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The effect of delivery mechanisms on the uptake of bed net re-impregnation in Kilifi District, Kenya

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The results of recently completed trials in Africa of insecticide-treated bed nets (ITBN) offer new possibilities for malaria control. These experimental trials aimed for high ITBN coverage combined with high re-treatment rates. Whilst necessary to understand protective efficacy, the approaches used to deliver the intervention provide few indications of what coverage of net re-treatment would be under operational conditions. Varied delivery and financing strategies have been proposed for the sustainable delivery of ITBNs and re-treatment programmes. Following the completion of a randomized, controlled trial on the Kenyan coast, a series of suitable delivery strategies were used to continue net re-treatment in the area. The trial adopted a bi-annual, house-to-house re-treatment schedule free of charge using research project staff and resulted in over 95% coverage of nets issued to children. During the year following the trial, sentinel dipping stations were situated throughout the community and household members informed of their position and opening times. This free re-treatment service achieved between 61–67% coverage of nets used by children for three years. In 1997 a social marketing approach, that introduced cost-retrieval, was used to deliver the net re-treatment services. The immediate result of this transition was that significantly fewer of the mothers who had used the previous re-treatment services adopted this revised approach and coverage declined to 7%. The future of new delivery services and their financing are discussed in the context of their likely impact upon previously defined protective efficacy and cost-effectiveness estimates.

Introduction

There has been a justified interest in the role of insecticide-treated bed nets (ITBN) in the control of malaria-related mortality among children living in sub-Saharan Africa following the impressive findings of five large-scale, randomized controlled trials across the continent (Alonso et al. 1991; D'Allesandro et al. 1995; Binka et al. 1996; Nevill et al. 1996; Habuletzel et al. 1997). All of these trials were conducted under quasi experimental conditions to determine protective efficacy estimates and thus their impact upon child survival under optimal conditions. The true effectiveness of intervention programmes when delivered under national and local operational conditions remains largely unknown (Lengeler and Snow 1996). Given the known efficacy under experimental conditions, perhaps the most important determinant of 'real life' effectiveness is that of intervention coverage.

There remains conflicting evidence on the precise role of untreated nets in reducing the fatal consequences of *P.falciparum* malaria (Bradley et al. 1986; Genton et al. 1994; Snow et al. 1988). However, it is generally accepted that the greatest effects of bed net programmes depend upon the treatment of nets with insecticides which serve as both a repellent and killer of local malaria vector populations. Whilst the local promotion of bed net purchase, or free provision, must serve as the primary step in insecticide net impregnation programmes, it is net treatment and re-treatment that will determine the long-term success or failure of ITBN control stratagems in Africa. Research is currently underway into appropriate and sustainable delivery mechanisms (TDR 1996). These approaches must allow for regular treatment/re-treatment given that insecticides in current use lose potency between 6–12 months, whilst more frequent re-impregnation may be necessary where nets are washed often (Lines 1996).

One of the large mortality trials was conducted on the Kenyan coast (Nevill et al. 1996). We report here the responses on the part of this community to changing delivery systems over the last four to five years through epidemiological surveys of coverage rates compared to an audit of programme activity.

Methods

Study area

In 1993 a community randomized, controlled intervention trial was started to assess the impact of permethrin-treated bed nets on mortality and morbidity attributed to malaria within a geographically defined research study area in Kilifi District on the Kenyan coast. The society represented in the study area is patriarchal and mostly polygamous, with Christian, Muslim and traditional Giriama beliefs co-existing

(Parkin 1991). The people farm maize, cassava and beans for home consumption. Household food self-sufficiency along this coastal strip is only 17.3% and can be much lower depending upon seasonal and annual rainfall patterns (GOK 1988). During periods of home-produce shortage, food is purchased outside the household with cash generated from cashew nut and coconut harvests and additional income from other household members working in the wage economies of Mombasa or Malindi. The area is economically typical of other rural areas along the Kenyan Coast (GOK 1994).

