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Impact on malaria morbidity of a programme supplying insecticide treated nets in children aged under 2 years in Tanzania: community cross sectional study

Salim Abdulla, Joanna Armstrong Schellenberg, Rose Nathan, Oscar Mukasa, Tanya Marchant, Tom Smith, Marcel Tanner, Christian Lengeler

Abstract

Objective To assess the impact of a social marketing programme for distributing nets treated with insecticide on malarial parasitaemia and anaemia in very young children in an area of high malaria transmission.

Design Community cross sectional study. Annual, cross sectional data were collected at the beginning of the social marketing campaign (1997) and the subsequent two years. Net ownership and other risk and confounding factors were assessed with a questionnaire. Blood samples were taken from the children to assess prevalence of parasitaemia and haemoglobin levels.

Setting 18 villages in the Kilombero and Ulanga districts of southwestern Tanzania.

Participants A random sample of children aged under 2 years.

Main outcome measures The presence of any parasitaemia in the peripheral blood sample and the presence of anaemia (classified as a haemoglobin level of <80 g/l).

Results Ownership of nets increased rapidly (treated or not treated nets: from 58% to 83%; treated nets: from 10% to 61%). The mean haemoglobin level rose from 80 g/l to 89 g/l in the study children in the successive surveys. Overall, the prevalence of anaemia in the study population decreased from 49% to 26% (an implementation of programmes to supply treated nets had a protective effect of 62% (95% confidence interval 38% to 77%) on the prevalence of parasitaemia and of 63% (27% to 82%) on anaemia.

Conclusions These results show that nets treated with insecticide have a substantial impact on morbidity when distributed in a public health setting.

Introduction

Several studies have shown that malarial parasitaemia is positively correlated with anaemia and that parasitaemia is the primary cause of anaemia in very young children in Africa. As a result, because malarial infection is the norm in high transmission areas, anaemia is common in young children. Assessment of the impact of chemoprophylaxis in Tanzanian infants showed that over 60% of the anaemia could be due to malaria. The emergence and spread of parasite resistance to commonly used antimalarial agents has exacerbated the problem of anaemia in sub-Saharan Africa.

Hopes for controlling malaria and malarial anaemia have recently been revitalised by the demonstration that nets treated with insecticide can reduce morbidity and mortality. A summary of randomised controlled trials showed an average protective effect of about 50% on mild malaria episodes in areas where the rate of transmission of malaria was stable. Moreover, protective effects were shown on the prevalence of parasitaemia with a high level (>5000/μl) of trophozoites (31%) and on overall mortality (19%). A modest improvement in packed cell volume (a rise of 0.02 (2%)) and weight gain was also observed in children sleeping under treated nets. Large scale implementation of programmes to supply treated nets is under way in several African countries.

It is not known whether the impact of treated nets in the context of well controlled randomised controlled trials can be replicated under programme conditions. We report the first assessment of the impact of treated bed nets when supplied in the context of a large scale social marketing programme (an approach using marketing techniques to promote and distribute socially beneficial interventions rather than commercial products) on morbidity indicators in children aged under 2 years in an area of Tanzania with a high prevalence of malaria.

Methods

Study area and population

Social marketing of treated bed nets started in the Kilombero net project (KINET) in 1997, covering the

A table showing the impact of net use on anaemia reported by other trials is available on the BMJ’s website. This article is part of the BMJ’s trial of open peer review, and documentation relating to this also appears on the website.
Kilombero and Ulanga districts (population 350 000) in southwestern Tanzania. Nets and insecticide (branded Zuia Mba) are now being promoted, distributed, and sold through public and private outlets and a system of community door to door distributors. When the project began, the retail price of a treated net was $5 (£3.60). Although this amount was not a negligible part of the average annual income in this community, many of the residents bought a net. The impact of the programme on morbidity and mortality indicators is being monitored in 18 villages under demographic surveillance. Population characteristics of this area of high perennial malaria transmission have been described elsewhere. Moderate anaemia (packed cell volume < 0.25 (<25%)) and severe anaemia occur in 61% and 14% respectively of children aged under 5 years who are admitted to the local St Francis District Hospital. Resistance to chloroquine is common: 65% of malaria infections do not clear within one week of chloroquine treatment.

