

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

Journal:	BMJ Open
Manuscript ID:	bmjopen-2013-003987
Article Type:	Research
Date Submitted by the Author:	13-Sep-2013
Complete List of Authors:	Marseille, Elliot; Health Strategies International, Jiwani, Aliya; Health Strategies International, Raut, Abhishek; Johns Hopkins Bloomberg School of Public Health, International Health Verguet, Stephane; University of Washington, Department of Global Health Walson, Judd; University of Washington, Department of Global Health Kahn, James; University of California, San Francisco, Philip R. Lee Institute for Health Policy Studies
Primary Subject Heading :	Global health
Secondary Subject Heading:	Global health, Health economics, Health policy, Health services research, HIV/AIDS
Keywords:	HEALTH ECONOMICS, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, HIV & AIDS < INFECTIOUS DISEASES, Tropical medicine < INFECTIOUS DISEASES, Epidemiology < TROPICAL MEDICINE

SCHOLARONE™ Manuscripts

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

Elliot Marseille^{1*}, MPP, DrPH; Aliya Jiwani², MPH; Abhishek Raut³, MD; Stéphane Verguet⁴, PhD; Judd Walson⁵, MD; James G. Kahn⁶, MD

Author affiliations:

- ¹ Health Strategies International, 555 59th street, Oakland, CA, 94609, USA
- ² Health Strategies International, 1138 North Vernon St., Arlington, VA, 22201, USA
- ³ Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland 21205
- ⁴ Department of Global Health, University of Washington, Box 359909, 325 Ninth Avenue, Seattle, WA 98115, USA
- ⁵ Departments of Global Health, Medicine, Pediatrics, and Epidemiology, University of Washington, Box 359909, 325 Ninth Avenue, Seattle, WA 98115, USA
- ⁶ Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco, 3333 California Street Suite 265, Box 0936, San Francisco, CA 94118; Global Health Sciences, University of California, San Francisco, 50 Beale Street, 12th floor, San Francisco, CA 94105

*Corresponding author information: Elliot Marseille emarseille@comcast.net 925-998-5745

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, multiway and scenario sensitivity analyses were conducted to document the strength of our findings. We used a societal perspective, discounted costs and DALYs at 3% per year, and denominated cost in 2012 U.S. dollars.

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

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

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

Strengths and limitations of this study.

Strengths

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

Limitations

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



Background

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

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

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

Methods

Overview

We modeled the health impact, cost, and cost-effectiveness of a diarrhea, malaria, and HIV IPC [5] in 70 countries by adapting a previously-published spreadsheet-based model that was applied to the original IPC in Western Kenya [8]. Countries were chosen for inclusion in the analysis based on two factors: they were classified as low- or middle-income as defined by the World Bank [9]; and they had a total DALY (Disability-adjusted-life-year) burden for the three diseases addressed by the IPC in the highest tertile of the 214 World Bank-defined economies (i.e., ≥ 87,000 DALYs; assessed in a companion paper (Jiwani et al., under review, 2013 [9]). We derived incidence and case fatality rates for each country from published reports, using regional averages and other

approximations when country-specific estimates were missing. We developed a mix of empirical (where available) and modeled (projected from empirical data) cost estimates applied to all 70 countries. Key outcomes examined included the cost of the IPC; net IPC costs adjusting for averted and additional medical costs; deaths and disease episodes averted; DALYs averted due to prevention, and to earlier and more HIV care; and finally, cost-effectiveness expressed as net cost per DALY averted. We used a societal perspective, and discounted long-term costs and DALYs at 3% per year [10]. Costs were denominated in 2012 U.S. dollars.

Detailed model features

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

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

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

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

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

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

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

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

initiation of 35 years, and a life expectancy at age 35 in Kenya of 37 years [55]. Each untreated HIV case incurs 15.1 discounted DALYs.

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

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

Table 1 about here

Relationship of opportunity to cost-effectiveness

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

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

Table 2 about here

Results

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

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

Table 3 and Figure 1 about here.

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

For each stratum of 10 countries ranked from most to least cost-effective, Table 5 displays the median cost-effectiveness for the first three-year campaigns, for possible second campaigns, and for ART. The cost-effectiveness of the first campaign compares more favorably to ART by a wide margin for each of the 10-country strata. For the second campaign ART is more cost-effective than IPC for the $51^{st} - 60^{th}$ 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, 53^{rd} of 70 countries. This is due to lower health benefits overall. For every 1,000 IPC participants, the campaign averts an estimated 0.9 deaths: 0.1 due to malaria, 0.8 due to diarrhea, and only 0.1 due to HIV. The campaign costs are \$35,658. When adjusted for modest offsetting savings from averted care, the net cost of the campaign is \$30,236. Cost-effectiveness is comparable with the estimated \$1,046 per DALY averted for ART for HIV. See Table 4 of the technical supplement for detailed results for all three countries.

Sensitivity analyses

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

Figure 2 about here

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

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

Figure 3 about here

Multivariate Monte Carlo sensitivity analysis. Table 6 displays the 80% confidence interval for a 20,000-trial simulation for three outcomes: DALYs averted, net costs, and net cost per DALY averted (cost –effectiveness). For Kenya and Nigeria the least favorable end of the cost-effectiveness range is more favorable than the 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 = -0.51)(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.

References

- 1. De Maeseneer, J., et al., *Strengthening primary care: addressing the disparity between vertical and horizontal investment*. Br J Gen Pract, 2008. **58**(546): p. 3-4.
- 2. Brady, M.A., P.J. Hooper, and E.A. Ottesen, *Projected benefits from integrating NTD programs in sub-Saharan Africa*. Trends Parasitol, 2006. **22**(7): p. 285-91.
- Linehan, M., et al., *Integrated implementation of programs targeting neglected tropical diseases through preventive chemotherapy: proving the feasibility at national scale.* Am J Trop Med Hyg, 2011. **84**(1): p. 5-14.
- 4. Desormeaux, J., et al., *Widespread HIV counseling and testing linked to a community-based tuberculosis control program in a high-risk population*. Bull Pan Am Health Organ, 1996. **30**(1): p. 1-8.
- 5. Lugada, E., et al., Rapid implementation of an integrated large-scale HIV counseling and testing, malaria, and diarrhea prevention campaign in rural Kenya. PLoS One, 2010. 5(8): p. e12435.
- 6. Murray, C.J., et al., *Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010.* Lancet, 2012. **380**(9859): p. 2197-223.
- 7. Kahn, J.G., et al., *Cost of community integrated prevention campaign for malaria, HIV, and diarrhea in rural Kenya.* BMC Health Serv Res, 2011. **11**: p. 346.
- 8. Kahn, J.G., et al., *Integrated HIV testing, malaria, and diarrhea prevention campaign in Kenya: modeled health impact and cost-effectiveness.* PLoS One, 2012. 7(2): p. e31316.
- 9. The World Bank. *How we Classify Countries*. 2012 [cited 2012 September 4]; Available from: http://data.worldbank.org/about/country-classifications.
- 10. The World Bank, World Development Report 1993: Investing in Health 1993.
- 11. United Nations General Assembly, *Resolution, Keeping the promise: united to achieve the Millennium Development Goals*, 2010.
- 12. Central Intelligence Agency. *Country comparison: GDP per capita (PPP)*. 2012 [cited 2013 March 5]; Available from: https://http://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html.
- 13. Mbonye, A.K., *Prevalence of childhood illnesses and care-seeking practices in rural Uganda*. ScientificWorldJournal, 2003. **3**: p. 721-30.
- 14. Smith, L.A., et al., From fever to anti-malarial: the treatment-seeking process in rural Senegal. Malar J, 2010. 9: p. 333.
- 15. Hetzel, M.W., et al., Obstacles to prompt and effective malaria treatment lead to low community-coverage in two rural districts of Tanzania. BMC Public Health, 2008. 8: p. 317.
- 16. Littrell, M., et al., 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. Malar J, 2011. 10: p. 327.
- 17. Alba, S., et al., *Improvements in access to malaria treatment in Tanzania following community, retail sector and health facility interventions -- a user perspective.* Malar J, 2010. **9**: p. 163.

- 18. Sumba, P.O., et al., *Malaria treatment-seeking behaviour and recovery from malaria in a highland area of Kenya*. Malar J, 2008. 7: p. 245.
- 19. ICF International. STATcompiler % of children under 5 with diarrhea in 2 wks preceding survey who received any kind of treatment. 2012 [cited 2012 September]; Available from: http://statcompiler.com/.
- 20. UNAIDS, Sub-Saharan Africa, regional fact sheet, 2012.
- 21. Galarraga, O., et al., *Unit costs for delivery of antiretroviral treatment and prevention of mother-to-child transmission of HIV: a systematic review for low-and middle-income countries.* Pharmacoeconomics, 2011. **29**(7): p. 579-99.
- 22. Menzies, N.A., et al., *The cost of providing comprehensive HIV treatment in PEPFAR-supported programs*. AIDS, 2011.
- 23. Marseille, E., et al., *Taking ART to scale: determinants of the cost and cost-effectiveness of antiretroviral therapy in 45 clinical sites in Zambia.* PLoS One, 2012. 7(12): p. e51993.
- 24. Marseille, E., et al., *The cost effectiveness of home-based provision of antiretroviral therapy in rural Uganda*. Appl Health Econ Health Policy, 2009. 7(4): p. 229-43.
- 25. Hounton, S.H., et al., *Costing universal access of highly active antiretroviral therapy in Benin.* AIDS Care, 2008. **20**(5): p. 582-7.
- 26. Bikilla, A.D., et al., Cost estimates of HIV care and treatment with and without anti-retroviral therapy at Arba Minch Hospital in southern Ethiopia. Cost Eff Resour Alloc, 2009. 7: p. 6.
- 27. Kombe, G., et al., *Human and financial resource requirements for scaling up HIV/AIDS services in Ethiopia*, 2004, Partners for Health Reform*plus* Project: Bethesda, MA.
- 28. Koenig, S.P., et al., *The cost of antiretroviral therapy in Haiti*. Cost Eff Resour Alloc, 2008. **6**: p. 3.
- 29. Jaffar, S., et al., *Rates of virological failure in patients treated in a home-based versus a facility-based HIV-care model in Jinja, southeast Uganda: a cluster-randomised equivalence trial.* Lancet, 2009. **374**(9707): p. 2080-9.
- 30. Gupta, I., M. Trivedi, and S. Kandamuthan, *Recurrent costs of India's free ART program*, in *HIV and AIDS in South Asia: an economic development risk.*, M. Haacker and M. Claeson, Editors. 2009, World Bank: Washington, DC. p. xxvi, 244.
- 31. John, K.R., N. Rajagopalan, and K.V. Madhuri, *Brief communication: economic comparison of opportunistic infection management with antiretroviral treatment in people living with HIV/AIDS presenting at an NGO clinic in Bangalore, India.* MedGenMed, 2006. **8**(4): p. 24.
- 32. Kombe, G., D. Galaty, and C. Nwagbara, *Scaling Up Antiretroviral Treatment in the Public Sector in Nigeria: A Comprehensive Analysis of Resource Requirements*, 2004, The Partners for Health Reform*plus* Project: Bethesda, MD.
- 33. Aracena-Genao, B., et al., *Costs and benefits of HAART for patients with HIV in a public hospital in Mexico*. AIDS, 2008. **22 Suppl 1**: p. S141-8.
- 34. Bautista, S.A., et al., *Costing of HIV/AIDS Treatment in Mexico*, 2003, The Partners for Health Reform*plus* Project: Bethesda, MD.

- 35. Bautista-Arredondo, S., et al., *Costing of scaling up HIV/AIDS treatment in Mexico*. Salud Publica Mex, 2008. **50 Suppl 4**: p. S437-44.
- 36. Cleary, S.M., D. McIntyre, and A.M. Boulle, *The cost-effectiveness of antiretroviral treatment in Khayelitsha, South Africa--a primary data analysis.* Cost Eff Resour Alloc, 2006. **4**: p. 20.
- 37. Martinson, N., et al., *Costs of providing care for HIV-infected adults in an urban HIV clinic in Soweto, South Africa.* J Acquir Immune Defic Syndr, 2009. **50**(3): p. 327-30.
- 38. Rosen, S., L. Long, and I. Sanne, *The outcomes and outpatient costs of different models of antiretroviral treatment delivery in South Africa*. Trop Med Int Health, 2008. **13**(8): p. 1005-15.
- 39. Deghaye, N., R.A. Pawinski, and C. Desmond, Financial and economic costs of scaling up the provision of HAART to HIV-infected health care workers in KwaZulu-Natal. S Afr Med J, 2006. **96**(2): p. 140-3.
- 40. Harling, G., L.G. Bekker, and R. Wood, *Cost of a dedicated ART clinic*. S Afr Med J, 2007. **97**(8): p. 593-6.
- 41. Harling, G. and R. Wood, *The evolving cost of HIV in South Africa: changes in health care cost with duration on antiretroviral therapy for public sector patients.* J Acquir Immune Defic Syndr, 2007. **45**(3): p. 348-54.
- 42. Kevany, S., et al., Clinical and financial burdens of secondary level care in a public sector antiretroviral roll-out setting (G. F. Jooste Hospital). S Afr Med J, 2009. **99**(5): p. 320-5.
- 43. US Dept. of Labor Bureau of Labor Statistics. *Consumer Price Index All Urban Consumers (CPI-U)*. 2013 [cited 2013 August 14]; Available from: ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.
- 44. Gapminder, Data in Gapminder World, in Estimated HIV prevalence % (ages 15-49).
- 45. Ethiopia Federal HIV/AIDS Prevention and Control Office, *Country Progress Report on HIV/AIDS Response: Federal Democratic Republic of Ethiopia*, 2012.
- 46. Republique Democratique Du Congo Programme National Multisectoriel de Lutte Contre le Sida (PNMLS), *Rapport d'Activite Sure la Riposte au VIH/SIDA en R.D.Congo* 2012.
- 47. Cibulskis, R.E., et al., *Worldwide incidence of malaria in 2009: estimates, time trends, and a critique of methods.* PLoS Med, 2011. **8**(12): p. e1001142.
- 48. The World Bank, *Population, total*.
- 49. Fischer Walker, C.L., et al., *Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review.* BMC Public Health, 2012. **12**: p. 220.
- 50. UN Department of Economic and Social Affairs Population Division, *World Population Prospects*, 2010 Revision, 2010.
- 51. UNICEF, The State of the World's Children 2011. Table 6: Demographic Indicators: under 5 population (2010), 2011.
- 52. Institute for Health Metrics and Evaluation. *Malaria Mortality Estimates by Country 1980-2010*. 2009 [cited 2012 September]; Available from: http://www.healthmetricsandevaluation.org/ghdx/record/malariamortality-estimates-country-1980-2010.

- 53. World Health Organization, Global Health Observatory Data Repository in Global Burden of Disease: Table 1 Estimated total deaths, by cause, sex, and WHO Member State (2008). Deaths from diarrhoeal diseases.2011.
- 54. Lubell, Y., et al., *Likely health outcomes for untreated acute febrile illness in the tropics in decision and economic models; a Delphi survey.* PLoS One, 2011. **6**(2): p. e17439.
- World Health Statistics 2012. *Life tables for WHO Member States*. 2009 [cited 2012 December 13]; Available from: http://www.who.int/healthinfo/statistics/mortality life tables/en/.
- 56. Mathers, C.D., A.D. Lopez, and C.J.L. Murray, *The Burden of Disease and Mortality by Condition: Data, Methods, and Results for 2001*, in *Global Burden of Disease and Risk Factors*, A.D. Lopez, et al., Editors. 2006: Washington (DC).
- 57. Snow, R., et al., *The Public Health Burden of Plasmodium falciparum Malaria in Africa: Deriving the Numbers.*, in *Disease Control Priorities Project Working Paper No. 11*2003, Fogarty International Center, National Institutes of Health: Bethesda, Maryland.
- 58. Lamberti, L.M., C.L. Fischer Walker, and R.E. Black, *Systematic review of diarrhea duration and severity in children and adults in low- and middle-income countries*. BMC Public Health, 2012. **12**: p. 276.
- 59. Walensky, R.P., et al., *When to start antiretroviral therapy in resource-limited settings*. Ann Intern Med, 2009. **151**(3): p. 157-66.
- 60. Mermin, J., et al., Effect of co-trimoxazole prophylaxis on morbidity, mortality, CD4-cell count, and viral load in HIV infection in rural Uganda. Lancet, 2004. **364**(9443): p. 1428-34.
- 61. Ayieko, P., et al., *The economic burden of inpatient paediatric care in Kenya:* household and provider costs for treatment of pneumonia, malaria and meningitis. Cost Eff Resour Alloc, 2009. 7: p. 3.
- 62. World Health Organization, Global Burden of Disease. Table 1: Estimated total deaths ('000), by cause, sex and WHO Member State, 2008, 2011.
- 63. Lengeler, C., *Insecticide-treated bed nets and curtains for preventing malaria*. Cochrane Database Syst Rev, 2004(2): p. CD000363.
- 64. Clasen, T., et al., Cost-effectiveness of water quality interventions for preventing diarrhoeal disease in developing countries. J Water Health, 2007. **5**(4): p. 599-608.
- 65. Denison, J.A., et al., *HIV voluntary counseling and testing and behavioral risk reduction in developing countries: a meta-analysis, 1990--2005.* AIDS Behav, 2008. **12**(3): p. 363-73.
- 66. Weller, S. and K. Davis, *Condom effectiveness in reducing heterosexual HIV transmission*. Cochrane Database Syst Rev, 2002(1): p. CD003255.
- 67. Smith, D.L., et al., *Infectious disease. Solving the Sisyphean problem of malaria in Zanzibar.* Science, 2011. **332**(6036): p. 1384-5.
- 68. Kahn, J.G., E. Marseille, and B. Auvert, *Cost-effectiveness of male circumcision for HIV prevention in a South African setting.* PLoS Med, 2006. **3**(12): p. e517.
- 69. Mulligan, J.A., J. Yukich, and K. Hanson, *Costs and effects of the Tanzanian national voucher scheme for insecticide-treated nets.* Malar J, 2008. 7: p. 32.

- 70. Kilian, A., et al., Long-term field performance of a polyester-based long-lasting insecticidal mosquito net in rural Uganda. Malar J, 2008. 7: p. 49.
- 71. Clasen, T., et al., Laboratory assessment of a gravity-fed ultrafiltration water treatment device designed for household use in low-income settings. Am J Trop Med Hyg, 2009. **80**(5): p. 819-23.
- 72. Das, A. and T.S. Ravindran, Factors affecting treatment-seeking for febrile illness in a malaria endemic block in Boudh district, Orissa, India: policy implications for malaria control. Malar J, 2010. 9: p. 377.
- Table Lubell, Y., et al., Cost-effectiveness of parenteral artesunate for treating children with severe malaria in sub-Saharan Africa. Bull World Health Organ, 2011. **89**(7): p. 504-12.
- 74. Tate, J.E., et al., Rotavirus disease burden and impact and cost-effectiveness of a rotavirus vaccination program in kenya. J Infect Dis, 2009. **200 Suppl 1**: p. S76-84.
- 75. Shillcutt, S., et al., Cost-effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of combination therapy. Bull World Health Organ, 2008. **86**(2): p. 101-10.
- 76. Kaiser Family Foundation. *The U.S. President's Emergency Plan for AIDS Relief (PEPFAR)*. 2013 March 25, 2013 [cited 2013 August 12, 2013]; Available from: http://kff.org/global-health-policy/fact-sheet/the-u-s-presidents-emergency-plan-for/.

Author contributions

the study,

Ata for the study, h.

data for the study and rev

with specifying data inputs, and h.

d implementation of the study, helped wit.

Aper.

Jonflicts of interest
None declared. EM conceived and designed the study, conducted the analyses, and drafted and revised

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

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

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

		Nigeria			Kenya		Bangladesh			
Input parameter	Base case	Min	Мах	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	0.513	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	2	1	3	2	1	3	2	1	3	
Duration of benefit malaria	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5	
Duration of benefit diarrhea	3	1.5	4.5	3	1.5	4.5	3	1.5	4.5	
Duration of benefit HIV	1	0.5	1.5	1	0.5	1.5	1	0.5	1.5	

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

****	• • • • • • • • • • • • • • • • • • • •	. 110001100	,110 ,,111	Costs Disease averted			Cost-effectiveness (CE)				
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1,143.3	\$26	\$7	\$1,005
2	Senegal	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	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	Low er 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	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
	Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$987
_	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
_	Mozambique	Low er middle	0.133	\$30,147	\$54,769 \$59,145	22.2	3,816	590.0	\$110 \$51	\$94 \$100	\$1,109
20	Cen. African Rep.	Low	0.141	\$30,147	\$37,525	13.8	2,819	373.3	\$51 \$73	\$100	\$1,109
21	Uganda	Low	0.105	\$27,392	\$37,525 \$40,192	14.9	3,492	399.8	\$73 \$79	\$101	\$7,230
_	-	Low Low er middle									
22	Congo, Rep.		0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170 \$103	\$107	\$756
_	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
	Zambia	Low er 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	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	Eritrea	Low	0.033	\$27,392	\$26,438	4.3	1,942	120.5	\$227	\$219	\$1,753
39	Botsw ana	Upper middle	0.080	\$137,595	\$185,872	26.8	1,111	734.1	\$187	\$253	\$577
40	Haiti	Low	0.028	\$30,836	\$31,570	4.4	3,128	123.0	\$251	\$257	\$869
41	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
_	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
_	Papua New Guinea	Low er middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$864
	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758
_	Namibia	Upper middle	0.038	\$75,606	\$204,271	15.6	1,528	402.7	\$188	\$507	\$606
_	Cambodia	Low	0.014	\$38,413	\$31,172	1.9	1,341	54.3	\$708	\$574	\$739
_	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883
_	Morocco	Low er middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650
_	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046
_	Algeria	Upper middle	0.007	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
_	Uzbekistan	Low er middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717
56	Ukraine	Low er middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,523	\$2,036	\$600
_			0.005			1.2		48.7			\$622
_	Thailand	Upper middle		\$90,759 \$56,331	\$100,377 \$46,677	0.7	455		\$1,863 \$2,709	\$2,061	
	Indonesia	Low or middle	0.008	\$56,321	\$46,677		814	20.8	\$2,708	\$2,244	\$793
_	Bolivia	Low er middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668
_	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
	Peru	Upper middle	0.004	\$95,580	\$59,439	0.6	1,497	19.0	\$5,026	\$3,126	\$613
_	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
-		Upper middle	0.003	\$147,238	\$101,854	0.6	1,097	18.1	\$8,155	\$5,642	\$577
66	Argentina										
66 67	Argentina Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$591
	•		0.004 0.001	\$138,284 \$29,459	\$104,408 \$58,058	0.6	930 1,784	17.6 6.1	\$7,858 \$4,821	\$5,933 \$9,501	\$591 \$582
67	Malaysia	Upper middle									

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

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

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

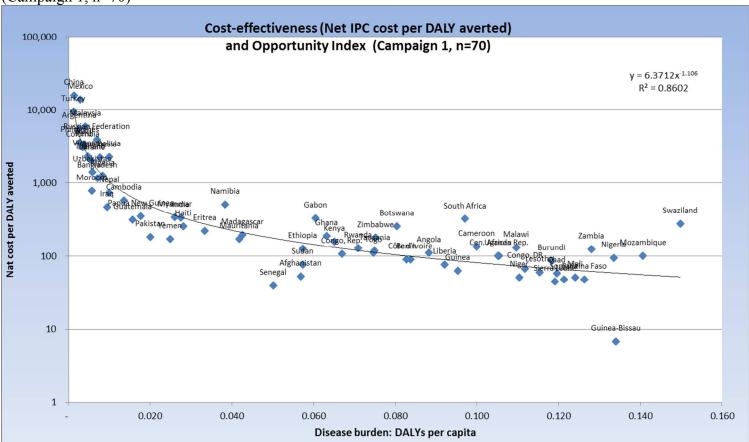


Table 6. Multiway sensitivity analysis; 20,000- trial Monte Carlo simulation, 80% confidence Interval for three IPC outcomes and cost per DALY averted by ART for HIV for Kenya, Bangladesh and Nigeria.

I	Outcome	Kenya	Bangladesh	Nigeria
I	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
ľ	Cost per DALY averted by ART for HIV	\$883	\$1,046	\$747



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



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

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

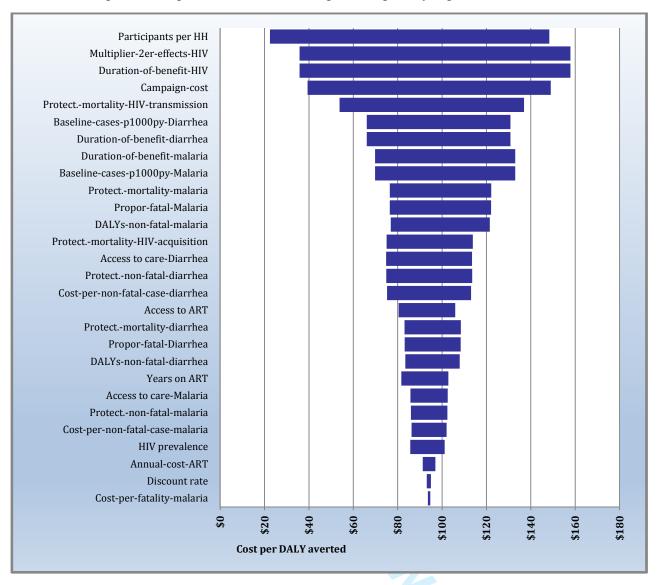


Figure 3. One-way sensitivity analysis of incremental cost-effectiveness by three key variables in 10-country increments ranked by IPC cost-effectiveness.

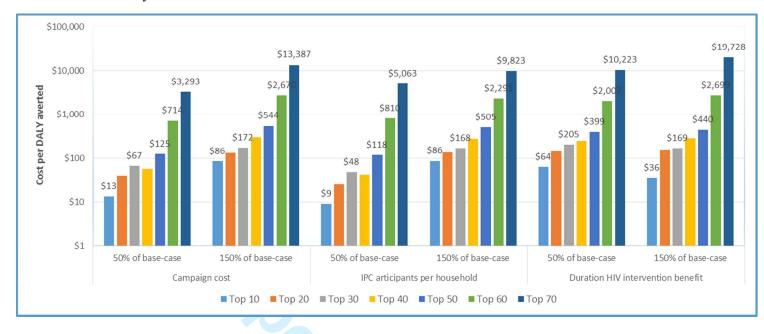
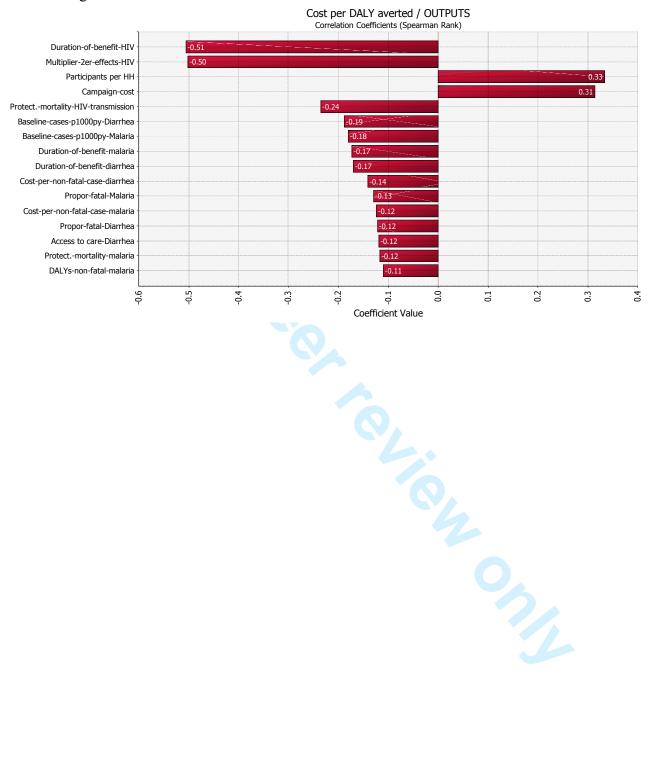


Figure 4. Result of 20,000-trial Monte Carlo simulation: Correlation between input values and cost per DALY averted – Nigeria.



Technical Supplement

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

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

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

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

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

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

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

Diarrhea: estimation of average cases per PY and annual cases

Using data on the number of episodes per year in children under 5 [2], we estimated the average number of episodes (cases) per person-year in the overall population by weighting the incidence by the percentage of the population under five [3] and over five. We then adjusted the incidence in the >5 year-old population by the ratio

IPC CEA Technical Supplement - 1

of the country <5 incidence to the average global <5 incidence [4]. Multiplying each estimate by the total population [5] provided estimates of the number of cases of diarrhea in each country.

