



Malaria in camps for internally-displaced persons in Uganda: evaluation of an insecticide-treated bednet distribution programme

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Summary Malaria is a key health problem among displaced populations in malaria-endemic areas. Mass distribution of insecticide-treated bednets (ITN) to prevent malaria is often carried out in complex emergencies, but there are few data on the outcome or operational effectiveness of such programmes. In June 2001, Médecins Sans Frontières completed a mass distribution of ITNs (Permanet®) to internally displaced persons in Bundibugyo, southwest Uganda, distributing one to four nets per household, and aiming to provide coverage for all residents. In July 2002, we did a cross-sectional survey using three-stage cluster sampling to evaluate the programme. A total of 1245 individuals from 835 households were interviewed. An ITN was present in 75.6% (95% CI 72.7–78.5) of the households, but only 56.5% (95% CI 52.3–60.4) of individuals were sleeping under an ITN, and nets were often damaged. The prevalence of malarial parasitaemia was 11.2% (95% CI 9.4–13.0), and was significantly lower in ITN users compared to non-users (9.2% vs. 13.8%, relative risk [RR] 0.63, 95% CI 0.46–0.87); ITNs with severe damage remained effective (RR for severely damaged net 0.58, 95% CI 0.35–0.98). There was no significant difference in haemoglobin concentration between ITN users and non-users.

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1. Introduction

Malaria causes between 300 and 500 million disease episodes and 1 to 2 million deaths annually, predominantly among young African children. Among infants, severe anaemia is the most important

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manifestation of malarial morbidity (Snow et al., 1997). Malaria remains a leading cause of morbidity and mortality in Uganda (Kamya et al., 2002), being responsible for up to 25% of all out-patient visits and 14% of in-hospital deaths. The disease is a particular problem in conflict areas sheltering internally displaced persons (IDP), and controlling malaria in such complex settings is a major challenge.

One of the strategies suggested by the WHO Roll Back Malaria Initiative is the use of insecticide-treated bednets (ITNs), which have been shown to have a significant effect on malarial morbidity and child mortality in short-term trials (Lengeler, 2003). However, uncertainties remain about the effectiveness of ITNs when implemented in operational settings. To our knowledge, few studies have investigated the operational effectiveness of bednets (Armstrong Schellenberg et al., 2001; D'Alessandro et al., 1995; Guyatt et al., 2002; Maxwell et al., 2002), and very few data are available on the use of this control measure in camps for refugees or displaced persons (Dolan et al., 1993; Rowland et al., 1996, 2002). We investigated this problem in Bundibugyo camps, an area of southwest Uganda experiencing recurrent insecurity, where the humanitarian organization Médecins Sans Frontières (MSF) works in collaboration with the Ugandan Ministry of Health (MoH) to provide health care for IDPs. Our aim was to evaluate a programme of mass distribution of ITNs carried out in this setting by MSF: specific objectives were to determine net use and condition one year after the completion of the distribution programme, and to compare indicators of malarial morbidity (prevalence of parasitaemia, haemoglobin concentration) amongst ITN users and non-users.

2. Methods

2.1. Study site and population

Figure 1 illustrates the study setting. In 1996, atrocities committed against civilians (mostly subsistence farmers) in the Rwenzori Mountains displaced the people to the nearby lowland areas of Bundibugyo town and Nyahuka. This area now shelters around 137 000 IDPs in 63 camps, mostly on the northwest slopes of the Rwenzori Mountains where the vegetation is dense forest. The camps have gradually become more organized with the building of small windowless mud houses with roofs of tin or plastic sheeting. Camps range in size from 420 to 30 000 people; those near Bundibugyo town are more densely populated. Most farmers return

