	1,145,312	1	45,08
Somalia	1,131,667	9,330,872	0.1213	21.8	534,781	5.85	512,605	0.7	84,28
Chad	1,341,959	11,227,208	0.1195	21.9	652,646	18.59	400,213	3.4	289,10
Sierra Leone	698,366	5,867,536	0.1190	20.9	246,659	12.94	405,647	1.6	46,06
Burundi	991,869	8,382,849	0.1183	23.6	393,025	9.25	461,645	3.3	137,20
Lesotho	250,467	2,171,318	0.1154	9.9	25,067	0.00	Unknown	23.6	225,40
Congo, DR	7,371,699	65,965,795	0.1118	18.5	3,414,271	17.02	3,389,027	1.3	568,40
Niger	1,711,372	15,511,953	0.1103	20.3	744,317	17.95	907,275	0.8	59,78
Malawi	1,632,385	14,900,841	0.1095	10.9	431,392	16.64	485,593	11	715,40
Cen. African Rep.	463,590	4,401,051	0.1053	17.3	140,555	14.32	272,074	4.7	50,96
Uganda	3,513,177	33,424,683	0.1051	16.0	1,078,814	22.40	1,258,363	6.5	1,176,0
Cameroon	1,957,804	19,598,889	0.0999	16.2	683,514	19.05	705,891	5.3	568,40
South Africa	4,851,895	49,991,300	0.0971	8.7	1,010,490	0.07	19,404	17.8	3,822,0
Guinea	950,891	9,981,590	0.0953	13.8	305,921	23.62	584,210	1.3	60,76
Liberia	367,478	3,994,122	0.0920	17.2	112,638	15.56	231,809	1.5	23,03
Angola	1,682,066	19,081,912	0.0881	25.0	974,838	8.41	491,628	2	215,60
Côte d'Ivoire	1,651,534	19,737,800	0.0837	13.2	518,311	21.10	966,623	3.4	166,60
Benin	732,327	8,849,892	0.0827	13.0	248,863	23.34	435,445	1.2	48,02
Botswana	161,239	2,006,945	0.0803	7.0	13,221	1.04	10,818	24.8	137,20
Zimbabwe	944,891	12,571,454	0.0752	9.2	132,798	3.43	204,493	14.3	607,60
Tanzania	3,360,788	44,841,226	0.0749	11.6	1,025,316	16.43	1,355,472	5.6	980,00
Тодо	450,236	6,027,798	0.0747	11.6	124,279	25.67	227,957	3.2	98,00
Rwanda	753,413	10,624,005	0.0709	22.6	357,674	5.91	309,499	2.9	86,24
Congo, Rep.	270,651	4,042,899	0.0669	14.3	81,602	23.85	125,349	3.4	63,70
Kenya	2,637,405	40,512,682	0.0651	20.5	796,738	10.94	762,667	6.3	1,078,0
Ghana	1,542,491	24,391,823	0.0632	9.5	669,521	26.25	657,370	1.8	215,60
Gabon	90,936	1,505,463	0.0604	5.9	16,740	29.32	38,915	5.2	35,28
Ethiopia	4,754,652	82,949,541	0.0573	22.8	3,507,206	6.78	1,247,446	1.5	Unknov
Sudan	1,925,260	33,603,637	0.0573	10.6	850,260	24.89	526,200	1.1	548,80
Afghanistan	1,954,973	34,385,068	0.0569	28.9	1,864,324	0.01	90,648	0.2	Unknov
Senegal	623,509	12,433,728	0.0501	14.8	229,547	18.73	335,162	0.9	58,80
Madagascar	881,807	20,713,819	0.0426	22.5	368,469	3.51	486,388	0.2	26,95
Mauritania	144,515	3,459,773	0.0418	15.7	83,866	13.33	46,929	0.7	13,72
Namibia	87,587	2,283,289	0.0384	6.3	15,072	5.11	15,675	13.1	56,84
Eritrea	175,006	5,253,676	0.0333	21.4	83,796	0.28	78,470	0.8	12,74
Haiti	280,740	9,993,247	0.0281	20.3	173,247	0.87	21,253	1.9	86,24
India	33,617,476	1,224,614,327	0.0275	13.0	30,747,070	0.34	1,498,406	0.3	1,372,0

59 60

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

33 34

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35 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

36 DALYS per capita: DALYS per person, calculated as total DALY burden, diahrrel disease divided by population.

37 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.

39 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.</p>

40 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

41 HIV burden: Prevalence in 15-49 year olds. Source: AIDSING d. DALYs (HIV): Total DALYs from HIV/AIDS. Source: derivation.