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

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

1 Guinea-Bissau 2 Sormalia 3 Afghanistan 4 Congo, DR 5 Niger 6 Mali 7 Burundi 8 Sierra Leone 9 Mozambique 10 Burkina Faso 11 Chad 12 Lesotho 13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rwanda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 South Africa 39 Ghana 40 Halti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Ipaq 40 Guatemala 51 Papua New Gu 54 Algeria 55 Uzbekistan 56 Idonesia 57 Thailand 58 Vieriam 59 Philippines 60 Ukraine 61 Roivia 64 Brazil 65 Russian Federa 66 Malaysia 66 Argetian				Co	sts	Disease	averted		Cost-effectiveness (CE)			
2 Sornalia 3 Afghanistan 4 Congo, DR 5 Niger 6 Mali 7 Burundi 8 Sierra Leone 10 Burkina Faso 11 Chad 12 Lesotho 13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Jimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Angola 24 Togo 25 Rwanda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 30 Kenya 31 Gabon 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Mauritania 37 Berin 38 Warana 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 41 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 56 Idzekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Utkraine 61 Bolivia 66 Russian Federa 66 Malaysia	y inco	d Bank ome fication	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 Afghanistan 4 Congo, DR 5 Niger 6 Maii 7 Burundi 8 Sierra Leone 9 Mozambique 10 Lesotho 11 Chad 12 Lesotho 13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'hoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Halti 41 Pakistan 42 South Africa 43 Nambia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 56 Indonesia 57 Thailand 58 Vietnam 59 Olyraine 61 Bolivia 62 Peru 63 Colombia 65 Russian Federe 66 Malaysia		OW	0.134	\$29,459	\$16,675	26.9	5,465.3	754.3	\$22	\$39	\$1,005	
4 Congo, DR 5 Niger 6 Mail 7 Burundi 8 Sierra Leone 9 Mozambique 10 Burkina Faso 11 Chad 12 Lesotho 13 Malaw i 14 Zambia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabw e 20 Côte d'hoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Olombia 69 Russian Federa 60 Ukraine 61 Bolivia 61 Russian Federa 61 Rollonia 62 Peru 63 Colombia 65 Russian Federa 66 Malaysia		ow ow	0.121 0.057	\$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	
5 Niger 6 Mali 7 Burundi 8 Sierra Leone 9 Mozambique 10 Burkina Faso 11 Chad 12 Lesotho 13 Malaw i 14 Zarrbia 15 Liberia 16 Cuinea 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Madagascar 37 Fritre		ow	0.057	\$24,637	\$22,700 \$24,258	9.3	1,851.9	342.0 259.2	\$94	\$84 \$95	\$819	
6 Mail 7 Burundi 8 Sierra Leone 9 Mozambique 10 Burkina Faso 11 Chad 12 Lesotho 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 30 Kenya 31 Gabon 30 Kenya 31 Gabon 30 Kenya 31 Gabon 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Mauritania 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 41 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 41 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Petilippines 60 Ukraine 61 Bolivia 62 Peru 63 Russian Federa 64 Malaysia		OW	0.112	\$28,081	\$24,250	10.0	2,648.0	282.6	\$86	\$99	\$1,535	
8 Sierra Leone 9 Mozambique 10 Burkina Faso 11 Chad 11 Chad 12 Lesotho 13 Malaw i 14 Zambia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabw e 20 Côte d'hvoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Olwraine 61 Bolivia 62 Peru 63 Colombia 64 Razzil 65 Russian Federa 66 Malaysia		ow	0.124	\$29,459	\$25,298	10.0	2,312.1	280.1	\$90	\$105	\$1,095	
9 Mozambique 10 Burkina Faso 11 Chad 12 Lesotho 13 Malaw i 14 Zarrbia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yermen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Thailand 56 Indonesia 57 Thailand 56 Peru 66 Russian Federa 66 Malaysia		ow	0.118	\$26,015	\$27,699	8.7	1,256.5	239.8	\$116	\$108	\$888	
10 Burkina Faso 111 Chad 12 Lesotho 13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Zen. African Re 18 Uganda 19 Zimbabw e 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Angola 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Narribia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Pilippines 60 Ukraine 61 Bolivia 62 Reusian Federa 64 Razzil 65 Russian Federa 66 Malaysia		ow	0.119	\$31,525	\$24,508	9.8	2,142.5	274.1	\$89	\$115	\$935	
111 Chad 12 Lesotho 13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Mauritania 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 41 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Idonesia 57 Thailand 58 Vietnam 59 Ouraine 61 Bolivia 62 Peru 63 Colombia 65 Russian Federa 66 Malaysia		ow	0.141	\$30,147	\$36,613	9.7	1,975.5	260.0	\$141	\$116	\$807	
12 Lesotho 13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabw e 20 Côte d'hoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 65 Russian Federa 66 Malaysia		w	0.126	\$31,525	\$26,076	9.6	2,153.3	270.2	\$96	\$117	\$738	
13 Malaw i 14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 56 O Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Razzil 65 Russian Federa 66 Malaysia		ow r middle	0.120 0.115	\$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	
14 Zambia 15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabw e 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Idonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazili 65 Russian Federa 66 Malaysia		ow	0.110	\$28,081	\$36,299	8.6	1,532.3	221.8	\$164	\$120	\$703	
15 Liberia 16 Guinea 17 Cen. African Re 18 Uganda 19 Zimbabw e 20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 33 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Halti 41 Pakistan 42 South Africa 43 Narribia 44 India 45 Botsw ana 44 Nepal 44 I Pakistan 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Peru 60 Ukraine 61 Bolivia 62 Peru 61 Razzii 65 Ruszian Federa 66 Malaysia		r middle	0.128	\$33,591	\$41,222	10.1	1,660.1	263.4	\$156	\$128	\$1,025	
177 Cen. African Re 18 Uganda 19 Zimbabwe 20 Côte d'hvoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 28 Swaziland 29 Ngeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Olombia 66 Peru 61 Bolivia 62 Peru 63 Colombia 64 Razzil 65 Russian Federa 66 Malaysia		ow	0.092	\$26,704	\$25,199	6.8	1,762.6	190.4	\$132	\$140	\$987	
18 Uganda 19 Zimbabwe 20 Côte d'Noire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rwanda 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botswana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Idzbekistan 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia	Lo	wc	0.095	\$29,459	\$25,199	7.4	2,175.8	208.8	\$121	\$141	\$910	
19 Zimbabwe 20 Côte d'hvoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 65 Russian Federa 66 Malaysia		OW	0.105	\$27,392	\$29,606	7.1	1,443.6	194.2	\$152	\$141	\$801	
20 Côte d'Ivoire 21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 33 Angola 34 Sudan 35 Mauritania 36 Mauritania 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 41 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 40 Hagan 41 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 58 Vietnam 58 Ouraine 61 Bolivia 62 Peru 64 Razsii 65 Russian Federa 66 Malaysia		OW	0.105	\$31,525	\$31,104	7.9	1,841.7	214.8	\$145	\$147	\$747	
21 Ethiopia 22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Swaziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Nambia 44 India 45 Botsw ana 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Gautemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Olombia 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Razil 65 Russian Federa 66 Malaysia)W middlo	0.075	\$25,326	\$40,453	6.9	905.4	165.8	\$244 \$145	\$153 \$156	\$1,109	
22 Cameroon 23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Idensia 56 Indonesia 57 Thailand 58 Vietnam 56 Philippines 66 Ukraine 61 Bolivia 62 Peru 65 Russian Federa 66 Malaysia		middle ow	0.084 0.057	\$33,591 \$30,147	\$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	
23 Senegal 24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Idzbekistan 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		r middle	0.057	\$30,147	\$28,881	8.1	1,128.0	223.1	\$159 \$177	\$166 \$169	\$749 \$756	
24 Togo 25 Rw anda 26 Tanzania 27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Halti 41 Palkistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh Morocco Algeria 55 Lzbekistan 56 In		middle	0.050	\$34,969	\$22,535	6.8	2,951.7	193.6	\$116	\$181	\$864	
26 Tanzania 27 Benin 28 Swaziland 29 Ngeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Firtrea 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 51 Jezbekistan 56 Indonesia 57 Thailand 58 Vietnam 56 O Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Razil 65 Russian Federa 66 Malaysia		ow	0.075	\$29,459	\$28,877	5.5	1,466.8	153.3	\$188	\$192	\$674	
27 Benin 28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 50 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 50 Ukr	Lo	ow	0.071	\$31,525	\$30,620	5.9	1,248.9	163.9	\$187	\$192	\$935	
28 Sw aziland 29 Nigeria 30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Idzbekistan 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia	Lo	ow	0.075	\$33,591	\$32,273	6.1	1,636.6	167.4	\$193	\$201	\$826	
29 Nigeria 30 Kenya 31 Gabon 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 41 Pakistan 44 India 45 Botsw ana 44 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia	Lo	ow	0.083	\$33,591	\$28,793	5.9	1,611.1	167.1	\$172	\$201	\$1,139	
30 Kenya 31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Hatti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Gautemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 51 Lzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Olombia 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Razzil 65 Russian Federa 66 Malaysia		r middle	0.150	\$58,387	\$87,699	11.5	1,280.6	281.0	\$312	\$208	\$768	
31 Gabon 32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Razil 65 Russian Federa 66 Malaysia		r middle	0.133	\$40,479	\$34,860	6.7	1,610.1	187.0	\$186	\$217	\$996	
32 Congo, Rep. 33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		ow middle	0.065 0.060	\$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	
33 Angola 34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.067	\$54,254	\$42,228	7.2	1,522.2	199.0	\$212	\$209	\$955	
34 Sudan 35 Mauritania 36 Madagascar 37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 44 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 51 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Vietnam 59 Ouraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.007	\$64,586	\$44,239	8.5	1,758.3	236.6	\$187	\$273	\$719	
36 Madagascar 37 Eritrea 38 Yernen 39 Ghana 40 Halti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.057	\$38,413	\$24,940	4.8	2,620.5	136.6	\$183	\$281	\$1,731	
37 Eritrea 38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uz-bekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia	Lower	middle	0.042	\$36,346	\$31,642	4.4	1,397.4	123.1	\$257	\$295	\$904	
38 Yemen 39 Ghana 40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 58 Vietnam 58 Vietnam 59 Ouraine 61 Bolivia 62 Peru 63 Colombia 64 Brazii 65 Russian Federa 66 Malaysia	Lo	ow	0.043	\$28,770	\$26,424	3.0	1,079.4	84.6	\$312	\$340	\$746	
39 Ghana 40 Hati 41 Pakistan 42 South Africa 43 Namibia 44 India 445 Botsw ana 446 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Vietnam 59 Olwraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		ow	0.033	\$27,392	\$26,191	2.8	1,117.1	78.5	\$334	\$349	\$1,025	
40 Haiti 41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.025	\$37,035	\$27,682	3.5	1,778.2	99.3	\$279	\$373	\$1,753	
41 Pakistan 42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 9 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazii 65 Russian Federa 66 Malaysia		middle ow	0.063 0.028	\$44,612 \$30,836	\$38,058 \$29,010	4.2 2.8	1,006.4 1,789.6	117.8 80.4	\$323 \$361	\$379 \$384	\$577 \$869	
42 South Africa 43 Namibia 44 India 45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 9 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		r middle	0.020	\$41,856	\$28,870	3.6	1,574.8	102.7	\$281	\$407	\$632	
444 India 445 Botsw ana 446 Myanmar 447 Cambodia 448 Nepal 449 Iraq 505 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.097	\$99,713	\$115,007	9.1	659.2	235.9	\$487	\$423	\$627	
45 Botsw ana 46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia	Upper	middle	0.038	\$75,606	\$106,711	5.9	855.9	150.8	\$708	\$502	\$582	
46 Myanmar 47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Bruzil 64 Brazil	Lower	r middle	0.027	\$48,744	\$40,648	3.4	713.2	96.2	\$422	\$506	\$613	
47 Cambodia 48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.080	\$137,595	\$139,112	9.9	634.1	262.4	\$530	\$524	\$733	
48 Nepal 49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 56 Indonesia 57 Thailand 58 Vietnam 56 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		OW	0.026	\$31,525	\$29,473	1.7	672.6	48.0	\$614	\$657	\$1,354	
49 Iraq 50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		OW OW	0.014	\$38,413	\$33,905	1.3	758.8	37.6 30.0	\$901	\$1,020 \$1,029	\$864	
50 Guatemala 51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Peru 64 Brazil 65 Russian Federa 66 Malaysia		ow middle	0.010	\$30,836 \$53,565	\$29,442 \$37,274	1.1	654.7 1,493.0	30.0 50.4	\$982 \$740	\$1,028 \$1,063	\$758 \$606	
51 Papua New Gu 52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		r middle	0.009	\$57,698	\$35,999	1.7	1,812.5	51.6	\$698	\$1,063	\$739	
52 Bangladesh 53 Morocco 54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 68 Pazzil 68 Russian Federa 66 Malaysia		r middle	0.018	\$40,479	\$31,703	1.2	1,488.7	35.8	\$885	\$1,130	\$883	
54 Algeria 55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		ow	0.007	\$35,658	\$32,480	0.8	617.4	23.0	\$1,413	\$1,551	\$650	
55 Uzbekistan 56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia	Lower	r middle	0.006	\$58,387	\$49,883	1.1	898.4	31.6	\$1,577	\$1,846	\$1,046	
56 Indonesia 57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.008	\$73,540	\$60,354	1.3	752.8	38.2	\$1,580	\$1,925	\$606	
57 Thailand 58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		r middle	0.006	\$45,989	\$34,086	0.5	1,357.2	14.9	\$2,282	\$3,079	\$717	
58 Vietnam 59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.008	\$56,321	\$50,560	0.5	463.2	14.3	\$3,545	\$3,949	\$600	
59 Philippines 60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.005 0.005	\$90,759 \$45,989	\$90,800 \$42,516	0.8	261.3 477.7	21.7 8.2	\$4,177 \$5,164	\$4,175 \$5,586	\$622 \$793	
60 Ukraine 61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		r middle r middle	0.005	\$45,989 \$51,499	\$42,516	0.3	743.4	8.8	\$5,164 \$5,026	\$5,854	\$668	
61 Bolivia 62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		r middle	0.003	\$74,228	\$69,343	0.3	359.1	11.5	\$6,052	\$6,479	\$664	
62 Peru 63 Colombia 64 Brazil 65 Russian Federa 66 Malaysia		middle	0.010	\$56,321	\$41,435	0.2	1,162.3	8.2	\$5,044	\$6,856	\$598	
64 Brazil 65 Russian Federa 66 Malaysia		middle	0.004	\$95,580	\$73,664	0.3	862.2	9.6	\$7,650	\$9,926	\$613	
65 Russian Federa 66 Malaysia	Upper	middle	0.003	\$95,580	\$75,850	0.3	817.2	8.8	\$8,575	\$10,806	\$581	
66 Malaysia		middle	0.004	\$104,534	\$81,187	0.3	798.2	9.0	\$9,029	\$11,626	\$724	
		onOECD	0.007	\$143,794	\$128,452	0.4	424.3	10.8	\$11,898	\$13,319	\$579	
o/ Argentina		middle	0.004	\$138,284	\$117,395	0.2	536.0	6.6	\$17,673	\$20,818	\$577	
		middle	0.003	\$147,238 \$125,107	\$119,687	0.2	632.8	6.8	\$17,487	\$21,512	\$591	
68 Turkey 69 China		middle	0.001 0.001	\$125,197 \$84,560	\$86,272 \$78,518	0.1	1,029.3 280.4	3.9 2.3	\$22,267 \$33,785	\$32,314 \$36,384	\$582 \$583	
70 Mexico		middle	0.001	\$127,264	\$129,804	0.1	0.1	3.2	\$40,371	\$39,581	\$638	

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

		l		Costs		Disease	averted	DALYs	Cost-ef	fectiveness	(CE)	
	Country	World Bank income classification	DALYs per capita	IPC campaign cost	Net cost	Deaths	Episodes	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	
3	Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1143.3	\$26	\$7	\$1,005	
4	Nigeria	Low er middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$747	
5	Zambia	Low er middle	0.128	\$33,591	\$69,806	21.8	3,107	564.3	\$60	\$124	\$826	
ô	Burkina Faso	Low	0.126	\$31,525	\$22,206	16.4	4,124	459.4	\$69	\$48	\$819	
7	Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$888	
8	Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,535	
9	Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$807	
10	Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$764	
11	Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$987	
12	Lesotho	Low er middle	0.115	\$35,658	\$47,366	31.3	1,756	779.4	\$46	\$61	\$738	
13	Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,493	
14	Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,095	
15	Malaw i	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996	
16 17	Cen. African Rep. Uganda	Low	0.105 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	
18	Cameroon	Low er middle	0.105	\$31,525	\$40,192 \$52.388	14.9	3,492	399.8	\$79 \$97	\$101 \$135	\$749	
9	South Africa	Upper middle	0.097	\$99,713	\$180,284	21.5	1,150	561.0	\$178	\$321	\$582	
0	Guinea	Low	0.095	\$29,459	\$22,324	12.6	4,272	353.8	\$83	\$63	\$928	
21	Liberia	Low	0.092	\$26,704	\$25,526	11.9	3,401	332.6	\$80	\$77	\$1,025	
22	Angola	Upper middle	0.088	\$64,586	\$35,794	11.5	3,268	320.8	\$201	\$112	\$674	
3	Côte d'Ivoire	Low er middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801	
4	Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$910	
25	Botsw ana	Upper middle	0.080	\$137,595	\$185,872	26.8	1,111	734.1	\$187	\$253	\$577	
26	Zimbabw e	Low	0.075	\$25,326	\$76,203	17.8	1,682	428.8	\$59	\$178	\$1,731	
27	Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$935	
28	Togo	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864	
9	Rw anda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768	
30	Congo, Rep.	Low er middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756	
31	Kenya Ghana	Low Low er middle	0.065	\$34,280 \$44,612	\$46,149 \$35,624	10.9	2,018 1,966	294.1 189.9	\$117 \$235	\$157 \$188	\$883 \$746	
33	Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613	
34	Ethiopia	Low	0.057	\$30,147	\$29,630	8.6	1,986	235.7	\$128	\$126	\$1,139	
35	Sudan	Low er middle	0.057	\$38,413	\$15,241	6.9	4,907	198.8	\$193	\$77	\$703	
36	Afghanistan	Low	0.057	\$28,770	\$18,906	12.7	4,146	356.6	\$81	\$53	\$935	
37	Senegal	Low er middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$768	
38	Madagascar	Low	0.043	\$28,770	\$24,895	4.5	1,910	127.8	\$225	\$195	\$1,025	
39	Mauritania	Lower middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$955	
40	Namibia	Upper middle	0.038	\$75,606	\$204,271	15.6	1,528	402.7	\$188	\$507	\$606	
41	Eritrea	Low	0.033	\$27,392	\$26,438	4.3	1,942	120.5	\$227	\$219	\$1,753	
42	Haiti	Low	0.028	\$30,836	\$31,570	4.4	3,128	123.0	\$251	\$257	\$869	
43	India	Low er middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$733	
44	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354	
45	Yemen Pakistan	Lower middle	0.025	\$37,035 \$41,856	\$21,139	4.3 3.8	3,128	122.9	\$301 \$387	\$172 \$182	\$719	
46 47		Lower middle Lower middle	0.020	\$41,856 \$40,479	\$19,714 \$25,117	2.4	2,748 2,868	108.1 71.2	\$387 \$568	\$182 \$353	\$904 \$864	
48	Guatemala	Low er middle	0.018	\$40,479	\$25,117	2.4	3,143	71.2	\$508	\$353 \$316	\$627	
40 49	Cambodia	Low	0.016	\$38,413	\$31,172	1.9	1,341	54.3	\$708	\$574	\$739	
50	Nepal	Low	0.014	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883	
51	Bolivia	Low er middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668	
52	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758	
53	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606	
54	Indonesia	Low er middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793	
55	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046	
6	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,954	1.1	735	31.2	\$4,607	\$3,907	\$579	
57	Uzbekistan	Low er middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717	
8	Morocco	Low er middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650	
59	Ukraine	Low er middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$600	
0	Thailand	Upper middle	0.005	\$90,759	\$100,377	1.8	455	48.7	\$1,863	\$2,061	\$622	
31	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664	
32	Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$591	
33	Brazil	Upper middle	0.004	\$104,534	\$65,501	0.6	1,385	19.2	\$5,431 \$5,026	\$3,403	\$581	
64 65	Peru Colombia	Upper middle Upper middle	0.004	\$95,580 \$95,580	\$59,439 \$63,657	0.6	1,497 1,419	19.0	\$5,026 \$4,652	\$3,126 \$3,098	\$613 \$598	
66	Mexico	Upper middle	0.003	\$127,264	\$134,901	0.8	0	9.6	\$4,652 \$13,197	\$13,989	\$583	
37	Philippines	Low er middle	0.003	\$127,204	\$134,901	0.3	1,289	10.9	\$4,746	\$3,597	\$724	
58	Argentina	Upper middle	0.003	\$147,238	\$101,854	0.6	1,097	18.1	\$8,155	\$5,642	\$577	
69	China	Upper middle	0.003	\$84,560	\$74,564	0.0	486	4.7	\$18,015	\$15,886	\$638	
-61		Upper middle	0.001	\$125,197	\$58,058	0.1	1,784	6.1	\$20,489	\$9,501	\$582	

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

Costs Disease aver						averted		Cost-effectiveness (CE)				
	Country	World Bank income	DALYs per	IPC campaign	Net cost	Deaths		DALYs averted	Campaign cost	Net cost per	CE of ART	
	Country	classification	capita	cost	Net cost	Deaths	Episodes	averteu	per DALY averted	DALY averted	CE OF ART	
1	Sw aziland	Low er middle	0.150	\$58,387	\$87,699	11.5	1,281	281.0	\$312	\$208	\$632	
2	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,976	260.0	\$141	\$116	\$1,109	
3	Guinea-Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465	754.3	\$22	\$39	\$1,005	
4	Nigeria	Lower middle	0.133	\$40,479	\$34,860	6.7	1,610	187.0	\$186	\$217	\$747	
5	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660	263.4	\$156	\$128	\$826	
6	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153	270.2	\$96	\$117	\$819	
7	Mali Somalia	Low	0.124 0.121	\$29,459 \$26,015	\$25,298 \$23,643	10.0 11.6	2,312 2,055	280.1 325.2	\$90 \$73	\$105 \$80	\$888 \$1,535	
9	Chad	Low	0.121			10.6			\$94		\$807	
_				\$35,658	\$27,805		2,258	294.9	, .	\$121		
10 11	Sierra Leone Burundi	Low	0.119 0.118	\$31,525	\$24,508	9.8 8.7	2,143	274.1	\$89	\$115 \$108	\$764 \$987	
12	Lesotho	Low er middle	0.116	\$26,015 \$35,658	\$27,699 \$37,171	11.7	1,256 919	283.6	\$116 \$131	\$106	\$738	
13	Congo, DR	Low	0.113	\$24,637	\$24,258	9.3	1,852	259.2	\$94	\$95	\$1,493	
14	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648	282.6	\$86	\$99	\$1,095	
15	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532	221.8	\$164	\$127	\$996	
16	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,444	194.2	\$152	\$141	\$1,230	
17	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,842	214.8	\$145	\$147	\$749	
18	Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620	223.1	\$177	\$169	\$741	
19 20	South Africa Guinea	Upper middle Low	0.097	\$99,713 \$29,459	\$115,007 \$25,199	9.1 7.4	659	235.9	\$487 \$121	\$423 \$141	\$582 \$928	
20	Liberia	Low	0.095	\$29,459 \$26,704	\$25,199 \$25,199	6.8	2,176 1,763	190.4	\$121 \$132	\$141 \$140	\$928 \$1,025	
22	Angola	Upper middle	0.092	\$64,586	\$44,239	8.5	1,758	236.6	\$132	\$140	\$1,025	
23	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$31,110	7.8	2,010	214.9	\$145	\$156	\$801	
24	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611	167.1	\$172	\$201	\$910	
25	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	
27	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,637	167.4	\$193	\$201	\$935	
28	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,467	153.3	\$188	\$192	\$864	
29	Rw anda	Low	0.071	\$31,525	\$30,620	5.9	1,249	163.9	\$187	\$192	\$768	
30	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522	199.0	\$212	\$273	\$756	
31	Kenya Ghana	Low Lower middle	0.065 0.063	\$34,280 \$44,612	\$35,682 \$38,058	5.2 4.2	1,131 1,006	142.8 117.8	\$250 \$323	\$240 \$379	\$883 \$746	
33	Gabon	Upper middle	0.060	\$29,826	\$46,367	4.2	972	110.7	\$419	\$269	\$613	
34	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128	181.8	\$159	\$166	\$1,139	
35	Sudan	Lower middle	0.057	\$38,413	\$24,940	4.8	2,620	136.6	\$183	\$281	\$703	
36	Afghanistan	Low	0.057	\$28,770	\$22,700	12.2	2,381	342.0	\$66	\$84	\$935	
37	Senegal	Lower middle	0.050	\$34,969	\$22,535	6.8	2,952	193.6	\$116	\$181	\$768	
38	Madagascar	Low	0.043	\$28,770	\$26,424	3.0	1,079	84.6	\$312	\$340	\$1,025	
39	Mauritania	Lower middle	0.042	\$36,346	\$31,642	4.4	1,397	123.1	\$257	\$295	\$955	
40	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	856	150.8	\$708	\$502	\$606	
41	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117	78.5	\$334	\$349	\$1,753	
42 43	Haiti	Low Lower middle	0.028	\$30,836 \$48,744	\$29,010 \$40,648	2.8	1,790 713	96.2	\$361 \$422	\$384 \$506	\$869 \$733	
44	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	673	48.0	\$614	\$657	\$1,354	
45	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778	99.3	\$279	\$373	\$719	
46	Pakistan	Lower middle	0.020	\$41,856	\$28,870	3.6	1,575	102.7	\$281	\$407	\$904	
47	Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,489	35.8	\$885	\$1,130	\$864	
48	Guatemala	Lower middle	0.016	\$57,698	\$35,999	1.8	1,813	51.6	\$698	\$1,118	\$627	
49	Cambodia	Low	0.014	\$38,413	\$33,905	1.3	759	37.6	\$901	\$1,020	\$739	
50	Nepal	Low	0.010	\$30,836	\$29,442	1.1	655	30.0	\$982	\$1,028	\$883	
51	Bolivia	Lower middle	0.010	\$56,321 \$53,565	\$41,435	0.2	1,162 1,493	8.2	\$5,044 \$740	\$6,856	\$668	
52 53	Iraq Algeria	Upper middle Upper middle	0.009	\$53,565 \$73,540	\$37,274 \$60,354	1.7	1,493 753	50.4 38.2	\$740 \$1,580	\$1,063 \$1,925	\$758 \$606	
54	Indonesia	Lower middle	0.008	\$73,540 \$56,321	\$50,560	0.5	463	14.3	\$1,560	\$1,925	\$793	
55	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617	23.0	\$1,413	\$1,551	\$1,046	
56	Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424	10.8	\$11,898	\$13,319	\$579	
57	Uzbekistan	Lower middle	0.006	\$45,989	\$34,086	0.5	1,357	14.9	\$2,282	\$3,079	\$717	
58	Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898	31.6	\$1,577	\$1,846	\$650	
59	Ukraine	Lower middle	0.006	\$74,228	\$69,343	0.4	359	11.5	\$6,052	\$6,479	\$600	
60	Thailand	Upper middle	0.005	\$90,759	\$90,800	0.8	261	21.7	\$4,177	\$4,175	\$622	
61	Vietnam	Lower middle	0.005	\$45,989	\$42,516	0.3	478	8.2	\$5,164	\$5,586	\$664	
62	Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536	6.6	\$17,673	\$20,818	\$591	
63	Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798	9.0	\$9,029	\$11,626	\$581	
64 65	Peru Colombia	Upper middle Upper middle	0.004	\$95,580 \$95,580	\$73,664 \$75,850	0.3	862 817	9.6	\$7,650 \$8,575	\$9,926 \$10,806	\$613 \$598	
66	Mexico	Upper middle	0.003	\$95,560	\$129,804	0.3	0	3.2	\$40,371	\$39,581	\$583	
67	Philippines	Lower middle	0.003	\$51,499	\$44,213	0.1	743	8.8	\$5,026	\$5,854	\$724	
68	Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	633	6.8	\$17,487	\$21,512	\$577	
69	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280	2.3	\$33,785	\$36,384	\$638	
70	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029	3.9	\$22,267	\$32,314	\$582	

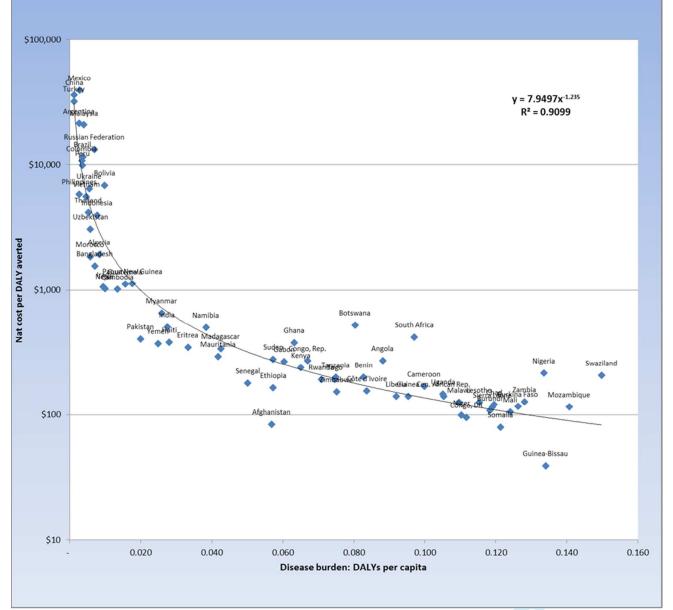
Tech. Suppl. - Table 4. Results for Kenya, Bangladesh and Nigeria, per 1000 campaign participants.

		Malaria LLITN	Diarrhea Filters	VCT	HIV Condoms	TOTAL
		Keny	/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			1	.23.5	123.5
	TOTAL	44.1	68.3	1	.81.8	294.1
Costs	Prevention	\$773	\$9,068	\$40,889	\$18,588	\$69,318
averted	Earlier HIV care			(\$8	31,187)	(\$81,187)
(added)	TOTAL	\$773	\$9,068	(\$2	21,710)	-\$11,869
Cost-	Campaign cost (unadjusted)					\$34,280
effective	Net cost (savings)					\$46,149
ness	Cost per DALY averted					\$157
		Bangla	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				1.2	1.2
	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	(5	\$195)	\$5,422
Cost-	Campaign cost (unadjusted)					\$36,658
effective ness	Net cost (savings)					\$30,236
11622	Cost per DALY averted					\$1,168
		Nige	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
DALYs	Prevention	168.8	97.6	21.8	10.2	298.4
averted	Earlier HIV care			•	70.8	70.8
	TOTAL	168.8	97.6	1	.02.9	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	(\$1	.4,813)	\$5,710
Cost-	Campaign cost (unadjusted)					\$40,479
effective	Net cost (savings)					\$34,769
ness	Cost per DALY averted					\$94

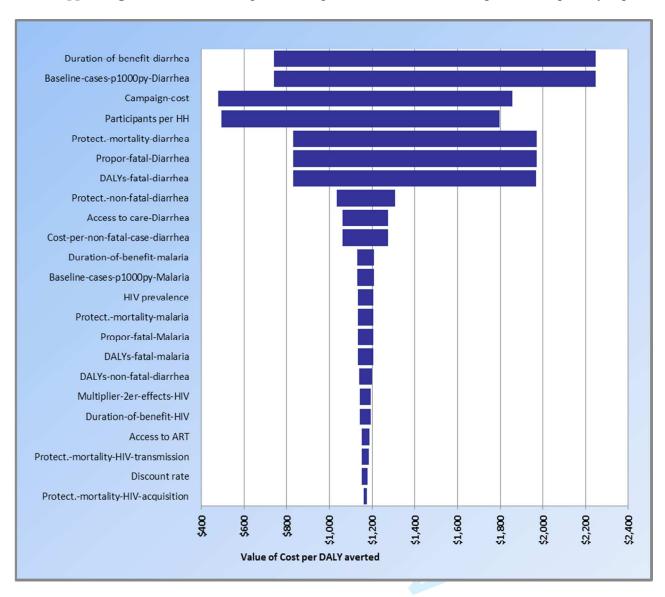
Tech. Suppl. - Table 4. Annual and cumulative results for campaigns 1 and 2 for Kenya, projected for 30 years. Assumes the second campaign starts 3 years after initial campaign. All outcomes discounted at 3% per annum.

