MALARIA MATTERS

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ITNs and IRS: Making Informed Choices for Malaria Prevention

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Much attention has been given recently to the large-scale use of indoor residual spraying (IRS) for malaria vector control. This has been due, in large part, to increased funding and support from the US President's Malaria Initiative as part of its comprehensive plan(1). New IRS efforts are now focusing on areas of intense malaria transmission in sub-Saharan Africa, where the burden of malaria is greatest.

Both insecticide-treated nets (ITNs) and IRS have proven effective in reducing malaria transmission. The appropriate choice of which intervention to apply in a given area depends on the efficacy and cost-effectiveness of interventions, as well as the epidemiology of malaria transmission, the behaviour and susceptibility of vectors, and public compliance. A key consideration is the capacity of health systems to effectively deliver the interventions at the levels of coverage required.

It is important to recognize that ITNs and IRS have different modes of action, with significant operational implications for malaria control. IRS is the application of long-acting chemical insecticides on the walls and roofs of all shelters in a given area, in order to kill the adult vector mosquitoes that land and rest on these surfaces(2). The majority of malaria vectors bite at night when people are indoors and asleep. Host-seeking mosquitoes do not generally rest before biting; however, when fully fed they tend to rest on a nearby wall or other surface to begin digesting the blood meal that is necessary for egg development. While some mosquitoes can be deterred from entering houses by an insecticide's excito-repellency, the main effect of IRS is the killing of mosquitoes that enter houses and rest on sprayed surfaces after biting. The efficacy of IRS thus relies on high coverage (e.g. >80%) of all dwellings in order to sufficiently reduce the life span and density of vectors and produce a community-wide reduction in malaria transmission. Achieving these high coverage levels is demanding in terms of logistics, infrastructure, and organization.

In contrast, ITNs provide a physical and chemical barrier between the mosquito and the person sleeping under the net. Host-seeking mosquitoes that contact the net are killed before they bite, so ITNs provide a measure of personal protection. The personal protection provided by ITNs allows their deployment in a progressive way, starting with low population coverage, as is currently the case in most rural areas of tropical Africa. With scaling-up, high coverage with ITNs can produce an additional community effect through mass killing of mosquitoes, thereby also giving protection to people without nets in nearby houses.

In Southern Africa, where large populations are exposed to unstable malaria transmission, IRS systems have been successfully and effectively maintained for many years. However, the majority of the rural population of sub-Saharan Africa is exposed to intense stable malaria and the systems needed for large-scale IRS do not exist. In these countries, the critical question is not whether one intervention is slightly more powerful than the other, but which of the two offers better prospects of achieving high nationwide coverage and long-term sustainability(3).

Further research is needed to better understand the epidemiological and entomological outcomes of large scale IRS programs in areas with intense malaria transmission in sub-Saharan Africa and in areas where vectors demonstrate resistance to insecticides.

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COMPARATIVE COST-EFFECTIVENESS OF ITNS OR IRS IN SUB-SAHARAN AFRICA

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In order to determine the relative cost-effectiveness of ITNs versus IRS, the Swiss Tropical Institute, with support from USAID, examined five insecticide-treated net (ITN) distribution programs and two indoor residual spraying (IRS) programs operating at large or national scales in sub-Saharan Africa. The ITN programs were chosen to represent the major distribution systems presently being used in sub-Saharan Africa, as well as to represent a geographically diverse selection of countries. They represent the following models: (1) free ITN delivery through integrated vaccination campaigns (Togo), (2) free ITN delivery through routine services and at the community level (Eritrea), (3) highly subsidized ITN delivery through routine services in the frame of a social marketing program (Malawi), (4) largely commercial sector promotion (Senegal), and (5) commercial sector promotion through social marketing combined with vouchers to reach high-risk groups (Tanzania). The two IRS programs were chosen largely based on scale and the accessibility of cost data. They represent (1) a national program funded locally (KwaZulu-Natal, South Africa) and (2) an international intervention funded by donors and a public-private partnership (Lubombo Spatial Development Initiative, Southern Mozambique). The methodological details of the programs are found in the full study report (www.rollback malaria.org/partnership/wg/wg_itn/docs/ Yukich2007.pdf).

The Swiss Tropical Institute researchers measured the costs related to each type of program locally or derived them from existing studies and focused on the provider perspective, supplemented by direct costs to users for net procurement. They measured effectiveness by combining outputs with standard effectiveness indicators derived from the existing Cochrane review on ITNs. Effectiveness for IRS was also based on these data because of the lack of sufficient IRS-specific data and the fact that past research had shown the effectiveness of the two interventions to be similar in several African settings.