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Tech. Suppl Table 5. Results for Kenya, Banglades	h and Nigeria, per 1000 campaign participants.
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Disease averted DALYs averted Costs averted (added)	Deaths Episodes Prevention Earlier HIV care TOTAL Prevention Earlier HIV care TOTAL	LLITN Keny 1.6 133.6 44.1 44.1 \$773	Filters 2.4 1,877.7 68.3 68.3 \$9,068	VCT 4.8 7.0 40.0 123.5 181.8 \$40,889	Condoms 2.2 18.2	TOTAL 10.9 2,018.3 170.6 123.5 294.1
averted DALYs averted Costs averted	Episodes Prevention Earlier HIV care TOTAL Prevention Earlier HIV care	1.6 133.6 44.1 44.1	2.4 <u>1,877.7</u> 68.3 68.3	7.0 40.0 123.5 181.8		2,018.3 170.6 123.5
averted DALYs averted Costs averted	Episodes Prevention Earlier HIV care TOTAL Prevention Earlier HIV care	133.6 44.1 44.1	1,877.7 68.3 68.3	7.0 40.0 123.5 181.8		2,018.3 170.6 123.5
DALYs averted Costs averted	Prevention Earlier HIV care TOTAL Prevention Earlier HIV care	133.6 44.1 44.1	1,877.7 68.3 68.3	7.0 40.0 123.5 181.8		2,018.3 170.6 123.5
averted Costs averted	Prevention Earlier HIV care TOTAL Prevention Earlier HIV care	44.1 44.1	68.3 68.3	40.0 123.5 181.8	18.2	170.6 123.5
averted Costs averted	Earlier HIV care TOTAL Prevention Earlier HIV care	44.1 44.1	68.3 68.3	123.5 181.8	18.2	170.6 123.5
averted Costs averted	Earlier HIV care TOTAL Prevention Earlier HIV care	44.1	68.3	123.5 181.8	18.2	123.5
Costs averted	TOTAL Prevention Earlier HIV care			181.8		
averted	Prevention Earlier HIV care					294 1
averted	Prevention Earlier HIV care					
averted	Earlier HIV care	\$773	\$9,068	<u> </u>		
				γ-0,00J	\$18,588	\$69,318
ζ ,						
	TOTAL			(\$81,187		(\$81,187
)		
	TOTAL	\$773	\$9,068	(\$21,710		-\$11,869
Cost-	Compaign coat)		¢24.00
effectiveness	Campaign cost (unadjusted)					\$34,280
	Net cost (savings)					\$46,14
	Cost per DALY averted					\$15
						ζ15
		Banglad	desh			
Disease averted	Deaths	0.1	0.8	0.0	0.0	0.9
aventeu	Episodes	14.7	1061.3	0.1		1076.1
DALYs	Prevention	1.7	22.4	0.4	0.2	24.7
averted					0	
	Earlier HIV care			1.2		1.2
	TOTAL	1.7	22.4	1.8		25.9
Costs averted	Prevention	\$89	\$5,527	\$389	\$189	\$6,196
(added)						
()	Earlier HIV care			(\$773)		(\$773)
	TOTAL	\$89	\$5 <i>,</i> 527	(\$195)		\$5,422
Cost-	Campaign cost					\$36,658
effectiveness	(unadjusted) Net cost (savings)					620.22
	Cost per DALY averted					\$30,23
					-	\$1,16
		Niger				
Disease	Deaths	6.0	3.4	2.7	1.3	13.4
averted	Episodes			4.0		
	200000	734.3	2,363.3	т. U		3,101.
DALYs	Prevention	168.8	97.6	21.8	10.2	298.4
averted						

	Earlier HIV care TOTAL	160.0	97.6	70.8 102.9		70.8
Costs averted	Prevention	168.8 \$6,223	\$14,300	\$28,605	\$13,379	369.3 \$62,507
(added)	Earlier HIV care			(\$55,797)		(\$55,797)
	TOTAL	\$6,223	\$14,300) (\$14,813)		\$5,710
Cost- effectiveness	Campaign cost (unadjusted) Net cost (savings)					\$40,479 \$34,769
	Cost per DALY averted					\$94

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

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.

otswana\$703Menzies, 2011razil\$1,786Acurcio, 2006 (Cited in Galarraga 2011)thiopia\$610Menzies 2011; Bikilla et al. 2009; aitiaiti\$1,120Koenig 2008idia\$230Gupta 2009esotho\$165Cleary 2006lexico\$5,990Bautista 2003; Bautista 2008; Aracena-Genaolorocco\$1,102Loubiere 2008 (Cited in Galarraga 2011)igeria\$938Menzies, 2011; Kombe 2004outh Africa\$1,260Cleary 2006; Kevany 2009; Deghaye 2006; Martinson 2009; Rosen 2008hailand\$3,994Kitajima 2003apada\$905Maragillo 2000; Jaffar 2000	ART UN	IT COSTS	
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	Vietnam	\$964	Menzies, 2011
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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.

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 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		Dise	ease		Cost-		
						ave	rted		effectiven	ess (CE)	
	Country	World Bank income classificat ion	DALY s per capit a	IPC campaig n cost	Net cost	Deaths	Episod es		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
1 0	Guinea	Low	0.095	\$31,875	\$21,102	12.6	4,272	355.2	\$90	\$59	\$928
1	Lesotho	Lower middle	0.115	\$55,557	\$54,805	31.3	1,756	859.0	\$65	\$64	\$738
2	Congo, DR	Low	0.112	\$25,386	\$25,306	13.4	3,517	376.8	\$67	\$67	\$1,493
1 3	Chad	Low	0.120	\$28,103	\$29,728	15.3	4,335	427.1	\$66	\$70	\$807
1 4	Liberia	Low	0.092	\$36,982	\$23,225	11.9	3,401	333.2	\$111	\$70	\$1,025
1 5	Côte d'Ivoire	Lower middle	0.084	\$43,278	\$30,730	14.1	4,021	393.7	\$110	\$78	\$801
1 6	Burundi	Low	0.118	\$28,504	\$34,224	14.3	2,267	393.6	\$72	\$87	\$987
1 7 1	Uganda	Low	0.105	\$37,888	\$36,726	14.9	3,492	409.5	\$93	\$90	\$749
8	Benin	Low	0.083	\$32,216	\$25,362	10.0	3,096	280.0	\$115	\$91	\$910
1 9	Nigeria	Lower middle	0.133	\$45,846	\$34,213	13.4	3,102	370.6	\$124	\$92	\$747
2 0	Mozambique	Low	0.141	\$31,652	\$58,371	22.2	3,816	606.8	\$52	\$96	\$1,109
2 1	Cen. African Rep.	Low	0.105	\$26,663	\$37,686	13.8	2,819	380.3	\$70	\$99	\$1,230
2	Congo, Rep.	Lower middle	0.067	\$42,684	\$33,709	11.5	2,981	319.7	\$134	\$105	\$756
3	Togo	Low	0.075	\$32,973	\$32,220	10.4	2,849	287.6	\$115	\$112	\$864
2 4	Zambia	Lower middle	0.128	\$38,512	\$68,361	21.8	3,107	594.6	\$65	\$115	\$826
2 5	Malawi	Low	0.110	\$34,146	\$58,110	18.3	2,965	496.4	\$69	\$117	\$996
6	Tanzania	Low	0.075	\$30,345	\$39,174	12.1	3,122	331.0	\$92	\$118	\$935
2 7	Ethiopia	Low	0.057	\$28,371	\$28,810	8.6	1,986	237.4	\$120	\$121	\$1,139

