

## Malaria control needs mass distribution of insecticidal bednets

Long-lasting insecticidal bednets (LLINs) are one of the major ways to control malaria, and they are widely accepted worldwide by communities in areas affected by malaria.<sup>1,2</sup> One LLIN costs about US\$5 to manufacture and is effective for about 5 years. They have two kinds of protective effects—one for the people directly under the nets, and one for the community at large. The second effect is important, but often ignored. By achieving high community coverage to ensure a substantial community protection, malaria-control efforts can be more powerful than when only individual protection is attempted.

The direct effect of LLINs is to protect the people sleeping under them, and it operates in three ways. First, the insecticide kills some of the *Anopheles* mosquitoes after a few minutes. Second, the LLIN repels a proportion of the mosquitoes after contact.<sup>3</sup> Third, the net acts as a mechanical barrier to biting. The mechanical barrier provides half or less of the protection, which is why bednets without insecticide are less effective than treated ones. A torn and untreated net offers little or no protection, but a torn pyrethroid-treated net still works well.<sup>4</sup> LLINs provide good protection at only about \$1 per net per year, with an average of around 1.7 people using every net.<sup>5,6</sup> The result is remarkable low-cost protection against disability and death, notably for people who are most vulnerable, including infants, small children, and pregnant women.

Insecticidal nets provide good, but not perfect, protection for users,<sup>7</sup> but the community effect<sup>6,8-10</sup> can extend the protection beyond that for the individuals under the nets. By greatly reducing malaria transmission, LLINs decrease the risk of others in the community coming into contact with an infected mosquito. Every LLIN user thereby contributes not only to his or her safety, but also to the safety of others—the mass effect. The effect is analogous to herd immunity from vaccines. To have maximum effect within communities, LLIN coverage should be as high as possible, with a target of complete coverage.

The mass effect works in three ways. First, mass coverage by LLINs reduces the number of mosquitoes in the community.<sup>6,8-10</sup> Second, mass coverage shortens the lifespan of the mosquitoes,<sup>8</sup> thus reducing the possibility for maturation of *Plasmodium* sporozoites and hence decreasing the proportion of mosquitoes that become infective.<sup>6,8-10</sup> Therefore the possibility of transmitting the illness to others is greatly reduced. Third, with some

*Anopheles* species, mass coverage might divert mosquitoes from human to animal biting, thereby reducing human-to-human transmission. However, *A. gambiae* is so anthropophilic that, even with nearly 100% coverage with insecticidal nets, about 80% of blood meals were found to come from human beings.<sup>8</sup> Taken together these effects on the vector population can greatly reduce transmission of disease,<sup>11,12</sup> but only if the coverage of mosquito nets is sufficiently high. Importantly, at low coverage, the mosquitoes that are deflected by the nets will tend to seek out another human being to bite. There would be little or no reduction in overall transmission, but only a diversion. If transmission was diverted from high-risk to low-risk individuals, that would be beneficial but there would be no major effect on intensity of transmission of malaria in the community.

Optimum community protection is achieved when mass coverage with LLINs is combined with universal access for the community to timely and effective treatment in the event of infection. Timely treatment can also be expected to have a community benefit. By clearing the infection in the patient as soon as possible, the individual is not only cured of the disease but is also no longer a reservoir of parasites for transmission to others. Therefore LLINs and timely treatment with appropriate medicines (eg, artemisinin-based combinations) should be seen as a package for protection of the individual and reduction of transmission in the community.

In devising bednet policies, many donor agencies aim to protect only the vulnerable groups rather than the entire community, and as a result do not achieve the full

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potential of the method to restrict or stop transmission of the disease. This is a false economy. First, the donors miss the chance to reduce malaria transmission if they narrow the protection against the disease. Second, and crucially, the donors' definition of vulnerable is too narrow. The donors seek to protect children younger than 5 years and women who are pregnant, on the grounds that malaria is especially likely to kill individuals in these two groups. Yet children older than 5 years and adults other than pregnant women are also vulnerable to severe illness, death, and substantial economic costs from the disease.

These risks will probably increase as climate change and population movements bring malaria epidemics to new regions and unprotected populations, in which children older than 5 years and adults have not acquired partial immunity. Even when adults do not die of the disease, they can become ill, at high economic and social cost to the community because malaria is especially common at seasons when labour is greatly needed for planting and harvesting.<sup>13</sup> Whole communities of adult workers at harvest time are often beset by illness that results in food insecurity all year round.

Moreover, links between malaria and AIDS emphasise the dangers of assuming that adults are not vulnerable groups. Malaria infection can raise the viral load of individuals infected with HIV, thereby increasing the probability of transmission of HIV through sexual contact. Malaria infection, in other words, might well be a cofactor in transmission of AIDS. Thus malaria control should also provide some protection against HIV-transmission.<sup>14,15</sup> Because malaria is a cofactor in many types of infectious diseases, its control will have many protective effects on health that extend beyond the direct effects on malaria itself.