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

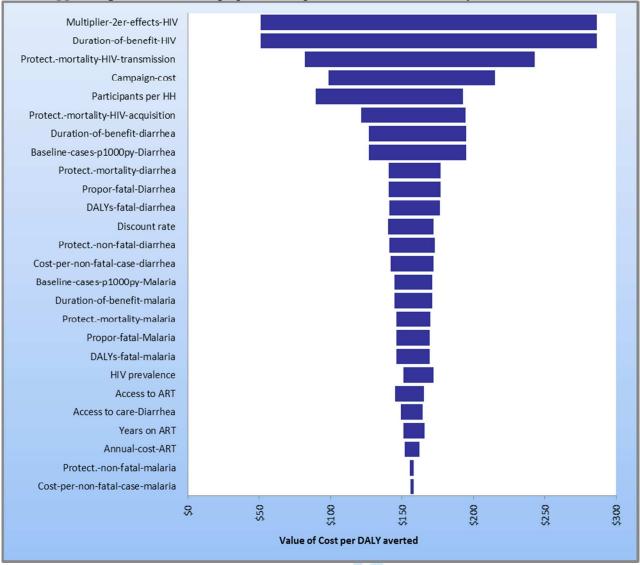
Tech. Suppl. - Figure 1. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (Campaign 2, n=70)



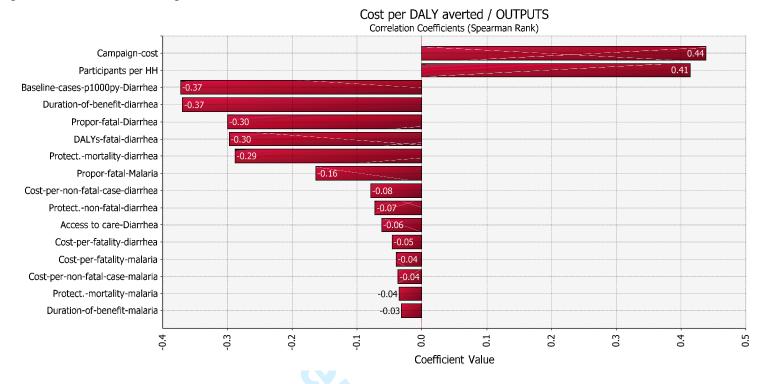
Tech. Suppl. - Figure 2. Tornado Graph of Cost per DALY averted – Bangladesh: Impact by Input



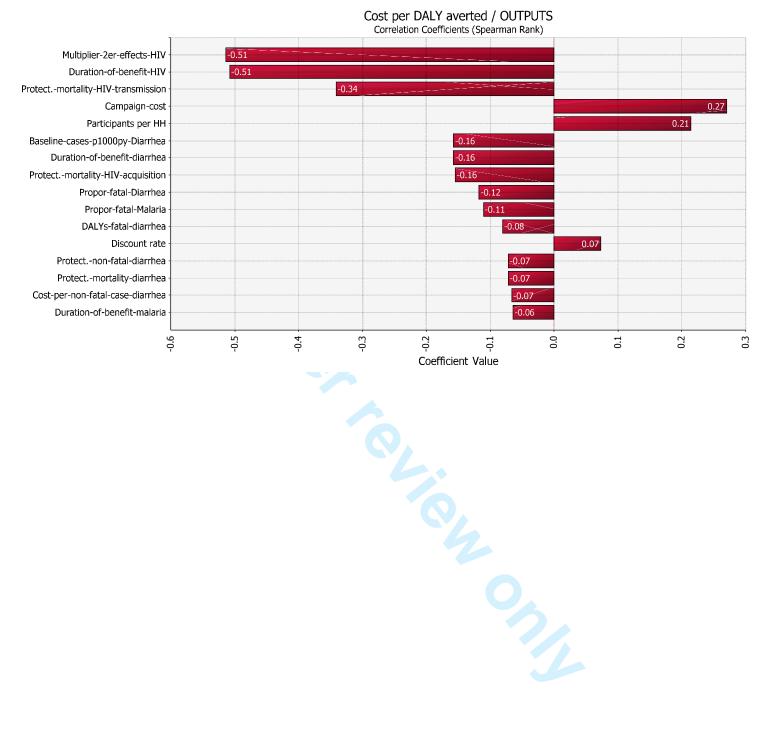
Tech. Suppl. - Figure 3. Tornado graph of cost per DALY averted – Kenya



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



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



Projection of costs and outcomes to 30 years

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

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

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



References

- 1. Kahn, J.G., E. Marseille, and B. Auvert, *Cost-effectiveness of male circumcision for HIV prevention in a South African setting*. PLoS Med, 2006. 3(12): p. e517.
- 2. Fischer Walker, C.L., et al., *Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review.* BMC Public Health, 2012. 12: p. 220.
- 3. UNICEF, The State of the World's Children 2011. Table 6: Demographic Indicators: under 5 population (2010), 2011.
- 4. UN Department of Economic and Social Affairs Population Division, *World Population Prospects, 2010 Revision, 2010.*
- 5. The World Bank, *Population, total*.
- 6. Kahn, J.G., et al., Integrated HIV testing, malaria, and diarrhea prevention campaign in Kenya: modeled health impact and cost-effectiveness. PLoS One, 2012. 7(2): p. e31316.
 - Iger.com/. ICF International. MEASURE DHS STATcompiler. 2012 June 13, 2013]; Available from: http://www.statcompiler.com/.

BMJ Open

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

Journal:	BMJ Open
Manuscript ID:	bmjopen-2013-003987.R1
Article Type:	Research
Date Submitted by the Author:	21-May-2014
Complete List of Authors:	Marseille, Elliot; Health Strategies International, Jiwani, Aliya; Health Strategies International, Raut, Abhishek; Johns Hopkins Bloomberg School of Public Health, International Health Verguet, Stephane; University of Washington, Department of Global Health Walson, Judd; University of Washington, Department of Global Health Kahn, James; University of California, San Francisco, Philip R. Lee Institute for Health Policy Studies
Primary Subject Heading :	Global health
Secondary Subject Heading:	Global health, Health economics, Health policy, Health services research, HIV/AIDS
Keywords:	HEALTH ECONOMICS, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, HIV & AIDS < INFECTIOUS DISEASES, Tropical medicine < INFECTIOUS DISEASES, Epidemiology < TROPICAL MEDICINE

SCHOLARONE™ Manuscripts

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

Elliot Marseille^{1*}, MPP, DrPH; Aliya Jiwani², MPH; Abhishek Raut³, MD; Stéphane Verguet⁴, PhD; Judd Walson⁵, MD; James G. Kahn⁶, MD

Author affiliations:

¹ Health Strategies International, 555 59th street, Oakland, CA, 94609, USA

² Health Strategies International, 1138 North Vernon St., Arlington, VA, 22201, USA

³ Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland 21205

⁴ Department of Global Health, University of Washington, Box 359909, 325 Ninth Avenue, Seattle, WA 98115, USA

⁵ Departments of Global Health, Medicine, Pediatrics, and Epidemiology, University of Washington, Box 359909, 325 Ninth Avenue, Seattle, WA 98115, USA

⁶ Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco, 3333 California Street Suite 265, Box 0936, San Francisco, CA 94118; Global Health Sciences, University of California, San Francisco, 50 Beale Street, 12th floor, San Francisco, CA 94105

*Corresponding author information: Elliot Marseille emarseille@comcast.net 925-998-5745

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

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

Strengths and limitations of this study.

Strengths

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

Limitations

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

Background

For many years, vertical (disease-specific) programming has dominated the sphere of global health funding in an effort to tackle the areas of greatest need. 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. As a success of the support of t

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. 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. 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. 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. 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 campaign by the ratio of GDP per capita in the target country versus Kenya. We selected per capita GDP rather than per capita health care spending as the basis for these adjustments, because the latter reflects overall access to care and our model accounts for access separately. (For a comparison of three cost adjustment methods and evidence of similar resulting cost estimates, see Technical Supplement).

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

higher than the 56% access reported for sub-Saharan Africa ²¹ and reflects likely increases in the context of the global commitment to access. ¹²

We calculated the per person-year cost of ART for each country by using published estimates for countries where available. ²²⁻⁴² The non-drug portion of each published unit cost figure was inflated to 2012 US dollars using the U.S. CPI. ⁴³ We then derived from the set of published figures an average figure for low-income, lower middle-income excluding India, and uppermiddle 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. 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 to 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 5⁴⁹ (details in technical supplement). Multiplying each estimate by the total population we 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

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

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

Sensitivity analyses

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

Figure 2 about here

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

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

Figure 3 about here

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

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

Table 6 and Figure 4 about here.

Discussion

We examined the costs and health benefits of IPC for 70 countries with a high combined burden of diarrhea, malaria and HIV. Together these countries comprise 76% of the world population ⁴⁸ and 98% of its disease burden. 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.

Page 12 of 126

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. (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.



Author contributions

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

Data sharing

No additional data available.

Conflicts of interest

None declared.

References

- 1. De Maeseneer J, van Weel C, Egilman D, Mfenyana K, Kaufman A, Sewankambo N. Strengthening primary care: addressing the disparity between vertical and horizontal investment. *The British journal of general practice : the journal of the Royal College of General Practitioners* 2008;58(546):3-4.
- 2. Brady MA, Hooper PJ, Ottesen EA. Projected benefits from integrating NTD programs in sub-Saharan Africa. *Trends Parasitol* 2006;22(7):285-91.
- 3. Linehan M, Hanson C, Weaver A, Baker M, Kabore A, Zoerhoff KL, et al. Integrated implementation of programs targeting neglected tropical diseases through preventive chemotherapy: proving the feasibility at national scale. *The American journal of tropical medicine and hygiene* 2011;84(1):5-14.
- 4. Desormeaux J, Johnson MP, Coberly JS, Losikoff P, Johnson E, Huebner R, et al. Widespread HIV counseling and testing linked to a community-based tuberculosis control program in a high-risk population. *Bulletin of the Pan American Health Organization* 1996;30(1):1-8.
- 5. Lugada E, Millar D, Haskew J, Grabowsky M, Garg N, Vestergaard M, et al. Rapid implementation of an integrated large-scale HIV counseling and testing, malaria, and diarrhea prevention campaign in rural Kenya. *PloS one* 2010;5(8):e12435.
- 6. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2197-223.
- 7. Kahn JG, Harris B, Mermin JH, Clasen T, Lugada E, Grabowksy M, et al. Cost of community integrated prevention campaign for malaria, HIV, and diarrhea in rural Kenya. *BMC health services research* 2011;11:346.
- 8. Kahn JG, Muraguri N, Harris B, Lugada E, Clasen T, Grabowsky M, et al. Integrated HIV testing, malaria, and diarrhea prevention campaign in Kenya: modeled health impact and cost-effectiveness. *PloS one* 2012;7(2):e31316.
- 9. Jiwani A, Matheson A, Kahn JG, Raut A, Verguet S, Marseille E, et al. Integrated disease prevention campaigns: assessing country opportunity for implementation via an index approach. *BMJ open* 2014;4(3):e004308.
- 10. The World Bank. How we Classify Countries. [cited 2012 September 4]; . Available from: http://data.worldbank.org/about/country-classifications., 2012.
- 11. World Bank. *World Development Report 1993: Investing in Health*. New York, N.Y.: Oxford University Press, 1993.
- 12. United Nations. Resolution adopted by the General Assembly: 65/1. Keeping the promise: united to achieve the Millenium Development Goals, 2010.
- 13. Central Intelligence Agency. Country comparison: GDP per capita (PPP), 2012.
- 14. Mbonye AK. Prevalence of childhood illnesses and care-seeking practices in rural Uganda. *TheScientificWorldJournal* 2003;3:721-30.
- 15. Hetzel MW, Obrist B, Lengeler C, Msechu JJ, Nathan R, Dillip A, et al. Obstacles to prompt and effective malaria treatment lead to low community-coverage in two rural districts of Tanzania. *BMC public health* 2008;8:317.

- 16. Alba S, Dillip A, Hetzel MW, Mayumana I, Mshana C, Makemba A, et al. Improvements in access to malaria treatment in Tanzania following community, retail sector and health facility interventions -- a user perspective. *Malaria journal* 2010;9:163.
- 17. Das A, Ravindran TS. Factors affecting treatment-seeking for febrile illness in a malaria endemic block in Boudh district, Orissa, India: policy implications for malaria control. *Malaria journal* 2010;9:377.
- 18. Smith LA, Bruce J, Gueye L, Helou A, Diallo R, Gueye B, et al. From fever to anti-malarial: the treatment-seeking process in rural Senegal. *Malaria journal* 2010;9:333.
- 19. Littrell M, Gatakaa H, Evance I, Poyer S, Njogu J, Solomon T, et al. 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. *Malaria journal* 2011;10:327.
- 20. ICF International. STATcompiler % of children under 5 with diarrhea in 2 wks preceding survey who received any kind of treatment: Measure DHS, 2012.
- 21. UNAIDS. Sub-Saharan Africa, Regional fact sheet. 2012.
- 22. Galarraga O, Wirtz VJ, Figueroa-Lara A, Santa-Ana-Tellez Y, Coulibaly I, Viisainen K, et al. Unit costs for delivery of antiretroviral treatment and prevention of mother-to-child transmission of HIV: a systematic review for low- and middle-income countries. *PharmacoEconomics* 2011;29(7):579-99.
- 23. Kitajima T, Kobayashi Y, Chaipah W, Sato H, Chadbunchachai W, Thuennadee R. Costs of medical services for patients with HIV/AIDS in Khon Kaen, Thailand. *Aids* 2003;17(16):2375-81.
- 24. Menzies NA, Berruti AA, Berzon R, Filler S, Ferris R, Ellerbrock TV, et al. The cost of providing comprehensive HIV treatment in PEPFAR-supported programs. *Aids* 2011;25(14):1753-60.
- 25. Marseille E, Kahn JG, Pitter C, Bunnell R, Epalatai W, Jawe E, et al. The cost effectiveness of home-based provision of antiretroviral therapy in rural Uganda. *Applied health economics and health policy* 2009;7(4):229-43.
- 26. Marseille E, Giganti M, Mwango A. Taking ART to Scale: Determinants of the Cost and Cost-Effectiveness of Antiretroviral Therapy in 45 Clinical Sites in Zambia. . *PLoS ONE. In Press* 2012.
- 27. Hounton SH, Akonde A, Zannou DM, Bashi J, Meda N, Newlands D. Costing universal access of highly active antiretroviral therapy in Benin. *AIDS Care* 2008;20(5):582-7.
- 28. Bikilla AD, Jerene D, Robberstad B, Lindtjorn B. Cost estimates of HIV care and treatment with and without anti-retroviral therapy at Arba Minch Hospital in southern Ethiopia. *Cost effectiveness and resource allocation : C/E* 2009;7:6.
- 29. Koenig SP, Riviere C, Leger P, Severe P, Atwood S, Fitzgerald DW, et al. The cost of antiretroviral therapy in Haiti. *Cost effectiveness and resource allocation : C/E* 2008;6:3.
- 30. Jaffar S, Amuron B, Foster S, Birungi J, Levin J, Namara G, et al. Rates of virological failure in patients treated in a home-based versus a facility-based HIV-care model in Jinja, southeast Uganda: a cluster-randomised equivalence trial. *Lancet* 2009;374(9707):2080-9.
- 31. Gupta I, M. Trivedi, S. Kandamuthan. Recurrent costs of India's free ART program, in HIV and AIDS in South Asia: an economic development risk., M. Haacker and M. Claeson, Editors. Washington, DC: World Bank, 2009: p. xxvi, 244.

- 32. John KR, Rajagopalan N, Madhuri KV. Brief communication: economic comparison of opportunistic infection management with antiretroviral treatment in people living with HIV/AIDS presenting at an NGO clinic in Bangalore, India. *MedGenMed : Medscape general medicine* 2006;8(4):24.
- 33. Kombe G, Smith O, Nwagbara C. Scaling Up Antiretroviral Treatment in the Public Sector in Nigeria: A Comprehensive Analysis of Resource Requirements: Report issued by PHRplus and Abt Associates, 2004.
- 34. Aracena-Genao B, Navarro JO, Lamadrid-Figueroa H, Forsythe S, Trejo-Valdivia B. Costs and benefits of HAART for patients with HIV in a public hospital in Mexico. *Aids* 2008;22 Suppl 1:S141-8.
- 35. Bautista-Arredondo S, Dmytraczenko T, Kombe G, Bertozzi SM. Costing of scaling up HIV/AIDS treatment in Mexico. *Salud publica de Mexico* 2008;50 Suppl 4:S437-44.
- 36. Cleary SM, McIntyre D, Boulle AM. The cost-effectiveness of antiretroviral treatment in Khayelitsha, South Africa--a primary data analysis. *Cost effectiveness and resource allocation : C/E* 2006;4:20.
- 37. Martinson N, Mohapi L, Bakos D, Gray GE, McIntyre JA, Holmes CB. Costs of providing care for HIV-infected adults in an urban HIV clinic in Soweto, South Africa. *Journal of acquired immune deficiency syndromes* 2009;50(3):327-30.
- 38. Rosen S, Long L, Sanne I. The outcomes and outpatient costs of different models of antiretroviral treatment delivery in South Africa. *Tropical medicine & international health:* TM & IH 2008;13(8):1005-15.
- 39. Deghaye N, Pawinski RA, Desmond C. Financial and economic costs of scaling up the provision of HAART to HIV-infected health care workers in KwaZulu-Natal. *S Afr Med J* 2006;96(2):140-3.
- 40. Harling G, Wood R. The evolving cost of HIV in South Africa: changes in health care cost with duration on antiretroviral therapy for public sector patients. *Journal of acquired immune deficiency syndromes* 2007;45(3):348-54.
- 41. Kevany S, Meintjes G, Rebe K, Maartens G, Cleary S. Clinical and financial burdens of secondary level care in a public sector antiretroviral roll-out setting (G. F. Jooste Hospital). *S Afr Med J* 2009;99(5):320-5.
- 42. Gapminder. Data in Gapminder World. Estimated HIV prevalence % (ages 15-49).
- 43. US Dept. of Labor Bureau of Labor Statistics. Consumer Price Index All Urban Consumers (CPI-U). Washington, DC, 2013.
- 44. The World Bank. How we Classify Countries, 2012.
- 45. Ethiopia Federal HIV/AIDS Prevention and Control Office. Country Progress Report on HIV/AIDS Response: Federal Democratic Republic of Ethiopia, 2012.
- 46. Republique Democratique Du Congo Programme National Multisectoriel de Lutte Contre le Sida (PNMLS). Rapport d'Activite Sure la Riposte au VIH/SIDA en R.D.Congo 2012.
- 47. Cibulskis RE, Aregawi M, Williams R, Otten M, Dye C. Worldwide incidence of malaria in 2009: estimates, time trends, and a critique of methods. *PLoS medicine* 2011;8(12):e1001142.
- 48. The World Bank. Population, total: The World Bank, 2010.
- 49. Fischer Walker CL, Perin J, Aryee MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC public health* 2012;12:220.

- 50. UN Department of Economic and Social Affairs Population Division. World Population Prospects, 2010 Revision, 2010.
- 51. UNICEF. The State of the World's Children 2011. Table 6: Demographic Indicators: under 5 population (2010), 2011.
- 52. Institute for Health Metrics and Evaluation. Malaria Mortality Estimates by Country 1980-2010, 2009.
- 53. World Health Organization. Global Health Observatory Data Repository. *Global Burden of Disease*. Geneva, 2011.
- 54. Lubell Y, Staedke SG, Greenwood BM, Kamya MR, Molyneux M, Newton PN, et al. Likely health outcomes for untreated acute febrile illness in the tropics in decision and economic models; a Delphi survey. *PloS one* 2011;6(2):e17439.
- 55. The World Bank. World Development Report 1993: Investing in Health 1993.
- 56. World Health Statistics 2012. Life tables for WHO Member States. Geneva: World Health Organization, 2009.
- 57. Mathers CD, Lopez AD, Murray CJL. The Burden of Disease and Mortality by Condition: Data, Methods, and Results for 2001. In: Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL, editors. *Global Burden of Disease and Risk Factors*. Washington (DC), 2006.
- 58. Snow R, Newton C, Craig M, Steketee R. The Public Health Burden of Plasmodium falciparum Malaria in Africa: Deriving the Numbers. . *Disease Control Priorities Project Working Paper No. 11*. Bethesda, Maryland: Fogarty International Center, National Institutes of Health, 2003.
- 59. Lamberti LM, Fischer Walker CL, Black RE. Systematic review of diarrhea duration and severity in children and adults in low- and middle-income countries. *BMC public health* 2012;12:276.
- 60. Kaiser Family Foundation. The U.S. President's Emergency Plan for AIDS Relief (PEPFAR), 2013.
- 61. World Health Organization. Global Burden of Disease. Table 1: Estimated total deaths ('000), by cause, sex and WHO Member State, 2008, 2011.
- 62. Walensky RP, Wolf LL, Wood R, Fofana MO, Freedberg KA, Martinson NA, et al. When to start antiretroviral therapy in resource-limited settings. *Annals of internal medicine* 2009;151(3):157-66.
- 63. Mermin J, Lule J, Ekwaru JP, Malamba S, Downing R, Ransom R, et al. Effect of cotrimoxazole prophylaxis on morbidity, mortality, CD4-cell count, and viral load in HIV infection in rural Uganda. *Lancet* 2004;364(9443):1428-34.
- 64. Ayieko P, Akumu AO, Griffiths UK, English M. The economic burden of inpatient paediatric care in Kenya: household and provider costs for treatment of pneumonia, malaria and meningitis. *Cost effectiveness and resource allocation : C/E* 2009;7:3.
- 65. Lengeler C. Insecticide-treated bed nets and curtains for preventing malaria. *The Cochrane database of systematic reviews* 2004(2):CD000363.
- 66. Clasen T, Haller L, Walker D, Bartram J, Cairncross S. Cost-effectiveness of water quality interventions for preventing diarrhoeal disease in developing countries. *J Water Health* 2007;5(4):599-608.
- 67. Denison JA, O'Reilly KR, Schmid GP, Kennedy CE, Sweat MD. HIV voluntary counseling and testing and behavioral risk reduction in developing countries: a meta-analysis, 1990--2005. *AIDS and behavior* 2008;12(3):363-73.

- 68. Weller S, Davis K. Condom effectiveness in reducing heterosexual HIV transmission. *The Cochrane database of systematic reviews* 2002(1):CD003255.
- 69. Smith DL, Cohen JM, Moonen B, Tatem AJ, Sabot OJ, Ali A, et al. Infectious disease. Solving the Sisyphean problem of malaria in Zanzibar. *Science* 2011;332(6036):1384-5.
- 70. Kahn JG, Marseille E, Auvert B. Cost-effectiveness of male circumcision for HIV prevention in a South African setting. *PLoS medicine* 2006;3(12):e517.
- 71. Mulligan JA, Yukich J, Hanson K. Costs and effects of the Tanzanian national voucher scheme for insecticide-treated nets. *Malaria journal* 2008;7:32.
- 72. Kilian A, Byamukama W, Pigeon O, Atieli F, Duchon S, Phan C. Long-term field performance of a polyester-based long-lasting insecticidal mosquito net in rural Uganda. *Malaria journal* 2008;7:49.
- 73. Clasen T, Naranjo J, Frauchiger D, Gerba C. Laboratory assessment of a gravity-fed ultrafiltration water treatment device designed for household use in low-income settings. *The American journal of tropical medicine and hygiene* 2009;80(5):819-23.
- 74. Lubell Y, Riewpaiboon A, Dondorp AM, von Seidlein L, Mokuolu OA, Nansumba M, et al. Cost-effectiveness of parenteral artesunate for treating children with severe malaria in sub-Saharan Africa. *Bull World Health Organ* 2011;89(7):504-12.
- 75. Tate JE, Rheingans RD, O'Reilly CE, Obonyo B, Burton DC, Tornheim JA, et al. Rotavirus disease burden and impact and cost-effectiveness of a rotavirus vaccination program in kenya. *J Infect Dis* 2009;200 Suppl 1:S76-84.
- 76. Shillcutt S, Morel C, Goodman C, Coleman P, Bell D, Whitty CJ, et al. Cost-effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of combination therapy. *Bull World Health Organ* 2008;86(2):101-10.

Figure Legends

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

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

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

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

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

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

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

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

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

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



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

	Malari	Diarrh	е	HIV	Source(s)					
	a	a =:::) /CT	6		P'U.	VOT /			
	LLIN	Filters	VCT	Condom	LLIN	Filters	VCT / condoms			
Health in ⁶¹ puts				S						
Campaign			2.5			Post-campaign surv	vev			
participant per			0			. 000 00pa8 00	,			
household										
Number	1.563	1.840	0.95	0.361		Post-campaign surv	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 survey			
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						1				
Campaign cost	\$34,280				[7] \$31,980 plus ad costs	ditional \$2,300 in rev	vised filter maintenance			
Discount rate	3.0%				[10]					
Health care	\$65	\$104	\$12,213	\$12,213	[64, 74]	[75]	Authors' construction			
incurred with					-		based on 22 years on ART at \$766 per			

each 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		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	\$10.50	\$5.25	\$15.75	\$7.00	\$3.50	\$10.50	\$7.78	\$3.89	\$11.67
diarrhea Annual cost ART	\$938	\$469	\$1,407	\$766	\$383	\$1,150	\$766	\$383	\$1,150
Discount rate	0.03	0.015	0.045	0.03	0.015	0.045	0.03	0.015	0.045
Access to care Diarrhea	0.565	0.424	0.706	0.678	0.509	0.848	0.663	0.497	0.829
Access to care Malaria	0.684	0.583	0.855	0.684	0.583	0.855	0.684	0.583	0.855
Access to ART	0.7	0.42	0.98	0.7	0.42	0.98	0.7	0.42	0.98
Years on ART	22	11	33	22	11	33	22	11	33
HIV prevalence	0.036	0.018	0.054	0.063	0.032	0.095	0.0006	0.0003	0.0009
Baseline cases p1000py Malaria	351.6	175.8	527.5	57.0	28.5	85.5	6.13	3.06	9.19
Baseline cases p1000py Diarrhea	765.3	382.7	1148.0	542.0	271.0	813.0	299.81	149.91	449.72
Propor fatal Malaria	0.008	0.004	0.012	0.012	0.006	0.018	0.004	0.002	0.006
Propor fatal Diarrhea	0.001	0.001	0.002	0.001	0.001	0.002	0.0007	0.0004	0.0011
Participants per HH	2.5	1.25	3.75	2.5	1.25	3.75	2.5	1.25	3.75
DALYs fatal malaria	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs fatal diarrhea	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
DALYs non-fatal malaria	0.366	0.183	0.549	0.366	0.183	0.549	0.366	0.183	0.549
DALYs non-fatal diarrhea	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191
Protect. mortality malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality diarrhea	0.630	0.315	0.945	0.630	0.315	0.945	0.630	0.315	0.945
Protect. non fatal malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. non fatal diarrhea	0.628	0.314	0.941	0.628	0.314	0.941	0.628	0.314	0.941
Protect. mortality HIV transmission	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
Protect. mortality HIV acquisition	0.255	0.128	0.383	0.255	0.128	0.383	0.255	0.128	0.383

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



Table 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most favorable to least favorable cost-effectiveness (net cost per DALY averted). The grey highlighted cells indicate CE ratio is

less favorable than investment in ART. Results shown are for the first 3-year campaign.

1000	TWY OT WOT O	n investment in		Cos			e averted	puigii.	Cost-effectiveness (CE		
										- (/	
	Country	World Bank income classification	DALYs per capita	IPC cost	Net cost	Deaths	Episodes	DALYs averted	Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
1	Guinea- Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1,143.3	\$26	\$7	\$1,005
2	Senegal	Lower middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$768
3	Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$764
4	Burkina Faso	Low	0.126	\$31,525	\$22,206	16.4	4,124	459.4	\$69	\$48	\$819
5	Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,535
6	Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,095
7	Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$888
8	Afghanistan	Low	0.057	\$28,770	\$18,906	12.7	4,146	356.6	\$81	\$53	\$935
9	Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$807
10	Lesotho	Lower middle	0.115	\$35,658	\$47,366	31.3	1,756	779.4	\$46	\$61	\$738
11	Guinea	Low	0.095	\$29,459	\$22,324	12.6	4,272	353.8	\$83	\$63	\$928
12	Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,493
13	Sudan	Lower middle	0.057	\$38,413	\$15,241	6.9	4,907	198.8	\$193	\$77	\$703
14	Liberia	Low	0.092	\$26,704	\$25,526	11.9	3,401	332.6	\$80	\$77	\$1,025
15	Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$987
16	Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$910
17	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801
18	Nigeria	Lower middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$747
19	Mozambique	Low	0.141	\$30,147	\$59,145	22.2	3,816	590.0	\$51	\$100	\$1,109
20	Cen. African Rep.	Low	0.105	\$27,392	\$37,525	13.8	2,819	373.3	\$73	\$101	\$1,230
21	Uganda	Low	0.105	\$31,525	\$40,192	14.9	3,492	399.8	\$79	\$101	\$749
22	Congo, Rep.	Lower middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756
23	Togo	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864
24	Angola	Upper middle	0.088	\$64,586	\$35,794	11.5	3,268	320.8	\$201	\$112	\$674
25	Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$935
26	Zambia	Lower middle	0.128	\$33,591	\$69,806	21.8	3,107	564.3	\$60	\$124	\$826
27	Ethiopia	Low	0.057	\$30,147	\$29,630	8.6	1,986	235.7	\$128	\$126	\$1,139
28	Rwanda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768
29	Malawi	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996
30	Cameroon	Lower middle	0.100	\$37,724	\$52,388	14.3	3,115	388.4	\$97	\$135	\$741
31	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
32	Mauritania	Lower middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$955
33	Yemen	Lower middle	0.025	\$37,035	\$21,139	4.3	3,128	122.9	\$301	\$172	\$719
34	Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	428.8	\$59	\$178	\$1,731
35	Pakistan	Lower middle	0.020	\$41,856	\$19,714	3.8	2,748	108.1	\$387	\$182	\$904
36	Ghana	Lower middle	0.063	\$44,612	\$35,624	6.8	1,966	189.9	\$235	\$188	\$746
37	Madagascar	Low	0.043	\$28,770	\$24,895	4.5	1,910	127.8	\$225	\$195	\$1,025
38	Eritrea	Low	0.033	\$27,392	\$26,438	4.3	1,942	120.5	\$227	\$219	\$1,753
39	Botswana	Upper middle	0.080	\$137,595	\$185,87 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
41	Swaziland	Lower middle	0.150	\$58,387	\$198,39 2	29.1	2,230	724.2	\$81	\$274	\$632

Pag	e 27 d	of 126				ВМЈ	Open						
1	42	Guatemala	Lower middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$627	
2	43	South Africa	Upper middle	0.097	\$99,713	\$180,28	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 7	46	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354	
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 16	53	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046	
17	54	Algeria Uzbekistan	Upper middle Lower middle	0.008	\$73,540 \$45,989	\$51,390 \$25,637	1.4	1,304 2,352	41.0 18.2	\$1,793 \$2,523	\$1,253	\$606 \$717	
18	55 56	Ukraine	Lower middle	0.006	\$74,228	\$68,364	0.6 1.2	623	33.6	\$2,523	\$1,406 \$2,036	\$600	
19	57	Thailand	Upper middle	0.005	\$90,759	\$100,37	1.8	455	48.7	\$1,863	\$2,061	\$622	
20 21	FO	Indonesia		0.000		7		814					
22	58 59	Indonesia Bolivia	Lower middle Lower middle	0.008	\$56,321 \$56,321	\$46,677 \$30,994	0.7	2,015	20.8	\$2,708 \$4,178	\$2,244 \$2,299	\$793 \$668	
23	60	Vietnam	Lower middle	0.010	\$45,989	\$40,910	0.4	828	17.6	\$2,616	\$2,327	\$664	
24	61	Colombia	Upper middle	0.003	\$95,580	\$63,657	0.6	1,419	20.5	\$4,652	\$3,098	\$598	
25 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	65	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,95 4	1.1	735	31.2	\$4,607	\$3,907	\$579	
30 31	66	Argentina	Upper middle	0.003	\$147,238	\$101,85	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	69	Mexico	Upper middle	0.003	\$127,264	\$134,90 1	0.3	0	9.6	\$13,197	\$13,989	\$583	
36 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 48 49 50 51 52 53 54 55 56 57 58 59													
60		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml											

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- effectiveness (compared with Net cost DALYs averted no intervention)		Net cost		co effecti (compa	mental st- 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
Top 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
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
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
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
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
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

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

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

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

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

Technical Supplement

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

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

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

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

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

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

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

Diarrhea: estimation of average cases per PY and annual cases

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

16 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. 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 26 the 2008 survey in Western Province. (b) **Refined data on care seeking**. The 2012 article assumed 100% careseeking 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.

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.