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2 8	Angola	Upper middle	0.088	\$53,374	\$39,069	11.5	3,268	321.5	\$166	\$122	\$674
2 9	Cameroon	Lower middle	0.100	\$39,729	\$52,377	14.3	3,115	394.2	\$101	\$133	\$741
3 0	Rwanda	Low	0.071	\$43,307	\$37,051	9.6	2,216	265.0	\$163	\$140	\$768
3 1	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
3	Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	478.9	\$53	\$159	\$1,731
) 3 3	Yemen	Lower middle	0.025	\$39,388	\$20,853	4.3	3,128	122.6	\$321	\$170	\$719
3	Mauritania	Lower middle	0.042	\$39,952	\$29,100	5.8	2,607	164.0	\$244	\$177	\$955
3	Ghana	Lower	0.063	\$37,606	\$34,488	6.8	1,966	189.9	\$198	\$182	\$746
$\frac{3}{5}$	Pakistan	Lower middle	0.020	\$35,334	\$20,601	3.8	2,748	108.0	\$327	\$191	\$904
\overrightarrow{b} $\overrightarrow{3}$ 7	Madagascar	Low	0.043	\$27,806	\$24,564	4.5	1,910	127.6	\$218	\$192	\$1,025
3	Eritrea	Low	0.033	\$24,332	\$25,362	4.3	1,942	119.5	\$204	\$212	\$1,753
$\frac{8}{3}$	Swaziland	Lower middle	0.150	\$88,325	\$197,22 5	29.1	2,230	800.0	\$110	\$247	\$632
4	Haiti	Low	0.028	\$34,310	\$31,765	4.4	3,128	121.7	\$282	\$261	\$869
2 0	Botswana	Upper	0.080	\$151,324	\$196,11 7	26.8	1,111	734.1	\$206	\$267	\$577
$\frac{1}{4}$	Guatemala	middle Lower	0.016	\$76,551	\$19,936	2.4	3,143	68.3	\$1,121	\$292	\$627
6 <u>4</u>	Myanmar	middle Low	0.026	\$25,550	\$25,518	2.9	1,306	83.1	\$307	\$307	\$1,354
7 <u>3</u> 3 4	India	Lower	0.027	\$45,178	\$33,274	3.7	1,255	104.6	\$432	\$318	\$733
$\frac{4}{4}$	Papua New	middle Lower	0.018	\$44,272	\$24,760	2.4	2,868	70.6	\$627	\$351	\$864
4	Guinea South Africa	middle Upper	0.097	\$167,731	\$223,29	21.5	1,150	579.7	\$289	\$385	\$582
2 6 4 7	Gabon	middle Upper	0.060	\$104,762	2 \$107,28	9.3	1,876	251.5	\$417	\$427	\$613
4	Iraq	middle Upper	0.009	\$43,990	8 \$25,081	1.9	2,587	55.5	\$792	\$452	\$758
5 8 6 4	Namibia	middle Upper	0.038	\$113,745	\$218,64	15.6	1,528	416.7	\$273	\$525	\$606
7 9 5 3 0	Cambodia	middle Low	0.014	\$41,971	2 \$32,821	1.9	1,341	53.9	\$779	\$609	\$739
5	Nepal	Low	0.010	\$33,760	\$30,891	1.4	1,135	39.2	\$861	\$788	\$883
) 1	Morocco	Lower	0.006	\$72,424	\$50,688	1.9	1,623	54.5	\$1,329	\$930	\$650
2 5	Bangladesh	middle Low	0.007	\$31,949	\$28,039	0.9	1,076	25.8	\$1,237	\$1,086	\$1,046
5	Algeria	Upper	0.008	\$87,063	\$59,839	1.4	1,304	40.8	\$2,136	\$1,468	\$606
5 <u>4</u> 5 5	Uzbekistan	middle Lower	0.006	\$54,666	\$26,791	0.6	2,352	18.1	\$3,021	\$1,481	\$717
5	Indonesia	middle Lower	0.008	\$44,169	\$38,316	0.7	814	20.5	\$2,158	\$1,872	\$793
6 6 5	Thailand	middle Upper	0.005	\$79,120	\$90,878	1.8	455	46.5	\$1,700	\$1,952	\$622
) 7 5	Bolivia	middle Lower	0.010	\$67,123	\$33,507	0.4	2,015	13.1	\$5,105	\$2,549	\$668
2 5	Vietnam	middle Lower	0.005	\$51,726	\$44,913	0.6	828	16.7	\$3,102	\$2,694	\$664
3 9 6	Ukraine	middle Lower	0.006	\$105,326	\$92,351	1.2	623	32.8	\$3,209	\$2,814	\$600
0	Peru	middle Upper	0.004	\$104,227	\$63,328	0.6	1,497	17.8	\$5,864	\$3,563	\$613
6 0 0	Philippines	middle	0.003	\$51,949	\$39,286	0.3	1,289	10.8	\$4,832	\$3,654	\$724
3 2		middle	0.000	φο1,040	<i>\\</i> 00,200	0.0	1,200	10.0	ψ 1,002	φ0,004	Ψ 1 Ε Τ

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6 3	Colombia	Upper middle	0.003	\$129,275	\$80,234	0.6	1,419	18.7	\$6,900	\$4,283	\$598
6 4	Malaysia	Upper middle	0.004	\$122,297	\$93,832	0.6	930	16.5	\$7,428	\$5,699	\$591
6 5	Brazil	Upper middle	0.004	\$186,498	\$105,36 5	0.6	1,385	18.1	\$10,306	\$5,822	\$581
6 6	Russian Federation	High: nonOECD	0.007	\$240,707	\$192,69 0	1.1	735	30.2	\$7,975	\$6,384	\$579
6 7	Argentina	Upper middle	0.003	\$252,229	\$164,21 3	0.6	1,097	16.6	\$15,161	\$9,871	\$577
6 8	Turkey	Upper middle	0.001	\$191,725	\$80,928	0.1	1,784	5.9	\$32,276	\$13,624	\$582
6 9	China	Upper middle	0.001	\$93,151	\$81,634	0.1	486	4.4	\$20,990	\$18,395	\$638
7 0	Mexico	Upper middle	0.003	\$179,550	\$187,18 7	0.3	0	8.7	\$20,612	\$21,489	\$583
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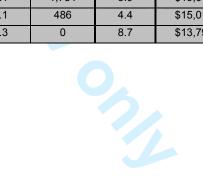
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Tech. Suppl. - Table 9. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. 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		_	ease erted		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	Mozambiqu	Low	0.141	\$28,771	\$59,852	22.2	3,816	606.8	\$47	\$99	\$1,10
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	Тодо	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
50	Linuod	2000	0.000	φ 2 0,001	<i>420,200</i>		1,042	110.0	<i><i><i><i>ψ</i>_20</i></i></i>	<i>\\</i>	ψ1,700

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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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.