Malaria constitutes the greatest threat to child survival outside the neonatal period in this area of Kenya (Snow et al. 1994), best reflected in the results of the experimental trial of ITBN which demonstrated a 33% reduction in mortality among children aged 1–59 months (Nevill et al. 1996). Before 1993 bed net use was uncommon (6% of the childhood population slept under a bed net) whilst local insect repellents and commercially available pyrethrum-based mosquito coils were more widely used (32% and 46% respectively of rooms where children aged below 12 years slept) (Snow et al. 1992). The populations' perception of 'malaria' as a disease and its treatment and prevention practices before the onset of the trial have been described in detail elsewhere (Mwenesi et al. 1995a; 1995b). The most pertinent observation made during these investigations was that the community did not perceive any adverse health consequences of mosquito bites (Mwenesi 1993). Despite the avoidance of this concept during early health messages of the ITBN programme, significant changes in the local beliefs occurred during the course of the trial with a definite shift towards a view that mosquitoes and malaria were indeed linked (Marsh et al. 1996).

ITBN intervention processes and delivery systems

Between May and June 1993, intensive community sensitization was undertaken through public meetings organized through local administrative structures, the District Development Committee and community leaders. Information about the trial, its objectives, the need for randomization and specific messages about bed nets and allied insecticide treatment were all conveyed at these meetings. The intervention trial involved the delivery of 17 742 pre-treated bed nets to over 96% of the beds registered in 2760 households (average household size was between 10–15 people) in 28 'zones' randomly selected to form the intervention population. The delivery took place between June and July 1993 and was conducted by 22 trained, research field staff supported by five landrovers and supervised by five senior members of staff over a period of 42 days. At each household, two people issued nets to each bed and demonstrated their correct use and hanging. The delivery exercise ran concomitantly with a house-to-house education programme using flip charts on how to use and care for the nets, and group meetings conducted by seven Public Health Technicians (PHT). Additional educational programmes were organized throughout the trial through local schools (Marsh et al. 1996).

Re-impregnation of nets was performed during the trial by field staff employed by the research programme who visited each of the scattered homesteads in either April or October (coinciding with the seasonal rises in vector activity). Households were pre-warned of a date when the field staff would arrive and were asked to wash their nets in preparation for re-impregnation through letters written in Kigiriama. Nets were collected in batches and dipped according to a defined algorithm of water-to-permethrin emulsifiable concentrate (Nevill et al. 1996). Families who were travelling at the time of each household visit were re-visited once during each round of re-impregnation. This procedure took on average 53 working days to complete with two vehicles, using between 12–16 project field staff and two supervisors.

Throughout the trial the communities residing in the remaining 28 control zones received no intervention until the end of the trial in October 1995 when 21 000 pre-treated nets were issued to these communities at the same time as the field staff re-treated the intervention communities' nets. Given the experimental nature of the trial, optimal coverage was intended and thus the resources necessary to achieve this were provided. Upon completion of the trial, this high cost, labour intensive approach was thought inappropriate for a locally defined sustainable programme. From April 1996, 13 sentinel delivery stations were identified throughout the study area, located where the community frequently travelled for shopping or public meetings and with a regular supply of water (Figure 1). The community were informed of their locations and operating times through a process of public meetings held at 12 sites in the study area and arranged through the local administrative system of government-appointed chiefs and sub-chiefs, women's groups and head-teachers; posters situated in key positions throughout the study area; and a mobile public address system mounted on top of a landrover which travelled the entire study area. For a total of 17 days, ten Public Health Technicians seconded from the District Primary Health Care programme were stationed at each dipping site with 12 field workers from the research project. An identical procedure was adopted during October 1996; however, the number of dipping stations was increased to 15 (Figure 1).

During 1997 a social marketing approach was developed for the re-treatment services by a) establishing a 'product' around the insecticide rather than the net which had been the emphasis during the trial; and b) developing new delivery channels involving the private sector and cost-recovery. In collaboration with an advertising agency in Nairobi, the brand name, *Fufua Neti Yako* (revive your net), was established to convey the message about the value of routine net re-treatment. Prior to all activities, a series of public meetings with community leaders and household heads was held throughout the study area to discuss the change in delivery system and introduce the concept of cost. To promote the brand concept several marketing strategies were adopted including sponsorship of local football tournaments, song competitions, posters, wall-sized murals and shopping bags carrying the product's brand name and logo, a picture of women crowding around a dipping agent, who is in the process of dipping a net.