12		its snown are			sts	Disease			Cost-	effectivenes	s (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 18	Guinea- Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465.3	754.3	\$22	\$39	\$1,005
12	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055.1	325.2	\$73	\$80	\$768
1 9	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
2 <u>2</u>	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312.1	280.1	\$90	\$105	\$1,095
27	Burundi	Low	0.118	\$26,015	\$27,699	8.7	1,256.5	239.8	\$116	\$108	\$888
23	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
25	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153.3	270.2	\$96	\$117	\$738
26	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
319 317	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,443.6	194.2	\$152	\$141	\$801
319	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,841.7	214.8	\$145	\$147	\$747
332	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
3 ₂4	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
36 324 325	Senegal	Lower middle	0.050	\$34,969	\$22,535	6.8	2,951.7	193.6	\$116	\$181	\$864
$2^{\frac{24}{7}}$	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,466.8	153.3	\$188	\$192	\$674
25	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,248.9	163.9	\$187	\$192	\$935
328	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
439	Swaziland	Lower middle	0.150	\$58,387	\$87,699	11.5	1,280.6	281.0	\$312	\$208	\$768
430 30	Nigeria	Lower middle	0.133	\$40,479	\$34,860	6.7	1,610.1	187.0	\$186	\$217	\$996
432 432	Kenya	Low	0.065	\$34,280	\$35,682	5.2	1,130.6	142.8	\$250	\$240	\$741
	Gabon Canaa Dan	Upper middle	0.060	\$29,826	\$46,367	4.0	972.5	110.7	\$419	\$269	\$883
433	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522.2	199.0	\$212	\$273	\$955 \$710
434	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5 4.8	1,758.3	236.6	\$187 \$182	\$273	\$719
45	Sudan	Lower middle Lower middle	0.057	\$38,413	\$24,940	4.8	2,620.5 1,397.4	136.6 123.1	\$183 \$257	\$281 \$295	\$1,731 \$904
436	Mauritania	Lower middle	0.042	\$36,346 \$28,770	\$31,642 \$26,424	3.0	1,397.4	84.6	\$257 \$312	\$295 \$340	\$904 \$746
437	Madagascar Eritrea	Low	0.043	\$20,770	\$26,424	2.8	1,079.4	78.5	\$334	\$340 \$349	\$1,025
	Yemen	Lower middle	0.033	\$37,035	\$27,682	3.5	1,778.2	99.3	\$279	\$373	\$1,753
438	Ghana	Lower middle	0.025	\$44,612	\$38,058	4.2	1,776.2	117.8	\$323	\$373 \$379	\$577
139 140	Haiti	Low	0.003	\$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
54 <u>₽</u>	South Africa	Upper middle	0.020	\$99,713	\$115,007	9.1	659.2	235.9	\$487	\$407	\$627
52	Count Amou	Oppor middle	0.001	ψου, ε το	ψ110,001	V. I	000.2	200.0	Ψ-707	ψ-720	ΨΟΖΙ

8,											
43	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	855.9	150.8	\$708	\$502	\$582
9 ⁴³ 149	India	Lower middle	0.027	\$48,744	\$40,648	3.4	713.2	96.2	\$422	\$506	\$613
1 <u>4</u> 2	Botswana	Upper middle	0.080	\$137,595	\$139,112	9.9	634.1	262.4	\$530	\$524	\$733
146	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	672.6	48.0	\$614	\$657	\$1,354
142	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
1 ₄₉ 1 ₄₉ 1 ₅₀	Iraq	Upper middle	0.009	\$53,565	\$37,274	1.7	1,493.0	50.4	\$740	\$1,063	\$606
154	Guatemala	Lower middle	0.016	\$57,698	\$35,999	1.8	1,812.5	51.6	\$698	\$1,118	\$739
155	Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,488.7	35.8	\$885	\$1,130	\$883
1,6	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617.4	23.0	\$1,413	\$1,551	\$650
156	Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898.4	31.6	\$1,577	\$1,846	\$1,046
18	Algeria	Upper middle	0.008	\$73,540	\$60,354	1.3	752.8	38.2	\$1,580	\$1,925	\$606
156	Uzbekistan	Lower middle	0.006	\$45,989	\$34,086	0.5	1,357.2	14.9	\$2,282	\$3,079	\$717
155 250 250	Indonesia	Lower 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	\$90,800	0.8	261.3	21.7	\$4,177	\$4,175	\$622
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
7 69	Ukraine	Lower middle	0.006	\$74,228	\$69,343	0.4	359.1	11.5	\$6,052	\$6,479	\$664
263 263 263	Bolivia	Lower 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
265	Colombia	Upper middle	0.003	\$95,580	\$75,850	0.3	817.2	8.8	\$8,575	\$10,806	\$581
26	Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798.2	9.0	\$9,029	\$11,626	\$724
2 ⁵ 7	Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424.3	10.8	\$11,898	\$13,319	\$579
28	Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536.0	6.6	\$17,673	\$20,818	\$577
293	Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	632.8	6.8	\$17,487	\$21,512	\$591
2g 3g	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029.3	3.9	\$22,267	\$32,314	\$582
J	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280.4	2.3	\$33,785	\$36,384	\$583
376 32	Mexico	Upper middle	0.003	\$127,264	\$129,804	0.1	0.1	3.2	\$40,371	\$39,581	\$638
34											
35 36 37 38 39 40 41 42 43											
36 37 38 39 40 41 42 43 44 45											
36 37 38 39 40 41 42 43 44 45 46											
36 37 38 39 40 41 42 43 44 45 46 47									\$40,371		
36 37 38 39 40 41 42 43 44 45 46 47											
36 37 38 39 40 41 42 43 44 45 46 47											
36 37 38 39 40 41 42 43 44 45 46 47 48											
36 37 38 39 40 41 42 43 44 45 46 47 48 49 50											
36 37 38 39 40 41 42 43 44 45 46 47 48											
36 37 38 39 40 41 42 43 44 45 46 47 48 49 50											
36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52				IP	C CEA Tech	nical Supį	olement -				
36 37 38 39 40 41 42 43 44 45 46 47 48 49 50				ĮP	C CEA Tech	nical Supț	olement -				

IPC CEA Technical Supplement - 4

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

12				Co	sts	Disease	e averted		Cost-eff	ectivene	ss (CE)
13 14	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
16	Swaziland	Lower middle	0.150	\$58,387	\$198,392	29.1	2,230	724.2	\$81	\$274	\$632
17	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
30⁵	Malawi	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996
316	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
333	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₿	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
4₹	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
42	Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$935
4 3 8	Togo	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864
4249	Rwanda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768
439	Congo, Rep.	Lower middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756
48	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
$4\frac{32}{7}$	Ghana	Lower middle	0.063	\$44,612	\$35,624	6.8	1,966	189.9	\$235	\$188	\$746
48	Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613
434	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
536 51	Afghanistan	Low	0.057	\$28,770	\$18,906	12.7	4,146	356.6	\$81	\$53	\$935

3											
37	Senegal	Lower middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$768
100	Madagascar	Low	0.043	\$28,770	\$24,895	4.5	1,910	127.8	\$225	\$195	\$1,025
39 1 1	Mauritania	Lower middle	0.042	\$36,346	\$28,117	5.8	2,607	164.2	\$221	\$171	\$955
	Namibia	Upper middle	0.038	\$75,606	\$204,271	15.6	1,528	402.7	\$188	\$507	\$606
41	Eritrea	Low	0.033	\$27,392	\$26,438	4.3	1,942	120.5	\$227	\$219	\$1,753
40 2 41 13 42 143	Haiti	Low	0.028	\$30,836	\$31,570	4.4	3,128	123.0	\$251	\$257	\$869
43	India	Lower middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$733
15	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354
1 <u>6</u> 1 <u>7</u> 6	Yemen	Lower middle	0.025	\$37,035	\$21,139	4.3	3,128	122.9	\$301	\$172	\$719
	Pakistan	Lower middle	0.020	\$41,856	\$19,714	3.8	2,748	108.1	\$387	\$182	\$904
1 .β. 10.	Papua New Guinea	Lower middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$864
19 20 49	Guatemala	Lower middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$627
49	Cambodia	Low	0.014	\$38,413	\$31,172	1.9	1,341	54.3	\$708	\$574	\$739
50 50 51 51 52	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883
51	Bolivia	Lower middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668
52	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758
253	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
254	Indonesia	Lower middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793
<u> </u>	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046
2 7 6	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,954	1.1	735	31.2	\$4,607	\$3,907	\$579
57	Uzbekistan	Lower middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717
28 57 29 58 39 39	Morocco	Lower middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650
359	Ukraine	Lower middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$600
360	Thailand	Upper middle	0.005	\$90,759	\$100,377	1.8	455	48.7	\$1,863	\$2,061	\$622
32	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664
362	Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$591
34	Brazil	Upper middle	0.004	\$104,534	\$65,501	0.6	1,385	19.2	\$5,431	\$3,403	\$581
35	Peru	Upper middle	0.004	\$95,580	\$59,439	0.6	1,497	19.0	\$5,026	\$3,126	\$613
363	Colombia	Upper middle	0.003	\$95,580	\$63,657	0.6	1,419	20.5	\$4,652	\$3,098	\$598
366	Mexico	Upper middle	0.003	\$127,264	\$134,901	0.3	0	9.6	\$13,197	\$13,989	\$583
383	Philippines	Lower middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$724
383	Argentina	Upper middle	0.003	\$147,238	\$101,854	0.6	1,097	18.1	\$8,155	\$5,642	\$577
169	China	Upper middle	0.001	\$84,560	\$74,564	0.1	486	4.7	\$18,015	\$15,886	\$638
17 p	Turkey	Upper middle	0.001	\$125,197	\$58,058	0.1	1,784	6.1	\$20,489	\$9,501	\$582
12											

IPC CEA Technical Supplement - 6

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 <u>second and subsequent 3-year campaigns</u>.

12 13					C	osts	Disease	averted		Cost-e	ffectivenes	ss (CE)
14 15 16	1 5	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	7 ¹	Swaziland	Lower middle	0.150	\$58,387	\$87,699	11.5	1,281	281.0	\$312	\$208	\$632
1	3 2	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,976	260.0	\$141	\$116	\$1,109
1) 3	Guinea- Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465	754.3	\$22	\$39	\$1,005
2(2) ₄ I	Nigeria	Lower middle	0.133	\$40,479	\$34,860	6.7	1,610	187.0	\$186	\$217	\$747
2	2 ⁵	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660	263.4	\$156	\$128	\$826
2	3 ⁶	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153	270.2	\$96	\$117	\$819
2	1 ⁷	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312	280.1	\$90	\$105	\$888
2	5 ⁸	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055	325.2	\$73	\$80	\$1,535
2	3 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
	311	Burundi	Low	0.118	\$26,015	\$27,699	8.7	1,256	239.8	\$116	\$108	\$987
2	12	Lesotho	Lower middle	0.115	\$35,658	\$37,171	11.7	919	283.6	\$131	\$126	\$738
3) ₁₃	Congo, DR	Low	0.112	\$24,637	\$24,258	9.3	1,852	259.2	\$94	\$95	\$1,493
ა 32	14	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648	282.6	\$86	\$99	\$1,095
٦ŀ	· ·	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532	221.8	\$164	\$127	\$996
3	16 1	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,444	194.2	\$152	\$141	\$1,230
3	17 0	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,842	214.8	\$145	\$147	\$749
3	318	Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620	223.1	\$177	\$169	\$741
3	7 9	South Africa	Upper middle	0.097	\$99,713	\$115,007	9.1	659	235.9	\$487	\$423	\$582
3	3 20	Guinea	Low	0.095	\$29,459	\$25,199	7.4	2,176	208.8	\$121	\$141	\$928
3	₽ 1	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,763	190.4	\$132	\$140	\$1,025
4	j ²²	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5	1,758	236.6	\$187	\$273	\$674
4	²³	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$31,110	7.8	2,010	214.9	\$145	\$156	\$801
	24	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611	167.1	\$172	\$201	\$910
	,	Botswana	Upper middle	0.080	\$137,595	\$139,112	9.9	634	262.4	\$530	\$524	\$577
4	1 26	Zimbabwe	Low	0.075	\$25,326	\$40,453	6.9	905	165.8	\$244	\$153	\$1,731
4	-	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
٦.	7 29	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,249	163.9	\$187	\$192	\$768
1	3 30	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522	199.0	\$212	\$273	\$756
1	-	Kenya	Low	0.065	\$34,280	\$35,682	5.2	1,131	142.8	\$250	\$240	\$883
) 82	Ghana	Lower middle	0.063	\$44,612	\$38,058	4.2	1,006	117.8	\$323	\$379	\$746
5[33	Gabon	Upper middle	0.060	\$29,826	\$46,367	4.0	972	110.7	\$419	\$269	\$613

IPC CEA Technical Supplement - 7

3						_		_			
34	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128	181.8	\$159	\$166	\$1,139
0^{35}	Sudan	Lower middle	0.057	\$38,413	\$24,940	4.8	2,620	136.6	\$183	\$281	\$703
1 ³⁶	Afghanistan	Low	0.057	\$28,770	\$22,700	12.2	2,381	342.0	\$66	\$84	\$935
237	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
4 ³⁹	Mauritania	Lower middle	0.042	\$36,346	\$31,642	4.4	1,397	123.1	\$257	\$295	\$955
5 ⁴⁰	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	856	150.8	\$708	\$502	\$606
6 ⁴¹	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117	78.5	\$334	\$349	\$1,753
7 42	Haiti	Low	0.028	\$30,836	\$29,010	2.8	1,790	80.4	\$361	\$384	\$869
B ⁴³	India	Lower middle	0.027	\$48,744	\$40,648	3.4	713	96.2	\$422	\$506	\$733
944	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	673	48.0	\$614	\$657	\$1,354
2 0 45	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778	99.3	\$279	\$373	\$719
1 46	Pakistan	Lower middle	0.020	\$41,856	\$28,870	3.6	1,575	102.7	\$281	\$407	\$904
247	Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,489	35.8	\$885	\$1,130	\$864
2 3 48	Guatemala	Lower middle	0.016	\$57,698	\$35,999	1.8	1,813	51.6	\$698	\$1,118	\$627
2 4 49	Cambodia	Low	0.014	\$38,413	\$33,905	1.3	759	37.6	\$901	\$1,020	\$739
2 5 50	Nepal	Low	0.010	\$30,836	\$29,442	1.1	655	30.0	\$982	\$1,028	\$883
2651	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
2653	Algeria	Upper middle	0.008	\$73,540	\$60,354	1.3	753	38.2	\$1,580	\$1,925	\$606
54	Indonesia	Lower middle	0.008	\$56,321	\$50,560	0.5	463	14.3	\$3,545	\$3,949	\$793
55	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617	23.0	\$1,413	\$1,551	\$1,046
156	Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424	10.8	\$11,898	\$13,319	\$579
57 13 ⁵⁷	Uzbekistan	Lower middle	0.006	\$45,989	\$34,086	0.5	1,357	14.9	\$2,282	\$3,079	\$717
258	Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898	31.6	\$1,577	\$1,846	\$650
3559	Ukraine	Lower middle	0.006	\$74,228	\$69,343	0.4	359	11.5	\$6,052	\$6,479	\$600
3600	Thailand	Upper middle	0.005	\$90,759	\$90,800	0.8	261	21.7	\$4,177	\$4,175	\$622
37 ⁶¹	Vietnam	Lower middle	0.005	\$45,989	\$42,516	0.3	478	8.2	\$5,164	\$5,586	\$664
38 ⁶²	Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536	6.6	\$17,673	\$20,818	\$591
39 ⁶³	Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798	9.0	\$9,029	\$11,626	\$581
₽ <mark>0</mark> 64	Peru	Upper middle	0.004	\$95,580	\$73,664	0.3	862	9.6	\$7,650	\$9,926	\$613
l 1 ⁶⁵	Colombia	Upper middle	0.003	\$95,580	\$75,850	0.3	817	8.8	\$8,575	\$10,806	\$598
	Mexico	Upper middle	0.003	\$127,264	\$129,804	0.1	0	3.2	\$40,371	\$39,581	\$583
1 3 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
· F	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280	2.3	\$33,785	\$36,384	\$638
1670	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029	3.9	\$22,267	\$32,314	\$582
7											

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

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

IPC CEA Technical Supplement - 9

Г	Myanmar	1,243,928	47,963,012	0.0259	12.8	403,734	1.75	673,594	0.6	166,600
ŀΓ	Yemen	599,468	24,052,514	0.0249	20.2	415,209	0.46	184,259	0.2	Unknown
Ί	Pakistan	3,465,577	173,593,383	0.0200	16.0	3,220,422	0.12	135,885	0.1	109,270
	Papua New	121,356	6,858,266	0.0177	5.2	31,732	7.29	58,264	0.9	31,360
_	Guinea									
≥ L	Guatemala	225,349	14,388,929	0.0157	19.1	152,755	0.00	1,054	0.8	71,540
Ľ	Cambodia	191,054	14,138,255	0.0135	7.1	121,042	0.78	53,352	0.5	16,660
. 上	Nepal	297,240	29,959,364	0.0099	14.7	229,536	0.02	20,664	0.4	47,040
ΣL	Bolivia	98,154	9,929,849	0.0099	15.2	85,256	0.02	648	0.2	12,250
١	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
, [Indonesia	1,849,471	239,870,937	0.0077	15.1	924,024	0.80	357,048	0.2	568,400
ľ	Bangladesh	1,057,299	148,692,131	0.0071	11.0	939,026	1.77	104,553	0.06	13,720
	Russian	990,798	141,920,000	0.0070	1.2	74,498	0.00	Unknown	1	916,300
, _	Federation									
╙	Uzbekistan	166,792	28,562,400	0.0058	12.0	97,702	0.00	0	0.1	69,090
۱.	Morocco	184,114	31,951,412	0.0058	12.4	149,814	0.00	Unknown	0.1	34,300
. L	Ukraine	255,845	45,870,700	0.0056	0.8	20,645	0.00	Unknown	1.1	235,200
ľ	Thailand	365,406	69,122,234	0.0053	1.9	237,657	0.50	10,149	1.3	117,600
ŀĽ	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
ŞΠ	Brazil	728,402	194,946,470	0.0037	5.3	292,349	0.06	4,853	0.45	431,200
ļΓ	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
3	Mexico	321,228	113,423,047	0.0028	5.5	175,197	0.00	12	0.3	146,020
) l	Philippines	255,050	93,260,798	0.0027	6.7	226,838	0.05	7,633	0.06	20,580
٦	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
ΙĽ	Turkey	89,042	72,752,325	0.0012	1.3	82,672	0.00	0	0.06	6,370

34 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 diarrhea, malaria and HIV/AIDS. Source: calculated as sum of DALYs across the 3 diseases.

Population: Total country population, 2010 data. Source: World Bank - http://data.worldbank.org/Indicator/SP.POP.TOTL

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

Diarrhea burden: percentage of childhood(<5) deaths due to diarrhea. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.

DALYs (Diarrhea): Total DALYs 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: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.

DALYs (Malaria): Total DALYs from malaria in children <5 yrs. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.

DALYs (Malaria): Total DALYs from malaria in children <5 yrs. Source: derivation.

HIV burden: Prevalence in 15-49 year olds. Source: AIDSInfo database, via Gapminder.org DALYs (HIV): Total DALYs from HIV/AIDS. Source: derivation.

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

)		Malaria	Diarrhea	HIV		
		LLITN	Filters	VCT	Condoms	TOTAL
		Keny	<i>r</i> a			
Disease averted	Deaths					
averteu	Episodes	1.6	2.4	4.8 7.0	2.2	10.9
	Episodes	133.6	1,877.7	7.0		2,018.3
DALYs	Prevention	44.1	68.3	40.0	18.2	170.6
averted	Earlier HIV care			422.5		422.5
				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)						
(audeu)	Earlier HIV care			(\$81,187		(\$81,187)
)		
İ	TOTAL	\$773	\$9,068	(\$21,710		-\$11,869
Cost-	Campaign cost				1	\$34,280
effectiveness	(unadjusted)					\$3 4 ,200
	Net cost (savings)					\$46,149
Cos	t per DALY averted					\$157
		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	Fortier LIIV core			4.3		
	Earlier HIV care TOTAL	1 7	22.4	1.2		1.2
Costs	Prevention	1.7 \$89	\$5,527	1.8 \$389	\$189	25.9 \$6,196
averted	i icvciitiOii	בטק	72,321	7202	2102	70,130
(added)						
	Farlier HIV care			(6772)		(¢772)
	Earlier HIV care	\$20	\$ 5 527	(\$773) (\$195)		(\$773) \$5.422
Cost-	TOTAL	\$89	\$5,527	(\$773) (\$195)		\$5,422
Cost- effectiveness	TOTAL Campaign cost (unadjusted)	\$89	\$5,527			\$5,422 \$36,658
effectiveness	TOTAL Campaign cost (unadjusted) Net cost (savings)	\$89	\$5,527			\$5,422 \$36,658 \$30,236
effectiveness	TOTAL Campaign cost (unadjusted)	,				\$5,422 \$36,658
effectiveness Cos	TOTAL Campaign cost (unadjusted) Net cost (savings) of per DALY averted	Niger	ia	(\$195)		\$5,422 \$36,658 \$30,236 \$1,168
effectiveness Cos Disease	TOTAL Campaign cost (unadjusted) Net cost (savings)	,			1.3	\$5,422 \$36,658 \$30,236
effectiveness Cos	TOTAL Campaign cost (unadjusted) Net cost (savings) of per DALY averted	Niger	ia	(\$195)	1.3	\$5,422 \$36,658 \$30,236 \$1,168
effectiveness Cos Disease	TOTAL Campaign cost (unadjusted) Net cost (savings) It per DALY averted Deaths	Niger	ia	(\$195)	1.3	\$5,422 \$36,658 \$30,236 \$1,168

	Earlier HIV care			70.8		70.8
00	TOTAL	168.8	97.6	102.9		369.3
1 Costs averted	Prevention	\$6,223	\$14,300	\$28,605	\$13,379	\$62,507
2 (added) 3 4 5	Earlier HIV care			(\$55,797		(\$55,797)
4)		
5	TOTAL	\$6,223	\$14,300	(\$14,813)		\$5,710
6 Cost- 7 effectivenes	Campaign cost					\$40,479
7 effectivenes 8	(unadjusted) Net cost (savings)					\$34,769
9	Cost per DALY averted					\$94
0						
1						
2						
3						
+ 5						
4 5 6						
7						
8						
9						
0 1						
2						
3						
4						
5						
6						
7 8						
9						
0						
1						
2						
3						
4 5						
6						
7						
, 0						

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.

U														
1		Ann	ual	(Cumulativ	е	An	nual DAL'	Ys aver	ted	Cumulative DALYs averted			
2	Year	Net costs	Net DALYs averted	Net costs	DALYs averted	CE (\$/DALY averted)	Malari a	Diarrhea	HIV	Total	Malari a	Diarrh ea	HIV	Total
4	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
5	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
0	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
1	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
2	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
3	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
4	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
5	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
6	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
7	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
8	16	\$1,840	17.2	\$76,807	181.9	\$422	1.3	3.0	12.9	17.2	25.5	56.7	99.7	181.9
	17	\$1,651	16.8	\$78,458	198.8	\$395	1.3	2.9	12.7	16.8	26.8	59.6	112.3	198.8
9	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
0	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
1	20	\$1,139	14.4	\$82,368	244.5	\$337	1.2	2.6	10.6	14.4	30.4	67.8	146.3	244.5
2	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
3	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
4	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
5	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
6	25	\$2,188	6.8	\$87,653	288.9	\$303	1.0	2.3	3.5	6.8	35.7	79.8	173.3	288.9
	26	\$2,020	6.6	\$89,673	295.5	\$304	1.0	2.2	3.4	6.6	36.7	82.1	176.7	295.5
7	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
8	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
9	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
0	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
4														

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.

10	3		•
11	ART UNI	T COSTS	
12 13 14	Country	ART per person-year (2012 US\$)	Sources
16	Benin	\$701	Hounton et al. 2008
17	Botswana	\$703	Menzies, 2011
18	DIazii	\$1,786	Acurcio, 2006 (Cited in Galarraga 2011)
	Ethiopia	\$610	Menzies 2011; Bikilla et al. 2009;
20	Haiti	\$1,120	Koenig 2008
21	India	\$230	Gupta 2009
	Lesotho	\$165	Cleary 2006
23	Mexico	\$5,990	Bautista 2003; Bautista 2008; Aracena-Genao
25 26	Morocco	\$1,102	Loubiere 2008 (Cited in Galarraga 2011)
	Nigeria	\$938	Menzies, 2011; Kombe 2004
28 29	South Africa	\$1,260	Cleary 2006; Kevany 2009; Deghaye 2006; Martinson 2009; Rosen 2008
30	Thailand	\$3,994	Kitajima 2003
ا 4	Uganda	\$805	Marseille 2009; Jaffar 2009
32	Zambia	\$794	Marseille 2012
33	Vietnam	\$964	Menzies, 2011
36 37 38 39 40 41 41 41 41 41 41 41 41 41 41 41 41 41			Loubiere 2008 (Cited in Galarraga 2011) Menzies, 2011; Kombe 2004 Cleary 2006; Kevany 2009; Deghaye 2006; Martinson 2009; Rosen 2008 Kitajima 2003 Marseille 2009; Jaffar 2009 Marseille 2012 Menzies, 2011
.8 .9 .0 .1 .2			



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 percapita GDP may reflects overall ability to pay it assumes that health care is a normal good in which consumption increases monotonically with income. It also lacks the specificity to capture both the unit cost and the relevant quantity utilized of various health inputs, such as inpatient days or outpatient visits. These utilization patterns can vary by country partially independently of income. An alternative index is per-capita spending on health care. This is a more direct measure of overall health care spending, but also fails to capture the detailed inputs cost and utilization mix. Finally, WHO-CHOICE provides country specific costs for inpatient days and outpatient visits at various levels of facilities (e.g. primary, secondary, and teaching hospitals). By comparing the WHO-CHOICE-derived costs for Kenya against the other 69 countries, yet a third index can be created. However, this WHO-CHOICE based index has its own short-comings. In addition to not reflecting the specific mix of inputs needed for the present analysis, the methods used to derive the costs are somewhat opaque. The regression model used to predict country health care costs includes per-capita GDP, and thus may be similar to using a per-capita GDP-based index.

22 The variation in the results yielded by each method is modest. Table 8 shows the base case results using the per23 capita health care spending approach; Table 9 uses the index derived from WHO-CHOICE. These show very little
24 difference in the cost effectiveness results by country rankings when compared with the per-capita GDP approach
25 (Table 3 in the main paper).

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

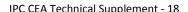
15					Costs		Dise	ease		Cos	st-	
16							ave			effectiven		
17 18 19 20		Country	World Bank income classificat ion	DALY s per capit a	IPC campaig n cost	Net cost	Deaths	Episod es		Campaign cost per DALY averted	Net cost per DALY averted	CE of ART
21	1	Guinea- Bissau	Low	0.134	\$31,652	\$2,286	40.7	10,523	1,145.2	\$28	\$2	\$1,005
22	2	Sierra Leone	Low	0.119	\$52,305	\$4,927	16.0	4,118	447.9	\$117	\$11	\$764
23 24	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
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	9	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 33	1	Congo, DR	Low	0.112	\$25,386	\$25,306	13.4	3,517	376.8	\$67	\$67	\$1,493
34	1	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 38	1 6	Burundi	Low	0.118	\$28,504	\$34,224	14.3	2,267	393.6	\$72	\$87	\$987
39	1 7	Uganda	Low	0.105	\$37,888	\$36,726	14.9	3,492	409.5	\$93	\$90	\$749
40	1	Benin	Low	0.083	\$32,216	\$25,362	10.0	3,096	280.0	\$115	\$91	\$910
41	1	Nigeria	Lower middle	0.133	\$45,846	\$34,213	13.4	3,102	370.6	\$124	\$92	\$747
42 43	2	Mozambique	Low	0.141	\$31,652	\$58,371	22.2	3,816	606.8	\$52	\$96	\$1,109
43 44	2	Cen. African Rep.	Low	0.105	\$26,663	\$37,686	13.8	2,819	380.3	\$70	\$99	\$1,230
45	2	Congo, Rep.	Lower middle	0.067	\$42,684	\$33,709	11.5	2,981	319.7	\$134	\$105	\$756
46	2	Togo	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 49	2 5	Malawi	Low	0.110	\$34,146	\$58,110	18.3	2,965	496.4	\$69	\$117	\$996
5 0	2	Tanzania	Low	0.075	\$30,345	\$39,174	12.1	3,122	331.0	\$92	\$118	\$935
51	2	Ethiopia	Low	0.057	\$28,371	\$28,810	8.6	1,986	237.4	\$120	\$121	\$1,139
52									1		ı l	

IPC CEA Technical Supplement - 16

,	2	Angola	Upper middle	0.088	\$53,374	\$39,069	11.5	3,268	321.5	\$166	\$122	\$674
0	2	Cameroon	Lower middle	0.100	\$39,729	\$52,377	14.3	3,115	394.2	\$101	\$133	\$741
1	3	Rwanda	Low	0.071	\$43,307	\$37,051	9.6	2,216	265.0	\$163	\$140	\$768
2	3	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
4	3	Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	478.9	\$53	\$159	\$1,731
5	3	Yemen	Lower middle	0.025	\$39,388	\$20,853	4.3	3,128	122.6	\$321	\$170	\$719
6	3 4	Mauritania	Lower middle	0.042	\$39,952	\$29,100	5.8	2,607	164.0	\$244	\$177	\$955
8	3 5	Ghana	Lower middle	0.063	\$37,606	\$34,488	6.8	1,966	189.9	\$198	\$182	\$746
9	3	Pakistan	Lower middle	0.020	\$35,334	\$20,601	3.8	2,748	108.0	\$327	\$191	\$904
20	3 7	Madagascar	Low	0.043	\$27,806	\$24,564	4.5	1,910	127.6	\$218	\$192	\$1,025
21	3 8	Eritrea	Low	0.033	\$24,332	\$25,362	4.3	1,942	119.5	\$204	\$212	\$1,753
23	3	Swaziland	Lower middle	0.150	\$88,325	\$197,22 5	29.1	2,230	800.0	\$110	\$247	\$632
24	4 0	Haiti	Low	0.028	\$34,310	\$31,765	4.4	3,128	121.7	\$282	\$261	\$869
25	4	Botswana	Upper middle	0.080	\$151,324	\$196,11 7	26.8	1,111	734.1	\$206	\$267	\$577
26	4	Guatemala	Lower middle	0.016	\$76,551	\$19,936	2.4	3,143	68.3	\$1,121	\$292	\$627
' / 28	4	Myanmar	Low	0.026	\$25,550	\$25,518	2.9	1,306	83.1	\$307	\$307	\$1,354
29	4	India	Lower middle	0.027	\$45,178	\$33,274	3.7	1,255	104.6	\$432	\$318	\$733
30	4 5	Papua New Guinea	Lower middle	0.018	\$44,272	\$24,760	2.4	2,868	70.6	\$627	\$351	\$864
31	4 6	South Africa	Upper middle	0.097	\$167,731	\$223,29 2	21.5	1,150	579.7	\$289	\$385	\$582
32 23	4 7	Gabon	Upper middle	0.060	\$104,762	\$107,28 8	9.3	1,876	251.5	\$417	\$427	\$613
34	4 8	Iraq	Upper middle	0.009	\$43,990	\$25,081	1.9	2,587	55.5	\$792	\$452	\$758
35	4 9	Namibia	Upper middle	0.038	\$113,745	\$218,64 2	15.6	1,528	416.7	\$273	\$525	\$606
36	5 0	Cambodia	Low	0.014	\$41,971	\$32,821	1.9	1,341	53.9	\$779	\$609	\$739
37 38	5 1	Nepal	Low	0.010	\$33,760	\$30,891	1.4	1,135	39.2	\$861	\$788	\$883
39	5 2	Morocco	Lower middle	0.006	\$72,424	\$50,688	1.9	1,623	54.5	\$1,329	\$930	\$650
ŀO	5 3	Bangladesh	Low	0.007	\$31,949	\$28,039	0.9	1,076	25.8	\$1,237	\$1,086	\$1,046
11	5 4	Algeria	Upper middle	0.008	\$87,063	\$59,839	1.4	1,304	40.8	\$2,136	\$1,468	\$606
2 3	5 5	Uzbekistan	Lower middle	0.006	\$54,666	\$26,791	0.6	2,352	18.1	\$3,021	\$1,481	\$717
14	5 6	Indonesia	Lower middle	0.008	\$44,169	\$38,316	0.7	814	20.5	\$2,158	\$1,872	\$793
15	5 7	Thailand	Upper middle	0.005	\$79,120	\$90,878	1.8	455	46.5	\$1,700	\$1,952	\$622
16	5 8	Bolivia	Lower middle	0.010	\$67,123	\$33,507	0.4	2,015	13.1	\$5,105	\$2,549	\$668
17	5 9	Vietnam	Lower middle	0.005	\$51,726	\$44,913	0.6	828	16.7	\$3,102	\$2,694	\$664
!8 !9	6	Ukraine	Lower middle	0.006	\$105,326	\$92,351	1.2	623	32.8	\$3,209	\$2,814	\$600
50	6	Peru	Upper middle	0.004	\$104,227	\$63,328	0.6	1,497	17.8	\$5,864	\$3,563	\$613
51	6	Philippines	Lower middle	0.003	\$51,949	\$39,286	0.3	1,289	10.8	\$4,832	\$3,654	\$724