Figure 6. Tech Suppl. - Figure 6.



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20	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 percapita 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 5583 million over three years (adjusted costs of 5398 million), averting 8.0 million DALYs. Extending IPC programs to all 70 of the identified high-burder countries at 15% coverage would cost an adjusted \$51.3 billion and avert 78.7 million DALYs. Incremental cost-effectiveness sranged from \$49 per DALY averted for the 10 countries with the most 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.



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19 20 21	Strengths and limitations of this study. Strengths	
22 23	 Synthesizes a large volume of epidemiological data from disparate sources into a unified method for orjociting 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 	
24 25 26	objective resource allocation decision-making for global health. <i>Limitations</i> • 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.	
27 28 29	 Regions or urban areas within countries may have costs and health benefits that depart from the overall country assessments. 	
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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 Recent initiatives have therefore sought to integrate programs for multiple diseases, and many have demonstrated feasibility, efficiencies and success.⁵

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, insecticid-treated bed nets (ITNs), point-of-use water filters, and HIV testing and counseling to more than 80% of the target population.⁷ Those testing positive for HIV were offered on-site CD4 count determination, cottimoxazole prophylaxis, and referral to comprehensive HIV are and reader and the campaign yielded large health benefits and net ecconomic savings.⁷ I arge-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 middel-income countries, finding that the opportunity for a diarrhea, malaria and HIV IPC is not limited to Kenya.⁸ I is plausible that IPCs can have a large impact on health in many resource-limite settings. resource-limited settings.

While the cost-effectiveness of this IPC in Western Kenya has been established8, the economic While the cost-effectiveness of this IPC in Western Kenya has been established', 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, see 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 Kenya⁸. Countries were closen for inclusion in the analysis based on two factors: they were classified as low- or middle-income as defined by the World Bank¹⁰, 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 commiss (i.e., 287,000 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 Sundament.¹ Supplement). We derived incidence and case fatality rates for each country from published



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	reports, using regional averages and other approximations when country-specific estimates were	
20	missing. We developed a mix of empirical (where available) and modeled (projected from empirical data) cost estimates applied to all 70 countries. Key outcome examined included the	
21	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;	
22	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	
23	denominated in 2012 U.S. dollars. The time frame of the analysis is three years for the empirical	
24	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	
25	HIV	
26	Detailed model features We adapted a Microsoft Excel spreadsheet that we had previously constructed to analyze the	
27	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	
28	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	
29	agenda for most HIV-affected countries.	
30	Cost estimates and projection methods. Campaign costs for the Kenya IPC were obtained from published empirical data supplemented by filter repair and replacement costs. ⁷⁸ We estimated	
31	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,	
32	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,	
33	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	
34	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	
35	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	
36	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.	
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spials). By comparing the WHO-CHOICE-derived costs for yet a third index can be created. However, the WHO- ort-comings. In addition to not reflecting the specific mix of s, the methods used to derive the costs are somewhat rodel used to predict country health care costs includes per- to using a per-capita GIDP-based index. Table 8 of the e-case results using the per-capita health care spending all Supplement uses the index derived from WHO-CHOICE. he cost-effectiveness results by country rankings when			
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20	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
21	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
22	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 \$7.5% of baseline. New nets and filters in a second campaign reduce disease risks
23	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
24 25	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
26	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
27	number of cases " by the total country population ". 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 ⁴⁰ (details in technical supplement). ⁸⁶¹ Multiplying each estimate by the total population ⁴⁸ yields the estimated number of cases in each country.
28	
29	We calculated country-specific case fatality rates for malaria and diarrhea as the number of deaths due to the disease ^{25,25} 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
30 31	assumed a case fatality rate for HIV of 100%.
32	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
33	non-fatal case of each disease as the product of the disability weight (0.19) for malaria and 0.105 for diarrhea) ⁵⁷ and the average duration of each case (7 days for malaria ⁸⁸ , 4.43 days for diarrhea, a severity weighted duration for children and adults ⁷⁸ , or 0.0037 and 0.0013 DALYs for
34	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
35	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.
36 37	Household size and beneficiaries per household. Using country-specific data of rural household
38	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
39	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
40	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
41	all countries. ⁸ See Table 1 for base case values and sources for data inputs.
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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 "opportanity 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 (relatively favorable); and Bangladesh, a low-income country at the 25th percentile (relatively favorable); and Bangladesh, a low-income country at the 25th percentile (relatively favorable); and Bangladesh, a low-income country at most and the mean. Maximum and minimum values were set as 1.5 and 0.5 times the base case, except for access to malatiar and diarthea 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 costeffectiveness. With the exception of Afghanistan, the 30 counties with the most favorable costeffectiveness are in sub-Saharan Africa. The cost-effectiveness of IPC compares favorably to the cost-effectiveness of ART in \$1 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 5883 million for the three-year campaign, with a net cost after adjusting for effects on health care spending of \$398 million for the first and second campaigns would avert 8.0 and 5.7 million DALY's 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. 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 costeffective than IPC for the 51^s – 60th and for the 61st – 70th country, as ranked by IPC costeffectiveness.