Data analysis
Analysis was done for the three cross sectional surveys combined. We estimated impact of the nets on haemoglobin level, anaemia, parasitaemia, and splenomegaly using multiple linear and logistic regression models, taking into account the sampling methods for years 2 and 3, and using robust regression approaches in STATA software. We included the effect of different time points of observation (surveys) as one of the explanatory variables. In the multivariate models the use of a net, condition of the net, age, sex, ethnicity, religion, nutritional status, and access to a dispensary, shops, and covered wells. Treatment history and "health seeking" attitudes were also included, as were factors related to family size and income.

Results
We identified 985 eligible children; the mothers of 16 of these children refused consent, and 142 mothers could not be traced at their homes. Therefore, mothers (or guardians) of 827 children were interviewed during the three cross sectional surveys. Sixty eight children were over 24 months old at the time of sampling, and the net status was not known for 11 children; therefore only 748 (91%) children were included in the analysis. Similar proportions of anaemia and of reported net ownership were found in the children analysed and those not analysed (data not shown).

We observed an increase in the mean haemoglobin level from 80 g/l to 89 g/l and a decline in the proportion of children with anaemia (49% to 26%), parasitaemia (63% to 38%), and splenomegaly (86% to 49%) during the successive surveys (table 1). The proportion of children with a net (treated or untreated) increased from 58% (140/240) to 83% (199/239), and those with treated nets increased substantially during the three years (from 10% to 61%), indicating a rapid uptake of the socially marketed treated nets, especially during the first year (table 1).

Ownership and use of nets
Predictors of net ownership included family income: families with a high income (highest quarter) were almost three times more likely to have a bed net than those with a low income (lowest quarter) (table 2). This

![Table 1](https://example.com/table1.png)

- **Table 1** Characteristics of children surveyed in three cross sectional surveys, 1997-9. Values are numbers (percentages) of children unless stated otherwise.

- **Year**
  - 1997
  - 1998
  - 1999
  - Overall

- **Eligible**
  - 325
  - 330
  - 330
  - 985

- **Interviewed**
  - 269 (83)
  - 291 (88)
  - 267 (81)
  - 827 (84)

- **Analysed**
  - 240 (74)
  - 269 (82)
  - 239 (72)
  - 748 (76)

- **Children analysed**

<table>
<thead>
<tr>
<th>Mean (range) age (months)</th>
<th>Eligible</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14.2 (3.3-26.4)</td>
<td>13.5 (3.0-24.7)</td>
<td>15.4 (2.4-25.5)</td>
<td>14.4 (2.4-26.4)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean (SE) haemoglobin (g/l)</th>
<th>Eligible</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>122 (51)</td>
<td>137 (51)</td>
<td>113 (47)</td>
<td>372 (50)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>80 (1.2)</td>
<td>89 (1.0)</td>
<td>89 (1.0)</td>
<td>86 (0.7)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Children with anaemia (haemoglobin &lt;80 g/l)</th>
<th>Eligible</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>No net</td>
<td>100 (42)</td>
<td>49 (18)</td>
<td>40 (17)</td>
<td>189 (25)</td>
<td></td>
</tr>
<tr>
<td>Untreated net</td>
<td>116 (48)</td>
<td>64 (24)</td>
<td>53 (22)</td>
<td>233 (31)</td>
<td></td>
</tr>
<tr>
<td>Treated net</td>
<td>24 (10)</td>
<td>158 (58)</td>
<td>146 (61)</td>
<td>328 (44)</td>
<td></td>
</tr>
</tbody>
</table>
Impact of treated bed nets on prevalence of anaemia (haemoglobin <80 g/l)

Table 2: Predictors of ownership of bed nets (logistic regression analysis: final model also included ethnic origin of child)

