

# Integrating insecticide-treated bednets into a measles vaccination campaign achieves high, rapid and equitable coverage with direct and voucher-based methods

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## Summary

Population coverage of insecticide-treated nets (ITNs) in Africa falls well below the Abuja target of 60% while coverage levels achieved during vaccination campaigns in the same populations typically exceed 90%. Household (HH) cost of ITNs is an important barrier to their uptake. We investigated the coverage, equity and cost of linking distribution of free ITNs to a measles vaccination campaign. During a national measles vaccination campaign in Zambia, children in four rural districts were given a free ITN when they received their measles vaccination. In one urban district, children were given a voucher, which could be redeemed for a net at a commercial distribution site. About 1700 HHs were asked whether they received vaccination and an ITN during a measles campaign, as well as questions on assets (e.g. type roofing material or bicycle ownership) to assess HH wealth. Net ownership was calculated for children in each wealth quintile. In the rural areas, ITN coverage among children rose from 16.7% to 81.1% and the equity ratio from 0.32 to 0.88 and in the urban area from 50.7% to 76.2% (equity ratio: 0.66–1.19). The operational cost per ITN delivered was \$0.35 in the rural area with direct distribution and \$1.89 in the urban areas with voucher distribution. Mass distribution of ITNs through vaccination campaigns achieves rapid, high and equitable coverage at low cost.

**keywords** vaccination, measles, malaria, mosquito nets, equity, Zambia

## Background

A key goal for malaria prevention in Africa is to make insecticide-treated nets (ITNs) available to 60% of children under 5 years of age (U5s) (WHO 2000). However, current delivery strategies are falling well short of this goal. Among the 28 African countries for which comparable national data are available between 1998 and 2002, ITN use for children less than 5 years old was at or less than 5% in 23 countries, at an overall median rate of 2% (Monasch *et al.* 2004). The most common method of ITN distribution, social marketing, has shown some success in improving ITN coverage and efforts are underway to introduce social marketing on a larger scale. Marketing of ITNs or using commercial distribution mechanisms imposes direct and indirect costs that may be barriers to equitable distribution. Although social marketing may not increase inequity for rural African populations (Nathan *et al.* 2004), additional

methods of subsidy or distribution are needed to address coverage and equity (Gallup & Sachs 2001).

In contrast to the low levels of ITN coverage, childhood vaccination commonly reaches high coverage levels, particularly when delivered through mass vaccination campaigns. Since 2001, the Measles Initiative has supported measles vaccination campaigns in 43 sub-Saharan African countries. These campaigns typically take place over 1 week and target every child in the country regardless of prior vaccination status. Through 2004, more than 200 million children have received measles vaccination through this approach. Vaccination campaigns typically reach greater than 90% of the target population, reduce virus transmission and essentially eliminate measles deaths for up to 3 years (Biellik *et al.* 2002; Otten *et al.* 2005). The campaigns are highly effective in reaching all children regardless of their economic status and are repeated every 3–4 years to sustain low disease transmission.

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In many populations where measles vaccination campaigns are conducted, malaria is a leading health risk to children. If each child who received measles vaccination during a campaign also received an ITN there theoretically would be a rapid, high and equitable increase in ITN coverage. The potential benefits of this approach have prompted recent global policy changes to encourage increased integration of ITN delivery and vaccination (WHO 2004). In a small study in one district in Ghana, linking ITN distribution to a measles vaccination campaign resulted in very high ITN coverage at low cost (Grabowsky *et al.* 2005). However, scaling up to multiple districts simultaneously presents a substantial logistics and management challenge, which might adversely affect coverage levels.

### Methods

The goal of this integrated campaign was to provide each child with one ITN at the time of vaccination. During 1 week in June 2003, a mass measles campaign was conducted in Zambia targeting 5 054 112 children aged 9 months to 14 years of age. We chose four poor, rural districts for integration of ITNs into the campaign (Chilubi, Kaputa, Mambwe and Nyimba) with a population of approximately 360 000 including approximately 65 000 children U5s. The four mass-distribution districts were proposed by the NMCP in consultation with in-country partners. The basis for selection included having modest and comparable size populations (due to the limited number of ITNs) and that there were no ongoing ITN distribution schemes. The voucher district was selected by NetMark as being of the appropriate size without pre-existing distribution schemes and where NetMark would introduce a post-campaign social marketing scheme.

Insecticide-treated mosquito nets were supplied to each vaccination post and each child was given an ITN at the time of vaccination. The types of ITNs provided were according to the size and colour preferences determined by the National Malaria Control Programme. The International Federation of Red Cross and Red Crescent Societies (IFRC) procured 75 000 ITNs for the four rural districts. Although the target was to provide 65 745 ITNs, an additional 9255 ITNs were procured to avoid stock-outs during the campaign. In addition, the number of children that visit health posts often exceeds the estimated national census figures (used as the baseline), a common occurrence during immunization campaigns in Zambia due to influxes of refugees and underestimates of population sizes. These long-lasting ITNs (LLITNs) were procured at a cost of US\$4.32 each. Campaign ITNs were not marked. There is a possibility that between distribution and assessment that

there was an influx of LLITNs into the community. However, as these particular nets were not available locally, this seems unlikely.