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 53,568. When adjusted for modest offisetting 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 analysts. Figure 2 is a tomado 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, S126 per DALY averted), followed by the multiplier that reflects prevention of secondary HIV transmission, the duration of the prevention benefits of HIV interventions (range, S122 per DALY averted) est of the IPC campaign (range, S110 per DALY averted), and the reduction in mortality due to reduced HIV transmission (range, S83 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, \$1,140 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 scondary 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, \$117 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 area jets more favorable than the cost-effectiveness of ART for HU, S304 versus S883 per DALY averted for Kenya and S208 versus 5747 per DALY averted for Nigeria. For Bangladesh, the least favorable end of the cost-effectiveness of ART for HU, S304 versus 5883 per DALY averted for Kenya and S208 versus 5747 per DALY averted for Nigeria. For Bangladesh, the least favorable end of the cost-effectiveness of 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 HU prevention of sectoradary HU transmission (r = 0.51), the number of IPC participants per household (r = 0.53), cost of the IPC campaign (r= 0.51), end the reducetion in mortality due to reduced HU transmission (r= -0.24), (Figure 4). See Technical Supplement Figure 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). Supplement Figure 6).



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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 eartier 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 population⁴⁸ ³⁹ and 98% of its disease burden.⁴¹ 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 S8% of the disease burden due to HIV, malaria and diarrheal disease in these countries. 54.9 billion is considerably less than the President's request to the United States Congress for FY 2013 for \$6.4 billion for the PEPFAR program⁴⁰ and thus might be affordable from a door'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 \$1 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 50th. 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 diseaseintervention pair such a finding would be unsurprising since the cost-effectiveness of most prevention interventions depend importantly on incidence. It is more networthy here since the relative prevalence of the three diseases varies greatly between the countries we studied, and the effect on medical care costs of interventing 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 suprisingly, the most important determinant of cost-effectiveness was the estimated duration of the benefits of the water filter and the baseline incidence or diarrhea. Kernya 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 making 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 dismarke sources in to a unifed method for moriectime the consecutore of IPC

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 costeffectiveness. 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.

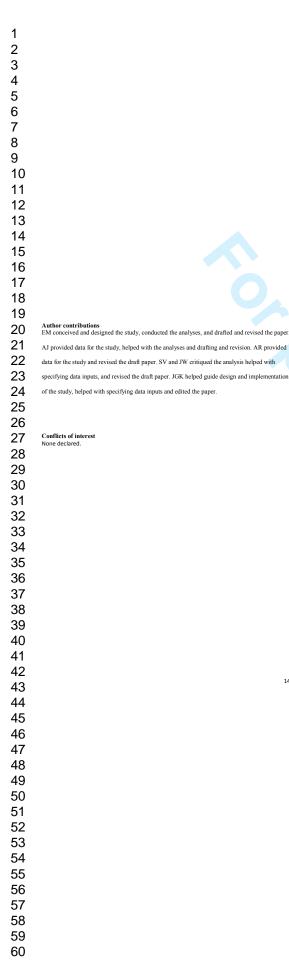
Limitations of our approach include incomplete availability of data relevant to the large number of countries analyzed. Methods for approximation were therefore necessary. For example, the costs of the campaigns themselves were extrapolated from empirical Kenya-specific data using per-capit GDP ratios 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 was accounted for uncertainty, and this produced wide confidence intervals around the model outcomes.

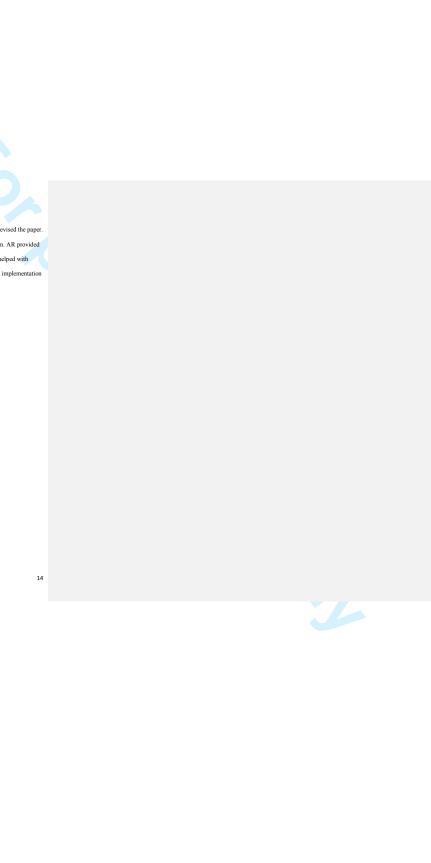
This study provides substantial evidence that IPC campaigns can be cost-effective in a large number of low and middle-income countries epidemic settings. However, it leaves unanswered important questions that need to be addressed when these broad findings are translated into a programs and policies. 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 impoed by all three disease is uneven. '(See Table 4 of the Technical Supplement for a breakdown of the contribution of each disease to the total burden disease). 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 more costly to cover the next community, while the benefit of covering that community inght decline. However, prior to implementation, country-specific analyses would be required to determine for which subset of countries it would be more oxite of cover the next community.