<table>
<thead>
<tr>
<th>Variable</th>
<th>No (%) of children with nets</th>
<th>Geometric mean for parasite density</th>
<th>Adjusted odd ratio (95% CI)</th>
<th>χ² test (P value)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income categories (quarters of total family income):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First (lowest)</td>
<td>124/183 (67)</td>
<td>Reference group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>130/184 (71)</td>
<td>1.23 (0.59 to 2.66)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>142/195 (73)</td>
<td>1.13 (0.74 to 1.72)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth (highest)</td>
<td>163/184 (89)</td>
<td>2.74 (1.58 to 4.75)</td>
<td>8.89 (0.031)</td>
<td></td>
</tr>
<tr>
<td>No access to covered wells†</td>
<td>191/245 (78)</td>
<td>0.61 (0.41 to 0.90)</td>
<td>3.90 (0.048)</td>
<td></td>
</tr>
<tr>
<td>Advised neighbours to get care for their sick children:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At formal health facility</td>
<td>367/464 (83)</td>
<td>2.27 (1.38 to 3.72)</td>
<td>3.90 (0.048)</td>
<td></td>
</tr>
<tr>
<td>From traditional healer</td>
<td>133 (23)</td>
<td>0.12 (0.01 to 1.07)</td>
<td>2.97 (0.085)</td>
<td></td>
</tr>
<tr>
<td>Child immunised</td>
<td>376/467 (84)</td>
<td>1.92 (0.86 to 4.29)</td>
<td>3.38 (0.066)</td>
<td></td>
</tr>
<tr>
<td>Mother educated</td>
<td>395/509 (79)</td>
<td>1.59 (0.85 to 3.00)</td>
<td>3.15 (0.076)</td>
<td></td>
</tr>
</tbody>
</table>

CI=confidence interval. *Likelihood ratio test. †Piped clean water.

was expected as the treated nets were being sold. By the end of the second year of the marketing campaign (1999), only 17% of the children were without a net. Children with no access to covered nets (piped clean water)—that is, not at the centre of the villages—were less likely to have nets (table 2). Mothers who mentioned that they would advise their neighbours to send their sick children to a formal health facility were more likely to have nets for their own children (odds ratio 2.27; likelihood ratio test χ² = 3.90, P value = 0.048) than mothers who advised care by a traditional healer. This might reflect an association between health seeking patterns or perceptions about the value of the formal health system and the decision to have a net or not.

Observation of sleeping places for 171 children in 1999 showed that 117 of the 126 (93%) mothers who claimed to be using nets had a net hanging at the sleeping place. For all nine children who had a missing net at the sleeping place, we were shown a net claimed to be used. Among those who claimed not to be using nets, 17% (8/45) had a net hanging at the sleeping place. Eight of the 45 (17%) mothers who claimed not to be using nets had a net hanging at the sleeping place. These observations showed that reported ownership and reported use provided a reasonable basis for defining net status.

Health impact of treated nets
We observed a protective efficacy—defined as (1 – odds ratio) × 100—on the prevalence of parasitaemia of 62% (95% confidence interval 38% to 77%) and 51% (0% to 70%) for treated and untreated nets respectively, when compared with children without nets (table 3). The prevalence of parasitaemia was also related to ethnic group, religion, use of the net in the previous month, and age of the child, with the prevalence in those aged over 1 year being four times higher than in those aged under 7 months (table 3). This is consistent with earlier studies in Tanzania that showed that prevalence of parasitaemia increased with age.11–14

The mean haemoglobin level was 77 g/l (95% confidence interval 74 g/l to 79 g/l) in children without nets, 86 g/l (83 g/l to 88 g/l) in those with untreated nets, and 92 g/l (90 g/l to 93 g/l) in those with treated nets. Multiple regression analysis showed that haemoglobin level increased by 13 g/l (8 g/l to 17 g/l) in those with treated nets and by 11 g/l (5 g/l to 17 g/l) in those with untreated nets, compared with those with no nets. On the basis of our classification of anaemia, a protective efficacy of 37% (~46%) to 73% for untreated nets and 65% (27%) to 82% for treated nets was observed. Children whose height was stunted or who had no access to covered nets were more likely to be anaemic (table 4). If the cut-off level for anaemia was set at 110 g/l, the protective efficacy of untreated nets was 78% (29% to 93%) and of treated nets was 82% (42% to 94%). Parasitaemia was associated with anaemia: children with severe parasitaemia had lower mean haemoglobin levels than those with no or mild parasitaemia (2 g/l for trend, P < 0.001). Lastly, nets also had a high impact on prevalence of splenomegaly, with a protective efficacy of 71% (39% to 87%) for children with untreated nets and 76% (52% to 88%) for those with treated nets.