During the first phase of the social-marketing project, the sentinel site delivery approach was retained and 18 re-dipping

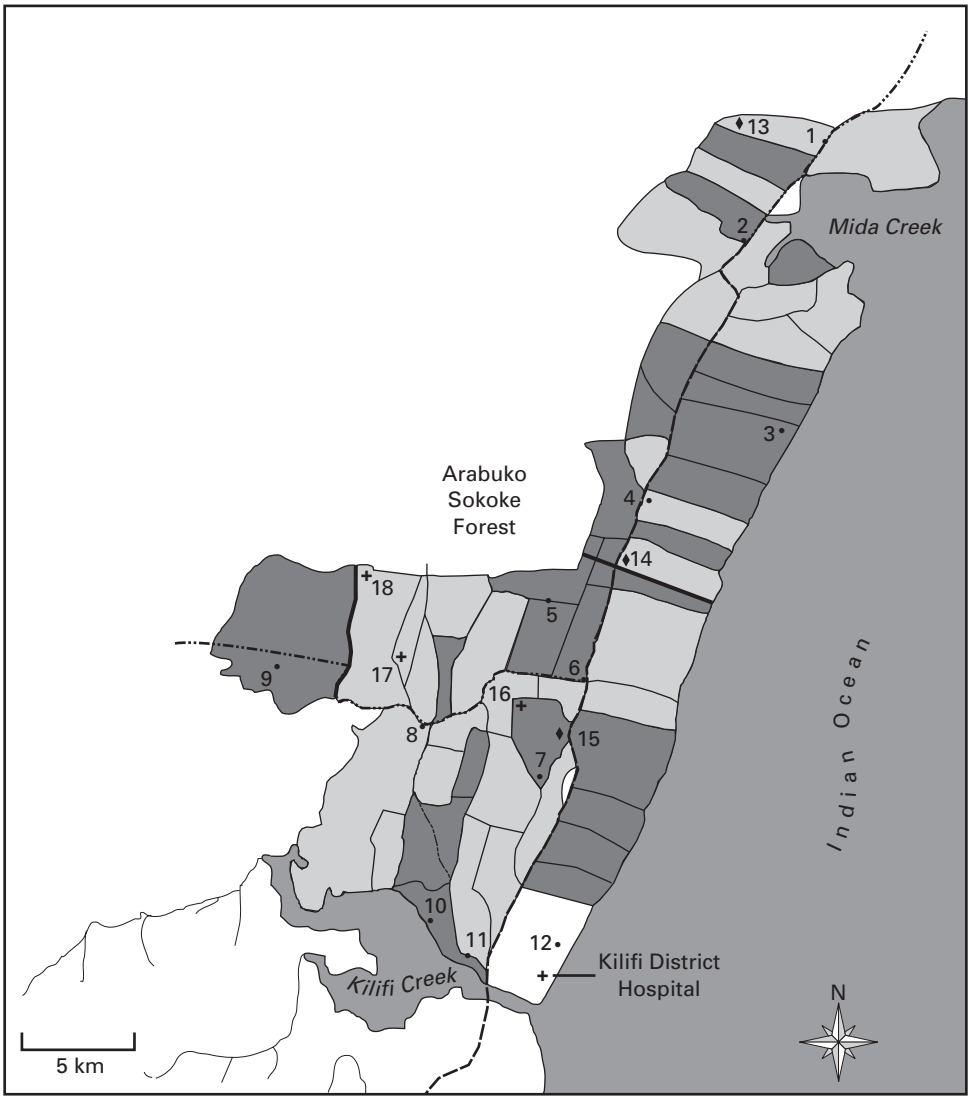

Figure 1. Distribution of intervention (shaded) and control (open) clusters used during the trial of insecticide treated bed nets between August 1993 and October 1995 and the position of sentinel dipping stations used in the delivery of re-impregnation services from April 1996 (dots), those added in October 1996 (diamonds) and those added in August 1997 (crosses). Note dipping station 8 dropped in 1997. Within the dark lines, the ocean and the creek lies the southern continuous demographic surveillance area