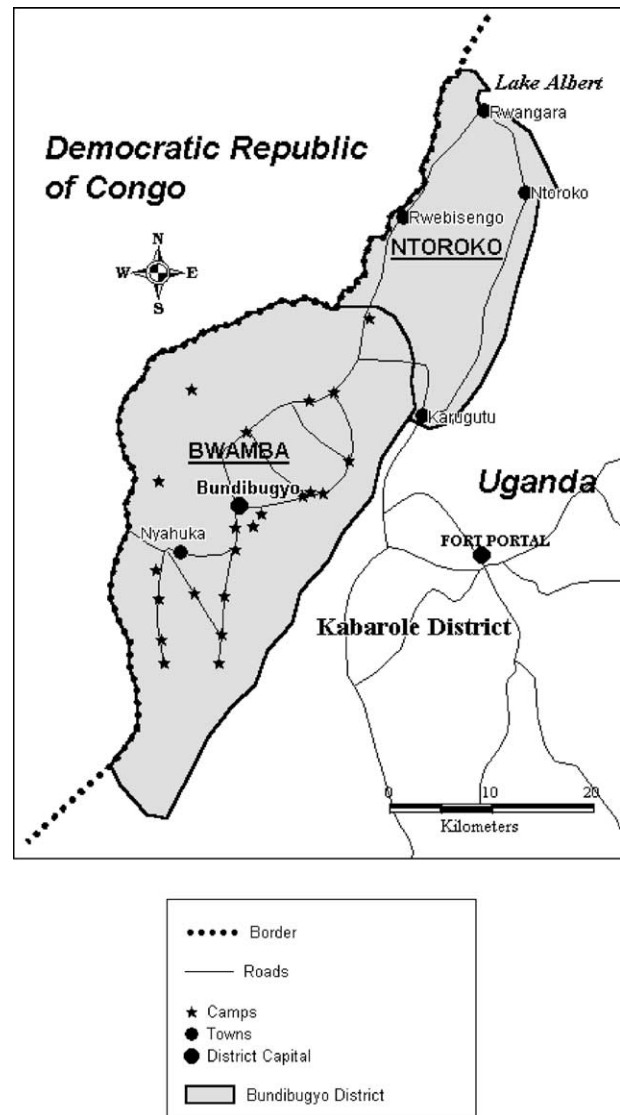


Figure 1 Map illustrating the location of the study area.

to work the crops on their original land by day but cannot remain safely in their original homes overnight. People survive on their own produce and food provided by the World Food Programme (WFP).

A collaboration between MSF and the Ugandan MoH to provide health care for these IDPs started in 1997. Malaria is transmitted throughout the year, with two peaks in March–May and October–November. Patients with malaria, usually due to *Plasmodium falciparum*, are seen in Bundibugyo hospital, Nyahuka health centre or at the two health units functioning in the district. The standard treatment for uncomplicated *P. falciparum* malaria is a combination of sulfadoxine–pyrimethamine and chloroquine. Malaria represents 30–40% of all out-patient

attendances at Bundibugyo hospital, and 35–80% of all paediatric ward admissions (MoH and MSF, unpublished data).

MSF therefore decided to start a vector control programme. Since the camps comprised mud houses, ITNs were selected as the most appropriate method of vector control. Experience from an ITN programme in 1999 run by the International Committee of the Red Cross in a neighbouring district suggested that ITNs were valued and would be used if distributed (Nijhof, 2001). There were no baseline data on net coverage before the survey. Nets were indeed observed in the camps, although they were infrequent.

Between March and June 2001, ITNs (PermaNetTM, Vestergaard-Fransen, Kolding, Denmark) were distributed to 62 712 people in 22 camps, with a total of 25 552 nets being distributed to 16 687 houses. The nets were provided free of charge because it was considered that the cost of a net would otherwise be prohibitive (a study in Uganda showed that the main reason for not buying a net was that they were perceived to be too expensive (Okello-Ogojo, 2001)). Each household received from one to four nets depending on the number of inhabitants. Such comprehensive coverage was intended to minimize resale. The ITN distribution was preceded by an educational campaign in schools and camps, including a one day training session for the camp, and drama performed in each camp. During the camp sessions, an educator demonstrated correct use of the net, addressing practical problems such as how to tuck in the net; not to sleep too close to the net where the mosquito can still bite; the net being too high or too low; and how to store the net during the day. The educational campaign also addressed issues such as drainage maintenance, filling holes and clearing bushes. A survey to estimate net coverage in the 22 camps was carried out in July 2001, one month after completion of the distribution (Nijhof, 2001).