IPC CEA Technical Supplement - 17

Colombia Urgor 0.000 \$129,275 \$80,234 0.6 1.419 18.7 \$30,000 \$4.283 \$5080	ı											
0												
0	, ,											
0	} . 6	Colombia	Upper	0.003	\$129,275	\$80,234	0.6	1,419	18.7	\$6,900	\$4,283	\$598
9 0 0 0 1 1 1 2 2 3 3 3 4 4 4 5 5 5 6 6 6 6 7 7 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	0 6	Malaysia	middle									
9 0 0 0 1 1 1 2 2 3 3 4 4 4 4 5 5 6 6 6 6 7 7 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	1 6	Brazil	Upper	0.004	\$186,498		0.6	1,385	18.1	\$10,306	\$5,822	\$581
9 0 0 1 1 2 3 3 4 4 4 5 5 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	$\frac{2}{6}$	Russian	High:	0.007	\$240,707	\$192,69	1.1	735	30.2	\$7,975	\$6,384	\$579
9 0 0 1 1 2 2 3 3 4 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	3 6 4 7	Argentina	Upper	0.003	\$252,229	\$164,21	0.6	1,097	16.6	\$15,161	\$9,871	\$577
9 0 0 1 1 2 2 3 3 4 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	5 6 8	Turkey	Upper			\$80,928						
9 0 0 1 1 2 2 3 3 4 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 3 4 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 4 5 5 6 6 6 7 7 8 8 9 9 0 0 1 1 2 2 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	6 6 9	China	middle	0.001	\$93,151	\$81,634	0.1	486	4.4	\$20,990	\$18,395	\$638
12		Mexico		0.003	\$179,550	\$187,18 7	0.3	0	8.7	\$20,612	\$21,489	\$583
2 3 4 4 5 6 6 7 8 9 9 9 9 10 11 12 12 19C CEA Technical Supplement - 18 14 15 16 17 18												
2 3 4 5 6 7 8 9 0 1 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 7 8												
2 3 4 5 6 7 8 9 0 1 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 7 8	2											
2 3 4 5 6 7 8 9 0 1 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 7 8	3 4											
2 3 4 5 6 7 8 9 0 1 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 6 7	5											
2 3 4 5 6 7 8 9 0 1 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 6 7	6											
2 3 4 5 6 7 8 9 0 1 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 7 8												
2 3 4 5 6 7 8 9 0 1 2 3 IPC CEA Technical Supplement - 18 4 5 6 7 8	9											
2 3 4 4 5 6 6 7 8 9 9 9 10 11 12 12 19C CEA Technical Supplement - 18 14 15 16 17 18												
12	32											
2 3 4 4 5 6 6 7 8 9 9 9 10 11 12 12 19C CEA Technical Supplement - 18 14 15 16 17 18	3											
2 3 4 4 5 6 6 7 8 9 9 9 10 11 12 12 19C CEA Technical Supplement - 18 14 15 16 17 18	5											
12	86											
12	1											
2 3 4 4 5 6 6 7 8 9 9 9 9 10 11 12 12 19C CEA Technical Supplement - 18 14 15 16 17 18	8											
12	9											
166 17 18 19 50 51 52 53 64 55 56 66 67	19 10											
166 17 188 199 100 11 162 13 19C CEA Technical Supplement - 18 164 165 166 167	9 0 1 2											
166 177 188 199 100 111 162 173 184 185 186 187 188	9 0 1 2 3											
18 19 50 51 52 63 64 55 66 67 68	19 10 11 12 13											
19 50 51 52 19C CEA Technical Supplement - 18 54 55 56 66 57	19 10 11 12 13 14 15 16											
50 51 52 53 54 55 56 66 57	19 10 11 12 13 14 15 16											
IPC CEA Technical Supplement - 18 IPC CEA Technica	19 10 11 12 13 14 15 16 17											
58	39 10 11 12 13 14 15 16 17 18 19											
58	39 40 41 42 43 44 45 46 47 48 49 50											
58	39 40 41 42 43 44 45 46 47 48 49 50 61											
58	39 40 41 42 43 44 45 46 47 48 49 50											
58	39 40 41 42 43 44 45 46 47 48 49 50 61											
,9	99 90 11 12 13 14 15 16 17 18 19 19 19 19 19 19 19 19 19 19 19 19 19											
0	9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 6 7 8 8 7 8 7 8 7 8 8 7 8 8 7 8 7 8 8 7 8 7 8 8 7 8 7 8 8 7 8 7 8 8 7 8 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 8 7 8 7 8 7 8 7 8 7 8 8 7 8 7 8 7 8 7 8 7 8 7 8 8 7 8 7 8 7 8 8 7 8 7 8 8 7 8 7 8 8 7 8 7 8 7 8 8 7 8 7 8 7 8 7 8 8 7 8 8 7 8 7 8 7 8 7 8 8 7 8 7 8 8 7 8 8 7 8 8 7 8 7 8 8 7 8 8 7 8 8 7 8 8 8 7 8 8 7 8 8 7 8 8 7 8 8 8 8 7 8 8 8 7 8 8 8 8 7 8 8 8 8 8 7 8 8 8 8 8 8 8 8 8 8 8 7 8											



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 <u>first 3-year campaign</u>. <u>Non-tradable portion of costs imputed from Kenya trial data based on WHO-</u> CHOICE data on costs for inpatient day and outpatient visit assuming 75% of costs are for outpatient; 25% for inpatient.

Formatted: Underline

5												(O=)
5 6					Cos	sts	_	ease erted		Cost-eff	ectivenes	s (CE)
7 8		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
9 0	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
1 2	3	Burkina Faso	Low	0.126	\$33,007	\$21,650	16.4	4,124	459.8	\$72	\$47	\$819
3	4	Sierra Leone	Low	0.119	\$28,338	\$22,441	16.0	4,118	447.9	\$63	\$50	#N/A
4	5	Mali	Low	0.124	\$31,186	\$22,527	15.9	4,222	445.4	\$70	\$51	\$888
5	6	Niger	Low	0.110	\$27,560	\$21,862	14.8	4,967	419.1	\$66	\$52	\$1,095
6	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
7	9	Guinea	Low	0.095	\$30,485	\$21,805	12.6	4,272	355.2	\$86	\$61	\$928
8	10	Chad	Low	0.120	\$32,650	\$27,127	15.3	4,335	427.1	\$76	\$64	\$807
9	11	Congo, DR	Low	0.112	\$24,540	\$25,512	13.4	3,517	376.8	\$65	\$68	\$1,493
0	12	Liberia	Low	0.092	\$25,154	\$26,045	11.9	3,401	333.2	\$75	\$78	\$1,025
1	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
2	15	Côte d'Ivoire	Lower middle	0.084	\$34,943	\$34,796	14.1	4,021	393.7	\$89	\$88	\$801
3	16	Benin	Low	0.083	\$33,846	\$25,342	10.0	3,096	280.0	\$121	\$91	\$910
4	17	Nigeria	Lower middle	0.133	\$38,931	\$34,929	13.4	3,102	370.6	\$105	\$94	\$747
5	18	Uganda	Low	0.105	\$32,646	\$39,581	14.9	3,492	409.5	\$80	\$97	\$749
6	19	Mozambiqu e	Low	0.141	\$28,771	\$59,852	22.2	3,816	606.8	\$47	\$99	\$1,109
7	20	Cen. African Rep.	Low	0.105	\$28,010	\$37,642	13.8	2,819	380.3	\$74	\$99	\$1,230
8 9	21	Congo, Rep.	Lower middle	0.067	\$51,672	\$33,891	11.5	2,981	319.7	\$162	\$106	#N/A
0	22	Togo	Low	0.075	\$31,613	\$32,267	10.4	2,849	287.6	\$110	\$112	\$864
	23	Angola	Upper middle	0.088	\$62,105	\$37,627	11.5	3,268	321.5	\$193	\$117	\$674
1	24	Tanzania	Low	0.075	\$32,091	\$38,786	12.1	3,122	331.0	\$97	\$117	\$935
2	25	Zambia	Lower middle	0.128	\$32,785	\$70,043	21.8	3,107	594.6	\$55	\$118	\$826
3	26	Malawi	Low	0.110	\$28,219	\$59,708	18.3	2,965	496.4	\$57	\$120	\$996
4	27	Ethiopia	Low	0.057	\$29,008	\$29,104	8.6	1,986	237.4	\$122	\$123	\$1,139
5	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
6	30	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
7	31	Yemen	Lower middle	0.025	\$41,823	\$20,557	4.3	3,128	122.6	\$341	\$168	\$719
8	32	Mauritania	Lower middle	0.042	\$38,314	\$28,653	5.8	2,607	164.0	\$234	\$175	\$955
9	33	Ghana	Lower middle	0.063	\$33,612	\$33,841	6.8	1,966	189.9	\$177	\$178	\$746
0	34	Pakistan	Lower middle	0.020	\$40,398	\$19,912	3.8	2,748	108.0	\$374	\$184	\$904
1	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
2					IPC CEA	Technica	l Supplen	nent - 19				

Formatted Table

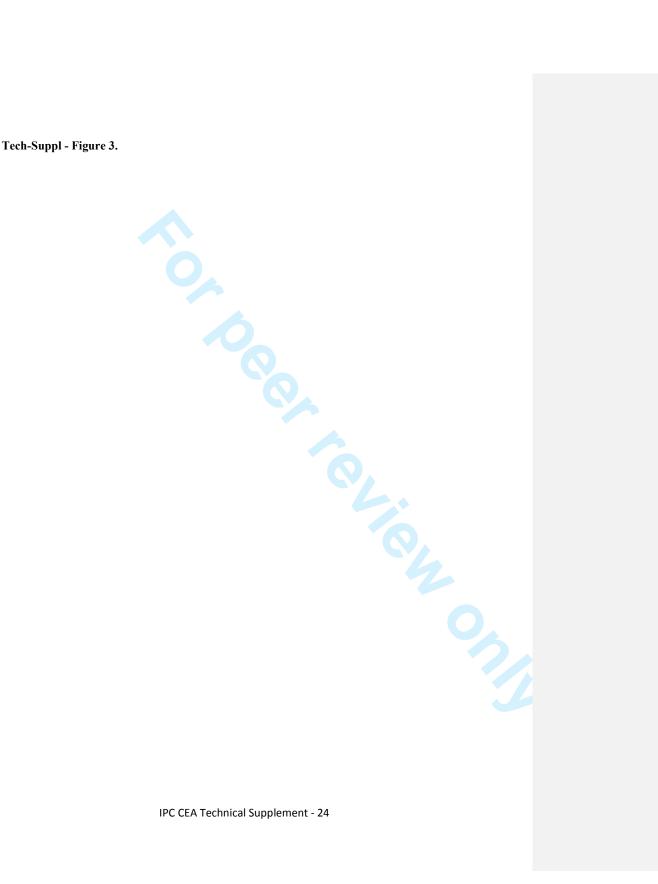
Tech. Suppl. - Table 10. Estimates of rates of care seeking for malaria.

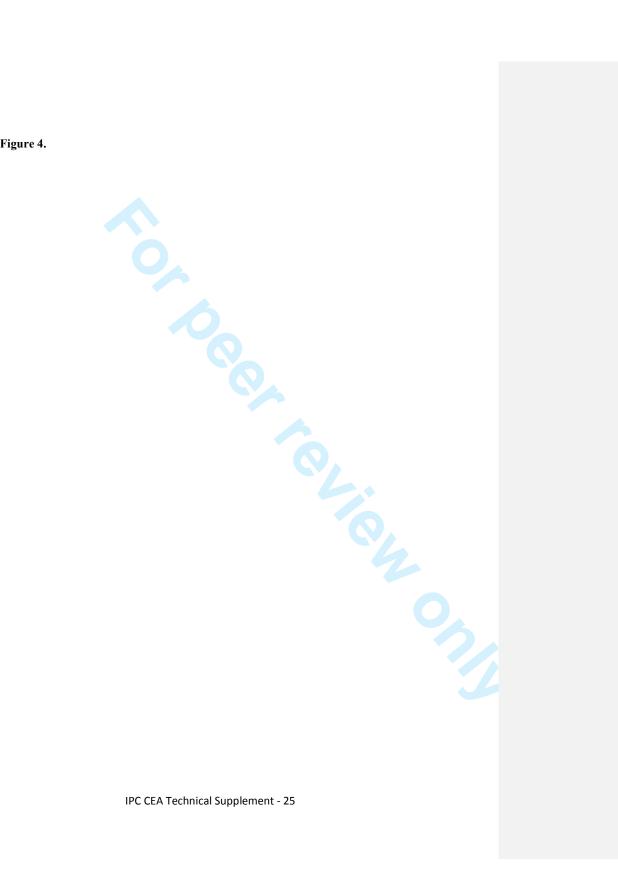
<u>Source</u>	<u>Location</u>	Care-seeking rate
ScientificWorldJournal. 2003 Aug 19;3:721-30. Prevalence of childhood illnesses and care-seeking practices in rural Uganda. Mbonye AK.	Rural Uganda	44.7%
Malar J. 2010 Nov 22;9:333. From fever to anti-malarial: the treatment-seeking process in rural Senegal.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

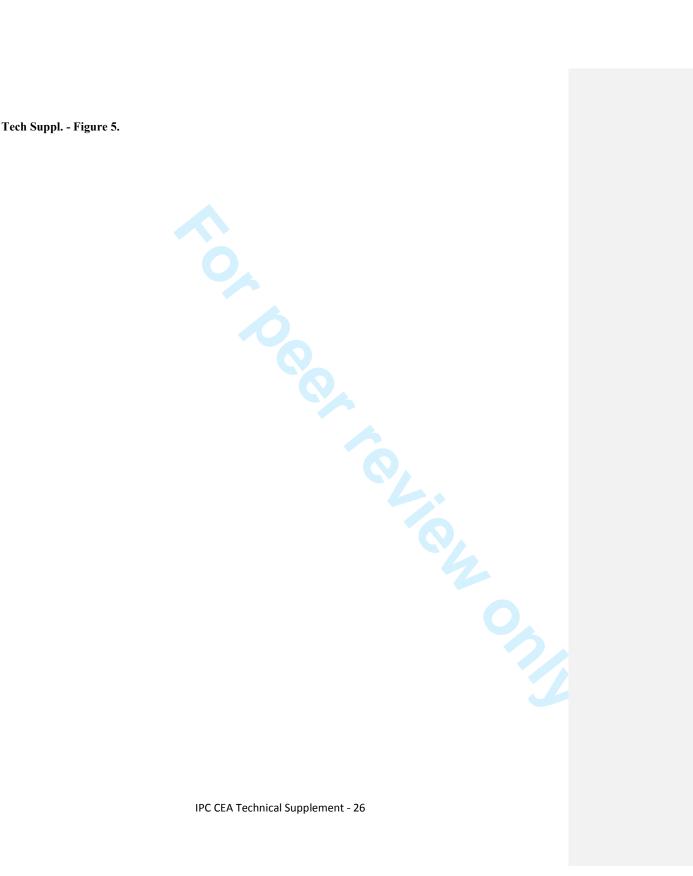


Tech-Suppl - Figure 2.









Projection of costs and outcomes to 30 years

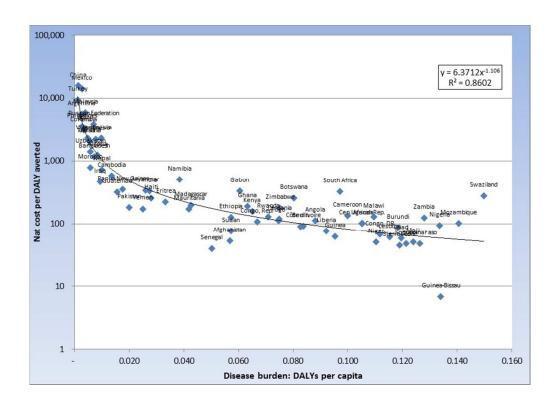
We projected cumulative costs and outcomes of the IPC campaign in Kenya for 30 years, assuming an initial 11 campaign and a second campaign three years later (Figure 6). Costs and benefits of the two campaigns were added 12 and reflect the lower effectiveness of the second campaign. The large rise in 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 17 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
- raign its. Malaria and diarrhea morbidity reduction is confined to the campaign itself.

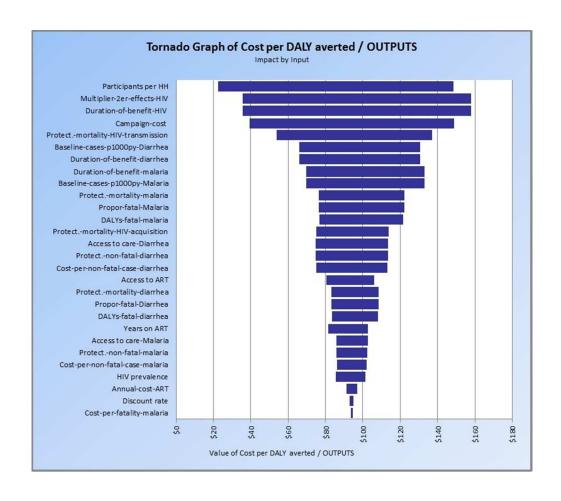
Tech Suppl. - Figure 6.

References

- 1. Kahn JG, Marseille E, Auvert B. Cost-effectiveness of male circumcision for HIV prevention in a South African setting. *PLoS medicine* 2006;3(12):e517.
- 2. Fischer Walker CL, Perin J, Aryee MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC Public Health* 2012;12:220.
- 14 3. UNICEF. The State of the World's Children 2011. Table 6: Demographic Indicators: under 5 population (2010), 15 2011.
- 16 4. UN Department of Economic and Social Affairs Population Division. World Population Prospects, 2010Revision, 2010.
- 18 5. The World Bank. Population, total.
- 19 6. Kahn JG, Muraguri N, Harris B, Lugada E, Clasen T, Grabowsky M, et al. Integrated HIV testing, malaria, and diarrhea prevention campaign in Kenya: modeled health impact and cost-effectiveness. *PloS one* 2012;7(2):e31316.
- 22 7. ICF International. MEASURE DHS STATcompiler, 2012.

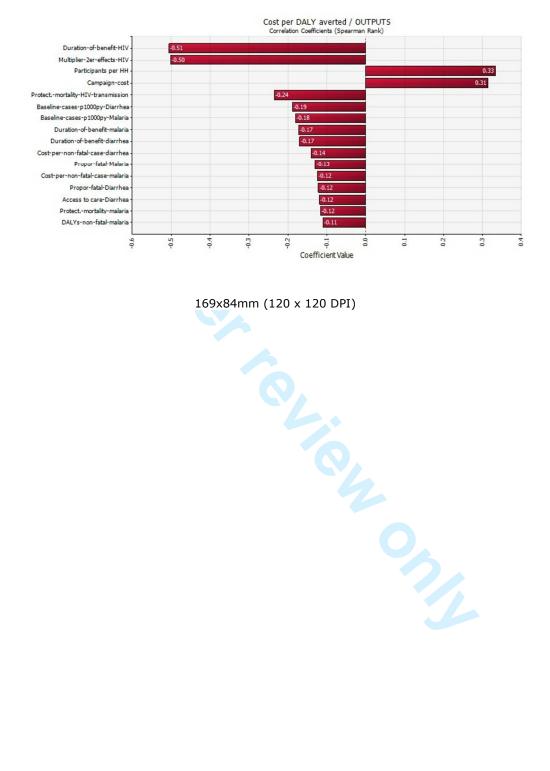


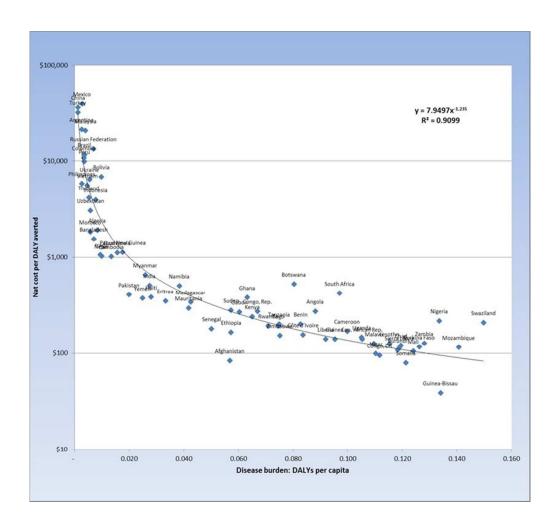
193x139mm (120 x 120 DPI)



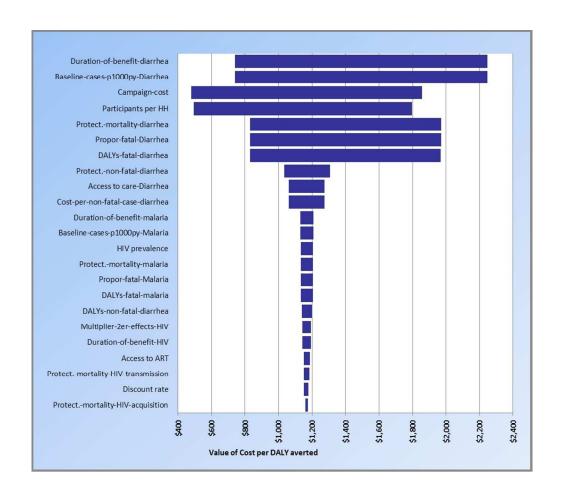
168x148mm (120 x 120 DPI)



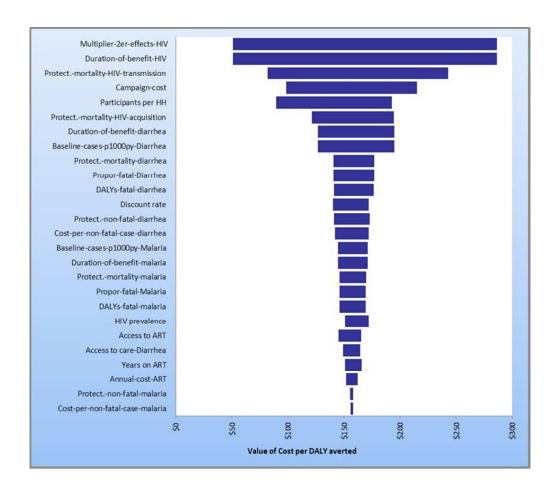




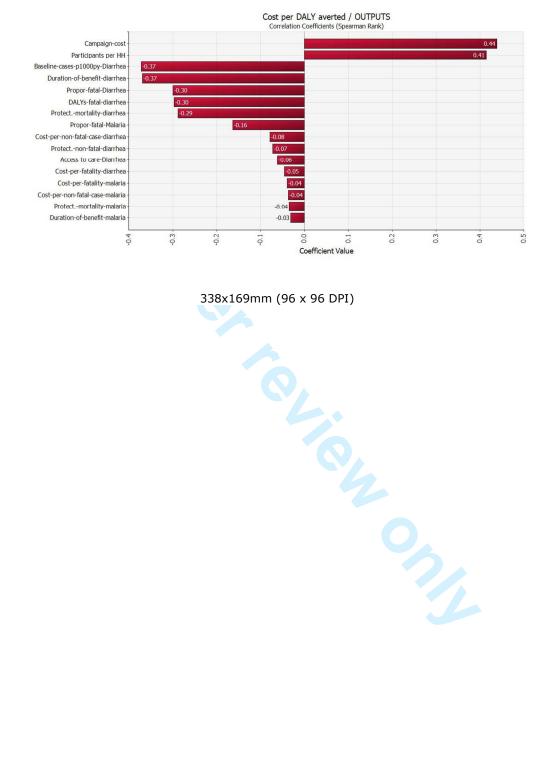
172x161mm (120 x 120 DPI)

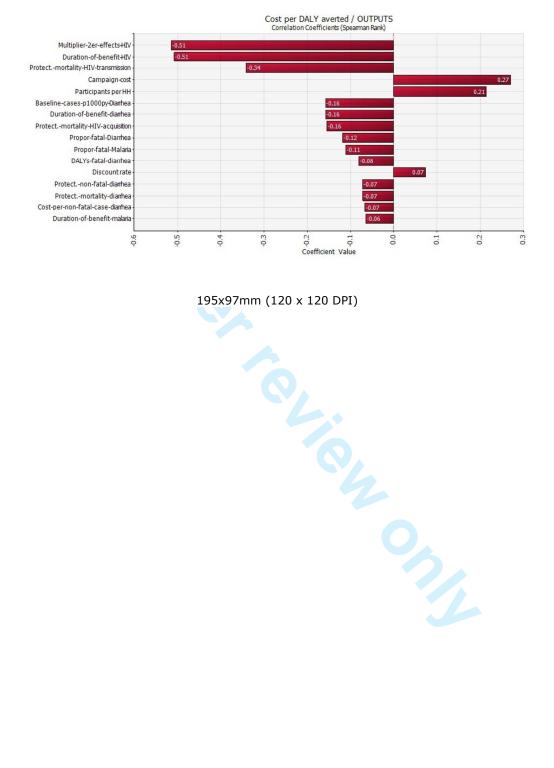


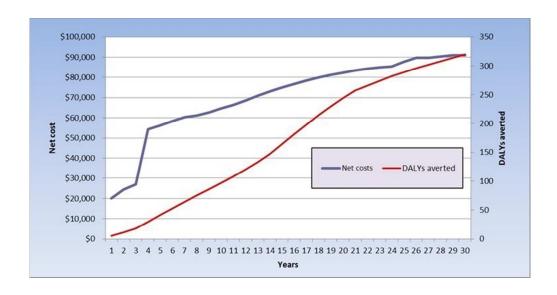
168x148mm (150 x 150 DPI)



168x148mm (120 x 120 DPI)







158x82mm (120 x 120 DPI)

Technical Supplement

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

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

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

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

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

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

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

Diarrhea: estimation of average cases per PY and annual cases

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

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. 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% careseeking for diarrhea and malaria. Subsequently, we obtained data on care-seeking patterns, though not specific to Kenya. The current article thus assumes 67.8% for diarrheal diseases and 68.4% for malaria. In addition, we adjusted two cost inputs. The campaign cost was updated to include a recent water filter maintenance program to \$34,280 from \$32,000 in the earlier paper. Based on a more complete review of the relevant literature including new findings on life expectancy for people receiving antiretroviral therapy (ART), we also increased the estimated lifetime cost of ART, from \$5,092 to \$12,213.

59

60

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.