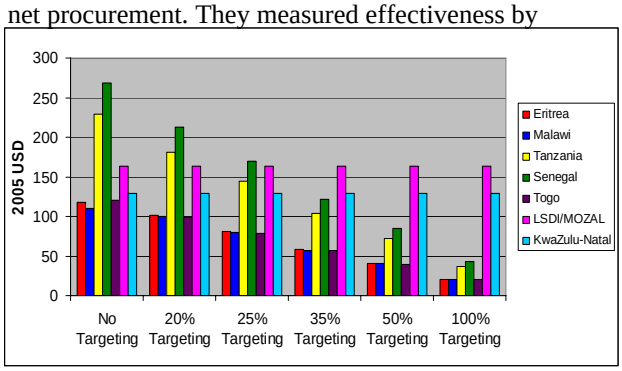

Figure 1: Cost per DALY averted at different targeting levels for ITNs - using full economic cost at scale. Baseline results for IRS are shown for comparative purposes.

The study results indicate that both ITN and IRS programs are cost-effective interventions and are attractive within low-income-country settings. Summary results of the study are shown in Tables 1 and 2.

Use of conventional ITNs

The annualized economic costs per conventional ITN distributed varied by a factor of about three across sites, i.e. from $3.23[1] per net in Togo to $8.05 in Senegal (less variation was seen in pure provider costs). The cost per net-year of protection ranged from $1.43 in Eritrea to U$6.05 in Senegal. Under this scenario, the cost per DALY averted ranged from $36 to $89 (Table 1), and the cost per death averted from $1,174 to $2,926 (in Togo and Senegal, respectively). Integrating ITN activities with other health interventions and operating at larger scales appeared to improve the cost effectiveness ratios for ITN interventions, especially where commodities were directly delivered (Eritrea and Malawi).

Table 1: Average annual economic cost for conventional ITN and IRS programs. (2005 figures)

ITN program	Average cost per ITN distributed	Average cost per TNY	Cost per death averted (ITN)	Cost per DALY averted (ITN)
Eritrea	4.74	1.43	1,722	52
Malawi	3.36	3.04	1,222	37
Tanzania	4.80	2.17	1,745	53
Senegal	8.05	6.05	2,926	89
Togo	3.23	3.23	1,174	36
IRS program	Cost per person protected (whole population)	Cost per under-five child protected	Cost per death averted	Cost per DALY averted
KwaZulu-Natal	3.27	23.96	4,357	132
LSDI/ MOZAL	3.90	21.63	3,933	119

Use of long-lasting insecticidal nets (LLIN)

For an LLIN giving 3 years of protection, the costs per net distributed were generally higher than for conven-

tional nets because of the higher purchase cost. However, the cost per treated-net year of protection was generally significantly lower, ranging from $1.48 in Eritrea to $2.64 in Senegal. As a result, the cost per DALY averted ranged from $16 in Eritrea to $29 in Senegal and the cost per death averted ranged from $539 to $960. In almost all cases the cost per death and DALY averted were even lower, though only marginally, when a LLIN with a 5 year life and $7 price was assumed.

The programs differed greatly in their potential for rapid ITN scale up, with Togo clearly demonstrating characteristics of a good "catch-up" strategy while the other four models were predominantly "keep-up" strategies - though all programs produced meaningful changes in ITN coverage and usage.

Use of indoor residual spraying

Costs per person-year protection by IRS were similar when the figures for the whole population were considered: the costs were $3.27 in KwaZulu Natal and $3.90 in Mozambique. However, the cost per under-five child protected was substantially higher for IRS than for ITNs, because IRS can not be targeted only to high-risk age groups in which expected health benefits are maximized: $23.96 (KZN) and $21.63 (Mozambique). As a result, cost per DALY averted ($119-132) and per death averted ($3,933-4,357) were also substantially higher for IRS compared to ITNs. Unfortunately, the researchers were not able to include the benefits of protection for adults as the effects of vector control in such groups are poorly quantified. However, in highly endemic areas, under-five children account for the vast majority of the malaria disease burden and effects from adult protection are likely to be minimal in comparison.

Sensitivity analysis

Sensitivity analysis indicated that the program factors having the greatest effects on overall cost and cost-effectiveness ratios for ITN programs were those related to either the length of protection offered by ITNs (or re-treatment kits) or to the net usage rates by children. In addition, the initial cost of ITNs had a large effect. These results suggest the clear potential for improving the cost-effectiveness of programs by switching to long-lasting insecticide-treated nets (LLINs) and stronger netting, targeting nets to highly vulnerable groups, and emphasizing the importance of behaviors associated with net programs. ITNs and insecticide commonly accounted for approximately 60% of the total costs of these programs.

For IRS programs, sensitivity analysis revealed that the most important factors were those relating to either the compliance/acceptability of spraying or with insecticide choice and the number of spraying rounds required per annum. For these programs, insecticide and staff costs accounted for the largest share of overall economic costs.

The results of this study indicated that targeting LLINs to children would likely prove to be the most cost effective way to deliver protection against malaria in highly endemic settings (Figure 1), though protection of the entire population or geographic targeting also has advantages which could not be examined in this study. Furthermore, in low prevalence or epidemic-prone settings, where there is a more evenly distributed burden of malaria across age groups, any benefits from targeting by age would be dampened.