We included one wealthier, urban district (Kalalushi) where nets were commercially available but had no ongoing public ITN distribution efforts. It had a population of approximately 90 000 with 16 000 U5 children. The distribution strategy was aligned along the existing national malaria control urban strategy developed by the National Malaria Control Centre (NMCC). Each child attending a vaccination site received a voucher, which entitled them to one free ITN which could be redeemed at selected retail stores. These shop owners received an incentive (equal to US\$1.30) for each voucher redeemed at their shop. Using funds from IFRC, 14 895 nets were procured within Zambia from the commercial markets, with the intent of coordinating closely with the type of net that NetMark used in their private sector approach. This allowed an assessment of the relative merits of a voucher method *vs.* direct distribution. Voucher redemption was 'passive', requiring caretakers to go to the redemption site to exchange the voucher for the net. Nets were procured for approximately US\$3.17 each and were packaged with a dose of insecticide.

There was an important difference between the nets delivered in the rural areas and those delivered in the urban area. The rural nets were pre-treated with insecticide and did not require any further treatment on the part of the caretakers for the life of the nets, often more than 20 washes. The nets for the urban areas were not pre-treated with insecticide to be consistent with the type and quality of net used in social marketing projects in Zambia. Each urban net was provided with a packet of insecticide with which the caretaker was required to treat the net prior to using it. For these nets, retreatment is recommended every 6–9 months.

From April until June 2003, planning meetings for incorporation of ITNs in the measles campaign were held on a weekly basis between the NMCC and the Universal Child Immunization (UCI) officers. Funds were allocated to the NMCC by IFRC to enable them to co-ordinate the ITN component of the measles campaign in all five districts. This support included: micro-planning meetings at each district, training of each District Health Management Team (DHMT) by NMCC trainers, and to provide supervision during the campaign.

The logistics for ITNs consisted of transporting the ITNs from the central warehouse in the capital, Lusaka, to the district capitals and then assuring distribution to the vaccination/distribution posts. Each district had a planning exercise to determine the number of eligible children and families at each vaccination post and to estimate the

number of ITNs they would need to achieve full coverage. They also estimated the number of ITNs each vaccination post would need for each day based on the number of anticipated measles vaccinations. Daily logistics and supplies were adjusted accordingly. On average, a post would vaccinate approximately 300 children each day.

For the rural districts, ITNs were delivered from the central level to the District Health Medical Office (DHMO) by the Zambia Red Cross Society (ZRCS). From there, in three of the districts (Chilubi, Mambwe, Nyimba), the DHMT was responsible for delivering the ITNs to each post. In Kaputa District, which presented a particularly difficult logistical challenge due to its isolation, poor roads, and widely dispersed population, ITNs were transported within the district by ZRCS in coordination with DHMT. Funds were provided to the DHMTs to pay allowances for district ITN managers, supervisors and malaria agents (Community Health Workers), to hold orientation meetings and conduct the ITN component of the measles campaign, and for transportation of personnel and supplies from each DHMT to all the Rural Health Centres and outreach posts.

In the urban district (Kalulushi), vouchers were distributed at each of the 10 vaccination sites and by three mobile vaccination teams. Of the eight voucher redemption sites, seven were commercial general goods stores or pharmacies and one was a government clinic. Redemption sites were chosen for their convenience to the population and willingness of the shop owners to participate. One was co-located with a vaccination site and no vaccination site was more than 15 km from a redemption site. On redemption of vouchers, caretakers were advised to treat the net with the supplied insecticide. The shopkeepers then returned the vouchers to NetMark to receive their incentive payments.

### Assessment methods

A single population-based survey was conducted 6 months post-campaign. The evaluation used a standard two-stage, cluster-sampling methodology (Henderson & Sundaresan 1982). Clusters were drawn from randomly selected standard enumeration areas (SEAs) within each of the five districts. The SEAs enabled the evaluation team to select from established divisions within each of the five districts clusters that ranged in size from 50 to 200 households (HHs).

Household wealth was measured by asking the head of HH questions on HH assets such as ownership of a bicycle, type of roofing material and source of water. A scoring system was taken from the Demographic and Health Surveys as developed and reported by the World Bank

(Gwatkin *et al.* 2000). Each HH was assigned a score for each asset, where the score differed depending on whether or not the HH owned that asset (or, in the case of sleeping arrangements, the number of people per room). These scores were summed by HH, and individuals were ranked according to the total score of the HH in which they resided. The sample was then divided into population quintiles – five groups with approximately the same number of individuals in each. For the rural areas, the cutoff values for wealth quintiles were determined to allow for approximately equal numbers of HHs in each quintile. To identify differences in wealth between urban and rural districts, the cutoff values for the rural districts were applied to the urban HHs, recognizing that more urban HHs will fall into the wealthier categories.