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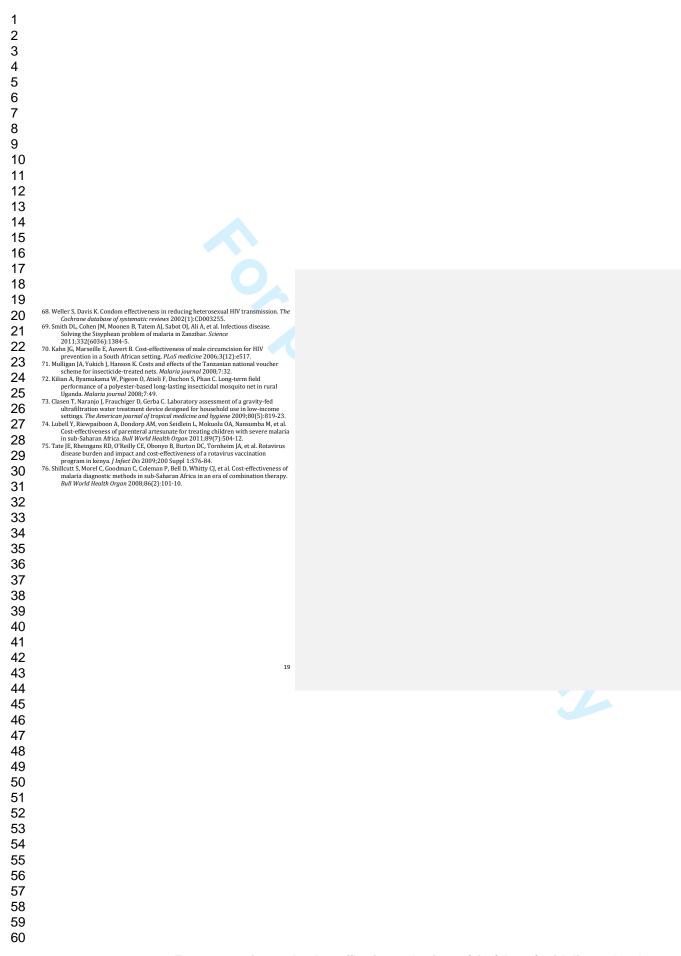
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41	public health 2012;12:220.	
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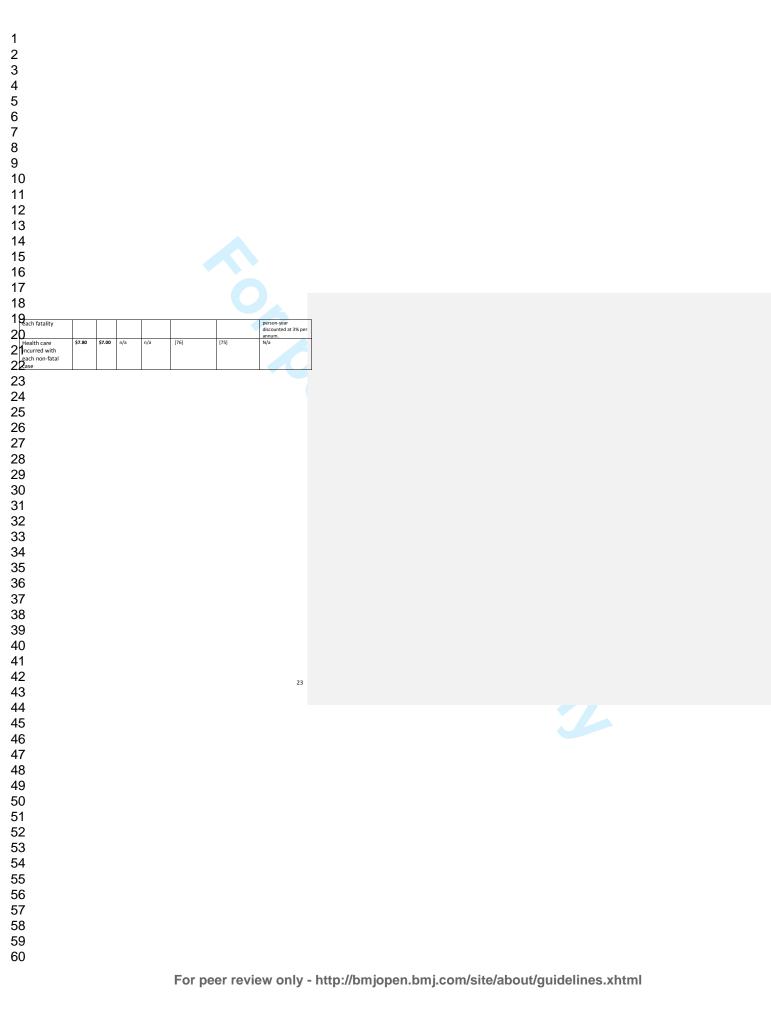
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	Figure Legends
20	Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (DALYs
21	per capita) (Campaign 1, n=70)
22	Figure 2. Tornado Graph of Cost per DALY averted –Nigeria: Impact by Input
23	Figure 3. One-way sensitivity analysis of incremental cost-effectiveness by three key variables in 10-country increments ranked by IPC cost-effectiveness.
24	Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and
23 24 25	cost per DALY averted – Nigeria.
26	Tech. Suppl Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index
27	(Campaign 2, n=70)
28	Tech. Suppl Figure 2. Tornado Graph of Cost per DALY averted – Bangladesh: Impact by Input
29	Tech. Suppl Figure 3. Tornado graph of cost per DALY averted - Kenya
30	Tech. Suppl Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between
30 31	input values and cost per DALY averted – Bangladesh.
32	Tech Suppl Figure 5. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Kenya.
33	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.
33 34	campaigns in Kenya, projected to 50 years, per 1,000 participants.
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O able 1. Base case v	alues and	sources for	r data ir	puts. Bold fi	gures represent vali	ues that change with	n each country.			
1	Malari a	Diarrhe a		HIV		Source(s)				
2	LLIN	Filters	VCT	Condom s	LLIN	Filters	VCT / condoms			
Blealth in ⁶¹ puts Campaign				,						
Campaign Participant per household		2	.5			Post-campaign sur	/ey			
Sumber Bumber benefiting per	1.563	1.840	0.95	0.361		Post-campaign sur	/ey			
Benefiting per Bampaign Participant			0							
aseline cases per year per individual	0.057	0.542	0.00 4	0.009	[47, 48]	[49-51]	[8,62-64] Post-campaign survey			
enefiting roportion of							(see text)			
Gases that are atal	0.012	0.001	1	1	[47, 52, 54]	[48, 49, 51, 59, 62]	Assumption			
ALYs incurred With each fatal	28.0	28.0	15.1	15.1	[56]	[56]	[56]			
With each fatal										
Case DALYs incurred With each non- Hatal case	0.0037	0.0012	n/a	n/a	[57, 58]	[57, 59]	N/a			
Brotective effect gainst mortality	0.50	0.63	0.50	0.26	[65], expert opinion	[66]	[67, 68]			
rotective effect gainst non-fatal	0.5	0.63	n/a	n/a	[65]	[66]	N/a			
Figainst non-fatal Fases Multiplier to		,			1501		1701 /			
6 enefits	n/a bit	n/a	2	2	[69]	N/a	[70] (see text)			
7 ears of benefit	3	3	1	1	[71, 72] Adjusted to 3 years per post-campaign evaluation.	[73] Adjusted to 3 years per post- campaign	[68]			
Access to care	0.684	0.678	0.70 0	0.700	evaluation. [14-19]	evaluation. [20]	Assumption			
Cost inputs	\$34,280				[7] \$21 090 plus -d	ditional \$2,200 in	ired filter mainter and			
O ^{ampaign cost}	3.0%				[7] \$31,980 plus ad costs [10]	unional \$2,500 IN PEV	ised filter maintenance			
Discount rate Health care	\$65	\$104	\$12,213	\$12,213	[64, 74]	[75]	Authors' construction based on 22 years on			
Health care incurred with							ART at \$766 per 22			
3							22			
4										
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change with each country.		Nigeria		-	Kenya		Ba	nalades	s that
Input parameter	Base	Min	Max	Base	Min	Max	Base	Min	Max
Campaign cost	case \$40,479	\$20.239	\$60,718	case \$34,280	\$17.140	\$51,420	case \$35.658	\$17.829	\$53,486
Campaign cost	\$40,479	\$20,239	\$60,716	\$34,200	\$17,140	\$51,420	\$35,656	\$17,029	\$53,400
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
5 Cost per non-fatal case	\$11.70	\$5.85	\$17.55	\$7.80	\$3.90	\$11.70	\$8.67	\$4.33	\$13.00
Cost per non-fatal case	\$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
8Access 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
rears 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	765.3	382.7	1148.0	542.0	271.0	813.0	299.81	149.91	449.72
Diarrhea Bropor 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
m)	0.366	0.183	0.549	0.366	0.183	0.549	0.366	0.183	0.549
DALYs non-fatal malaria									
DALYs non-fatal malaria DALYs non-fatal diarrhea	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191
DALYs non-fatal malaria	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191