Clearly, some strategies were more cost-effective than others but each strategy also brings specific advantages, both in the short-term and over the longer-term. It is the consideration of these many mainly local factors, based on the cost-effectiveness results presented in this report, which should guide national planners.

Clearly, both IRS and ITN vector control programs are excellent public health investments and should be expanded rapidly. This is a time of unprecedented opportunities for malaria control, with growing global interest and resources, as well as increased commitment by endemic country governments. It is time to substantially reduce the unacceptable burden of disease due to malaria. The full report is available at: www.rollback malaria.org/partnership/wg/wg_itn/docs/Yukich2007.pdf

[1] All figures in US$

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Table 2: Average annual economic costs for LLIN ITN with 3 years duration and IRS programs. (2005 figures).

ITN program	Average cost per LLIN distributed	Average cost per TNY	Cost per death averted (TNY)	Cost per DALY averted (TNY)
Eritrea	7.64	1.48	539	16
Malawi	5.18	2.19	798	24
Tanzania	6.04	1.83	664	20
Senegal	7.58	2.64	960	29
Togo	3.47	2.37	862	26
IRS program	Cost per person protected (whole population)	Cost per under-five child protected	Cost per death averted	Cost per DALY averted
KwaZulu-Natal	3.27	23.96	4,357	132
LSDI/ MOZAL	3.90	21.63	3,933	119

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Suggestions for further reading:

- Tan-Torres Edejer T, Baltussen R, Adam T, Hutubessy R, Acharya A, Evans D, Murray C, 2003. *Making Choices in Health: WHO Guide to Cost-Effectiveness Analysis*. Geneva: World Health Organization.
- Goodman CA, Coleman PG, Mills A, 1999. Cost-effectiveness of malaria control in sub-Saharan Africa. *Lancet 354:* 378–385
- Lengeler, C. & Sharp, B, 2003. Indoor Residual Spraying and Insecticide-Treated Nets. In Global Health Council (Ed.), *Reducing Malaria's Burden: evidence of effectiveness for decision makers* (pp. 17-24). Global Health Council.

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Further reading:

1. President's Malaria Initiative: www.fightingmalaria.gov
2. World Health Organization 2006. WHO Technical Report Series No. 936. Malaria Vector Control and Personal Protection: http://www.who.int/malaria/docs/WHO-TRS-936s.pdf
3. Roll Back Malaria Partnership Consensus Statement on Personal Protection and Vector Control Options for Prevention of Malaria, March 2004: http://rbm.who.int/partnership/wg/wg_itn/docs/RBMWINStatementVector.pdf
4. Global Malaria Programme 2006. WHO Position Statement on Indoor Residual Spraying. WHO/HTM/MAL/2006.1112.
5. WHO Global Malaria Programme: http://www.who.int/malaria/indoorresidualspraying.html

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The Net Benefits Program sells ITNs to travel health clinics and retailers to protect Canadian travellers from malaria and to raise awareness of the global burden of the disease. For more information go to: www.healthbridge.ca/mosquitonets_e.cfm

First Production of Long-Lasting Insecticidal Bednets in Africa

Master batch of granules containing permethrin and the polyethylene-based formulation technology.

The new Olyset® long-lasting bednet factory in Arusha, Tanzania, represents strengthened partnership between African and Northern businesses, significantly increasing local capacity to fight malaria and supporting local job creation.

Olyset Long Lasting Insecticidal Net (LN) was the first long lasting bednet to achieve the World Health Organization's Pesticide Evaluation Scheme (WHOPES) recommendation. Production of Olyset nets began in Arusha in 2003, when A to Z Textile Mills, an established local company, was provided with a royalty-free technology license by Sumitomo Chemical to facilitate local production.

Production of the nets was accommodated within A to Z's existing facility, and annual production grew from 300,000 nets in 2003 to the 4 million nets now produced. Following this initial success, in 2005 A to Z and Sumitomo Chemical announced that they would build a new factory, just outside Arusha, that would be managed through a joint venture between the two parties. The new joint venture company, Vector Health International (VHI), began construction of the new factory in 2006 with assistance from the Tanzanian Government. The new facility will be opened officially in October 2007 by the Tanzanian President His Excellency Jakaya Mrisho Kikwete, and should result in an increased production of Olyset nets in Tanzania to around 10 million per annum, with anticipated employment of more than 4,000 people in the local economy. In addition to the Olyset factory in Tanzania, spin-off sewing operations for Olyset nets are now generating employment opportunities in Kenya and other countries are being scrutinized.

This commitment by A to Z Textiles and Sumitomo Chemical and the common vision shown by the Tanzanian Government, who supplied electricity, water and tarmac road to the factory, provides a model for economic development in Africa, showing African capacity to develop world class manufacturing facilities and African ability to tackle it's own public health issues on a significant scale.