The survey team members read and recorded the survey questions on handheld computers, referred to as personal digital assistants (PDAs). The PDAs in this study were Visor Neos (Handspring Inc.) using the Palm Operating System, Version 3.5 (Palm Inc.). The PDAs were supplied by Satellife Inc. Programming of questionnaires into the PDAs was done prior to shipping them to the field by using Pendragon Forms 3.2. Data analysis specialists (J.S. and A.W.) oversaw training and data collation and analysis. The assessment data were transferred from the PDAs to a laptop computer as an Access database using the synchronizing software and cradle supplied with the PDA. The data were analysed using a combination of EpiInfo 6.0, SAS, Excel, and SUDAAN.

For determination of whether a child slept under the ITN, we assessed children who were 6–59 months of age at the time of the campaign. A HH was defined as the location where a single-family group eats together. The index child was defined as the youngest child who usually sleeps in that HH who was at least 6 months of age at the time of the campaign. An ITN was defined as a pre-treated, LLITN delivered during the campaign or a non-long lasting net that was treated with insecticide within the previous 6 months. ITN retention was defined as whether a surveyor observed a campaign ITN in a HH where the caretaker reported receiving a campaign net. ITN hanging was defined as whether the surveyor observed the ITN over then bed reported by the caretaker to be the bed where the child usually slept. ITN coverage was defined as a HH having one or more ITNs. A child was determined to have slept under an ITN if the caretaker reported that the child slept under an ITN the previous night. To assess whether an outcome measure was correlated with increasing wealth status, we considered each wealth quintile a separate stratum and applied the chi-square test for trend (EpiInfo 6.0). The equity ratio was defined as the ratio of ITN ownership in the lowest quintile to that in the highest

quintile. Records with missing responses were excluded from analyses.

The marginal costs of ITN were defined as those costs that were in addition to the costs of the measles vaccination campaign. Costs, which would have been incurred by the measles campaign in the absence of ITN distribution, were not apportioned to ITN costs. Cost information was taken directly from the funded budgets for the ZRCS, NetMark, the Ministry of Health and the IFRC. Total programme costs were defined as the cost of ITN procurement (including ITN purchasing and delivery to the country) and the operational cost of delivering the ITNs (including training, in-country transportation and community education). Costs of external consultants and assessment costs were excluded from this analysis. Efficiency was defined as the percent of total program costs that was used for purchasing ITNs. All costs are given in US dollars.

## Results

### Wealth characteristics of households

Table 1 shows the distribution of the 1705 rural HHs and the 369 urban HHs into wealth quintiles and the mean asset index scores from the community based survey. By definition, 20% of the rural HHs were assigned to each quintile. There were uneven numbers of HHs in each quintile because there was more than one HH at the scoring breakpoints. When the rural cutoff values were applied to the urban sample, 308 HHs (83%) fell into the wealthiest quintile. There were accordingly small numbers of HHs in each of the poorer quintiles for the urban district. The mean asset index score of the urban wealthy was higher than the score of the rural wealthy, suggesting that not only were there more urban HHs in the wealthiest stratum but that the urban HHs in the wealthiest stratum were, on average, wealthier than the rural HHs in the same stratum.

### Insecticide-treated mosquito net coverage of children and equity

In the rural districts prior to the campaign, ITN coverage among children was low overall with 284 HHs (16.7%, Table 2, Figure 1) reported having an ITN. Coverage was substantially lower in the poorest quintiles compared to the richest (equity ratio = 0.32) and there was a strong statistical association between greater wealth and higher coverage ( $P < 0.001$ ). Post-campaign, overall coverage in the rural districts had risen with 1382 (81.1%) observed to have an ITN with greater equity (equity ratio = 0.88). There remained a strong association between wealth and higher coverage ( $P < 0.001$ ).

In the urban district prior to the campaign, overall ITN coverage was higher than in the rural areas with 187 HHs (50.7%) reporting having an ITN (Table 2, Figure 2). There was less disparity between the poorest and wealthiest quintiles than in the rural districts (equity ratio = 0.66) but a statistically significant association between wealth and higher coverage ( $P < 0.01$ ). Within the 369 eligible HHs there were 466 eligible children who received a voucher during the campaign. Of these vouchers, 402 (86.3%) were redeemed for a net. Post-campaign, overall coverage had risen to 281 (76.2%) and the equity ratio increased to 1.19. Post-campaign, there was not a statistically significant association between wealth and higher coverage ( $P = 0.39$ ).