6 7				Co	osts	Disease	averted		Cost-	effectivenes	s (CE)
8 9 10 11	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
12 13 ¹	Guinea- Bissau	Low	0.134	\$29,459	\$16,675	26.9	5,465.3	754.3	\$22	\$39	\$1,005
14 <u>-2</u> 15 16	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055.1	325.2	\$73	\$80	\$768
16 ³	Afghanistan	Low	0.057	\$28,770	\$22,700	12.2	2,380.6	342.0	\$66	\$84	\$764
17	Congo, DR	Low	0.112	\$24,637	\$24,258	9.3	1,851.9	259.2	\$94	\$95	\$819
18 ⁵	Niger	Low	0.110	\$28,081	\$24,250	10.0	2,648.0	282.6	\$86	\$99	\$1,535
19 ⁶	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312.1	280.1	\$90	\$105	\$1,095
207	Burundi	Low	0.118	\$26,015	\$27,699	8.7	1,256.5	239.8	\$116	\$108	\$888
218	Sierra Leone	Low	0.119	\$31,525	\$24,508	9.8	2,142.5	274.1	\$89	\$115	\$935
229	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,975.5	260.0	\$141	\$116	\$807
2 3 0	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153.3	270.2	\$96	\$117	\$738
241	Chad	Low	0.120	\$35,658	\$27,805	10.6	2,258.2	294.9	\$94	\$121	\$928
2 5 ₂	Lesotho	Lower middle	0.115	\$35,658	\$37,171	11.7	919.3	283.6	\$131	\$126	\$1,493
26 ₁₃	Malawi	Low	0.110	\$28,081	\$36,299	8.6	1,532.3	221.8	\$164	\$127	\$703
27 4	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660.1	263.4	\$156	\$128	\$1,025
28 ₅	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,762.6	190.4	\$132	\$140	\$987
296	Guinea	Low	0.095	\$29,459	\$25,199	7.4	2,175.8	208.8	\$121	\$141	\$910
3 9 7 31	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,443.6	194.2	\$152	\$141	\$801
32/8	Uganda	Low	0.105	\$31,525	\$31,104	7.9	1,841.7	214.8	\$145	\$147	\$747
3 3 9	Zimbabwe	Low	0.075	\$25,326	\$40,453	6.9	905.4	165.8	\$244	\$153	\$1,109
34 ₂₀	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$31,110	7.8	2,009.7	214.9	\$145	\$156	\$1,230
35 ₁	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128.0	181.8	\$159	\$166	\$749
3 6 2 37	Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620.0	223.1	\$177	\$169	\$756
3 52 38 39 ⁴ 40 ⁵	Senegal	Lower middle	0.050	\$34,969	\$22,535	6.8	2,951.7	193.6	\$116	\$181	\$864
3 <u>9</u> -	Togo	Low	0.075	\$29,459	\$28,877	5.5	1,466.8	153.3	\$188	\$192	\$674
40 ²⁵	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,248.9	163.9	\$187	\$192	\$935
u 46	Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,636.6	167.4	\$193	\$201	\$826
4 2 7	Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611.1	167.1	\$172	\$201	\$1,139
4 3 8	Swaziland	Lower middle	0.150	\$58,387	\$87,699	11.5	1,280.6	281.0	\$312	\$208	\$768
4 4 9	Nigeria	Lower middle	0.133	\$40,479	\$34,860	6.7	1,610.1	187.0	\$186	\$217	\$996
4 § 0	Kenya	Low	0.065	\$34,280	\$35,682	5.2	1,130.6	142.8	\$250	\$240	\$741
4 6 1	Gabon	Upper middle	0.060	\$29,826	\$46,367	4.0	972.5	110.7	\$419	\$269	\$883
4 7 32	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522.2	199.0	\$212	\$273	\$955
48 3 ₄α₄	Angola	Upper middle	0.088	\$64,586	\$44,239	8.5	1,758.3	236.6	\$187 \$102	\$273	\$719 \$4.724
4 9 4 503	Sudan	Lower middle	0.057	\$38,413	\$24,940	4.8	2,620.5	136.6	\$183	\$281	\$1,731
5 1 36	Mauritania	Lower middle	0.042	\$36,346	\$31,642	4.4	1,397.4	123.1	\$257	\$295	\$904
	Madagascar	Low	0.043	\$28,770	\$26,424	3.0	1,079.4	84.6	\$312	\$340	\$746
53/	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117.1	78.5	\$334	\$349	\$1,025 \$1,753
5 4 2	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778.2	99.3	\$279	\$373	\$1,753
5 5 ,	Ghana	Lower middle	0.063	\$44,612	\$38,058	4.2	1,006.4	117.8	\$323	\$379	\$577
5 6 ,	Haiti	Low	0.028	\$30,836	\$29,010	2.8	1,789.6	80.4	\$361	\$384	\$869
52/37 53/8 54/39 55/40 56/41 57/42	Pakistan	Lower middle	0.020	\$41,856	\$28,870	3.6	1,574.8	102.7	\$281	\$407	\$632
58 ²	South Africa	Upper middle	0.097	\$99,713	\$115,007	9.1	659.2	235.9	\$487	\$423	\$627

4														
1 43	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	855.9	150.8	\$708	\$502	\$582			
2 44	India	Lower middle	0.027	\$48,744	\$40,648	3.4	713.2	96.2	\$422	\$506	\$613			
45 45	Botswana	Upper middle	0.080	\$137,595	\$139,112	9.9	634.1	262.4	\$530	\$524	\$733			
5 ⁴⁶	Myanmar	Low	0.026	\$31,525	\$29,473	1.7	672.6	48.0	\$614	\$657	\$1,354			
6 ⁴⁷	Cambodia	Low	0.014	\$38,413	\$33,905	1.3	758.8	37.6	\$901	\$1,020	\$864			
7 ⁴⁸	Nepal	Low	0.010	\$30,836	\$29,442	1.1	654.7	30.0	\$982	\$1,028	\$758			
8 49	Iraq	Upper middle	0.009	\$53,565	\$37,274	1.7	1,493.0	50.4	\$740	\$1,063	\$606			
9 50	Guatemala	Lower middle	0.016	\$57,698	\$35,999	1.8	1,812.5	51.6	\$698	\$1,118	\$739			
1 9 1	Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,488.7	35.8	\$885	\$1,130	\$883			
1 <u>1</u> 12 ⁵²	Bangladesh	Low	0.007	\$35,658	\$32,480	0.8	617.4	23.0	\$1,413	\$1,551	\$650			
₁ 5⁄3	Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898.4	31.6	\$1,577	\$1,846	\$1,046			
14 ⁴	Algeria	Upper middle	0.008	\$73,540	\$60,354	1.3	752.8	38.2	\$1,580	\$1,925	\$606			
1 5 5	Uzbekistan	Lower middle	0.006	\$45,989	\$34,086	0.5	1,357.2	14.9	\$2,282	\$3,079	\$717			
1 6 6	Indonesia	Lower middle	0.008	\$56,321	\$50,560	0.5	463.2	14.3	\$3,545	\$3,949	\$600			
1787	Thailand	Upper middle	0.005	\$90,759	\$90,800	0.8	261.3	21.7	\$4,177	\$4,175	\$622			
1 8 8	Vietnam	Lower middle	0.005	\$45,989	\$42,516	0.3	477.7	8.2	\$5,164	\$5,586	\$793			
1 9 9	Philippines	Lower middle	0.003	\$51,499	\$44,213	0.3	743.4	8.8	\$5,026	\$5,854	\$668			
2 0 0	Ukraine	Lower middle	0.006	\$74,228	\$69,343	0.4	359.1	11.5	\$6,052	\$6,479	\$664			
2 6 1	Bolivia	Lower middle	0.010	\$56,321	\$41,435	0.2	1,162.3	8.2	\$5,044	\$6,856	\$598			
2 2 62	Peru	Upper middle	0.004	\$95,580	\$73,664	0.3	862.2	9.6	\$7,650	\$9,926	\$613			
2 3 3	Colombia	Upper middle	0.003	\$95,580	\$75,850	0.3	817.2	8.8	\$8,575	\$10,806	\$581			
264 25	Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798.2	9.0	\$9,029	\$11,626	\$724			
24 25 25 26 26	Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424.3	10.8	\$11,898	\$13,319	\$579			
2 7 66	Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536.0	6.6	\$17,673	\$20,818	\$577			
28 7	Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	632.8	6.8	\$17,487	\$21,512	\$591			
2 9 8	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029.3	3.9	\$22,267	\$32,314	\$582			
369	China	Upper middle	0.001	\$84,560	\$78,518	0.1	280.4	2.3	\$33,785	\$36,384	\$583			
3 1/ 0	Mexico	Upper middle	0.003	\$127,264	\$129,804	0.1	0.1	3.2	\$40,371	\$39,581	\$638			
33							0/2			•	_			
34														
35														
36														
37														
38														
39														
40														
41														
42														
43														
44														
44 45 46														
46														
47 48														
40														

2

3

59

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.

Baseline Cost Property Cost Property	6				Co	sts	Disease	averted		Cost-effectiveness (CI		
	8 9	Country	income	per	IPC cost	Net cost	Deaths	Episodes		cost per DALY	per DALY	CE of ART
	11	Swaziland	Lower middle	0.150	\$58,387	\$198,392	29.1	2,230	724.2	\$81	\$274	\$632
14	1 <i>2</i> 2	Mozambique	Low	0.141	\$30,147	\$59,145	22.2	3,816	590.0	\$51	\$100	\$1,109
10	13 ₃	Guinea-Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1143.3	\$26	\$7	\$1,005
1,86 Burkina Faso Low 0.124 \$31,625 \$32,026 16.4 4,124 469.4 \$69 \$48 \$819 197 Mali Low 0.124 \$29,459 \$23,016 15.9 4,222 445.8 \$66 \$52 \$88 208 Somalia Low 0.121 \$26,015 \$32,775 16.8 3,682 470.5 \$55 \$48 \$1,532 20 Sierra Leone Low 0.119 \$31,525 \$20,112 16.0 4,118 446.7 \$71 \$45 \$764 261 Burundi Low 0.118 \$36,016 \$33,639 14.3 2,267 389.9 \$67 \$86 \$8987 262 Lesotho Low 0.112 \$24,037 \$32,688 13.4 3,517 375.9 \$66 \$688 \$14.98 263 Lesotho Low 0.110 \$28,081 \$21,620 14.8 4,967 419.7 \$66 \$688 \$14.93		Nigeria	Lower middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$747
1,86 Burkina Faso Low 0.124 \$31,625 \$32,026 16.4 4,124 469.4 \$69 \$48 \$819 197 Mali Low 0.124 \$29,459 \$23,016 15.9 4,222 445.8 \$66 \$52 \$88 208 Somalia Low 0.121 \$26,015 \$32,775 16.8 3,682 470.5 \$55 \$48 \$1,532 20 Sierra Leone Low 0.119 \$31,525 \$20,112 16.0 4,118 446.7 \$71 \$45 \$764 261 Burundi Low 0.118 \$36,016 \$33,639 14.3 2,267 389.9 \$67 \$86 \$8987 262 Lesotho Low 0.112 \$24,037 \$32,688 13.4 3,517 375.9 \$66 \$688 \$14.98 263 Lesotho Low 0.110 \$28,081 \$21,620 14.8 4,967 419.7 \$66 \$688 \$14.93	10 ₅	Zambia	Lower middle			\$69,806					\$124	
Composition 18 ⁶	Burkina Faso	Low	0.126	\$31,525	\$22,206	16.4	4,124	459.4	\$69	\$48	\$819	
2-12-20 Chad Low 0.120 \$36,658 \$24,848 15.3 4,335 424.6 \$84 \$59 \$807 2-30 Sierra Leone Low 0.119 \$31,525 \$20,112 16.0 4,118 446.7 \$71 \$45 \$764 2-4 Burundi Low 0.118 \$26,015 \$33,639 14.3 2,267 389.9 \$67 \$86 \$987 2-8 Lesotho Lower middle 0.115 \$35,658 \$47,366 31.3 1,756 779.4 \$46 \$61 \$738 2-73 Congo, DR Low 0.110 \$28,081 \$21,820 14.8 4,967 419.7 \$67 \$52 \$1,095 316 Malawi Low 0.105 \$27,392 \$37,525 13.8 2,819 373.3 \$73 \$101 \$1,230 316 Cen. African Low 0.105 \$31,525 \$40,192 14.9 3,492 399.8 \$79 \$101 <t< td=""><td></td><td>Mali</td><td>Low</td><td>0.124</td><td>\$29,459</td><td>\$23,016</td><td>15.9</td><td>4,222</td><td>445.8</td><td>\$66</td><td>\$52</td><td>\$888</td></t<>		Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$888
Sierra Leone		Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,535
Burundi		Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$807
Burundi	$\frac{23_0}{24}$	Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$764
26 2 Lesotho Lower middle 0.115 \$35,658 \$47,366 31.3 1,756 779.4 \$46 \$61 \$738 273 Congo, DR Low 0.112 \$24,637 \$25,488 13.4 3,517 375.9 \$66 \$68 \$1,493 29 4 Niger Low 0.110 \$28,081 \$21,620 14.8 4,967 419.7 \$67 \$52 \$1,093 30 5 Malawi Low 0.110 \$28,081 \$59,745 18.3 2,965 462.2 \$61 \$129 \$996 316 Cen. African Low 0.105 \$27,392 \$37,525 13.8 2,965 462.2 \$61 \$129 \$996 348 Cameroon Lower middle 0.100 \$37,724 \$52,388 14.3 3,115 388.4 \$97 \$135 \$741 359 South Africa Upper middle 0.097 \$99,713 \$180,284 21.5 1,150 561.0 \$178 \$321 \$582	25 ¹¹	Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$987
Niger	26 2	Lesotho	Lower middle	0.115	\$35,658	\$47,366	31.3	1,756	779.4	\$46	\$61	\$738
3/5 Malawi Low 0.110 \$28,081 \$69,745 18.3 2,965 462.2 \$61 \$129 \$996 3/16 Cen. African Low 0.105 \$27,392 \$37,525 13.8 2,819 373.3 \$73 \$101 \$1,230 3/4 Uganda Low 0.105 \$31,525 \$40,192 14.9 3,492 399.8 \$79 \$101 \$749 3/48 Cameroon Lower middle 0.100 \$37,724 \$52,388 14.3 3,115 388.4 \$97 \$135 \$741 3/59 South Africa Upper middle 0.097 \$99,713 \$180,284 21.5 1,150 561.0 \$178 \$321 \$582 3/60 Guinea Low 0.095 \$29,459 \$22,324 12.6 4,272 353.8 \$83 \$63 \$92 3/61 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77		Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,493
3/5 Malawi Low 0.110 \$28,081 \$69,745 18.3 2,965 462.2 \$61 \$129 \$996 3/16 Cen. African Low 0.105 \$27,392 \$37,525 13.8 2,819 373.3 \$73 \$101 \$1,230 3/4 Uganda Low 0.105 \$31,525 \$40,192 14.9 3,492 399.8 \$79 \$101 \$749 3/48 Cameroon Lower middle 0.100 \$37,724 \$52,388 14.3 3,115 388.4 \$97 \$135 \$741 3/59 South Africa Upper middle 0.097 \$99,713 \$180,284 21.5 1,150 561.0 \$178 \$321 \$582 3/60 Guinea Low 0.095 \$29,459 \$22,324 12.6 4,272 353.8 \$83 \$63 \$92 3/61 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77	28 29	Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,095
32 Rep. Juganda Low 0.105 \$31,525 \$40,192 14.9 3,492 399.8 \$79 \$101 \$749 348 Cameroon Lower middle 0.100 \$37,724 \$52,388 14.3 3,115 388.4 \$97 \$135 \$741 359 South Africa Upper middle 0.097 \$99,713 \$180,284 21.5 1,150 561.0 \$178 \$321 \$582 370 Guinea Low 0.095 \$29,459 \$22,324 12.6 4,272 353.8 \$83 \$63 \$928 392 Angola Upper middle 0.088 \$64,586 \$35,794 11.5 3,268 320.8 \$201 \$112 \$674 403 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 <	3Ø ⁵	Malawi	Low	0.110	\$28,081	\$59,745	18.3	2,965	462.2	\$61	\$129	\$996
337 Uganda Low 0.105 \$31,525 \$40,192 14.9 3,492 399.8 \$79 \$101 \$749 348 Cameroon Lower middle 0.100 \$37,724 \$52,388 14.3 3,115 388.4 \$97 \$135 \$741 369 South Africa Upper middle 0.097 \$99,713 \$180,284 21.5 1,150 561.0 \$178 \$321 \$582 361 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77 \$1,025 392 Angola Upper middle 0.088 \$64,586 \$35,794 11.5 3,268 320.8 \$201 \$112 \$674 403 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 \$120			Low	0.105	\$27,392	\$37,525	13.8	2,819	373.3	\$73	\$101	\$1,230
35q South Africa Upper middle 0.097 \$99,713 \$180,284 21.5 1,150 561.0 \$178 \$321 \$582 36q Guinea Low 0.095 \$29,459 \$22,324 12.6 4,272 353.8 \$83 \$63 \$928 3g1 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77 \$1,025 3g2 Angola Upper middle 0.088 \$64,586 \$35,794 11.5 3,268 320.8 \$201 \$112 \$674 4023 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 \$120 \$91 \$910 425 Botswana Upper middle 0.080 \$137,595 \$185,872 26.8 1,111 734.1 \$187	33 ¹⁷	Uganda	Low	0.105	\$31,525	\$40,192	14.9	3,492	399.8	\$79	\$101	\$749
366/370 Guinea Low 0.095 \$29,459 \$22,324 12.6 4,272 353.8 \$83 \$63 \$928 381 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77 \$1,025 392 Angola Upper middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 403 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 \$120 \$91 \$910 435 Botswana Upper middle 0.080 \$137,595 \$185,872 26.8 1,111 734.1 \$187 \$253 \$577 456 Zimbabwe Low 0.075 \$25,326 \$76,203 17.8 1,682 428.8 \$59 \$178 </td <td></td> <td>Cameroon</td> <td>Lower middle</td> <td>0.100</td> <td>\$37,724</td> <td>\$52,388</td> <td>14.3</td> <td>3,115</td> <td>388.4</td> <td>\$97</td> <td>\$135</td> <td>\$741</td>		Cameroon	Lower middle	0.100	\$37,724	\$52,388	14.3	3,115	388.4	\$97	\$135	\$741
381 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77 \$1,025 392 Angola Upper middle 0.088 \$64,586 \$35,794 11.5 3,268 320.8 \$201 \$112 \$674 403 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 \$120 \$91 \$910 435 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 \$1,731 478 Togo Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 </td <td>35₁₉</td> <td>South Africa</td> <td>Upper middle</td> <td>0.097</td> <td>\$99,713</td> <td>\$180,284</td> <td>21.5</td> <td>1,150</td> <td>561.0</td> <td>\$178</td> <td>\$321</td> <td>\$582</td>	35 ₁₉	South Africa	Upper middle	0.097	\$99,713	\$180,284	21.5	1,150	561.0	\$178	\$321	\$582
381 Liberia Low 0.092 \$26,704 \$25,526 11.9 3,401 332.6 \$80 \$77 \$1,025 392 Angola Upper middle 0.088 \$64,586 \$35,794 11.5 3,268 320.8 \$201 \$112 \$674 403 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 \$120 \$91 \$910 435 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 \$1,731 478 Togo Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 </td <td>37^{0}</td> <td>Guinea</td> <td>Low</td> <td>0.095</td> <td>\$29,459</td> <td>\$22,324</td> <td>12.6</td> <td>4,272</td> <td>353.8</td> <td>\$83</td> <td>\$63</td> <td>\$928</td>	37^{0}	Guinea	Low	0.095	\$29,459	\$22,324	12.6	4,272	353.8	\$83	\$63	\$928
463 Côte d'Ivoire Lower middle 0.084 \$33,591 \$35,069 14.1 4,021 387.2 \$87 \$91 \$801 424 Benin Low 0.083 \$33,591 \$25,345 10.0 3,096 280.0 \$120 \$91 \$910 435 Botswana Upper middle 0.080 \$137,595 \$185,872 26.8 1,111 734.1 \$187 \$253 \$577 456 Zimbabwe Low 0.075 \$25,326 \$76,203 17.8 1,682 428.8 \$59 \$178 \$1,731 457 Tanzania Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 \$935 478 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 429 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128	38 ²¹	Liberia	Low	0.092	\$26,704	\$25,526	11.9	3,401	332.6	\$80	\$77	\$1,025
435 Botswana Upper middle 0.080 \$137,595 \$185,872 26.8 1,111 734.1 \$187 \$253 \$577 446 Zimbabwe Low 0.075 \$25,326 \$76,203 17.8 1,682 428.8 \$59 \$178 \$1,731 457 Tanzania Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 \$935 478 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 489 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 490 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 50 Sill Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157		Angola	Upper middle	0.088	\$64,586	\$35,794	11.5	3,268	320.8	\$201	\$112	\$674
435 Botswana Upper middle 0.080 \$137,595 \$185,872 26.8 1,111 734.1 \$187 \$253 \$577 446 Zimbabwe Low 0.075 \$25,326 \$76,203 17.8 1,682 428.8 \$59 \$178 \$1,731 457 Tanzania Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 \$935 478 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 489 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 490 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 50 Sill Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157	40 ₂₃	Côte d'Ivoire	Lower middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801
435 Botswana Upper middle 0.080 \$137,595 \$185,872 26.8 1,111 734.1 \$187 \$253 \$577 446 Zimbabwe Low 0.075 \$25,326 \$76,203 17.8 1,682 428.8 \$59 \$178 \$1,731 457 Tanzania Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 \$935 478 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 489 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 490 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 50 Sill Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157	42 ²⁴	Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$910
45/467 Tanzania Low 0.075 \$33,591 \$38,453 12.1 3,122 326.9 \$103 \$118 \$935 4/28 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 4/29 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 4/30 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 5/1 Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157 \$883 5/22 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 5/33 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 <td>43²⁵</td> <td>Botswana</td> <td>Upper middle</td> <td>0.080</td> <td>\$137,595</td> <td>\$185,872</td> <td>26.8</td> <td>1,111</td> <td>734.1</td> <td>\$187</td> <td>\$253</td> <td>\$577</td>	43 ²⁵	Botswana	Upper middle	0.080	\$137,595	\$185,872	26.8	1,111	734.1	\$187	\$253	\$577
478 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 489 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 490 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 50 Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157 \$883 522 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 533 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 \$613 5434 Ethiopia Low 0.057 \$30,147 \$29,630 8.6 1,986 235.7 \$128 \$126		Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	428.8	\$59	\$178	\$1,731
478 Togo Low 0.075 \$29,459 \$32,147 10.4 2,849 288.7 \$102 \$111 \$864 489 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 490 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 50 Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157 \$883 522 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 533 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 \$613 5434 Ethiopia Low 0.057 \$30,147 \$29,630 8.6 1,986 235.7 \$128 \$126	45 ₇	Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$935
489 Rwanda Low 0.071 \$31,525 \$34,034 9.6 2,216 266.1 \$118 \$128 \$768 490 Congo, Rep. Lower middle 0.067 \$54,254 \$33,944 11.5 2,981 318.5 \$170 \$107 \$756 50 51 Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157 \$883 522 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 533 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 \$613 5434 Ethiopia Low 0.057 \$30,147 \$29,630 8.6 1,986 235.7 \$128 \$126 \$1,139 565 Sudan Lower middle 0.057 \$38,413 \$15,241 6.9 4,907 198.8 \$193 <td>478</td> <td>Togo</td> <td>Low</td> <td>0.075</td> <td>\$29,459</td> <td>\$32,147</td> <td>10.4</td> <td>2,849</td> <td>288.7</td> <td>\$102</td> <td>\$111</td> <td>\$864</td>	4 7 8	Togo	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864
50 5 1 1 Kenya Low 0.065 \$34,280 \$46,149 10.9 2,018 294.1 \$117 \$157 \$883 522 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 533 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 \$613 54 55 56 Ethiopia Low 0.057 \$30,147 \$29,630 8.6 1,986 235.7 \$128 \$126 \$1,139 56 Sudan Lower middle 0.057 \$38,413 \$15,241 6.9 4,907 198.8 \$193 \$77 \$703 576 Afghanistan Low 0.057 \$28,770 \$18,906 12.7 4,146 356.6 \$81 \$53 \$935		Rwanda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1	\$118	\$128	\$768
522 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 533 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 \$613 54/34 Ethiopia Low 0.057 \$30,147 \$29,630 8.6 1,986 235.7 \$128 \$126 \$1,139 56/35 Sudan Lower middle 0.057 \$38,413 \$15,241 6.9 4,907 198.8 \$193 \$77 \$703 5766 Afghanistan Low 0.057 \$28,770 \$18,906 12.7 4,146 356.6 \$81 \$53 \$935	49 ₃₀	Congo, Rep.	Lower middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756
522 Ghana Lower middle 0.063 \$44,612 \$35,624 6.8 1,966 189.9 \$235 \$188 \$746 533 Gabon Upper middle 0.060 \$29,826 \$84,306 9.3 1,876 255.0 \$117 \$331 \$613 54/34 Ethiopia Low 0.057 \$30,147 \$29,630 8.6 1,986 235.7 \$128 \$126 \$1,139 56/35 Sudan Lower middle 0.057 \$38,413 \$15,241 6.9 4,907 198.8 \$193 \$77 \$703 5766 Afghanistan Low 0.057 \$28,770 \$18,906 12.7 4,146 356.6 \$81 \$53 \$935	50 51 ³¹	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
54 brack 54 brack 54 brack 55 brack 56 brac		Ghana	Lower middle	0.063	\$44,612	\$35,624	6.8	1,966	189.9	\$235	\$188	\$746
5766 Afghanistan Low 0.057 \$28,770 \$18,906 12.7 4,146 356.6 \$81 \$53 \$935		Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613
5766 Afghanistan Low 0.057 \$28,770 \$18,906 12.7 4,146 356.6 \$81 \$53 \$935	54 34 55	Ethiopia	Low	0.057	\$30,147	\$29,630	8.6	1,986	235.7	\$128	\$126	\$1,139
5766 Afghanistan Low 0.057 \$28,770 \$18,906 12.7 4,146 356.6 \$81 \$53 \$935	56 ³⁵	Sudan	Lower middle	0.057	\$38,413	\$15,241	6.9	4,907	198.8	\$193	\$77	\$703
	5786 58	Afghanistan	Low	0.057	\$28,770	\$18,906	12.7	4,146	356.6	\$81	\$53	\$935

1											
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
0 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 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 ⁴8	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
18 50 19	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883
20 ⁵ 1	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
2 2 53	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
23 24 ⁵⁴	Indonesia	Lower middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793
2 5 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
28 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 ₅₉	Ukraine	Lower middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$600
31 32	Thailand	Upper middle	0.005	\$90,759	\$100,377	1.8	455	48.7	\$1,863	\$2,061	\$622
3361	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664
3 4 62	Malaysia	Upper middle	0.004	\$138,284	\$104,408	0.6	930	17.6	\$7,858	\$5,933	\$591
3 5 ,3 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
38 5	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 41	Philippines	Lower middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$724
42 ⁶⁸	Argentina	Upper middle	0.003	\$147,238	\$101,854	0.6	1,097	18.1	\$8,155	\$5,642	\$577
43 69	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
45											

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

7						Disease	averted		Cost-e	ffectivenes	ss (CE)
3) 0 1	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
2 1	Swaziland	Lower middle	0.150	\$58,387	\$87,699	11.5	1,281	281.0	\$312	\$208	\$632
4 2	Mozambique	Low	0.141	\$30,147	\$36,613	9.7	1,976	260.0	\$141	\$116	\$1,109
5 3		Low	0.134	\$29,459	\$16,675	26.9	5,465	754.3	\$22	\$39	\$1,005
6 <u> </u>	Bissau Nigeria	Lower middle	0.133	\$40,479	\$34,860	6.7	1,610	187.0	\$186	\$217	\$747
8 <u> </u>	Zambia	Lower middle	0.128	\$33,591	\$41,222	10.1	1,660	263.4	\$156	\$128	\$826
2Q 6	Burkina Faso	Low	0.126	\$31,525	\$26,076	9.6	2,153	270.2	\$96	\$117	\$819
21 7 22	Mali	Low	0.124	\$29,459	\$25,298	10.0	2,312	280.1	\$90	\$105	\$888
23 8	Somalia	Low	0.121	\$26,015	\$23,643	11.6	2,055	325.2	\$73	\$80	\$1,535
24 9 25	Chad	Low	0.120	\$35,658	\$27,805	10.6	2,258	294.9	\$94	\$121	\$807
26 10) Sierra Leone	Low	0.119	\$31,525	\$24,508	9.8	2,143	274.1	\$89	\$115	\$764
27 28	I Burundi	Low	0.118	\$26,015	\$27,699	8.7	1,256	239.8	\$116	\$108	\$987
	2 Lesotho	Lower middle	0.115	\$35,658	\$37,171	11.7	919	283.6	\$131	\$126	\$738
	Congo, DR	Low	0.112	\$24,637	\$24,258	9.3	1,852	259.2	\$94	\$95	\$1,493
31 <u> </u>	1 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
34 ₁₆ 35	Cen. African Rep.	Low	0.105	\$27,392	\$29,606	7.1	1,444	194.2	\$152	\$141	\$1,230
36 17		Low	0.105	\$31,525	\$31,104	7.9	1,842	214.8	\$145	\$147	\$749
	3 Cameroon	Lower middle	0.100	\$37,724	\$39,507	8.1	1,620	223.1	\$177	\$169	\$741
88 <u> </u>	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
เว ₂ .	Liberia	Low	0.092	\$26,704	\$25,199	6.8	1,763	190.4	\$132	\$140	\$1,025
3 22	2 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
5 ₂₄	1 Benin	Low	0.083	\$33,591	\$28,793	5.9	1,611	167.1	\$172	\$201	\$910
7 25	Botswana	Upper middle	0.080	\$137,595	\$139,112	9.9	634	262.4	\$530	\$524	\$577
18 26 19		Low	0.075	\$25,326	\$40,453	6.9	905	165.8	\$244	\$153	\$1,731
19 27	7 Tanzania	Low	0.075	\$33,591	\$32,273	6.1	1,637	167.4	\$193	\$201	\$935
1 28	3 Togo	Low	0.075	\$29,459	\$28,877	5.5	1,467	153.3	\$188	\$192	\$864
.3	Rwanda	Low	0.071	\$31,525	\$30,620	5.9	1,249	163.9	\$187	\$192	\$768
³⁰	Congo, Rep.	Lower middle	0.067	\$54,254	\$42,228	7.2	1,522	199.0	\$212	\$273	\$756
	Kenya	Low	0.065	\$34,280	\$35,682	5.2	1,131	142.8	\$250	\$240	\$883
57	2 Ghana	Lower middle	0.063	\$44,612	\$38,058	4.2	1,006	117.8	\$323	\$379	\$746
8 33	Gabon	Upper middle	0.060	\$29,826	\$46,367	4.0	972	110.7	\$419	\$269	\$613

1 2	34	Ethiopia	Low	0.057	\$30,147	\$28,881	6.5	1,128	181.8	\$159	\$166	\$1,139
3	35	Sudan	Lower 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 6	37	Senegal	Lower middle	0.050	\$34,969	\$22,535	6.8	2,952	193.6	\$116	\$181	\$768
7	38	Madagascar	Low	0.043	\$28,770	\$26,424	3.0	1,079	84.6	\$312	\$340	\$1,025
8	39	Mauritania	Lower middle	0.042	\$36,346	\$31,642	4.4	1,397	123.1	\$257	\$295	\$955
9 10	40	Namibia	Upper middle	0.038	\$75,606	\$106,711	5.9	856	150.8	\$708	\$502	\$606
	41	Eritrea	Low	0.033	\$27,392	\$26,191	2.8	1,117	78.5	\$334	\$349	\$1,753
12 13	42	Haiti	Low	0.028	\$30,836	\$29,010	2.8	1,790	80.4	\$361	\$384	\$869
14	43	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
16 17	45	Yemen	Lower middle	0.025	\$37,035	\$27,682	3.5	1,778	99.3	\$279	\$373	\$719
18		Pakistan	Lower middle	0.020	\$41,856	\$28,870	3.6	1,575	102.7	\$281	\$407	\$904
19 20		Papua New Guinea	Lower middle	0.018	\$40,479	\$31,703	1.2	1,489	35.8	\$885	\$1,130	\$864
21		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
23 24	50	Nepal	Low	0.010	\$30,836	\$29,442	1.1	655	30.0	\$982	\$1,028	\$883
25		Bolivia	Lower middle	0.010	\$56,321	\$41,435	0.2	1,162	8.2	\$5,044	\$6,856	\$668
26	52	Iraq	Upper middle	0.009	\$53,565	\$37,274	1.7	1,493	50.4	\$740	\$1,063	\$758
27 28	53	Algeria	Upper middle	0.008	\$73,540	\$60,354	1.3	753	38.2	\$1,580	\$1,925	\$606
29	54	Indonesia	Lower middle	0.008	\$56,321	\$50,560	0.5	463	14.3	\$3,545	\$3,949	\$793
30 31	55	Bangladesh	Low	0.007	\$35,658	\$32,480	8.0	617	23.0	\$1,413	\$1,551	\$1,046
32		Russian Federation	High: nonOECD	0.007	\$143,794	\$128,452	0.4	424	10.8	\$11,898	\$13,319	\$579
33		Uzbekistan	Lower middle	0.006	\$45,989	\$34,086	0.5	1,357	14.9	\$2,282	\$3,079	\$717
34 35	58	Morocco	Lower middle	0.006	\$58,387	\$49,883	1.1	898	31.6	\$1,577	\$1,846	\$650
36	59	Ukraine	Lower middle	0.006	\$74,228	\$69,343	0.4	359	11.5	\$6,052	\$6,479	\$600
37 38		Thailand	Upper middle	0.005	\$90,759	\$90,800	0.8	261	21.7	\$4,177	\$4,175	\$622
39	61	Vietnam	Lower middle	0.005	\$45,989	\$42,516	0.3	478	8.2	\$5,164	\$5,586	\$664
40	62	Malaysia	Upper middle	0.004	\$138,284	\$117,395	0.2	536	6.6	\$17,673	\$20,818	\$591
41 42	63	Brazil	Upper middle	0.004	\$104,534	\$81,187	0.3	798	9.0	\$9,029	\$11,626	\$581
43		Peru	Upper middle	0.004	\$95,580	\$73,664	0.3	862	9.6	\$7,650	\$9,926	\$613
44 15		Colombia	Upper middle	0.003	\$95,580	\$75,850	0.3	817	8.8	\$8,575	\$10,806	\$598
45 46		Mexico	Upper middle	0.003	\$127,264	\$129,804	0.1	0	3.2	\$40,371	\$39,581	\$583
47		Philippines	Lower middle	0.003	\$51,499	\$44,213	0.3	743	8.8	\$5,026	\$5,854	\$724
48 40		Argentina	Upper middle	0.003	\$147,238	\$119,687	0.2	633	6.8	\$17,487	\$21,512	\$577
Su		China	Upper middle	0.001	\$84,560	\$78,518	0.1	280	2.3	\$33,785	\$36,384	\$638
51 52	70	Turkey	Upper middle	0.001	\$125,197	\$86,272	0.1	1,029	3.9	\$22,267	\$32,314	\$582

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

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

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

Total DALY burden: Total annual DALYs for diarrhea, malaria and HIV/AIDS. Source: calculated as sum of DALYs across the 3 diseases.