service administrators were trained as net treatment service providers. They were paid a small lunch allowance and 10 Kenyan Shillings commission per net treated. Four administrators, at sites 1,11,12 & 13 in Figure 1, were converted to re-dipping service entrepreneurs on an experimental basis. The insecticide was sold to them on credit at a cost which enabled them to earn 25 Kenyan Shillings (100% margin) on each net re-treatment and encouraged them to actively seek clients. As with all previous re-treatment services, nets were dipped in insecticide-to-water mixes prepared in situ and nets were returned to customers in *Fufua Neti Yako* bags to be carried home. All dipping stations were open between 8.30 a.m. and 5.00 p.m., Mondays to Fridays. The entrepreneurs reported to the programme on an as-needed basis to re-stock insecticide while the dipping agents travelled to a central location each Saturday to report all weekly sales, thereby reducing overhead costs of frequent site visits by programme vehicles. By September 1997 it was decided to disband the fixed service administrator approach and move to an entirely entrepreneurial approach, and 25 re-dipping agents were recruited and trained for the programme. Each agent was assigned to a dipping site but encouraged to travel door-to-door to create their client base. All of the transitions in delivery systems since 1993 are shown in Table 1.

Re-dipping evaluation groups

Throughout the randomized trial six-weekly vital registration was maintained to identify all migrations, births and deaths, and census schedules were re-checked every six months by means of a full re-enumeration of every household. A 'bed register' was also maintained to identify needs for new nets within households. On completion of the trial, demographic surveillance was maintained by means of re-enumeration of

Table 1. Time-table of ITBN activity within the Kilifi study area

Dates	Activity
May–July 1993 (6 weeks)	Community preparation: meetings with community leaders, public meetings, identification of bed net contacts, community education programme through group meetings, posters and house-to-house visits
August 1993 (6 weeks)	Delivery of pre-impregnated nets to 2,760 households using 22 project field staff, 5 drivers, 5 vehicles, 7 Public Health Technicians and 5 supervisors, using a system of house-to-house delivery and re-education (included 4 weeks of reduced delivery team follow-up)
October 1993 (3 weeks)	Preparation of the community through house-to-house visits by project field staff to ensure every household was aware of their dipping-day. Re-impregnation of intervention communities' nets using 20 project field staff, 2 drivers, 2 vehicles and 3 supervisors, using a system of house-to-house delivery (included 4 weeks of reduced delivery team follow-up)
April 1994 (3 weeks)	As above and the initiation of a school-based education programme (included 4 weeks of reduced delivery team follow-up)
October 1994 (3 weeks)	As above (included 4 weeks of reduced delivery team follow-up)
April 1995 (3 weeks)	As above (included 4 weeks of reduced delivery team follow-up)
October 1995 (6 weeks)	Delivery of pre-impregnated nets to 3000 previously defined control households using 20 project field staff, 2 drivers, 2 vehicles, 6 Public Health Technicians and 3 supervisors, using a system of house-to-house delivery combined with house-to-house re-impregnation of all intervention communities' nets
April 1996 (5 weeks)	Community preparation for change in delivery system through public meetings, posters and a public address system. Sentinel site delivery of re-impregnation services at 13 stations
October 1996 (5 weeks)	As above at 15 locations
April–May 1997 (16 weeks)	Community sensitization to discuss delivery system changes and costs. Sentinel site re-impregnation services at 18 locations with cost-retrieval using administrator and entrepreneur systems; accompanied by 12 Public Health Technicians to serve as community mobilizers
October 1997 onwards	25 re-dipping service entrepreneurs based half-time at sentinel sites and remaining time travelling house-to-house

all children born into a fixed cohort in the southern part of the original study area (area indicated in Figure 1).

Two study populations were identified. First, 632 children who were born in the intervention communities of the southern study area during the first year of the randomized trial (between 8/93 and 7/94), representing over 60% of all the births from the entire study area shown in Figure 1 where the intervention was delivered. Of these children, 62 (9.8%) were never issued nets because they either moved away from the study area soon after birth or the mothers were not resident at the time of household visits by the survey team. Mothers of the remaining children were questioned about net re-impregnation after every round between October 1993 and August 1997. Nets issued to these children were examined by field staff in October 1995 and in August 1997, between 2 and 4 years of use respectively, to assess their condition. Field staff were asked to establish whether the net was in a good and usable condition, the presence of any holes or tears in the nets and whether the nets had evidence of having been burnt or were so damaged they were no longer useable. After the April 1996, October 1996 and May 1997 re-treatment schedules, mothers who had not taken their child's net for re-impregnation were asked to provide reasons. All information was collected onto structured questionnaires and open-ended sections on reasons were coded after the completion of the survey.