### Household insecticide-treated mosquito net coverage

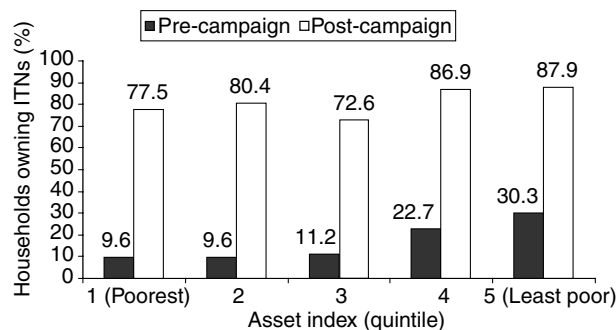
Table 3 shows the distribution HHs by number (per cent) of ITNs received during the campaign. In the rural areas, HH coverage rose from 21.1% to 88.0% and in the urban areas from 49.0% to 82.3%. HH coverage was slightly higher than child coverage post-campaign. Approximately one-fourth of HHs had more than one campaign ITN and the average number of ITNs per HH was slightly more than one.

**Table 1** Distribution of child's HHs in studied districts by wealth status. Entries in table are number (per cent) of children in each district in that stratum. ITN ownership reported pre-campaign and observed post-campaign, by wealth status

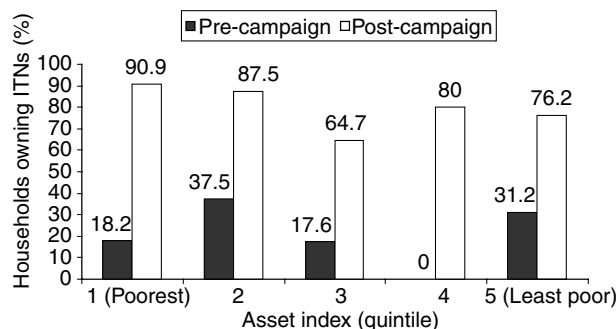
Area	Time	Wealth quintiles					Total
		Poorest	2	3	4	Least Poor	
Rural	<i>n</i>	342	342	340	335	346	1705
	%	20.0	20.0	19.9	19.6	20.3	100
	Mean asset score	-0.463	-0.352	-0.295	-0.223	0.117	-0.242
Urban	<i>n</i>	11	8	17	25	308	369
	%	3.0	2.2	4.6	6.8	83.5	100
	Mean asset score	-0.470	-0.383	-0.244	-0.116	1.206	0.965

**Table 2** Distribution of children's ITN ownership by HH economic status, pre- and post-campaign. Entries in table are number (per cent) of children in each district in that stratum. ITN ownership reported pre-campaign and observed post-campaign, by wealth status

Area	Time	Wealth quintiles					Total		Equity measures	
		Poorest	2	3	4	Least poor	P value, chi-square test for trend	Equity ratio (poorest/least poor)		
Rural	Pre-campaign	33/342 (9.6)	32/342 (9.6)	38/340 (11.2)	76/335 (22.7)	105/346 (30.3)	284/1705 (16.7)	<0.001	0.32	
	Post-campaign	265/342 (77.5)	275/342 (80.4)	247/340 (72.6)	291/335 (86.9)	304/346 (87.9)	1382/1705 (81.1)	<0.001	0.88	
Urban	Pre-campaign	4/11 (36.4)	3/8 (37.5)	6/17 (35.3)	5/25 (20.0)	169/308 (54.9)	187/369 (50.7)	<0.01	0.66	
	Post-campaign	10/11 (90.9)	7/8 (87.5)	11/17 (64.7)	20/25 (80.0)	233/308 (75.6)	281/369 (76.2)	0.39	1.19	



**Figure 1** ITN ownership of eligible children by HH socio-economic status, four rural districts, 2003.



**Figure 2** ITN ownership of eligible children by HH socio-economic status, one urban district, 2003.

**Insecticide-treated mosquito net use**

In both rural and urban areas the rate of proper use of ITNs was substantially below the rate of ownership. In the rural areas, while 1382 HHs (81.1%) possessed an ITN post-campaign, caretakers reported that only 962 (56.4%) of the index children slept under an ITN on the previous night (Table 4). The most important factor contributing to the dropout from ownership to use in the rural areas was whether HHs hung up the ITNs they received. In those HHs that received an ITN, only 1000 of 1382 (72.4%) were observed to have hung it up. The remaining 382 (27.6%) had the ITN in the home but did not hang it up. The other factor contributing to the drop out was that only 817 of 1000 children (81.7%) slept under a net when it was properly hung.