Our evaluation was carried out in July 2002, one year after the ITN distribution, in the same 22 camps (Figure 1). All residents of those camps constituted the study population. Camps were classified as either urban, around Bundibugyo Town and Nyahuka, or rural. The population of a camp varied from 420 to 11 060 people. Most camps covered a small area (100–500 m in diameter) and altitudes varied from 868 m (around Nyahuka camp) to 1244 m (for the highest camp, Kakuka).

The priority of the MSF/MoH programme was healthcare rather than research, and thus there were no population-based data on the prevalence of malarial parasitaemias prior to the ITN distribution, nor estimates of malaria-related morbidity

such as haemoglobin concentration. At the time of the study, there was ongoing local conflict and thus research activities were somewhat constrained by the need for tight security measures.

2.2. Outcome measures

The outcomes were: (i) Household ITN coverage, defined as the proportion of houses with at least one net, irrespective of whether the net was in use: ITNs were distinguished from untreated nets. (ii) Individual ITN coverage, defined as the proportion of persons sleeping under a net, estimated firstly by dividing the number of persons sleeping under a net in the houses sampled by the total number of persons sleeping in these houses (house interview), and secondly by dividing the number of persons interviewed sleeping under a net by the total number of persons interviewed (individual interview). (iii) Prevalence of malarial infection, defined as the proportion of the sampled population with a positive thick blood film. (iv) Mean haemoglobin concentration. (v) The proportion of individuals reporting fever in the last 24 hours and the proportion of individuals with measured fever at the time of the survey.

2.3. Study design and analysis

The design was a cross-sectional community-based population survey. Data were collected using a three-stage random cluster sampling technique, derived from the WHO Expanded Programme on Immunisation (EPI) method to estimate vaccine coverage (Henderson and Sundaresan, 1982). The sampling unit was the individual and the number of clusters selected was 30.

People who had slept in the house the night before were counted (excluding babies less than 14 days old), and one child in the under five years age group and one person in the five years and over age group were randomly selected, interviewed and had a finger-prick blood sample taken for haemoglobin measurement and examination for malaria parasites. For children, the parent or guardian was interviewed. In the interview, information was collected about the household (number of nets distributed and present, demographic data concerning the family), and about the selected individuals (demographics: age and gender; nets: presence, use, condition, cause of damage, whether washed and if so how frequently; clinical: recorded fever [$\geq 37.5^\circ\text{C}$ axillary] and reported fever in last 24 hours; thick and thin blood film and haemoglobin concentration). Nets were considered 'not damaged' (perfect condition), 'damaged' (at least one hole of any size less than 40 cm^2), or

'severely damaged' (at least one hole measuring 40 cm² or more). Factors considered to be potential confounders of the association between net use and malaria (educational level of the mother, camp altitude) were also recorded. People missing from the house at the time of the survey were looked for at least twice (at the end of the day and the next day) before another person from the same house was selected. Locked houses were revisited the same day and the next day.

The sample size was estimated as the number of persons required to detect, in each age group, an estimated 75% individual net coverage, with a precision of 5%, a type 1 error of 0.05 and a design effect of 2. This gave a sample size of 575 individuals in each age group; taking into account an expected 5% non-response rate, the sample size was increased to 600. We estimated that we would be able to select one person from each age group in each house, so the number of houses to be sampled was 600, with 20 houses per cluster. Assuming a prevalence of malarial parasitaemia of 20% in the absence of ITNs, a type 1 error of 0.05 and a power of 80%, these 1200 individuals were estimated to be sufficient to detect a reduction in malaria prevalence to 10% in ITN users, assuming that 75% of the 1200 individuals would be net users. Means for temperature and haemoglobin concentration were compared using the *t* distribution and the ANOVA test statistic. Comparisons between proportions were done using the χ^2 test and presented with a 95% confidence interval and a *P* value.