Population: Total country population, 2010 data. Source: World Bank - http://data.worldbank.org/indicator/SP.POP.TOTL

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

Diarrhea burden: percentage of childhood(<5) deaths due to diarrhea. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.

Annual deaths: Total number of deaths from diarrheal disease in children <5 yrs. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.

 $\textbf{DALYs (Diarrhea):} \ \textbf{Total DALYs from diarrheal disease in children < 5 yrs. \ Source: derivation.$

Malaria burden: Percentage of childhood (<5) deaths due to malaria. Source: Black et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010.

DALYs (Malaria): Total DALYs from malaria in children < 5 yrs. Source: derivation.

HIV burden: Prevalence in 15-49 year olds. Source: AIDSInfo database, via Gapminder.org

DALYs (HIV): Total DALYs from HIV/AIDS. Source: derivation.

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

		Malaria LLITN	Diarrhea Filters	HIV VCT	Condoms	TOTAL
		Keny	<i>r</i> a			
Disease	Deaths	•				
averted	Episodes	1.6	2.4	4.8 7.0	2.2	10.9
		133.6	1,877.7			2,018.3
DALYs averted	Prevention	44.1	68.3	40.0	18.2	170.6
averteu	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)						
(added)	Earlier HIV care			(\$81,187		(\$81,187)
	TOTAL	\$773	\$9,068) (\$21,710)		-\$11,869
Cost-	Campaign cost			•		\$34,280
effectiveness	(unadjusted) Net cost (savings)					\$46,149
	Cost per DALY averted					\$157
		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			1.2		1.2
	TOTAL	1.7	22.4	1.8		25.9
Costs	Prevention	\$89	\$5,527	\$389	\$189	\$6,196
averted (added)						
()	Earlier HIV care			(\$773)		(\$773)
	TOTAL	\$89	\$5,527	(\$195)		\$5,422
Cost- effectiveness	Campaign cost (unadjusted)					\$36,658
	Net cost (savings)					\$30,236
	Cost per DALY averted	-	-	-	-	\$1,168
	_	Niger				
Disease averted	Deaths	6.0	3.4	2.7	1.3	13.4
	Episodes			4.0		
	_	734.3	2,363.3			3,101.7
DALYs averted	Prevention	168.8	97.6	21.8	10.2	298.4

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

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

	Ann	ual	(Cumulativ	е	An	nual DAL	Ys aver	ted	Cumulative DALYs averted			
Year	Net	Net	Net costs	DALYs	CE (\$/DALY	Malari	Diarrhea	HIV	Total	Malari	Diarrh	HIV	Total
	costs	DALYs		averted	averted)	а				а	ea		
	000 454	averted	000 454	5.0	00.050	4 7	0.0	0.0		4 7	0.0	0.0	
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		\$24,318	11.3	\$2,161	1.6	3.0	1.4	6.0	3.3	6.2	1.7	11.3
3	\$2,700	7.1	\$27,019	18.3	\$1,475	1.6	2.9	2.6	7.1	4.9	9.1	4.3	18.3
4	\$27,259	11.6	\$54,278	29.9	\$1,817	1.9	4.7	4.9	11.6	6.9	13.8	9.2	29.9
5	\$1,996	11.5	\$56,274	41.4	\$1,360	1.9	4.5	5.1	11.5	8.7	18.3	14.3	41.4
6	\$2,136	11.5	\$58,410	52.9	\$1,104	1.8	4.4	5.4	11.5	10.5	22.7	19.7	52.9
7	\$1,878	11.5	\$60,288	64.4	\$936	1.7	3.9	5.9	11.5	12.2	26.6	25.6	64.4
8	\$874	11.2	\$61,162	75.6	\$809	1.7	3.8	5.8	11.2	13.9	30.3	31.4	75.6
9	\$1,668	10.9	\$62,830	86.5	\$727	1.6	3.7	5.6	10.9	15.5	34.0	37.0	86.5
10	\$1,786	10.6	\$64,616	97.0	\$666	1.6	3.5	5.5	10.6	17.1	37.5	42.4	97.0
11	\$1,896	11.3	\$66,511	108.3	\$614	1.5	3.4	6.3	11.3	18.6	41.0	48.7	108.3
12	\$2,149	12.0	\$68,661	120.3	\$571	1.5	3.3	7.2	12.0	20.0	44.3	55.9	120.3
13	\$2,239	12.7	\$70,900	133.0	\$533	1.4	3.2	8.0	12.7	21.5	47.6	63.9	133.0
14	\$2,100	14.3	\$73,000	147.3	\$496	1.4	3.1	9.8	14.3	22.9	50.7	73.7	147.3
15	\$1,967	17.4	\$74,967	164.7	\$455	1.3	3.1	13.0	17.4	24.2	53.8	86.7	164.7
16	\$1,840	17.2	\$76,807	181.9	\$422	1.3	3.0	12.9	17.2	25.5	56.7	99.7	181.9
17	\$1,651	16.8	\$78,458	198.8	\$395	1.3	2.9	12.7	16.8	26.8	59.6	112.3	198.8
18	\$1,471	16.6	\$79,929	215.3	\$371	1.2	2.8	12.5	16.6	28.0	62.4	124.9	215.3
19	\$1,301	14.7	\$81,230	230.1	\$353	1.2	2.7	10.8	14.7	29.2	65.1	135.7	230.1
20	\$1,139	14.4	\$82,368	244.5	\$337	1.2	2.6	10.6	14.4	30.4	67.8	146.3	244.5
21	\$985	12.7	\$83,354	257.2	\$324	1.1	2.6	9.0	12.7	31.5	70.3	155.3	257.2
22	\$840	8.8	\$84,193	266.0	\$317	1.1	2.5	5.2	8.8	32.6	72.8	160.6	266.0
23	\$702	8.2	\$84,895	274.2	\$310	1.1	2.4	4.8	8.2	33.7	75.2	165.3	274.2
24	\$571	7.8	\$85,466	282.1	\$303	1.0	2.3	4.5	7.8	34.7	77.6	169.8	282.1
25	\$2,188	6.8	\$87,653	288.9	\$303	1.0	2.3	3.5	6.8	35.7	79.8	173.3	288.9
26	\$2,020	6.6	\$89,673	295.5	\$304	1.0	2.2	3.4	6.6	36.7	82.1	176.7	295.5
27	\$106	6.4	\$89,779	301.9	\$297	0.9	2.1	3.3	6.4	37.6	84.2	180.0	301.9
28	\$617	6.2	\$90,396	308.1	\$293	0.9	2.1	3.2	6.2	38.6	86.3	183.3	308.1
29	\$575	6.0	\$90,971	314.1	\$290	0.9	2.0	3.1	6.0	39.4	88.3	186.4	314.1
30	\$0	5.9	\$90,971	320.0	\$284	0.9	2.0	3.0	5.9	40.3	90.3	189.4	320.0

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

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 costeffectiveness results by country rankings when compared with the per-capita GDP approach shown in Table 3 in the main paper.

Table 8. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from highest to lowest cost-effectiveness. Grey cells indicate cost-effectiveness ratios less favorable than investment in ART. Results shown are for the <u>first 3-year campaign</u>. 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.

0 1 2			Costs Disease Cost- averted effectiveness							s (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	
3 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 1	Lesotho	Lower middle	0.115	\$55,557	\$54,805	31.3	1,756	859.0	\$65	\$64	\$738	
3 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	Uganda	Low	0.105	\$37,888	\$36,726	14.9	3,492	409.5	\$93	\$90	\$749	
8 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	
0	Mozambique Con African	Low	0.141	\$31,652	\$58,371	22.2	3,816	606.8	\$52 \$70	\$96	\$1,109 \$1,230	
2 1 2	Cen. African Rep. Congo, Rep.	Lower	0.105 0.067	\$26,663 \$42,684	\$37,686 \$33,709	13.8 11.5	2,819 2,981	380.3	\$134	\$99 \$105	\$1,230 \$756	
$\begin{pmatrix} 2 \\ 2 \\ 2 \end{pmatrix}$	Togo	Lower middle	0.067	\$42,684	\$33,709	10.4	2,849	287.6	\$134 \$115	\$105 \$112	\$864	
3 2	Zambia	Lower	0.075	\$32,973	\$68,361	21.8	3,107	594.6	\$115	\$112	\$826	
4	Zambia	middle	0.120	ψυυ,υ 12	ψυυ,υυ ι	21.0	3,107	J34.U	ΨΟΟ	φιισ	ψυΖυ	
2 5	Malawi	Low	0.110	\$34,146	\$58,110	18.3	2,965	496.4	\$69	\$117	\$996	
2 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	

1	l o
2	2
3	2
1	9
-	3
5	0
6	3
7	1
8	3
9	2
10	3
11	3
11	3
12	4
13	3
14	2
15	6
16	3
17	7
18	3
10	8
19	3
20	9
21	4
22	0
2 3 4 5 6 7 8 9 10 11 2 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38	99 331 332 333 344 335 537 338 339 441 444 444 445 500
24	1
25	4
26	4
20	4
21	4
28	4
29	4
30	5
31	4
32	6
33	4
24	7
25	4
35	8
36	4
37	9
38	0
39	5
40	1
41	5
42	2
	5
43	3
44	5
45	4
46	5
47	5
48	5
	6
49	5
50	- /
51	S S
52	5
53	9
54	6
55	0
00	6

2	2	Angola	Upper middle	0.088	\$53,374	\$39,069	11.5	3,268	321.5	\$166	\$122	\$674
3 4	2	Cameroon	Lower	0.100	\$39,729	\$52,377	14.3	3,115	394.2	\$101	\$133	\$741
5	3	Rwanda	Low	0.071	\$43,307	\$37,051	9.6	2,216	265.0	\$163	\$140	\$768
6 7	3	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883
8	3	Zimbabwe	Low	0.075	\$25,326	\$76,203	17.8	1,682	478.9	\$53	\$159	\$1,731
9 10	3	Yemen	Lower middle	0.025	\$39,388	\$20,853	4.3	3,128	122.6	\$321	\$170	\$719
11 12	3 4	Mauritania	Lower middle	0.042	\$39,952	\$29,100	5.8	2,607	164.0	\$244	\$177	\$955
13	3	Ghana	Lower	0.063	\$37,606	\$34,488	6.8	1,966	189.9	\$198	\$182	\$746
14 15	3	Pakistan	Lower middle	0.020	\$35,334	\$20,601	3.8	2,748	108.0	\$327	\$191	\$904
16 17	3	Madagascar	Low	0.043	\$27,806	\$24,564	4.5	1,910	127.6	\$218	\$192	\$1,025
18	3	Eritrea	Low	0.033	\$24,332	\$25,362	4.3	1,942	119.5	\$204	\$212	\$1,753
19 20	3	Swaziland	Lower middle	0.150	\$88,325	\$197,22 5	29.1	2,230	800.0	\$110	\$247	\$632
21 22	4	Haiti	Low	0.028	\$34,310	\$31,765	4.4	3,128	121.7	\$282	\$261	\$869
23	4	Botswana	Upper middle	0.080	\$151,324	\$196,11 7	26.8	1,111	734.1	\$206	\$267	\$577
24 25	4	Guatemala	Lower	0.016	\$76,551	\$19,936	2.4	3,143	68.3	\$1,121	\$292	\$627
26	4 3	Myanmar	Low	0.026	\$25,550	\$25,518	2.9	1,306	83.1	\$307	\$307	\$1,354
27 28	4	India	Lower middle	0.027	\$45,178	\$33,274	3.7	1,255	104.6	\$432	\$318	\$733
29 30	4 5	Papua New Guinea	Lower middle	0.018	\$44,272	\$24,760	2.4	2,868	70.6	\$627	\$351	\$864
31	4	South Africa	Upper middle	0.097	\$167,731	\$223,29 2	21.5	1,150	579.7	\$289	\$385	\$582
32 33	4	Gabon	Upper middle	0.060	\$104,762	\$107,28 8	9.3	1,876	251.5	\$417	\$427	\$613
34 35	4 8	Iraq	Upper middle	0.009	\$43,990	\$25,081	1.9	2,587	55.5	\$792	\$452	\$758
36	4 9	Namibia	Upper middle	0.038	\$113,745	\$218,64 2	15.6	1,528	416.7	\$273	\$525	\$606
37 38	5	Cambodia	Low	0.014	\$41,971	\$32,821	1.9	1,341	53.9	\$779	\$609	\$739
39 40	5	Nepal	Low	0.010	\$33,760	\$30,891	1.4	1,135	39.2	\$861	\$788	\$883
41	5 2	Morocco	Lower middle	0.006	\$72,424	\$50,688	1.9	1,623	54.5	\$1,329	\$930	\$650
42 43	5	Bangladesh	Low	0.007	\$31,949	\$28,039	0.9	1,076	25.8	\$1,237	\$1,086	\$1,046
44	5 4	Algeria	Upper middle	0.008	\$87,063	\$59,839	1.4	1,304	40.8	\$2,136	\$1,468	\$606
45 46	5 5	Uzbekistan	Lower	0.006	\$54,666	\$26,791	0.6	2,352	18.1	\$3,021	\$1,481	\$717
47 48	5 6	Indonesia	Lower	0.008	\$44,169	\$38,316	0.7	814	20.5	\$2,158	\$1,872	\$793
49	5	Thailand	Upper middle	0.005	\$79,120	\$90,878	1.8	455	46.5	\$1,700	\$1,952	\$622
50 51	7 5 8	Bolivia	Lower	0.010	\$67,123	\$33,507	0.4	2,015	13.1	\$5,105	\$2,549	\$668
52 53	5 9	Vietnam	Lower	0.005	\$51,726	\$44,913	0.6	828	16.7	\$3,102	\$2,694	\$664
54	6 0	Ukraine	Lower middle	0.006	\$105,326	\$92,351	1.2	623	32.8	\$3,209	\$2,814	\$600
55 56	6	Peru	Upper	0.004	\$104,227	\$63,328	0.6	1,497	17.8	\$5,864	\$3,563	\$613
57	6	Philippines	middle Lower	0.003	\$51,949	\$39,286	0.3	1,289	10.8	\$4,832	\$3,654	\$724
58 50	2		middle									

2	6	Colombia	Upper middle	0.003	\$129,275	\$80,234	0.6	1,419	18.7	\$6,900	\$4,283	\$598
} 1	6	Malaysia	Upper middle	0.004	\$122,297	\$93,832	0.6	930	16.5	\$7,428	\$5,699	\$591
5	6 5	Brazil	Upper middle	0.004	\$186,498	\$105,36 5	0.6	1,385	18.1	\$10,306	\$5,822	\$581
7	6	Russian Federation	High: nonOECD	0.007	\$240,707	\$192,69 0	1.1	735	30.2	\$7,975	\$6,384	\$579
3	6	Argentina	Upper middle	0.003	\$252,229	\$164,21 3	0.6	1,097	16.6	\$15,161	\$9,871	\$577
0	6 8	Turkey	Upper middle	0.001	\$191,725	\$80,928	0.1	1,784	5.9	\$32,276	\$13,624	\$582
1 2	6 9	China	Upper middle	0.001	\$93,151	\$81,634	0.1	486	4.4	\$20,990	\$18,395	\$638
3 4	7	Mexico	Upper middle	0.003	\$179,550	\$187,18 7	0.3	0	8.7	\$20,612	\$21,489	\$583
5 6 7 8												
19												
20 21												
22												
23												
24 25												
26												
27												
28 29												
30												
31												
32 33												
34												
35												
36												
37 38												
10												
11 12												
13												
14												
15												
10 17												
18												
19												
39 10 11 12 13 14 15 16 17 18 19 50												
, ,												

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 <u>first 3-year campaign</u>. <u>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/</u>

				Cos	sts	_	ease erted		Cost-eff	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 e	Low	0.141	\$28,771	\$59,852	22.2	3,816	606.8	\$47	\$99	\$1,109		
20	Cen. African Rep.	Low	0.105	\$28,010	\$37,642	13.8	2,819	380.3	\$74	\$99	\$1,230		
21	Congo, Rep.	Lower middle	0.067	\$51,672	\$33,891	11.5	2,981	319.7	\$162	\$106	#N/A		
22	Togo	Low	0.075	\$31,613	\$32,267	10.4	2,849	287.6	\$110	\$112	\$864		
23	Angola	Upper middle	0.088	\$62,105	\$37,627	11.5	3,268	321.5	\$193	\$117	\$674		
24	Tanzania	Low	0.075	\$32,091	\$38,786	12.1	3,122	331.0	\$97	\$117	\$935		
25	Zambia	Lower middle	0.128	\$32,785	\$70,043	21.8	3,107	594.6	\$55	\$118	\$826		
26	Malawi	Low	0.110	\$28,219	\$59,708	18.3	2,965	496.4	\$57	\$120	\$996		
27	Ethiopia	Low	0.057	\$29,008	\$29,104	8.6	1,986	237.4	\$122	\$123	\$1,139		
28	Rwanda	Low	0.071	\$30,681	\$33,818	9.6	2,216	265.0	\$116	\$128	\$768		
29	Cameroon	Lower middle	0.100	\$39,111	\$52,380	14.3	3,115	394.2	\$99	\$133	\$741		
30	Kenya	Low	0.065	\$34,280	\$46,149	10.9	2,018	294.1	\$117	\$157	\$883		
31	Yemen	Lower middle	0.025	\$41,823	\$20,557	4.3	3,128	122.6	\$341	\$168	\$719		
32	Mauritania	Lower middle	0.042	\$38,314	\$28,653	5.8	2,607	164.0	\$234	\$175	\$955		
33	Ghana	Lower middle	0.063	\$33,612	\$33,841	6.8	1,966	189.9	\$177	\$178	\$746		
34	Pakistan	Lower middle	0.020	\$40,398	\$19,912	3.8	2,748	108.0	\$374	\$184	\$904		
35	Madagascar	Low	0.043	\$30,438	\$25,467	4.5	1,910	127.6	\$239	\$200	\$1,025		
36	Eritrea	Low	0.033	\$26,867	\$26,253	4.3	1,942	119.5	\$225	\$220	\$1,753		

Ĩ	27	Deteuvene	Linnar middla	0.000	C11C 101	¢472.027	26.0	1 111	724.4	¢150	0007	\$577
	37	Botswana	Upper middle	0.080	\$116,424	\$173,837	26.8	1,111	734.1	\$159	\$237	1
	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
0	44	Papua New Guinea	Lower middle	0.018	\$39,103	\$25,246	2.4	2,868	70.6	\$554	\$358	\$864
1	45	Gabon	Upper middle	0.060	\$56,344	\$92,439	9.3	1,876	251.5	\$224	\$368	\$613
2	46	Iraq	Upper middle	0.009	\$47,126	\$25,378	1.9	2,587	55.5	\$848	\$457	\$758
3	47	Namibia	Upper middle	0.038	\$68,440	\$201,570	15.6	1,528	416.7	\$164	\$484	\$606
4	48	Cambodia	Low	0.014	\$38,523	\$31,223	1.9	1,341	53.9	\$715	\$579	\$739
5 6	49	Nepal	Low	0.010	\$30,887	\$29,027	1.4	1,135	39.2	\$788	\$740	\$883
7	50	Morocco	Lower middle	0.006	\$54,334	\$40,545	1.9	1,623	54.5	\$997	\$744	\$650
8	51	Bangladesh	Low	0.007	\$32,639	\$28,448	0.9	1,076	25.8	\$1,264	\$1,101	\$1,046
9	52	Algeria	Upper middle	0.008	\$80,074	\$55,887	1.4	1,304	40.8	\$1,965	\$1,371	\$606
0	53	Uzbekistan	Lower middle	0.006	\$43,037	\$25,245	0.6	2,352	18.1	\$2,379	\$1,395	\$717
1	54	Brazil	Upper middle	0.004	\$34,045	\$31,218	0.6	1,385	18.1	\$1,881	\$1,725	\$581
2	55	Thailand	Upper middle	0.005	\$79,636	\$91,299	1.8	455	46.5	\$1,711	\$1,961	\$622
3	56	Ukraine	Lower middle	0.006	\$74,578	\$68,634	1.2	623	32.8	\$2,272	\$2,091	\$600
4 5	57	Indonesia	Lower middle	0.008	\$51,988	\$43,696	0.7	814	20.5	\$2,540	\$2,135	\$793
o 6	58	Bolivia	Lower middle	0.010	\$53,963	\$30,445	0.4	2,015	13.1	\$4,105	\$2,316	\$668
7	59	Vietnam	Lower middle	0.005	\$43,303	\$39,035	0.6	828	16.7	\$2,597	\$2,341	\$664
8	60	Peru	Upper middle	0.004	\$82,397	\$53,509	0.6	1,497	17.8	\$4,636	\$3,011	\$613
9	61	Philippines	Lower middle	0.003	\$48,596	\$37,382	0.3	1,289	10.8	\$4,520	\$3,477	\$724
0	62	Colombia	Upper middle	0.003	\$124,448	\$77,859	0.6	1,419	18.7	\$6,643	\$4,156	\$598
1 2	63	Russian Federation	High: nonOECD	0.007	\$156,317	\$131,095	1.1	735	30.2	\$5,179	\$4,343	\$579
3	64	Argentina	Upper middle	0.003	\$119,219	\$85,212	0.6	1,097	16.6	\$7,166	\$5,122	\$577
4	65	Malaysia	Upper middle	0.004	\$118,529	\$91,339	0.6	930	16.5	\$7,199	\$5,548	\$591
5	66	Turkey	Upper middle	0.001	\$116,707	\$55,139	0.1	1,784	5.9	\$19,647	\$9,283	\$582
6	67	China	Upper middle	0.001	\$66,612	\$59,793	0.1	486	4.4	\$15,010	\$13,474	\$638
7	68	Mexico	Upper middle	0.003	\$120,196	\$127,833	0.3	0	8.7	\$13,799	\$14,675	\$583
8												

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

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

Tech-Suppl - Figure 1.



Tech-Suppl - Figure 2.



Tech-Suppl - Figure 3.



Tech. Suppl. - Figure 4.



Tech Suppl. - Figure 5.



Projection of costs and outcomes to 30 years

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

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

Tech Suppl. - Figure 6.

References

- 1. Kahn JG, Marseille E, Auvert B. Cost-effectiveness of male circumcision for HIV prevention in a South African setting. *PLoS medicine* 2006;3(12):e517.
- 2. Fischer Walker CL, Perin J, Aryee MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC public health* 2012;12:220.
- 3. UNICEF. The State of the World's Children 2011. Table 6: Demographic Indicators: under 5 population (2010), 2011.
- 4. UN Department of Economic and Social Affairs Population Division. World Population Prospects, 2010 Revision, 2010.
- 14 5. The World Bank. Population, total.
 - 6. Kahn JG, Muraguri N, Harris B, Lugada E, Clasen T, Grabowsky M, et al. Integrated HIV testing, malaria, and diarrhea prevention campaign in Kenya: modeled health impact and cost-effectiveness. *PloS one* 2012;7(2):e31316.
 - 7. ICF International. MEASURE DHS STATcompiler, 2012.
 - 8. World Health Organization. CHOosing Interventions that are Cost Effective (WHO-CHOICE), 2014.

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

Elliot Marseille 1* , MPP, DrPH; Aliya Jiwani 2 , MPH; Abhishek Raut 3 , MD; Stéphane Verguet 4 , PhD; Judd Walson 5 , MD; James G. Kahn 6 , MD

- Author affiliations:

 Health Strategies International, 555 59th street, Oakland, CA, 94609, USA

 Health Strategies International, 1138 North Vermon St., Arlington, VA, 22201, USA

 Department of International Health, Johns Hopkins Bloomberg School of Public Health,
 Ballimore, Maryland 21205

 Department of Global Health, University of Washington, Box 359909, 325 Ninth Avenue,
 Seattle, WA 98115, USA

 Departments of Global Health, Medicine, Pediatrics, and Epidemiology, University of
 Washington, Box 159909, 325 Ninth Avenue, Seattle, WA 98115, USA

 Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco, 3333

 California Street Suite 265, Box 0936, San Francisco, CA 94118; Global Health Sciences,
 University of California, San Francisco, 50 Beale Street, 12th floor, San Francisco, CA 94105

*Corresponding author information: Elliot Marseille

emarseille@comcast.net 925-998-5745

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 \$583 million over three years (adjusted costs of \$598 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 flavourable cost-effectiveness to \$119, \$518, \$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.
- cost-effectiveness alone.

 Methods presented here may be applied to other disease areas and facilitate more objective resource allocation decision-making for global health.

 Limitations

 Incomplete availability of data relevant to the large number of countries analyzed.

 Infeasible to develop cost-effectiveness thresholds that reflected the full array of local public health options against which IPC could be considered.

 Regions or urban areas within countries may have costs and health benefits that depart from the overall country assessments.

Background

For many years, vertical (disease-specific) programming has dominated the sphere of global health funding in an effort to tackle the areas of greatest need. 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.

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 8% of the target population. ⁷ 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. ⁷⁸ targe-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. ⁸ It is plausible that IPCs can have a large impact on health in many resource-limited 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 addpring a previously-published spreadsheet-based model that was applied to
the original IPC in Western Kenya.* 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.*0, 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. *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
Sunplement). We derived incidence and case fatality rates for each country from published 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.* 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 appriation 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. 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. The cost of non-tradable lemse, primarily personnel, were adjusted according to the per-capita GDP ratio, in International dollars, between Kenya and each study country. For each country, we estimated the costs of averted medical care due to the IPC by adjusting the sosts for health care incurred per fatal and non-fatal cases in the Kenya campaign by the ratio of GDP per capita in the target country versus Kenya. We selected per capita GDP rather than per capita health care spending as the basis for these adjustments, because the latter reflects overall access to care and our model accounts for access separately.

It is worth noting that there is no recognized "gold standard" for adjusting program and health care costs by country. While per-capita GDP reflects overall ability to pay, it assumes that health care is a normal good in which consumption increases monotonically with income. A per-capita GDP-based index also lacks the specificity to capture both the unit cost and the relevant quantity GDP'-based index also lacks the specificity to capture both the unit cost and the relevant quanti-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-cap 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.

Formatted: Font: Font color: Auto

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

access to are and out-medi-security for a comparison of core adjustmenta, because the latter reflects overall adjustment methods, see Technical Supplement). For malaria, [free are few country-specific data on access to care for malaria except for some of the more-affected countries, mostly in Africa. Whe therefore used global average rates of treatment access, estimated at 68.49% based on published literature.

14-10 See Technical Appendix for the country-specific figures underlying this value).
28 noted in Table 2, the value of 68.49% was varied from 51.39% to 85.59% in sensitivity analyses. For access to care for diarrhea, we used country-specific estimates based on demographic and health survey data on the percent of children under five years of age with diarrhea in the two weeks preceding the survey who received any kind of treatment for diarrhea. ²⁰ We used an average rate of access to ART of 70%. This is considerably higher than the 56% access reported for sub-Saharan Africa. ²¹ and reflects likely increases in access in the context of the global commitment to access.

We calculated the per person-year cost of ART for each country by using published estimates for countries where available. ²⁻²⁴ The non-drug portion of each published unit cost figure was inflated to 2012 US dollars using the U.S. CPI. ⁴⁵ We then derived from the set of published figures an average figure for low-income, lower middle-income excluding India, and uppermiddle income countries as defined by the World Bank. ⁷ 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. ³⁷ 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 derived from the ART unit cost studies described above which includes the breakdown of costs

Formatted: Font: (Default) Times New Roman, Font color: Auto Formatted: Font: (Default) Times New Roman, Font color: Auto Formatted: Font: (Default) Times New Roman, Font color: Auto Formatted: Check spelling and grammar, Not Superscript/ Subscript Formatted: Font: (Default) Times New Roman
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 46 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 of by the total country population ⁴⁸. For diarhea, 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 ⁵⁸ (details in technical supplement). ⁵⁰⁵ Multiplying each estimate by the total population. ⁶⁸ 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%.5°, 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. ° 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) ° and the average duration of each case (7 days for malaria*, 4.43 days for each non-fatal case of malaria and diarrhea, respectively. Assuming 70% access to ART, we estimated 10 DALYs for traiting the control of the contro

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. § 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 PIC 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 PIC, 2) a sum of burden ranks for each disease, and 3) a
composite of burden and intervention opportunity. Here, we extend this opportunity analysis by
examining the relationship between a country's opportunity rank (in DALYs per capita) and its
cost-effectiveness for IPC implementation.

Sensitivity analyses. To assess the effect of uncertainty in inputs, we conducted one-way and multi-way Monte Carlo sensitivity analyses for three countries: Kenya, a low-income country where the IPC trial was performed and is at the 44° percentile for cost-effectiveness of the 70 countries analyzed; Nigeria, a lower-inddle income country at the 75° percentile (relatively favorable); and Bangladesh, a low-income country at the 25° between the 50° and between 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

Result

Across the 70 high opportunity countries, the cost-effectiveness of the first campaign ranges from 57 (Guinea-Bissau) to \$15,886 (China) per DALY averted (IQR \$96 - \$1,071 per DALY averted) (Table 3). At \$182 per DALY averted, Pakistan is at the \$50^{th} percentile for cost-effectiveness. With the exception of Afghanistan, the 30 counties with the most favorable cost-effectiveness are in sub-Saharan Africa. The cost-effectiveness of IPC compares favorably to the cost-effectiveness of ART in 51 countries. The 30 countries with the lowest cost-effectiveness estimates are geographically more diverse and include only three in sub-Saharan Africa (Swaziland, South Africa, and Namibia).

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

Table 3 and Figure 1 about here.

Table 4 displays the cumulative results, grouped in 10-country increments, assuming 15% population coverage, and moving from most to least attractive cost-effectiveness. IPC in the top 10 countries would cost 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 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 0 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 $51^{\rm st}-60^{\rm th}$ and for the $61^{\rm st}-70^{\rm th}$ 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, \$1st 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, 53^{*d} 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 \$53,658. 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.

ç

Sensitivity analyses

One-way sensitivity analysis. Figure 2 is a tomado 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 cost-effectiveness of ART for HIV, \$304 vertus \$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 of sectional yr HIV transmission (r = 0.50), the number of IPC participants per household (r = 0.33), 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). Supplement Figure 6).

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 ⁵⁰ and 98% of its disease burden. 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 \$10.4 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 \$5% 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 rend 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.

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 DALT 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.

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 4m² 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 pairs such a finding would be unsupprising since the cost-effectivenes of most prevention interventions depend importantly on incidence. It is more noteworthy here since the relative prevadence 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

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 epidenie, 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 high IPC cost-effectiveness anking 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-capits after Tatios between Kenya and the other countries to estimate the non-tradable commodity portion of costs. For other variables such as the protective effects of HIV prevention, bed nets and water filters where country-specific information was absent we employed wide ranges in the sensitivity analyses to ensure that we accounted for uncertainty, and this produced wide confidence intervals around the model outcomes.