In the urban area, while 281 HHs (76.2%) possessed a campaign net, only 143 children (38.8%) slept under a campaign-provided ITN on the previous night. The most important factor contributing to this dropout was not treating the net with insecticide before hanging it up. Because the urban nets were not pre-treated by the

M. Grabowsky *et al.* Integrating mosquito nets into a measles campaign**Table 3** Distribution of HHs by number (per cent) of ITNs received during the campaign, by area

Area	HHs	Time	Total ITNs	ITNs/HH	Number of ITNs per HH				
					0	1	2	≥3	≥3 total
Rural	1612	Pre	435	0.27	265 (16.4)	279 (17.2)	46 (2.9)	15 (0.6)	340 (21.1)
		Post	1901	1.18	193 (12.3)	988 (61.3)	392 (24.3)	39 (2.4)	1419 (88.0)
Urban	406	Pre	285	0.70	188 (46.3)	143 (35.2)	48 (11.8)	8 (1.9)	199 (49.0)
		Post	472	1.16	72 (17.7)	219 (53.9)	102 (25.1)	13 (2.5)	334 (82.3)

ITN, insecticide-treated mosquito net; HH, household.

Households have one entry regardless of the number of eligible children in that HH. Entries in table are number HHs in each category that were observed to have that number of campaign ITNs.

**Table 4** Distribution of children by use of ITNs received during the campaign

Area	Net received during campaign	Child slept under any ITN previous night	Campaign net treated	If net treated, ITN hung over bed	If ITN hung, child slept under it	Child slept under campaign ITN
Rural	1382/1705 (81.1)	962/1705 (56.4)	1382/1382 (100)*	1000/1382 (72.4)	817/1000 (81.7)	817/1705 (47.9)
Urban	281/369 (76.2)	285/369 (77.2)	162/281 (57.7)	160/162 (98.8)	143/160 (89.4)	143/369 (38.8)

ITN, insecticide-treated mosquito net.

Entries in table are number (per cent) of HH in each district in that stratum.

\* All nets in rural areas were pre-treated.

manufacturer (as were the nets used in the rural areas), the caretakers were required to treat the nets with the supplied insecticide after receiving them. Only 162 of the 281 HHs (57.7%) that possessed a campaign net treated it with the insecticide. If the net was treated, the rates of hanging it up (98.8%) and of the child sleeping under it (89.4%) were high. The overall rate of sleeping under a net was higher because many children slept under nets acquired before the campaign. Of the 285 children who slept under an ITN, 42 (14.7%) did not receive a campaign net and likely had their net before the campaign. The pre-campaign nets account for most of the difference between the urban and rural rates of ITN use. Among those who hung up a campaign net, only 160/265 (60.4%) reported treating it with insecticide. Had these nets been properly treated and used,

the overall ITN use rate would have increased to 331/369 (89.7%, data not shown). Of the 84 children who did not sleep under a net from any source in the urban areas, 46 (54.8%) received a net during the campaign but did not use it.

#### Association between insecticide-treated mosquito net distribution and vaccination coverage

Table 5 shows the association of receiving an ITN or net and measles vaccination coverage. Receiving an ITN during the campaign was associated with higher vaccination coverage. In the rural areas, among the 1473 children who received an ITN, 1269 (86%) received a measles vaccination. Among the 242 rural children who did not

District		Received vaccination		Rate of receiving vaccination	Rate ratio (95% CI)	
		Yes	No			
Rural	Received ITN	Yes	1269	204	0.86	1.77 (1.55, 2.02)
		No	113	119	0.49	
Urban	Received net	Yes	265	78	0.77	1.26 (0.92, 1.71)
		No	16	10	0.62	

ITN, insecticide-treated mosquito net.

Entries in table are number of children who did or did not receive either vaccination or an ITN or net. Rate ratio is comparison of the rate of vaccination among those children receiving an ITN and those who did not receive an ITN, by district.

**Table 5** Impact of receipt of ITNs during the campaign on receipt of measles vaccine during the campaign, by district

receive an ITN, 113 (49%) received a measles vaccination. Those who received an ITN were 1.77 times as likely to receive a measles vaccination (95% CI: 1.55, 2.02). For the urban districts, there was a positive but not statistically significant positive association of receiving a net on vaccination coverage (RR = 1.26, 95% CI: 0.92, 1.71).

#### Costs of insecticide-treated mosquito net delivery

Table 6 shows programme costs. For the rural area, total programme costs for procuring and delivering the 75 000 ITNs was US\$344 887. This included US\$324 000 for procurement (US\$4.323/each), US\$2087 for the operational and logistics costs of delivering the ITNs from Lusaka to the vaccination posts, and US\$3342 of central-level management costs apportioned to the rural areas. The average total cost per ITN delivered was US\$4.67, of which, US\$0.35 was attributable to operational costs. The fraction of total programme costs spent of commodities instead of operational costs, the programme efficiency, was 0.93.

For the urban area, total programme costs for procuring and delivering the 14 895 nets and insecticide for treatment was US\$75 269. This included US\$47 221 for procurement (@US\$3.17/each), US\$27 212 for the operational and logistics costs of delivering the nets from Lusaka to the vaccination posts, and US\$836 of central-level management costs apportioned to the urban area. There was also an incentive of US\$1.30 provided to the shopkeepers for each voucher redeemed. The average total cost per ITN delivered was US\$5.06, of which US\$1.89 was attributable to operational costs (US\$0.59 if incentives are excluded). The urban programme efficiency was 0.63.