Prior to data collection, four investigation teams were trained to perform the interviews, after which a two day pilot study was conducted in a camp which was not part of our sample. Each team comprised a nurse (who recorded temperature and took finger-prick blood sample), a laboratory technician (who made blood film and performed haemoglobin measurement), an assistant (who numbered houses and looked for people when absent from the house, etc.) and a team leader (who randomized houses and subjects, and provided overall supervision). Interviews were conducted in the local language by Ugandan workers, seconded by the team leader. Due to security restrictions, data collection was only possible between 10:00 and 16:00 hours. Data were recorded on an individual record form, double-entered in two separate databases (house interview and individual interview), checked and validated using Epi-Info 6.04 (CDC, Atlanta, GA, USA).

The protocol was approved by the ethics committee of the London School of Hygiene and Tropical Medicine and authorized by the Ugandan Ministry of Health. Written informed consent was sought

from each study participant, or from the parent or guardian for persons under 18 years.

2.4. Laboratory methods

Haemoglobin was measured with the portable HemoCue B-Haemoglobin analyser (Ängelholm, Sweden). This instrument is easily used by any health care worker and has been shown to be reliable (Bridges et al., 1987). Examination for malaria parasites followed the recommendations of WHO. In brief, slides were stained with Giemsa at the end of each day and stored in a special box. They were subsequently transported to Mbarara University laboratory and read by a trained technician. *Plasmodium* species were identified, parasitaemia was counted against 200 white blood cells (WBC) and calculated according to the formula parasitaemia (/ μ l) = number of parasites \times 8000/number of leucocytes. A slide was considered negative after 200 high power fields had been examined. As a quality control procedure, 20% of the slides were checked by an independent trained laboratory technician masked to the original results.

3. Results

3.1. Study population

The inhabitants of 92 houses (11%) could not be interviewed as they were absent at each of three visits. We sampled 835 houses, a mean of 27.8 houses per cluster (range 20–37), higher than predicted because in some houses there were no children aged under five years. These households included 3298 individuals, 897 in the under five years age group and 2401 in the five years and over age group. For the individual interviews, four people out of 1249 selected (one adult woman and three children) refused to participate. The total number of individuals included was thus 1245; in the under five years age group, 320 of 606 (52.8%) were female, and in the five years and over age group, 448 of 639 (70.1%) were female. The proportion of interviewees reporting fever was higher in the under five years compared to the five years and over age group (27.4% vs. 20.2%, *P* = 0.002). Fever was recorded by 4.2% of interviewees, with no significant difference between the age groups.

3.2. Coverage and condition of nets

An ITN was present in 631/835 (75.6%, 95% CI 72.7–78.5) of the houses; 22 houses (2.6%) had an

untreated net and only 6 (0.7%) had an untreated net in the absence of an ITN. The total number of ITNs received by households was 1263, of which 256 (20.3%) were missing; 14.1% (95% CI 11.5–17.2) of the interviewees said that they had not received an ITN the previous year. The main reason given for missing nets was 'moved away' (114/256, 44.5%), i.e. taken by a house resident who moved to another place (travelling to the main town for work, returning back to their farm, going to school in another village); other reasons were 'stolen' (22%), 'locked away' (13%), 'burned' (12%), 'sold' (3%), and 'other or unknown' (5%). The individual coverage as assessed by household interview was 56.6% (95% CI 54.9–58.4), compared with 56.9% (95% CI 54.2–59.6) as assessed by individual interview, with no significant difference between age groups. When an individual said that he/she had slept under a net the night before, in 96.3% of cases the net was hanging, in 3.5% the net was close to the bed (<50 cm) and in 0.2% there was either no net or the net was far from the bed.