The second study group was identified in August 1997 and represented 407 resident children (born between August 1993 and July 1994) from previously defined control areas of the southern part of the main bed net trial area. These children had been issued nets at the end of the randomized controlled trial in October 1995. Mothers of these children were questioned about net re-impregnation.

Results

Re-impregnation audit over time

Bed registers maintained during the intervention trial identified coverage targets for re-impregnation throughout the intervention communities. Re-impregnation rates were in excess of 85% for the entire population between October 1993 and October 1995. A total of 27 315 nets were re-impregnated during the first sentinel dipping exercise in April 1996, representing 66% of the estimated target number of 41 000

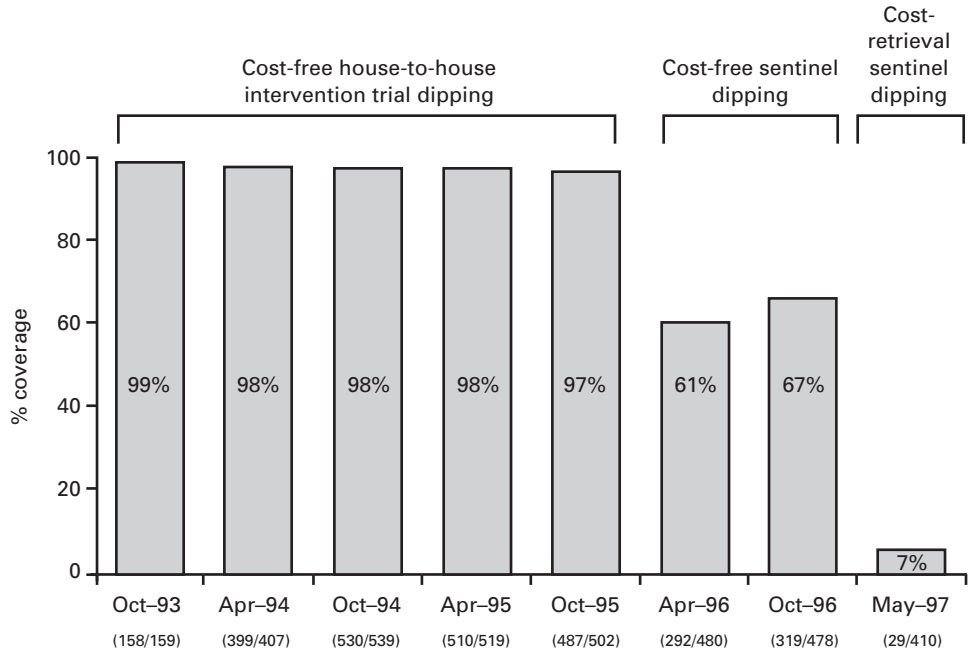

Figure 2. Percentage coverage of net re-impregnation for children born between August 1993 and July 1994 who were issued nets during the first year of the intervention trial and maintained under demographic surveillance through to 1997

nets distributed to both the intervention and control study communities. In 1997 approximately 1600 nets were re-treated over four months.

Figure 2 shows the changes in the proportions of children born in the intervention zones during the first year of the controlled trial who had had their nets re-impregnated at scheduled times between October 1993 and May 1997. Whilst coverage was in excess of 97% throughout the house-to-house delivery of insecticide re-treatment during the course of the intervention study, it fell to between 61–67% when a system of sentinel site delivery of free net re-treatment was introduced in 1996. Of mothers who reported not having their child's net re-impregnated in April 1996, 89 (47%) said they had not heard of the revised programme of sentinel site stations nor where these were situated. A similar proportion of non-attenders reported the same reason in October 1996 (44%). Travelling during the operating periods of the dipping stations was the second most common reason for not attending during both surveys in 1996 (34/347, 9.8%). The remaining reasons were due to problems of transport, too occupied whilst farming or the mothers were unable to provide any obvious reason.