**Table 6** Programme costs, by area

Area	Rural	Urban
Distribution method	Direct	Voucher
Total nets delivered	75 000	14 895
Central costs, apportioned	US\$3342	US\$836
Total costs	US\$344 887	US\$75 269
LLITN or net procurement	US\$324 000	US\$47 221
Delivery/logistics	US\$20 887	US\$8788
Incentives for voucher redemption	0	US\$19 365
Costs per ITN or net delivered	US\$4.67	US\$5.06
Procurement of ITNs/nets/insecticide	US\$4.32	US\$3.17
Delivery/logistics	US\$0.35	US\$0.59
Incentives for voucher redemption	0	US\$1.30
Programme efficiency*	0.94	0.63

ITN, insecticide-treated mosquito nets; LLITN, long-lasting ITN.

\* Programme efficiency is defined as the fraction of total programme funds used to procure ITNs, nets or insecticide.

#### Discussion

These findings suggest that integrating ITN distribution into vaccination campaigns can achieve high and equitable ITN coverage at a cost that is lower to both providers and consumers than other delivery strategies. In the rural areas, coverage rose from 16.7% to 81.1% with an increase in equity ratio of 0.32–0.88. In the urban areas, coverage rose from 50.7% to 76.2% with an increase in equity ratio of 0.66–1.19. The operational cost per ITN was US\$0.34 for direct distribution in the rural areas and US\$1.89 for voucher-based net distribution in the urban area. Both direct distribution in rural areas and voucher-based distribution in urban areas were effective means of delivering ITNs or nets.

The rate of use was lower than the rate of possession. In the rural areas, 56.4% of children slept under any ITN and 47.9% slept under a campaign ITN. For the urban area, 77.2% slept under any ITN and 38.8% slept under a campaign ITN. In this study, the distribution and assessment took place over the dry season and there was not an intervening rainy season. Low rates of net use during the low biting season are consistent with previous reports from Zambia that among children under five in net-owning HHs, 48% had slept under a net the prior night, and avoiding insect bites, rather than malaria prevention, was the reason for children to sleep under nets (Academy for Educational Development 2001a). The mean number of months that nets were hung was 6.8 in the rural areas and 6.2 in the urban areas, corresponding to the duration of the malaria transmission season (Academy for Educational Development 2001b). Assuring and monitoring proper net use during the ensuing high transmission season may be an important component of mass distribution.

A worrisome element of compliance is the failure to properly treat the nets prior to use in the urban areas. Among those who received and hung up the nets, only 60.4% treated the net with the supplied insecticide. It seems unlikely that these nets will ever be treated or retreated without additional interventions. As LLITNs are pre-treated, they should be the preferred product for mass distribution. However, if nets are not pre-treated, mass distribution should be accompanied by intensive efforts to assure proper treatment.

Our findings suggest that the voucher system and direct distribution achieved comparable levels of coverage. However, the voucher-based system was costlier and used a cheaper, untreated net to maintain comparable total costs. Programme efficiency is a measure of the proportion of programme costs spent on commodities in the form of an ITN or net as opposed to the costs of delivery. The rural areas had a higher efficiency than the urban areas (0.93 *vs.*

0.63) because the rural areas used a more expensive net and had lower delivery costs. That is, in the rural areas, 93% of all funds spent by the programme were transferred to the consumer in the form of an ITN. Using a pre-treated, long-lasting net effectively moves the costs of treatment and retreatment from the consumer to the provider resulting in greater value to the consumer. If the voucher-based system in the urban areas had provided the same, higher quality ITN as used in the rural areas, costs would have risen to US\$6.21 per ITN delivered and programme efficiency to 0.70.

The costs to the providers of voucher-based distribution in the urban area were substantially greater than that of direct distribution in the rural areas (US\$ 1.89 *vs.* US\$ 0.35 per ITN delivered). Without the US\$1.30 incentive per voucher redeemed in the urban areas, the operational costs were comparable for the two strategies. The level of incentives was chosen by NetMark to be consistent with social marketing strategies for private sector involvement. Without the incentives, the shopkeepers may not have provided the logistics and management support to deliver the nets. It is unknown if a lower or alternative incentive approach would achieve comparable efficiencies or coverage levels. The operational cost of this voucher system is comparable to those reported elsewhere (Schellenberg *et al.* 2001) and substantially less than those of other social marketing schemes where operational costs are reported to be US\$6–15 per net distributed (RBM 2002). In an earlier study in Zambia, a community-based project was estimated to cost US\$17–22 per net distributed (cited in Hanson *et al.* 2003) and a clinic-based revolving fund approach in Mozambique cost US\$10 per net delivered (Dgedge *et al.* 1999). A highly successful social marketing approach in Tanzania gives a project financial cost of US\$8.30 per net delivered (Hanson *et al.* 2003). As noted by Hanson, these costs exclude the contributions of users and do not reflect the true value of the resources consumed in delivering nets. The cost of the Zambia and Mozambique approaches covered some additional services that were not provided by our approach. These included long-term IEC and other behaviour change elements. Because we distributed the nets free of charge during the campaigns, there were no additional direct or opportunity costs to caretakers. One reason for the high coverage of campaigns compared to routine services, particularly amongst the poorest, is that costs of accessing nets are transferred from the beneficiary to the provider/health services. Specifically, the investment in extensive outreach lowers the beneficiaries barriers to participation due to transport and time. Careful evaluation of a measles campaign in Kenya reported that the campaign approach reduced direct costs to caretakers for attending the measles campaign by 75% compared to