Damage was seen in 78.1% (95% CI 73.2–82.2) of the observed ITNs and 28.0% were severely damaged. The main cause of damage was 'eaten by rats' (46%); other reasons given were 'torn' (24%), 'burned' (8%), 'unknown' (20%), and 'other' (2%). Interviewees reported that 98.2% of the nets had been washed at least once since distribution, and 69.5% were reported to be washed regularly.

3.3. Effect of ITNs on prevalence of malarial parasitaemia

Among the 1169 individuals who had a blood film examined for malaria (94% of the sample), 131 (11.2%, 95% CI 9.4–13.0) were positive for malaria: all but one were *P. falciparum*. The prevalence of malaria parasites was not significantly different between the two age groups (12.1% in under five years vs. 10.3% in five years and over, $P = 0.33$) (see Table 1). The risk of malarial parasitaemia was sig-

nificantly lower in net users compared to non-users (9.2% vs. 13.8%, relative risk [RR] 0.63, 95% CI 0.46–0.87), and the geometric mean parasitaemia was lower in users compared to non-users of nets (370.8 trophozoites/ μ l vs. 512.8 trophozoites/ μ l), although the difference was not statistically significant ($P = 0.35$, t test). This lower risk was seen in both age groups, although it was smaller and not statistically significant in the under five years age group (RR 0.67, 95% CI 0.43–1.03) and of borderline statistical significance in the five years and over age group (RR 0.59, 95% CI 0.37–0.96). The prevalence of malarial parasitaemia did not vary significantly with altitude (<999 m: 10.5%; 1000–1101 m: 12.1%; 1232 m and above: 16.2%, χ^2 for trend 2.51, $P = 0.11$). The risk of having malarial parasitaemia was greater among people living in a house where the mother had a lower level of education (no schooling, 12.8%; primary school not completed, 10.0%; primary school completed, 7.3%; χ^2 for trend = 5.7, $P = 0.02$). There was no difference in ITN use according to the mother's level of education (no schooling, 57.8%; primary school not completed, 60.5%; primary school completed, 61.2%; χ^2 for trend = 0.7, $P = 0.40$). The association between a positive blood film and ITN use was statistically significant both when the exposure was 'use of an intact net' (RR 0.51, 95% CI 0.28–0.93), 'use of a damaged net' (RR 0.43, 95% CI 0.27–0.69) and 'use of a severely damaged net' (RR 0.58, 95% CI 0.35–0.98).

3.4. Effects of ITN on haemoglobin concentration

The overall mean haemoglobin level was 12.1 g/dl (SD 2.03) but was significantly lower in the under five years age group (10.2 g/dl, SD 1.52) compared to the five years and over age group (13.2 g/dl, SD 1.83) (Table 2). There was no statistically significant difference between mean haemoglobin concentration among ITN users and non-users, neither

Table 1 Proportion of subjects with a positive thick blood film, stratified by insecticide-treated net (ITN) use and age group

Age group	No. positive/total (%)	ITN use	No. positive/total (%)	Relative risk (95% CI)
Overall	131/1169 (11.2)	Users	61/661 (9.2)	0.63 (0.46–0.87)
		Non-users	70/508 (13.8)	1
0–4 years	70/578 (12.1)	Users	34/331 (10.3)	0.67 (0.43–1.03)
		Non-users	36/247 (14.6)	1
≥5 years	61/591 (10.3)	Users	27/330 (8.2)	0.59 (0.37–0.96)
		Non-users	34/261 (13.0)	1

Table 2 Mean haemoglobin levels stratified by age group and insecticide-treated net (ITN) use

Age group	Mean Hb (SD)	ITN use	Mean Hb (SD)	P
Overall (<i>n</i> = 1224)	12.1 (2.03)	Users	12.0 (2.03)	0.33
		Non-users	12.1 (2.04)	
0–4 years (<i>n</i> = 601)	10.2 (1.52)	Users	10.9 (1.52)	0.42
		Non-users	11.0 (1.53)	
≥5 years (<i>n</i> = 623)	13.2 (1.83)	Users	13.2 (1.79)	0.44
		Non-users	13.1 (1.88)	

in the entire sample (12.0 vs. 12.1 g/dl, $P = 0.33$, t test) nor when subdivided by age group. The prevalence of anaemia (<11.0g/dl) was similar in both users and non-users of ITN (29.2% in both groups).