Of the 188 nets which had not been re-treated in April 1996, 109 (58%) were taken for treatment in October 1996 and 80 (50%) of the 159 nets not dipped in October 1996 were taken for re-impregnation by these mothers 6 months earlier in April. Each of the dipping stations shown in Figure 1 were equally well attended in April 1996, with no obvious preference for any one site by the community (data not shown). In 1997, during the social marketing campaign based at sentinel sites, coverage declined further to 7.1% (29/410) among those children still resident in the southern study area who had had nets since 1993, and was 5.2% (21/407) among those issued nets in 1995. The overwhelming response for the 381 mothers who did not take their child's net for re-treatment prior to the onset of the rains in 1997 was financial (87%, 331/381). Compared to earlier approaches, far fewer mothers indicated that they were unaware of the dates and positions of the sentinel dipping stations (5.5%).

Condition of the nets after sustained household use

Observations made by field staff in October 1995 of 450 nets used by children for a period of 15 and 27 months revealed that whilst 301 (67%) were deemed in a complete and useable condition, 14 (3%) had evidence of having been burnt or damaged beyond repair, and 135 (30%) had evidence of holes or tears. In August 1997 following a period of 36 and 48 months of use, the examination of 352 nets indicated that 42% were in a complete and usable state, 51% had evidence of holes or tears and 6.5% were damaged beyond repair including 7 destroyed by fire. Among the control children who had been using their nets since October 1995, 52% of the nets (194/372) were in a satisfactory condition whilst 1.3% (5) were damaged beyond repair including four which had been damaged by fire.

Discussion

Not surprisingly, during the randomised controlled trial in Kilifi District re-impregnation rates of bed nets issued free to over 24 000 people were high. Clinical trials of new interventions must aim for optimal delivery to establish whether the intervention can or cannot significantly reduce morbidity and mortality. It is within the context of such trials in The Gambia (Picard et al. 1993) and Ghana (Binka et al. 1997) that cost-effectiveness has been measured. The impact on mortality

during the first Gambian trials was large, demonstrating a 63% reduction in child mortality (Alonso et al. 1991), which has been equated to a highly cost-effective health 'buy' at approximately US$ 8 per healthy life saved (Picard et al. 1993). However, subsequent pragmatic trials operated under national programme conditions (D'Allesandro et al. 1995) demonstrated a reduced impact on mortality (25%), highlighting the differences between efficacy and effectiveness estimates of health impact (Lengeler and Snow 1996). Whilst the overwhelming contribution to net re-impregnation costs remains the price of the insecticide (over 80% in the Gambian studies), resource-constrained health authorities must rationalize the costs and therefore mechanisms by which the intervention is delivered to the target populations. Resources devoted to mobilization of community awareness and the mode of targeted delivery all contribute to the extent to which re-impregnation services are used by communities who own bed nets (Lines 1996).

At the end of 1995 when the experimental trial of ITBN in Kilifi came to an end, the research programme was under an obligation to develop a more sustainable delivery system in collaboration with the District Heath Management Team (DHMT). The greatest delivery costs encountered during the trial related to personnel and transport. It was therefore decided to move toward a system of sentinel delivery sites manned by Public Health Technicians working with research staff during the first year. Although we did not undertake a formal economic study of capital and recurring costs, the savings in man-days and mileage costs were significant: 836 person-days used on house-to-house delivery and an average total of 9184 km per dipping period compared to 360 person-days and 4394 km per dipping period of sentinel delivery services. Despite a reduced project input, the time and transport costs would still pose a significant demand on the limited resources allocated to the DHMT for their out-reach MCH services in a given year.