39 rotect. non fatal malaria

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ect. mortality HIV

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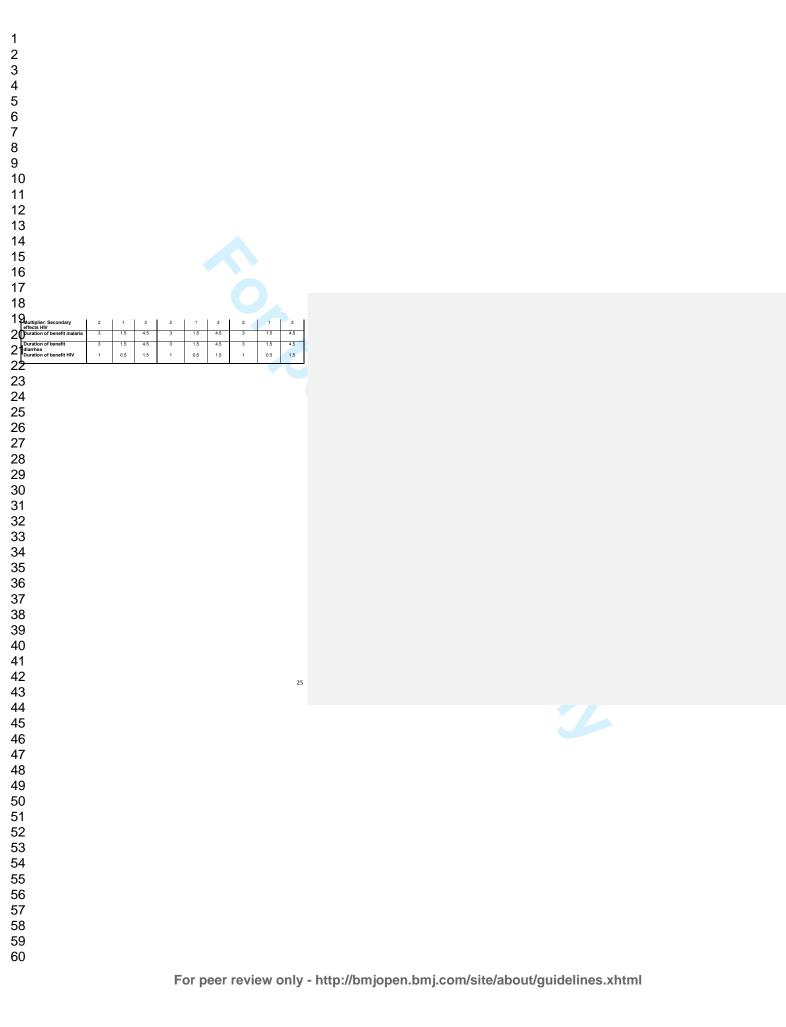
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20 ^{ess}	le 3. Summar rable to least favorable that	y costs and co favorable cost n investment i	st-effective -effective n ART. R	esults sho	wn are for	the first	3-year can	for 70 co grey highl paign.				
21	Country	World Bank	DALYs	Co IPC cost		Di seas Deaths	e averted	DALYs	Cost-eff Campaign	Net cost		
22 23	oounity	income classification	per capita		Net cost	beams	Episodes	averted	cost per DALY averted	per DALY averted	CE of ART	
23 24	Guinea- Bissau Senegal	Low	0.134	\$29,459 \$34,969	\$7,814 \$12,190	40.7	10,523	1,143.3	\$26 \$114	\$7 \$40	\$1,005 \$768	
25	Sierra Leone Burkina Faso	Low Low	0.119	\$31,525 \$31,525	\$20,112 \$22,206	16.0 16.4	4,118 4,124	446.7 459.4	\$71 \$69	\$45 \$48	\$764 \$819	
26 ⁵	Somalia Niger Mali	Low Low Low	0.121 0.110 0.124	\$26,015 \$28,081 \$29,459	\$22,754 \$21,620 \$23,016	16.8 14.8 15.9	3,682 4,967 4,222	470.5 419.7 445.8	\$55 \$67 \$66	\$48 \$52 \$52	\$1,535 \$1,095 \$888	
2 <mark>7</mark> ,	Afghanistan Chad Lesotho	Low Low Lower middle	0.067 0.120 0.115	\$28,770 \$35,658 \$35,658	\$18,906 \$24,848 \$47,366	12.7 15.3 31.3	4,146 4,335 1,756	356.6 424.6 779.4	\$81 \$84 \$46	\$53 \$59 \$61	\$935 \$807 \$738	
28 [°]	Guinea Congo, DR	Low Low	0.095	\$29,459 \$24,637	\$22,324 \$25,488	12.6 13.4	4,272 3,517	353.8 375.9	\$83 \$66	\$63 \$68	\$928 \$1,493	
29	Sudan Liberia Burundi	Lower middle Low Low	0.057 0.092 0.118	\$38,413 \$26,704 \$26,015	\$15,241 \$25,526 \$33,639	6.9 11.9 14.3	4,907 3,401 2,267	198.8 332.6 389.9	\$193 \$80 \$67	\$77 \$77 \$86	\$703 \$1,025 \$987	
3 <u>4</u> 8	Benin Côte d'Ivoire Nigeria	Low Lower middle Lower middle	0.083 0.084 0.133	\$33,591 \$33,591 \$40,479	\$25,345 \$35,069 \$34,769	10.0 14.1 13.4	3,096 4,021 3,102	280.0 387.2 369.3	\$120 \$87 \$110	\$91 \$91 \$94	\$910 \$801 \$747	
32	Mozambique Cen. African Rep.	Low Low	0.141	\$30,147 \$27,392	\$59,145 \$37,525	22.2	3,816 2,819	590.0 373.3	\$51 \$73	\$100 \$101	\$1,109 \$1,230	
33	Uganda Congo, Rep. Togo	Low Lower middle Low	0.105 0.067 0.075	\$31,525 \$54,254 \$29,459	\$40,192 \$33,944 \$32,147	14.9 11.5 10.4	3,492 2,981 2,849	399.8 318.5 288.7	\$79 \$170 \$102	\$101 \$107 \$111	\$749 \$756 \$864	
34 ⁴ / ₂₅	Angola Tanzania	Upper middle Low	0.088	\$64,586 \$33,591	\$35,794 \$38,453	11.5 12.1	3,268 3,122	320.8 326.9	\$201 \$103	\$112 \$118	\$674 \$935	
35	Zambia Ethiopia Rwanda	Lower middle Low Low	0.128 0.057 0.071	\$33,591 \$30,147 \$31,525	\$69,806 \$29,630 \$34,034	21.8 8.6 9.6	3,107 1,986 2,216	564.3 235.7 266.1	\$60 \$128 \$118	\$124 \$126 \$128	\$826 \$1,139 \$768	