3.5. Additional observations

The low reported proportion of nets sold is supported by the lack of any evident black market in ITN. Adult males were often absent from the houses and therefore difficult to interview: the explanation given was that adult males often leave the house early in the morning to work in the fields and come back late in the afternoon (when it was too late to perform the interview because of the insecure situation in the camps).

4. Discussion

In this study, we investigated what happened in practice following mass distribution of ITNs in an IDP camp. Individual coverage of 57% overall may seem low, but is encouraging compared with figures from Tanzania (Armstrong Schellenberg et al., 2001), where coverage of ITNs in infants was 45% one year after the launching of a net programme. However, strict comparisons are difficult since in the Tanzanian study both the type of distribution (based on social marketing) and the context (stable) were different. In our setting, most people had settled in the camps recently because of violence in the surrounding areas, living conditions are precarious and population movements are relatively frequent. Where nets were missing, 45% had been taken by the net's owner when she/he moved away, and 14% of households reported not having received a net. Nets did appear to be valued and there were few reports or other evidence of resale. If we accept that only 86% of households received a net, coverage would be estimated at 65%, which is encouraging in this setting, but suggests

a need to ensure that new arrivals in the camp receive ITNs.

Damage to nets was frequent, perhaps because we used a strict definition, but the relatively high proportion severely damaged after only one year is a concern, suggesting that, without further intervention, the effective lifespan of nets may be rather short. It was encouraging that even severely damaged nets appeared to have a protective effect but ultimately it may be important to provide equipment and training on the repair of nets to prolong their effective lifespan. Our survey suggested that the pre-distribution educational campaign concerning net use was effective; for example in the great majority of cases, when individuals reported using nets, the net was hanging by or was close to the bed. This augurs well for the repair of nets if appropriate materials were provided.

We do not think that this population would be able to pay for the nets and, like other authors (Curtis et al., 2003; Maxwell et al., 2002), we believe that nets should be provided free of charge by the public sector with financial contribution from donors and/or assistance of non-governmental organizations in aspects such as training in their use and in their maintenance, delivery of educational messages such as the importance of rodent control (in our survey, rats were the main cause of net damage [46%]), and replacing missing or damaged nets. Our judgement does not apply to other settings like rural villages in stable conditions where social-marketing of ITN proved to be a good alternative to free distribution (Armstrong Schellenberg et al., 2001; Rowland et al., 2002).

Our survey showed that a very small proportion of the nets distributed had been sold indicating that, indeed, they were not seen as resale goods. This was confirmed by our observations showing no MSF nets being sold in Bundibugyo market. The education and information campaign was probably also a key factor. A good example is the fact that a large proportion of nets had been washed regularly showing that the messages delivered during

this campaign had probably been understood by the people.

With respect to effectiveness of ITNs at an individual level, we found that, under operational conditions in camps for IDPs in southwestern Uganda, people sleeping under ITNs had a 37% lower risk of having malarial parasitaemia than people not using them. After stratification by age, the protective effect of ITNs was smaller and no longer statistically significant in the under five years age group. The lack of statistical significance among children aged under five years is most likely because we powered the study assuming both a higher prevalence of malaria and a larger reduction in the prevalence of parasitaemia among net users. Hence on the basis of this study, we estimate that ITNs reduced malaria by 33% among children aged under five years, but we cannot exclude the possibility that this was a chance finding and that ITNs had no true effect in this age group.