This study provides substantial evidence that IPC campaigns can be cost-effective in a large number of low and middle-income countries epidemic settings. However, it leaves unanswered important questions that need to be addressed when these broad findings are translated into programs and policies. For example, in settings with high prevalence of both HIV and malaria, as community HIV prevalence is reduced, malaria susceptibility may decline, thus reducing the benefits associated with malaria prevention. Such interactions are not accounted for in our analysis. In some countries the relative contributions of each disease to the total burden imposed by all three diseases is uneven. (See Table 4 of the Technical Supplement for a breakdown of the contribution of each disease to the total for all three diseases). Swaziland, for example, has a high burden of HIV and a low burden of malaria. In Swaziland and similar settings, it may be sensible to focus the IPC campaign in areas of relatively high malaria endemicity, by other means to target the malaria prevention component. Our cost projections posit relatively low IPC coverage, 15%. At this level it is reasonable to assume that in most countries, many high-prevalence areas would not be fully covered and planners need not be concerned that a point of diminishing returns would be met in which it becomes more costly to cover the next community, while the benefit of covering that community might decline. However, prior to implementation, country-specific analyses would be required to determine for which subset of countries it would be more cost-effective to scale up to higher coverage levels even if it means that some countries

are excluded from implementation altogether. The current study also was not designed to consider how program costs and effectiveness might vary according to whether a more vertical or more integrated approach is adopted, or depending on the level of prior scale of existing diarrheal disease, malaria or HIV programs. These important program design considerations will depend on the organization of the health care system in each of the countries considering an IPC program.

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

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

.3

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

Conflicts of interest

References

- 1. De Maeseneer J, van Weel C, Egilman D, Mfenyana K, Kaufman A, Sewankambo N.

- 1. De Maeseneer J, van Weel C, Egilman D, Mfenyana K, Kaufman A, Sewankambo N. Strengthening primary care: addressing the disparity between vertical and horizontal investment. The British journal of general practice: the journal of the Royal College of General Practitioners 2008;58(546):3-4.

 2. Brady MA, Hooper PJ, Ottesen EA. Projected benefits from integrating NTD programs in sub-Saharan Africa. Trends Parasitol 2006;22(7):285-91.

 3. Lineham M, Hanson C, Weaver A, Baker M, Kabore A, Zoerhoff KL, et al. Integrated implementation of programs targeting neglected tropical diseases through preventive chemotherapy: proving the feasibility at national scale. The American journal of tropical medicine and hygiene 2011;84(1):5-14.

 4. Desormeaux J, Johnson MP, Coberly JS, Losikoff P, Johnson E, Hebbner R, et al. Widespread HIV counseling and testing linked to a community-based tuberculosis control program in a high-risk population. Bulletin of the Pan American Health Organization 1996;30(1):1-8.

 5. Lugada E, Millar D, Haskew J, Grabowsky M, Garg N, Vestergaard M, et al. Rapid implementation of an integrated large-scale HIV counseling and testing, malaria, and diarrhea prevention campaign in rural Kenya. PloS one 2010;5(8):e12435.

 6. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DAJX's) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380(985'9):2197-223.

 7. Kahn JG, Harris B, Mermin JH, Classen T, Lugada E, Grabowksy M, et al. Cost of community integrated prevention campaign for malaria, HIV, and diarrhea in rural Kenya. BMC health services research 2011;11:346.

 8. Kahn JG, Murrayur N, Harris B, Lugada E, Clasen T, Grabowsky M, et al. Integrated HIV testing, malaria, and diarrhea prevention campaign in Kenya: modeled health impact and cost-effectiveness. PloS one 2012;7(2):e31316.

 9. Jiwani A, Matheson A, Kahn JG, Raut A, Verguet S, Marsellle E, et al. Integrated disease pr

- Alba S, Dillip A, Hetzel MW, Mayumana I, Mshana C, Makemba A, et al. Improvements in access to malaria treatment in Tanzania following community, retail sector and health facility interventions -a user perspective. Malaria journal 2010;9:163.
 Das A, Ravindran TS. Factors affecting treatment-seeking for febrile illness in a malaria endemic block in Boudh district, Orissa, India: policy implications for malaria control. Malaria journal 2010;9:377.
 Smith LA, Bruce J, Gueye L, Helou A, Diallo R, Gueye B, et al. From fever to anti-malarial: the treatment-seeking process in rural Senegal. Malaria journal 2010;9:333.
 Littrell M, Gatakaa H, Evance J, Poyer S, Njogu J, Solomon T, et al. 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. Malaria journal 2011;10:327.
 LICF International. STATcompiler -% of children under 5 with diarrhea in 2 wks preceding survey who received any kind of treatment Measure DHS, 2012.
 UINAIDS. Sub-Saharan Africa, Regional fact sheet. 2012.
 Galarraga O, Wirtz VJ, Figueroa-Lara A, Santa-Ana-Tellez Y, Coulibaly I, Viisainen K, et al. Unit costs for delivery of antiretroviral treatment and prevention of mother-to-child transmission of HIV: a systematic review for low- and middle-income countries. PharmacoEconomics 2011;29(7):579-99.
 Kittajima T, Kobayashi Y, Chaipah W, Sato H, Chadbunchachai W, Thuennadee R. Costs of medical services for patients with HIV/AIDS in Khon Kaen, Thailand. Aids 2003;17(16):2375-81.
 Menzies NA, Berruti AA, Berzon R, Filler S, Ferris R, Ellerbrock TV, et al. The cost of providing comprehensive HIV treatment in PEPFAR-supported programs. Aids 2011;25(14):1753-60.
 Marseille E, Kahn JG, Pitter C, Bunnell R, Epalatai W, Jawe E, et al. The cost effectiveness of home-based provision of antiret

- Marseille E, Kahn JG, Pitter C, Bunnell R, Epalatai W, Jawe E, et al. The cost effectiveness of home-based provision of antiretroviral therapy in rural Uganda. Applied health economics and health policy 2009;7(4):229-43.
 Marseille E, Giganti M, Mwango A. Taking ART to Scale: Determinants of the Cost and Cost-Effectiveness of Antiretroviral Therapy in 45 Clinical Sites in Zambia. PLoS ONE. In Press 2012.
 Hounton SH, Akonde A, Zannou DM, Bashi J, Meda N, Newlands D. Costing universal access of highly active antiretroviral therapy in Benin. AIDS Care 2008;20(5):582-7.
 Bikilla AD, Jerene D, Robberstad B, Lindjorn B. Cost estimates of HIV care and treatment with and without anti-retroviral therapy at Arba Minch Hospital in southern Ethiopia. Cost effectiveness and resource allocation: C/E 2009;7:6.
 Koenig SP, Riviere C, Leger P, Severe P, Atwood S, Fitzgerald DW, et al. The cost of antiretroviral therapy in Haiti. Cost effectiveness and resource allocation: C/E 2008;6:3.
- Jaffar S, Amuron B, Foster S, Birungi J, Levin J, Namara G, et al. Rates of virological failure in patients treated in a home-based versus a facility-based HIV-care model in Jinja, southeast Uganda: a cluster-randomised equivalence trial. *Lancet* 2009;374(9707):2080-9.
- 31. Gupta I, M. Trivedi, S. Kandamuthan. Recurrent costs of India's free ART program, in HIV and AIDS in South Asia: an economic development risk., M. Haacker and M. Claeson, Editors. Washington, DC: World Bank, 2009: p. xxvi, 244.

- John KR, Rajagopalan N, Madhuri KV. Brief communication: economic comparison of opportunistic infection management with antiretroviral treatment in people living with HIV/AIDS presenting at an NGO clinic in Bangalore, India. MedGenMed: Medscope general medicine 2006;8(4):24.
 Kombe G, Smith O, Nwagbara C. Scaling Up Antiretroviral Treatment in the Public Sector in Nigeria: A Comprehensive Analysis of Resource Requirements: Report issued by PHRplus and Abt Associates, 2004.
 Aracena-Genao B, Ravarro JO, Lamadrid-Figueroa H, Forsythe S, Trejo-Valdivia B. Costs and benefits of HAART for patients with HIV in a public hospital in Mexico. Aids 2008;22 Suppl 1:S141-8.
 Bautista-Arredondo S, Dmytraczenko T, Kombe G, Bertozzi SM. Costing of scaling up HIV/AIDS treatment in Mexico. Salud publica de Mexico 2008;50 Suppl 4:S437-44.
 Cleary SM, Melntyre D, Boulle AM. The cost-effectiveness of antiretroviral treatment in Khayelitsha, South Africa-a-primary data analysis. Cost effectiveness and resource allocation: C/E 2006;4:20.
 Martinson N, Mohapi L, Bakos D, Gray GE, McIntyre JA, Holmes CB. Costs of providing care for HIV-infected adults in an urban HIV clinic in Soweto, South Africa. Journal of acquired immune deficiency syndromes 2009;50(3):327-30.
 Rosen S, Long L, Sanne I. The outcomes and outpatient costs of different models of antiretroviral treatment delivery in South Africa. Tropical medicine & international health: TM & HI 2008;13(8):1005-15.
 Deghaye N, Pawinski RA, Desmond C. Financial and economic costs of scaling up the provision of HAART to HIV-infected health care workers in KwaZulu-Natal. S Afr. Med J 2006;96(2):140-3.
 Harling G, Wood R. The evolving cost of HIV in South Africa: changes in health care cost with duration on antiretroviral therapy for public sector patients. Journal of acquired immune deficiency syndromes 2007;45(3):348-54.
 Kevany S, Mehtige G, Rebe K, Maartens G, Cleary 32. John KR, Rajagopalan N, Madhuri KV. Brief communication: economic comparison of

- 48. The World Bank. Population, total: The World Bank, 2010.
 49. Fischer Walker CL, Perin J, Aryse MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low-and middle-income countries in 1990 and 2010: a systematic review.

- UN Department of Economic and Social Affairs Population Division. World Population Prospects, 2010 Revision, 2010.
 UNICEF. The State of the World's Children 2011. Table 6: Demographic Indicators: under 5 population (2010), 2011.
 Institute for Health Metrics and Evaluation. Malaria Mortality Estimates by Country 1980-2010, 2009.
 World Health Organization. Global Health Observatory Data Repository. Global Burden of Disease. Geneva, 2011.
 Lubell Y, Staedke SG, Greenwood BM, Kamya MR, Molyneux M, Newton PN, et al. Likely health outcomes for untreated acute febrile illness in the tropics in decision and economic models; a Delphi survey. PloS one 2011;6(2):e17439.
 The World Bank. World Development Report 1993: Investing in Health 1993.
 Mort Health Statistics 2012. Life tables for WHO Member States. Geneva: World Health Organization, 2009.
 Mathers CD, Lopez AD, Murray CJL. The Burden of Disease and Mortality by Condition: Data, Methods, and Results for 2001. In: Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL, editors. Global Burden of Disease and Risk Factors. Washington (DC), 2006.
- DT, Murray CH, editors. Global Burden of Disease and Risk Factors. Washington (DC), 2006.
 58. Snow R, Newton C, Craig M, Steketee R. The Public Health Burden of Plasmodium falciparum Malaria in Africa: Deriving the Numbers. Disease Control Priorities Project Working Paper No. 11. Bethesda, Maryland: Fogarty International Center, National Institutes of Health, 2003.
 59. Lambert LiM, Fischer Walker CL, Black RE. Systematic review of diarrhea duration and severity in children and adults in low- and middle-income countries. BMC public health 2012;12:276.
 60. Kaiser Family Foundation. The U.S. President's Emergency Plan for AIDS Relief (PEPFAR), 2013.
 61. World Health Organization. Global Burden of Disease. Table 1: Estimated total deaths.

- Saser Family Foundation. The U.S. President's Emergency Plan for AIDS Reher (PEPFAR), 2013.
 World Health Organization. Global Burden of Disease. Table 1: Estimated total deaths (2000), by cause, sex and WHO Member State, 2008, 2011.
 Walensky RP, Wolf LL, Wood R, Fofana MO, Freedberg KA, Martinson NA, et al. When to start antiretroviral therapy in resource-limited settings. Annals of internal medicine 2009;151(3):157-66.
 Mermin J, Lule J, Ekwaru JP, Malamba S, Downing R, Ransom R, et al. Effect of cotrimoscaole prophylaxis on morbidity, mortality, CD4-cell count, and viral load in HIV infection in rural Uganda. Lancet 2004;364(9443):1428-34.
 Ayieko P, Akumu AO, Griffiths UK, English M. The economic burden of inpatient paediatric care in Kenya: household and provider costs for treatment of pneumonia, malaria and meningitis. Cost effectiveness and resource allocation: C/E 2009;7:3.
 Lengeler C. Insecticide-treated bed nets and curtains for preventing malaria. The Cochrane database of systematic reviews 2004(2):CD000363.
 Clasen T, Haller L, Walker D, Bartran J, Cairncross S. Cost-effectiveness of water quality interventions for preventing diarrhoeal disease in developing countries. J Water Health 2007;5(4):599-608.
 Denison JA, O'Reilly KR, Schmid GP, Kennedy CE, Sweat MD. HIV voluntary counseling

- 67. Denison JA, O'Reilly KR, Schmid GP, Kennedy CE, Sweat MD. HIV voluntary counseling and testing and behavioral risk reduction in developing countries: a meta-analysis, 1990–2005. AIDS and behavior 2008;12(3):363-73.

- Weller S, Davis K. Condom effectiveness in reducing heterosexual HIV transmission. The Cochrane database of systematic reviews 2002(11):C0003255.
 Smith DL, Cohen JM, Moonen B, Tatem AJ, Sabot OJ, Ali A, et al. Infectious disease. Solving the Sisyphean problem of malaria in Zanzibar. Science 2011;332(6036):1384-5.
 Kahn JG, Marseille E, Auvert B. Cost-effectiveness of male circumcision for HIV prevention in a South African setting. PLoS medicine 2006;3(12):e517.
 Mulligan JA, Yukich J, Hanson K. Costs and effects of the Tanzanian national voucher scheme for insecticide-treated nets. Malaria journal 2008;7:32.
 Zi Kilian A, Byanukama W, Pigeon O, Atteil F, Duchon S, Phan C. Long-term field performance of a polyester-based long-lasting insecticidal mosquito net in rural Uganda. Malaria journal 2008;7:49.
 Clasen T, Naranjo J, Frauchiger D, Gerba C. Laboratory assessment of a gravity-fed ultrafiltration water treatment device designed for household use in low-income settings. The American journal of tropical medicine and hygiene 2009;80(5):819-23.
 Lubell Y, Riewpaiboon A, Dondorp AM, von Seidlein L, Mokuolu OA, Nansumba M, et al. Cost-effectiveness of parenteral artesunate for treating children with severe malaria in sub-Saharan Africa. Bull World Health Organ 2011;89(7):504-12.
 Tate JE, Rheingans RD, O'Reilly CE, Obonyo B, Burton DC, Tornheim JA, et al. Rotavirus disease burden and impact and cost-effectiveness of a rotavirus vaccination program in kenya. J Infect Dis 2009;200 Suppl 1:5:66-84.
 Shillcutt S, Morel C, Goodman C, Coleman P, Bell D, Whitty CJ, et al. Cost-effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of combination therapy. Bull World Health Organ 2008;86(2):101-10.

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.

 $\label{eq:Tech.Suppl.} \textbf{- Figure 1}. Cost-effectiveness (Net IPC cost per DALY averted) and Opportunity Index (Campaign 2, n=70)$

 $\textbf{Tech. Suppl.} \textbf{-} \textbf{Figure 2.} \ \textbf{Tornado Graph of Cost per DALY averted} - \textbf{Bangladesh: Impact by Input}$

 $\boldsymbol{Tech.\,Suppl.}$ - $\boldsymbol{Figure\,\,3.}$ Tornado graph of cost per DALY averted – Kenya

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

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

 $\label{thm:continuous} \textbf{Tech Suppl. - Figure 6.} \ Discounted cumulative net costs, and DALYs averted for two IPC campaigns in Kenya, projected to 30 years, per 1,000 participants.$

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

:11	Malari Diarrhe a a			HIV	Source(s)			
2	LLIN	Filters	VCT	Condom s	LLIN	Filters	VCT / condom	
Alealth 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					
6ampaign Participant								
Paseline cases per	0.057	0.542	0.00	0.009	[47, 48]	[49-51]	[8,62-64]	
			4				Post-campaign sur	
enefiting							(see text)	
roportion of	0.012	0.001	1	1	[47, 52, 54]	[48, 49, 51, 59,	Assumption	
gases that are						62]		
ALYs 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- tatal case								
atal case								
3rotective effect gainst mortality	0.50	0.63	0.50	0.26	[65], expert opinion	[66]	[67, 68]	
	0.5	0.63	,	,		rees	N/a	
Protective effect against non-fatal	0.5	0.63	n/a	n/a	[65]	[66]	N/a	
Multiplier to	n/a bit	n/a	2	2	[69]	N/a	[70] (see text)	
	nya bit	liya	1	-	[09]	14/4	[70] (see text)	
Sapture secondary enefits								
Years of benefit	3	3	1	1	[71, 72] Adjusted	[73] Adjusted to	[68]	
/ Delicit					to 3 years per	3 years per post-		
8					post-campaign	campaign		
Access to care	0.684	0.678	0.70	0.700	evaluation. [14-19]	evaluation. [20]	Assumption	
	0.064	0.078	0.70	0.700	[14-19]	[20]	Assumption	
Qost inputs	l		Ť					
Oampaign cost	\$34,280				[7] \$31,980 plus ad costs	ditional \$2,300 in rev	ised filter maintena	
Discount rate	3.0%				[10]			
Health care	\$65	\$104	\$12,213	\$12,213	[64, 74]	[75]	Authors' construct	
incurred with							based on 22 years	
·							ART at \$766 per	

19 able 2. Sensitivity analysis variables, base case, minimum and maximum values. All variables have beta constitutions with alpha and beta parameters of 2. Minimum and maximum values are 0.5 and 1.5 of base case values, sepectively, except for access to diarrhea disease care and malaria care which have minimum and maximums of 0.6 and 1.1, and access to HIV ART which has a minimum and maximum of 0.75 and 1.25. Bold figures represent values that shange with each country.

22		Nigeria			Kenya		Ba	nglades	h
Input parameter	Base case	Min	Max	Base case	Min	Max	Base case	Min	Max
2 Campaign cost	\$40,479	\$20,239	\$60,718	\$34,280	\$17,140	\$51,420	\$35,658	\$17,829	\$53,486
24 ^{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
25 Cost per non-fatal case malaria	\$11.70	\$5.85	\$17.55	\$7.80	\$3.90	\$11.70	\$8.67	\$4.33	\$13.00
26 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
27 Discount rate	0.03	0.015	0.045	0.03	0.015	0.045	0.03	0.015	0.045
28 Access to care Diarrhea	0.565	0.424	0.706	0.678	0.509	0.848	0.663	0.497	0.829
29 ^{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
30 Years on ART	22	11	33	22	11	33	22	11	33
31 ^{HIV prevalence}	0.036	0.018	0.054	0.063	0.032	0.095	0.0006	0.0003	0.0009
Baseline cases p1000py	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
33 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
O ⁴ Participants per HH	2.5	1.25	3.75	2.5	1.25	3.75	2.5	1.25	3.75
35PALYs fatal malaria	27.8	13.9	41.7	27.8	13.9	41.7	27.8	13.9	41.7
36 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
37DALYs non-fatal diarrhea	0.127	0.064	0.191	0.127	0.064	0.191	0.127	0.064	0.191
38 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
39 rotect. non fatal malaria	0.500	0.250	0.750	0.500	0.250	0.750	0.500	0.250	0.750
40 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	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
42									24

19 able 3. Summary costs and cost-effectiveness results per 1,000 IPC participants for 70 countries ordered from most 20 avorable to least favorable cost-effectiveness (net cost per DALY averted). The grey highlighted cells indicate CE ratio is savorable than investment in ART. Results shown are for the first 3-year campaign.

Costs | Disassas supred | Costs effectiveness (CE)

		Costs Disease averted		Cost-effectiveness (CE)									
								1					
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- Bissau	Low	0.134	\$29,459	\$7,814	40.7	10,523	1,143.3	\$26	\$7	\$1,005			
Senegal	Lower middle	0.050	\$34,969	\$12,190	10.7	5,735	306.0	\$114	\$40	\$768			
Sierra Leone	Low	0.119	\$31,525	\$20,112	16.0	4,118	446.7	\$71	\$45	\$764			
Burkina Faso	Low	0.126	\$31,525	\$22,206	16.4	4,124	459.4	\$69	\$48	\$819			
Somalia	Low	0.121	\$26,015	\$22,754	16.8	3,682	470.5	\$55	\$48	\$1,535			
Niger	Low	0.110	\$28,081	\$21,620	14.8	4,967	419.7	\$67	\$52	\$1,095			
Mali	Low	0.124	\$29,459	\$23,016	15.9	4,222	445.8	\$66	\$52	\$888			
Afghanistan	Low	0.057	\$28,770	\$18,906	12.7	4,146	356.6	\$81	\$53	\$935			
Chad	Low	0.120	\$35,658	\$24,848	15.3	4,335	424.6	\$84	\$59	\$807			
Lesotho	Lower middle	0.115	\$35,658	\$47,366	31.3	1,756	779.4	\$46	\$61	\$738			
Guinea	Low	0.095	\$29,459	\$22,324	12.6	4,272	353.8	\$83	\$63	\$928			
Congo, DR	Low	0.112	\$24,637	\$25,488	13.4	3,517	375.9	\$66	\$68	\$1,493			
Sudan	Lower middle	0.057	\$38,413	\$15,241	6.9	4,907	198.8	\$193	\$77	\$703			
Liberia	Low	0.092	\$26,704	\$25,526	11.9	3,401	332.6	\$80	\$77	\$1,025			
Burundi	Low	0.118	\$26,015	\$33,639	14.3	2,267	389.9	\$67	\$86	\$987			
Benin	Low	0.083	\$33,591	\$25,345	10.0	3,096	280.0	\$120	\$91	\$910			
Côte d'Ivoire	Lower middle	0.084	\$33,591	\$35,069	14.1	4,021	387.2	\$87	\$91	\$801			
Nigeria	Lower middle	0.133	\$40,479	\$34,769	13.4	3,102	369.3	\$110	\$94	\$747			
Mozambique	Low	0.141	\$30,147	\$59,145	22.2	3,816	590.0	\$51	\$100	\$1,109			
Cen. African Rep.	Low	0.105	\$27,392	\$37,525	13.8	2,819	373.3	\$73	\$101	\$1,230			
Uganda	Low	0.105	\$31,525	\$40,192	14.9	3,492	399.8	\$79	\$101	\$749			
Congo, Rep.	Lower middle	0.067	\$54,254	\$33,944	11.5	2,981	318.5	\$170	\$107	\$756			
Togo	Low	0.075	\$29,459	\$32,147	10.4	2,849	288.7	\$102	\$111	\$864			
Angola	Upper middle	0.088	\$64,586	\$35,794	11.5	3,268	320.8	\$201	\$112	\$674			
Tanzania	Low	0.075	\$33,591	\$38,453	12.1	3,122	326.9	\$103	\$118	\$935			
Zambia	Lower middle	0.128	\$33,591	\$69,806	21.8	3,107	564.3	\$60	\$124	\$826			
Ethiopia	Low	0.057	\$30,147	\$29,630	8.6	1,986	235.7	\$128	\$126	\$1,139			
Rwanda	Low	0.071	\$31,525	\$34,034	9.6	2,216	266.1 462.2	\$118	\$128	\$768 \$996			
Malawi	Low Lower middle	0.110	\$28,081 \$37,724	\$59,745 \$52,388	18.3	2,965 3,115	462.2 388.4	\$61 \$97	\$129 \$135	\$996 \$741			
	Lower middle	0.100			10.9		294.1	\$97 \$117		\$883			
Kenya Mauritania	Low Lower middle	0.065	\$34,280 \$36,346	\$46,149 \$28,117	10.9	2,018	294.1 164.2	\$117 \$221	\$157 \$171	\$883 \$955			
Yemen	Lower middle	0.042	\$30,346	\$20,117	4.3	3.128	122.9	\$221	\$171	\$900			
Zimbabwe	Low	0.025	\$25,326	\$76.203	17.8	1.682	428.8	\$59	\$172	\$1.731			
Pakistan	Lower middle	0.020	\$41,856	\$19,714	3.8	2,748	108.1	\$387	\$178	\$1,731			
Ghana	Lower middle	0.020	\$41,650	\$19,714	6.8	1,966	189.9	\$235	\$188	\$746			
Madagascar	Lower middle	0.003	\$28,770	\$24,895	4.5	1,900	127.8	\$235	\$195	\$1.025			
Fritrea	Low	0.043	\$27,392	\$26,438	4.3	1,910	120.5	\$227	\$219	\$1,023			
Botswana	Upper middle	0.080	\$137,595	\$185,87	26.8	1,111	734.1	\$187	\$253	\$577			
Haiti	Low	0.028	\$30.836	\$31.570	4.4	3.128	123.0	\$251	\$257	\$869			
Swaziland	Lower middle	0.150	\$58,387	\$198,39	29.1	2,230	724.2	\$81	\$274	\$632			
1				2									

1		
2		
3		
4		
5		
6		
7		
Ω		
0		
9	^	
1	U	
1	1	
1	2	
1	3	
1	4	
1	5	
1	6	
1	7	
1	1 2 3 4 5 6 7 8 9	
1	a	
4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2	ع رائ	
2 2 2 2 2 2	Ų ₄ 45	l
4	47	
2	2.	I
2	3	I
2	4 ¹	
2	5 *	
2	6⁵	
2	~ 7≋	I
2	59 O 0	l
4	ت م	
422222223	95 8€	
3	O *	l
3	167	l
3	2.	
3	3⁰	l
3	4	
3	5	
3	6	
3		
	8	
	9	
	0	
4		
4		
4		
4		
4	5	
4	6	
4	7	
4		
4	9	
5		
5	1	
5	1	
5		
5		
5	4	
5	5	
5		
5		
5	8	
_	~	

,											
`											
2₂	Guatemala	Lower middle	0.016	\$57,698	\$22,134	2.4	3,143	70.1	\$823	\$316	\$627
1 3	South Africa	Upper middle	0.097	\$99,713	\$180,28 4	21.5	1,150	561.0	\$178	\$321	\$582
44	Gabon	Upper middle	0.060	\$29,826	\$84,306	9.3	1,876	255.0	\$117	\$331	\$613
45	India	Lower middle	0.027	\$48,744	\$34,973	3.7	1,255	104.9	\$464	\$333	\$733
46	Myanmar	Low	0.026	\$31,525	\$28,249	2.9	1,306	83.7	\$377	\$337	\$1,354
5 7	Papua New Guinea	Lower middle	0.018	\$40,479	\$25,117	2.4	2,868	71.2	\$568	\$353	\$864
48	Iraq	Upper middle	0.009	\$53,565	\$25,989	1.9	2,587	55.8	\$960	\$466	\$758
\$ 9	Namibia	Upper middle	0.038	\$75,606	\$204,27 1	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
ē1	Nepal	Low	0.010	\$30,836	\$28,994	1.4	1,135	39.8	\$776	\$729	\$883
2	Morocco	Lower middle	0.006	\$58,387	\$42,818	1.9	1,623	54.8	\$1,066	\$782	\$650
53	Bangladesh	Low	0.007	\$35,658	\$30,236	0.9	1,076	25.9	\$1,377	\$1,168	\$1,046
3 4	Algeria	Upper middle	0.008	\$73,540	\$51,390	1.4	1,304	41.0	\$1,793	\$1,253	\$606
55	Uzbekistan	Lower middle	0.006	\$45,989	\$25,637	0.6	2,352	18.2	\$2,523	\$1,406	\$717
56	Ukraine	Lower middle	0.006	\$74,228	\$68,364	1.2	623	33.6	\$2,210	\$2,036	\$600
57	Thailand	Upper middle	0.005	\$90,759	\$100,37 7	1.8	455	48.7	\$1,863	\$2,061	\$622
68	Indonesia	Lower middle	0.008	\$56,321	\$46,677	0.7	814	20.8	\$2,708	\$2,244	\$793
59	Bolivia	Lower middle	0.010	\$56,321	\$30,994	0.4	2,015	13.5	\$4,178	\$2,299	\$668
5 0	Vietnam	Lower middle	0.005	\$45,989	\$40,910	0.6	828	17.6	\$2,616	\$2,327	\$664
Ø1	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
gs .	Brazil	Upper middle	0.004	\$104,534	\$65,501	0.6	1,385	19.2	\$5,431	\$3,403	\$581
64	Philippines	Lower middle	0.003	\$51,499	\$39,031	0.3	1,289	10.9	\$4,746	\$3,597	\$724
∮	Russian Federation	High: nonOECD	0.007	\$143,794	\$121,95 4	1.1	735	31.2	\$4,607	\$3,907	\$579
66	Argentina	Upper middle	0.003	\$147,238	\$101,85 4	0.6	1,097	18.1	\$8,155	\$5,642	\$577
67	Malaysia	Upper middle	0.004	\$138,284	\$104,40 8	0.6	930	17.6	\$7,858	\$5,933	\$591
98	Turkey	Upper middle	0.001	\$29,459	\$58,058	0.1	1,784	6.1	\$4,821	\$9,501	\$582
6 9	Mexico	Upper middle	0.003	\$127,264	\$134,90 1	0.3	0	9.6	\$13,197	\$13,989	\$583
3 ⁰	China	Upper middle	0.001	\$84,560	\$74,564	0.1	486	4.7	\$18,015	\$15,886	\$638

population	covered by II			ed or added	due to the ca		ss. "Net co Results ass		
<u>2</u> 3		Net	cost	DALYs	averted	effecti (compa	ost- veness red with vention)	effecti (compa	mental st- veness red with us row)
4 ^{Countrie}	Campaig n cost	Camp. 1	Camp. 2	Camp. 1	Camp. 2	Camp.	Camp.	Camp. 1	Camp.
Top 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
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
O 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
7 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
O Top 50*	1.624E+10	1.342E+1	1.395E+1	7.265E+0 7	4.983E+0 7	\$185	\$280	\$335	\$440
Top 60	2.226E+10	1.863E+1	1.941E+1	7.573E+0	5.186E+0	\$246	\$374	\$1,692	\$2,699
) _{Top 70}	5.129E+10	4.350E+1	4.629E+1	7.871E+0	5.322E+0	\$553	\$870	\$8,340	\$19,72

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

Countries ranked by IPC cost- effectiveness	Campaign 1	Campaign 2	Antiretroviral therapy for HIV
Top 10	\$50	\$102	\$854
11 - 20	\$88	\$141	\$958
11 - 30	\$121	\$197	\$797
31 - 40	\$185	\$318	\$894
41 - 50	\$335	\$591	\$683
51 - 60	\$1,721	\$3,514	\$666
61 - 70	\$4.774	\$17.068	\$597

22	utcomes and cost per DALY averted by	ART for HIV in I	Kenya, Bangladesh, a	nd Nigeria.		
	*Table 6. Multiway sensitivity analysis; 20				I for 3	IPC

Ι	Outcomes	Kenya	Bangladesh	Nigeria
7	DALYs averted	206 - 407	13.1 - 45.8	228 - 564
Ψ	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
4	 Cost per DALY averted by ART for HIV 	\$883	\$1,046	\$747