The full value of LLINs in personal protection and reduced malaria transmission will therefore depend on high rates of LLIN coverage, combined with effective and timely management of malaria infections when they arise. For a typical household of five people, there will be three sleeping sites that need bednet coverage, so that each net on average will protect about 1.7 individuals. The yearly costs of protection are therefore minimal—about \$0.60 per person per year.

Present coverage in Africa with insecticide-treated bednets remains low with, in many places, 10% or fewer people being provided for. However, in a small but growing number of countries, campaigns of mass distribution of

bednets are now being supported by the International Red Cross, the Global Fund against AIDS, Tuberculosis and Malaria, and other partners. Until these recent mass-distribution campaigns, the usual donor strategy has been social marketing of bednets and insecticides, with subsidies to vulnerable groups. Social marketing of bednets has not been a success, and coverage has remained low, especially in rural areas where malaria transmission is far more intense than it is in urban areas.<sup>16</sup> This strategy has led to low and slow uptake of nets and insecticides<sup>17–20</sup> and sales have been limited to the narrowly defined vulnerable groups, and to individuals who can afford to pay. The aim has generally been to sell bednets to vulnerable groups at what donors regard as low cost—eg, \$1–2 per net, which are sold to pregnant mothers at antenatal clinics. Yet even this low cost is too high for tens of millions of households, especially in rural areas, with little cash income and with restricted access to formal health services (where the nets are marketed).<sup>17–21</sup> Intensive marketing efforts have often taken 5 or more years to reach even a third of the vulnerable population. Many human and financial resources have been devoted by donor agencies to such efforts. Large amounts of money are spent on advertising and promotion of the nets, rather than on the nets themselves.

Education of poor communities to properly use LLINs and artemisinin-based combinations is a good strategy, but unless awareness is coupled with free availability of the essential commodities, the outcome is futile—knowledge will not serve these communities if they do not have access to these commodities because of poverty. Poor people cannot afford the nets<sup>17–21</sup> or the drugs, and the present marketing approach has left most of Africa at risk.

Free mass-distribution of LLINs—with the highest priority given to rural areas where malaria transmission is most intense, but aiming to cover all regions of malaria transmission—can work most effectively if the distribution is not only to especially vulnerable individuals but to all sleeping sites in every household. Successful mass-distribution campaigns have occurred in several countries, led by the International Red Cross or by national efforts supported financially by the Global Fund and other partners.<sup>22</sup> Ethiopia offers an important example.

Ethiopia needs around 20 million nets for 34 million residents in malaria-transmission areas. Between 1990 and 2004, donor agencies obliged Ethiopia to sell the

bednets to achieve partial cost recovery. About 1.5 million nets were imported to the country over 10 years under the cost-recovery scheme, and national net coverage was low. With a new commitment by the health authorities in favour of mass distribution of free nets, backed by the Global Fund, a striking increase in bednet distribution and coverage has been achieved since 2004.

2005 saw the importation and distribution of 4.3 million nets, rising to 7.4 million in 2006 and another 6.7 million nets in 2007 being procured, for a total of 18.4 million nets in 3 years. This substantial effort at free distribution has had many supporters, including the Global Fund, UNICEF, World Bank, Department for International Development (UK), Canadian International Development Agency, Japanese International Cooperation Agency, and the Carter Center (USA). Because of such goodwill and co-operative spirit of international agencies and the donor community, almost complete net-coverage in the malarious areas has been feasible in a short time. Yet although the success stories in Ethiopia, Niger, Togo, São Tomé and Príncipe, and some other countries with mass distribution are exciting, the shocking truth is that major donor agencies have continued to promote social marketing, despite its clear inadequacy. They also continue to support a narrow definition of vulnerable groups, thereby leaving most of the society vulnerable to malaria and failing to reduce malaria transmission through the mass effect.

Tragically, funds mobilised for malaria prevention and control are not used for saving lives, but are instead diverted to try to create new markets for bednets that do not exist. This approach has compromised the effectiveness of malaria control efforts. We strongly suggest that malaria-endemic countries and donor agencies should abandon the idea of social marketing, especially in rural areas greatly affected by malaria, and also in urban areas with malaria transmission. They should also commit to a policy that regards antimalarial commodities—such as drugs, diagnostic methods, and insecticides—as public goods to be available free of charge for mass distribution to affected communities. Comprehensive malaria control in Africa is achievable by 2010, at the minimal cost of \$3 billion per year if sound principles of public health and economics are observed.<sup>5,18,23</sup> Millions of lives can be saved, and Africa will be given vital help in escaping from the vicious circle of poverty and disease that continues to grip the continent.

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