Although a meta-analysis of randomized controlled trials has shown that ITNs reduce child mortality and morbidity from malaria (Lengeler, 2003), there are few data on the effectiveness of nets in operational settings. In Kenya, when ITNs were distributed district-wide to individuals after a malaria epidemic, the prevalence of a positive immunochromatographic detection test for malaria (*P. falciparum* antigen, Pf HRP-2) was 63% lower (4.7% compared with 12.7%) among individuals who had received an ITN compared with those who did not (Guyatt et al., 2002). In the evaluation of the Gambian National Insecticide Impregnated Bednet Programme, there was a statistically significant reduction of about 50% in parasitaemia among children aged one to nine years among ITN users compared to non-users (D'Alessandro et al., 1995). These two results are consistent with the 37% (95% CI 13–54%) reduction demonstrated in our study among ITN users versus non-users. There are few data on the effect of ITNs in refugee camps (Rowland et al., 1996) or IDP camps, which are estimated to concentrate more than 21 million people worldwide (USCR, 2000). In east Afghanistan, the year following resettlement, a reduction of 59% (95% CI 25–66%) in *P. falciparum* parasitaemia was observed among ITN users versus non-users (Rowland et al., 2002). Our evaluation has shown that community-wide distribution of ITNs may be useful for people living in settings such as Bundibugyo, even when the results of the distribution are far from ideal.

The absence of effect of bednets on haemoglobin levels was surprising. Anaemia is a consequence of malaria infection (Menendez et al., 2000) and therefore we would have expected that people

sleeping under a net (therefore protected against malaria), would have had a significant higher haemoglobin level than people not using nets, which was not the case. One likely explanation could be that the prevalence of malaria was relatively low, and therefore the contribution of malaria to anaemia in this population may have been less important than in areas of more intense malarial transmission. Other causes of anaemia, which we did not investigate, such as dietary deficiencies, helminths and other infections, evenly distributed among net users and non-users, may have played a more important role in causing anaemia, therefore reducing the role of malaria. A second explanation could be that mean levels of haemoglobin were relatively high in our sample, and therefore there was not much room for improvement in people sleeping under a net.

One limitation of our study is that we did not have population-based data on prevalence of parasitaemia or malaria-related morbidity or mean haemoglobin levels available prior to the ITN distribution. We are therefore not able to document whether the ITN distribution had any impact on malaria burden at the community level in Bundibugyo. Previous work (Hawley et al., 2003; Maxwell et al., 2002) has shown that community-wide ITN distribution can have a mass effect in reducing the prevalence of malaria even among individuals not themselves using an ITN. Also, the association between malaria and use of nets found in our study may have been confounded by factors such as health-seeking behaviour or socio-economic factors that we did not investigate. Therefore, results have to be interpreted with caution. Moreover, the higher proportion of women in our sample compared to that in the general population of Bundibugyo may have introduced some bias. Adult males may be at lower risk of malaria since they travel more often to highland areas where transmission is probably lower. On the other hand, male IDPs who are away from the camp overnight presumably would not have slept under a net while away, and therefore could have been at increased risk of malaria.

Another potential limitation was that responses to the questions may have been influenced by a desire to report the 'correct' answer, especially since the survey was carried out by the same organization which distributed the nets. We attempted to minimize this problem by training interviewers to ask questions in a non-judgemental way. The observation that net coverage was almost identical when measured by the household interview as compared with the individual interview was reassuring. In addition, where individuals reported

sleeping under a bed net, in the great majority of cases, a net was hanging over the bed or was close by it.

5. Conclusion

Our data support the idea that ITN distribution programmes could have an important role in malaria prevention in IDP settings such as Bundibugyo. On the basis of our evaluation their effect appeared modest but useful as part of a larger malaria control strategy including case management of malaria patients. Further studies monitoring malaria prevalence before and after ITN distribution would be useful to determine whether the community-wide distribution of ITNs in an IDP population has a 'mass effect' in the reduction of community prevalence of malarial parasitaemia. To maintain high coverage after mass distribution, we suggest that individuals entering the community need to be offered ITNs. A high proportion of nets were damaged after one year; although we were encouraged that damaged nets were also protective, this suggests that net lifespan may be short, and that individuals need training and materials to enable them to mend their nets.

Conflicts of interest statement

The authors have no conflicts of interest concerning the work reported in this paper.

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