travelling to routine vaccination delivered at a health centre (KEPI 2002).

The costs are those that would be the external donor costs to replicate this programme elsewhere. These are also the marginal costs over and above the underlying measles campaign. If there were no underlying measles campaign, it is likely that the distribution costs would have been significantly higher for a stand-alone ITN distribution.

Integrated distribution has several limitations for ITN coverage. Eligibility for vaccination starts at 6 months of age and thereby excludes younger infants who would benefit from ITNs. Similarly, pregnant women are not protected by this approach. As campaigns are conducted only every 3–4 years, newly pregnant women and newly born children will not receive a campaign net. Optimal coverage will be achieved by combining episodic mass distribution with routine distribution methods. However, among the rural poor, there are few examples of successful routine ITN delivery programmes. Also, the point estimate of coverage of a one-time distribution effort is not strictly comparable to ongoing distribution.

While the overall vaccination and distribution sessions were smoothly run, in some cases, there were operational and logistics problems due mainly to delays in ITN deliveries to peripheral health centres due to their late arrival in country. There were drop-ins from neighbouring districts as word spread on the integrated effort. Many of these communications and drop-in problems were caused by distribution being limited to only five widely dispersed districts. This required a different and separate training and communication strategy for these districts. If there had been a national strategy, then it is more likely that consistent and intensive communication could have been conducted.

The high coverage achieved through mass campaigns may create the possibility of protecting those who do not receive the intervention. Studies from areas of high malaria transmission with high ITN coverage indicate that the primary effect of INTs is via area-wide effects on the mosquito population and not, as commonly supposed, by simple imposition of a physical barrier protecting individuals from biting (Hawley *et al.* 2003). Communities with high coverage may create large areas of overlapping protection from HH with ITNs. The impact on disease in a community with high coverage achieved by mass distribution, particularly in high-transmission, rural areas, may exceed that achieved due to individual protection.

As the purpose of this effort was to evaluate the delivery phase of the strategy, there was little additional effort at the critical element of assuring appropriate use of the nets following distribution. We believe that this preliminary



study provides sufficient guidance to advance to the next level of developing this strategy, a nationwide distribution effort to include intensive pre- and post-campaign communication for behaviour change, additional follow up for appropriate ITN use, close monitoring of costs, measurement of impact on morbidity and mortality and assessment of cost-effectiveness.

These results have encouraged the authors to proceed to a national level scale-up which (in Togo) to further evaluate the programmatic issues and challenges. While mass vaccination campaigns are relatively cost-effective as a means of achieving specific disease-control objectives (Uzicanin *et al.* 2004), they can be disruptive to the routine delivery of services. This is principally due to the high demands on health care workers for the planning and conduct of the campaigns. Other disruptions may be due to the high demand on limited logistics capacity. These disruptions might lead to lower levels of service delivery in the routine system. While possibly important, these adverse effects are difficult to measure and are rarely quantitatively studied. A complete assessment would include a comparison of the disruptions attributable to other distribution strategies, such as social marketing. Mass campaigns integrating ITNs and other services likely cause a greater disruption than vaccination campaigns alone. Whether the additional gains in disease control justify this disruption has not yet been evaluated. While campaigns will always have a degree of disruption, additional efforts are required to minimize the adverse impact of integrated campaigns, possibly through better coordination and planning.

We believe that linking ITNs to measles campaigns presents an important opportunity for reaching malaria control goals and merits larger-scale implementation and evaluation. Measles campaigns are typically nationwide and integrating ITN delivery into these larger-scale efforts will present additional challenges, as well as creating opportunities for additional efficiencies. The WHO/UNICEF strategy for measles control calls for 'second opportunity' vaccination campaigns to be conducted in all measles-endemic countries (WHO-UNICEF 2001). As practiced in the Americas and in sub-Saharan Africa, campaigns are repeated each 3–4 years for U5 children. Current plans call for vaccination of more than 50 million children in African countries during these campaigns each year (Henao-Restrepo *et al.* 2003). Each vaccination may represent a missed opportunity to deliver ITNs. If all measles campaigns included ITN distribution and achieved coverage levels reported in this study, the Abuja targets for ITN ownership could be achieved rapidly at substantially lower cost than current approaches.