A significant effort was made to sensitize the community to this change in access to free re-impregnation services; nevertheless, coverage declined from over 97% to 60% among children whose nets had previously been re-treated at home. Whilst lack of awareness was suggested as the reason for non-attendance among 40% of mothers interviewed, over 50% of nets not re-impregnated in October 1996 had been re-treated at sentinel sites the previous April. Some have argued that the provision of free bed-net delivery and treatment services engenders a passive attitude and can lead to low compliance (Rashed et al. 1997). During 1996 it was decided to commercialize the delivery process in an attempt to recover operating and insecticide costs. In August 1997, four months after the cost-retrieval system had been in operation through an expanded sentinel site delivery system, net re-treatment rates fell to 7% within the cohort of children whose re-impregnation compliance had been monitored since 1993. Awareness of programme activity and the transition was not cited as a problem among the non-attending population, indicating the success of the education and marketing campaign; however, over 80% of mothers who did not bring nets for re-treatment maintained that they could not afford the cost. The Gambian experience was similar, net re-treatment coverage fell from 85% to 14% when the national programme decided to introduce a flexible system of cost-retrieval (Aikins 1995; Cham et al. 1997). Both communities are exceptionally poor and, as has been previously documented in Kilifi (GOK 1988), food often takes priority over other expenditures for the limited household cash resources. Community financing mechanisms described in Tanzania (Makemba et al. 1995) and The Gambia (Mills et al. 1994) require established village or community structures not well defined among the scattered settlement populations along the Kenyan Coast (Parkin 1991). However, the timing of payments (for example, after harvests), which may not correspond to epidemiologically defined re-treatment times, may offer greater flexibility and improve coverage (Gyapong et al. 1996; Binka and Adongo 1997).

The decline in coverage rates between 1996 and 1997 is not necessarily a reflection of the viability and potential success of social marketing approaches. Arguably both the Gambian and Kilifi populations represent artificial situations where people previously used to free services were then expected to pay, despite the fact that both populations expressed a certain willingness to pay (Mills et al. 1994; E Some, unpublished observations) and had had positive experiences with the intervention for several years. It takes time for communities to re-adjust their 'price expectations', during transitional periods in delivery approaches, whether these be investments in time or cash. Indeed there was a perceptible change in coverage between April and October 1996 during the sentinel site free-delivery approach.

Social marketing programmes of net re-treatment services are in their nascent stages, and developing health cultures and demands takes many years. For example, the social marketing campaign for condom distribution in Kenya conducted by PSI demonstrated a slow market response for several years, whereupon demand and sales increased exponentially (Berman, unpublished data). Bed net re-treatment services may undergo a faster growth rate as evidenced following subtle, recent changes in the social marketing approach in Kilifi, which provided a more flexible approach to payment and decision making. Following the transition to the entirely entrepreneurial approach, net re-treatment sales figures per agent jumped from 5–8 nets per week to 30–50 nets per week implying that the delivery approach is very important for programmes which depend upon cost-retrieval.

The question of whether or not large-scale ITBN programmes should be financed by governments and international donors remains contentious. Mixed financing strategies have been proposed, sharing costs between donors and recipient communities (Evans et al. 1997). Delivery costs will still be a significant burden for district health budgets if delivered in the manner described for our intervention trial. Less expensive and potentially more sustainable approaches may involve sentinel site delivery but whether minimal cost-retrieval or free services are provided, coverage will, for several years, probably remain considerably less than aggressive house-to-house delivery systems. Whatever delivery approach is selected, monitoring coverage of net re-treatment practices within the varied delivery approaches described by Lines (1996) must be a priority area. Previous emphasis has been upon the numbers

of nets delivered to communities across Africa (Brinkmann and Brinkmann 1995), and whilst an important part of the overall equation, offers no indication of how effective an ITBN programme is likely to be without data on net treatment and re-treatment practices.

An immediate implication of changing coverage in net re-treatment is its intrinsic effects upon previously defined impacts upon child survival. The relationship between ITBN coverage and health impact remains unclear; the relative contribution of 'mass' effects of wide-spread insecticide coverage upon local vector populations versus the individual protection afforded by a single treated net has yet to be clearly defined. Both must certainly operate as indicated by the results of parasitological surveys among infants during the Kilifi trial. The *P.falciparum* infection rate among infants sleeping under treated nets in communities with high ITBN use was 12% compared to 15% for infants who were not under nets and living in the same communities, nevertheless both compared favorably to the 25% infection rate among non-bed net users in control areas (Snow, unpublished data). If one assumes the relationship between coverage and impact is linear, a 40% reduction in coverage may imply a 13% reduction in childhood mortality in the Kilifi area rather than 33%; whilst a 93% reduction in coverage (for example in 1997) may translate to only a 2–3% reduction in mortality. It is clear that economists, epidemiologists and health planners must work together to re-define cost-effectiveness estimates under a variety of epidemiological and coverage conditions. Meanwhile operational research must identify sustainable delivery mechanisms to improve net re-treatment rates in areas where distribution has been successful or local use of nets is already high.

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