36	Malawi Cameroon Kenya	Low Lower middle Low	0.110 0.100 0.065	\$28,081 \$37,724 \$34,280	\$59,745 \$52,388 \$46,149	18.3 14.3 10.9	2,965 3,115 2,018	462.2 388.4 294.1	\$61 \$97 \$117	\$129 \$135 \$157	\$996 \$741 \$883	
3 <u>7</u> ₂ 38³	Mauritania Yemen	Lower middle Lower middle	0.042	\$36,346 \$37,035	\$28,117 \$21,139	5.8 4.3	2,607 3,128	164.2 122.9	\$221 \$301	\$171 \$172	\$955 \$719	
3 <u>9</u>	Zimbabwe Pakistan Ghana	Low Lower middle Lower middle	0.075 0.020 0.063	\$25,326 \$41,856 \$44,612	\$76,203 \$19,714 \$35,624	17.8 3.8 6.8	1,682 2,748 1,966	428.8 108.1 189.9	\$59 \$387 \$235	\$178 \$182 \$188	\$1,731 \$904 \$746	
40°	Madagascar Eritrea Botswana	Low Low Upper middle	0.043 0.033 0.080	\$28,770 \$27,392 \$137,595	\$24,895 \$26,438 \$185,87	4.5 4.3 26.8	1,910 1,942 1,111	127.8 120.5 734.1	\$225 \$227 \$187	\$195 \$219 \$253	\$1,025 \$1,753 \$577	
4 1	Haiti Swaziland	Low Lower middle	0.028	\$30,836 \$58,387	2 \$31,570 \$198,39	4.4 29.1	3,128 2,230	123.0 724.2	\$251 \$81	\$257 \$274	\$869 \$632	
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23		Net cost		DALYs averted		no intervention)		previous row)	
24 ^{Countrie}	Campaig n cost	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp. 1	Camp. 2
	5.832E+08	3.979E+0 8	4.685E+0 8	8.048E+0 6	5.708E+0 6	\$49	\$82	n/a	n/a
25 ^{Top 10} Top 20	2.387E+09	2.054E+0 9	2.068E+0 9	2.706E+0 7	1.629E+0 7	\$76	\$127	\$87	\$151
26 Top 30	3.715E+09	3.554E+0 9	3.338E+0 9	3.961E+0 7	2.382E+0 7	\$90	\$140	\$119	\$169
27 ^{Top 40*}	5.614E+09	4.943E+0 9	4.858E+0 9	4.731E+0 7	2.916E+0 7	\$104	\$167	\$181	\$284
28 ^{Top 50*}	1.624E+10	1.342E+1 0	1.395E+1 0	7.265E+0 7	4.983E+0 7	\$185	\$280	\$335	\$440
Top 60	2.226E+10	1.863E+1 0	1.941E+1 0	7.573E+0 7	5.186E+0 7	\$246	\$374	\$1,692	\$2,699
29 _{Top 70}	5.129E+10	4.350E+1 0	4.629E+1 0	7.871E+0 7	5.322E+0 7	\$553	\$870	\$8,340	\$19,728
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19 rable 4. IPC costs, DALYs averted, and cost-effectiveness compared with no intervention, and incremental 20 cost-effectiveness for 70 countries in increments of 10, ranked by cost-effectiveness. "Net costs" consist of IPC 2 population covered by IPC in each country. Costs in 2012 USS.

Incremental cost-effectiveness (compared with 23 Cost-effectiveness (compared with 24^c



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19 _{Fable 5.} 20 ^{ffectiver}	Median cost-effectiveness (net cost per DALY averted) by 10-country increments in order of cost- ness
20 21	Countries ranked by Cost- IPC cost- effectiveness Antiretroviral therapy for HIV
22	Top 10 \$50 \$102 \$854 11 - 20 \$88 \$141 \$958 11 - 30 \$121 \$197 \$797
23 24	31-40 \$185 \$318 \$894 41-50 \$335 \$591 \$683 51-60 \$1,721 \$3,514 \$666 61-70 \$4,774 \$17,068 \$587
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