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## References

- Academy for Educational Development (2001a) *NetMark Formative Qualitative Research on Insecticide Treated Materials (ITMs) in Zambia*. Netmark Project, Washington.
- Academy for Educational Development (2001b). *NetMark Baseline Survey on Insecticide Treated Materials (ITMs) in Zambia*. Netmark Project, Washington.
- Biellik R, Madema S, Taole A *et al.* (2002) First 5 Years of measles elimination in Southern Africa: 1996–2000. *Lancet* 359, 1564–1568.
- Dgedge M, Kumaranayake L, Cossa H, Hogh B, Lines J (1999) *Can the Expansion of a Subsidised ITN Project Become Self-sufficient? The Experience from an ITN Project in Mozambique*. Second International Conference on Insecticide Treated Nets, Dar es Salaam.
- Gallup JL, & Sachs JD (2001) The economic burden of malaria. *The American Journal of Tropical Medicine and Hygiene* 64 (Suppl.), 85–96.
- Grabowsky M, Nobiya T, Ahun M *et al.* (2005) Distributing insecticide-treated bednets during measles vaccination: a low-cost means of achieving high and equitable coverage. *Bulletin of The World Health Organization* 83, 195–201.
- Gwatkin DR, Rustein S, Johnson K, Pande R & Wagstaff A (2000) Socio-economic differences in health, nutrition, and population in Togo. Paper prepared for the HNP/Poverty Thematic Group of The World Bank. Asset questionnaires and weighting of asset factor scoring for each country can be found at <http://www1.worldbank.org/prem/poverty/health/data/togo/togo.xls> [accessed 20 November 2004].

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- Hawley WA, Phillips-Howard PA, ter Kuile FO *et al.* (2003) Community-wide effects of permethrin-treated bed nets on child mortality and malaria morbidity in western Kenya. *The American Journal of Tropical Medicine and Hygiene* 68 (Suppl.), 121–127.
- Hanson K, Kikumbih N, Schellenberg JA *et al.* (2003) Cost-effectiveness of social marketing of insecticide-treated nets for malaria control in the United Republic of Tanzania. *Bulletin of The World Health Organization (Genev)* 81, 269–276.
- Henderson RH & Sundaresan T (1982) Cluster sampling to assess immunization coverage: a review of experience with a simplified sampling method. *Bulletin of The World Health Organization* 60, 253–260.
- Henaio-Restrepo AM, Strebel P, John Hoekstra E, Birmingham M & Bilous J (2003) Experience in Global Measles Control, 1990–2001. *Journal of Infectious Diseases* 187 (Suppl. 1), S15–S21.
- Kenya Expanded Programme on Immunization (KEPI) and Division of Planning & Development, Central Bureau of Statistics, and Ministry of Finance and Planning (2002) *Vaccination Coverage and Economic Evaluation of Supplemental and Routine Measles Immunization*. Kenya Ministry of Health, Nairobi.
- Monasch R, Reinisch A, Steketee R, Korenromp E, Alnwick D & Bergevin Y (2004) Child coverage with mosquito nets and malaria treatment from population-based surveys in African countries: a baseline for monitoring progress in roll back malaria. *The American Journal of Tropical Medicine and Hygiene* 71 (Suppl.), 232–238.
- Nathan R, Masanja H, Mshinda H *et al.* (2004) Mosquito nets and the poor: can social marketing redress inequities in access? *Tropical Medicine & International Health* 9, 1121–1126.
- Otten M, Kezaala R, Fall *et al.* (2005) Public-health impact of accelerated measles control in the WHO African Region 2000–03. *Lancet* 366, 832–839.
- Roll Back Malaria Technical Support Network for Insecticide Treated Netting Materials (2002) *Scaling Up Insecticide Treated Netting (itn) Programmes in Africa: A Strategic Framework for Coordinated National Action*. World Health Organization, Geneva.
- Schellenberg JR, Abdulla S, Nathan R *et al.* (2001) Effect of large-scale social marketing of insecticide-treated nets on child survival in rural Tanzania. *Lancet* 357, 1241–1247.
- Uzicanin A, Zhou F, Eggers R, Webb E & Strebel P (2004) Economic analysis of the 1996–1997 mass measles immunization campaigns in South Africa. *Vaccine* 22, 3419–3426.
- WHO-UNICEF (2004) *Joint Statement – Malaria Control and Immunisation: A sound Partnership with Great Potential*. WHO, Geneva.
- WHO (World Health Organization) (2000) *Declaration, African Summit on Roll Back Malaria, Abuja, Nigeria, April 25, 2000*. (WHO/CDS/RBM/2000.17.) WHO, Geneva.
- WHO-UNICEF (United Nations Children's Fund) (2001) *Joint Statement on Strategies to Reduce Measles Mortality Worldwide*. (WHO/V&B/01.40 or UNICEF/PD/Measles/01) WHO, Geneva.

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