In children without nets the prevalence of anaemia remained relatively stable (49% to 58%) over the study period; this was also the case for the prevalence of parasitaemia (68% to 71%). This suggests that the transmission rate of malaria did not change substantially during the study.
Nets treated with insecticide distributed through a social marketing programme rapidly and substantially reduced the prevalence of parasitaemia and anaemia in children aged under 2 years. This strategy has high potential in the control of malaria in sub-Saharan Africa.

We thank the children and guardians who participated in the study; Dr H Molinda, the director, and the other staff of the Ifakara Health Research and Development Centre for facilitating the conduct of the study; Drs F Lwila and P Mbena (district medical officers) and the health workers in the Kilombero and Ulangi districts.

Contributors: SA contributed to the design and planning of the work and was responsible for the field implementation, the analysis and interpretation of the data, and the writing of the paper. JAS has substantially contributed to the design, implementation, analysis and interpretation of the data, and to the writing of the paper. CL had overall responsibility for the work and contributed to all key aspects, including the interpretation of the findings and the writing of the paper. SA, JAS, CL will act as guarantors for the paper.

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Competing interests: During the past five years CL has received financial support from several manufacturers of insecticide and mosquito nets to attend scientific meetings.

Discussion

These results have shown that the social marketing approach of distributing bed nets treated with insecticide was highly successful and resulted quickly in more than 80% of children aged under 2 years having access to a net. Our results suggest a good overall impact of social marketing of treated nets on health outcomes in the community, with an improvement of mean haemoglobin levels (from 80 g/l to 89 g/l) and a decline in the total proportion of children with anaemia (from 49% to 26%), parasitaemia, or splenomegaly. The treated nets had an apparent individual protective efficacy of over 60% on the prevalence of anaemia, parasitaemia, and splenomegaly. In this study untreated nets were also found to be protective. Overall, most of the changes occurred in the first year of the study.

These efficacy estimates are higher than those found in most controlled trials (see table on the BMJ’s website). May this finding be the result, therefore, of residual confounding despite efforts to control for it? This question is especially pertinent because our comparison group comprised children who did not own nets in the same community. The tools used to measure confounding factors such as socioeconomic status and health seeking behaviour may not be sensitive enough to allow for proper control of confounding. Factors related to the dynamics of the malaria infection and the associated disease presentation, however, may also explain this finding. Variations in transmission, for example, strongly affect the estimates of morbidity and mortality in very young children. Therefore at a given transmission intensity, the age of the study participants may be crucial in determining the level of protection. Our finding of high impact in children under 2 years is in line with other studies that included very young children (see web page table).

Lower impact estimates than ours were observed in a randomised study near Ifakara in a similar age group. This may be because our study covered a larger geographical area and included study children with a lower mean haemoglobin level (mean level in those without nets 77 g/l in our study, 87 g/l in the Ifakara study, t test = 3.9, P = 0.0001). Children with more severe anaemia are probably more likely to benefit from intervention than children with milder anaemia.

Randomised controlled trials of materials treated with insecticide have consistently shown short term impact on malaria morbidity and mortality

Whether these benefits can still be observed when such materials are distributed in public health programmes is not known

Bed nets treated with insecticide and distributed as part of a large scale social marketing programme can rapidly and substantially reduce the prevalence of malarial parasitaemia and anaemia in very young children

What is already known on this topic

What this study adds

References


4 Lengeler C. Insecticide-treated bednets and curtains for preventing malaria. *Cochrane Database Syst Rev* 2000;CD000036.


12 Stata statistical software, release 6.0. College Station, TX: Stata Corporation, 1999.


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