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Business plan for stimulating the development, manufacturing, and widespread distribution of long-lasting insecticidal nets

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ROLL BACK MALARIA

WORLD HEALTH ORGANIZATION

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Business plan for stimulating the development, manufacturing, and widespread distribution of long-lasting insecticidal nets

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ACRONYMS

ACSD	Accelerated Child Survival and Development (program) [UNICEF]
CFA	Communauté Financière Africaine
CFR	cost and freight (price)
COMESA	Common Market for Eastern and Southern Africa
ECOWAS	Economic Community of West African States
EPI	Expanded Programme on Immunization [WHO]
EPZ	export zone
FAO	Food and Agriculture Organization [U.N.]
FOB	free on board
GFATM	Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria
GNI	gross national income
HDPE	high-density polyethylene
HPLC	high-performance liquid chromatography
IEC	Information, Education, and Communication (campaign)
IMCI	Integrated Management of Childhood Illness
ITN	insecticide-treated net
LLIN	long-lasting insecticidal net
MEDA	Mennonite Economic Development Associates
MICS	multiple indicator cluster survey
MIS	management information system
MSH	Management Sciences for Health
NGO	nongovernmental organization
PSI	Population Services International
QC	quality control
RBM	Roll Back Malaria
SADC	Southern African Development Community
SSA	sub-Saharan Africa
UN	United Nations
UNICEF	United Nations Children's Fund
USD	U.S. dollar
VAT	value-added tax
WAEMU	West African Economic and Monetary Union
WHO	World Health Organization
WHOPES	WHO Pesticide Evaluation Scheme

EXECUTIVE SUMMARY

The World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the Rockefeller Foundation commissioned Management Sciences for Health (MSH) to prepare a strategic plan for the accelerated development, manufacturing, and widespread distribution of long-lasting insecticidal nets (LLINs) to reduce the transmission of malaria.

Ninety percent of the population of sub-Saharan Africa (SSA) lives in areas at risk for endemic or epidemic malaria. As treatment becomes more difficult because of the increase in drug resistance, it is necessary to focus on and to reinforce prevention. For this objective, at the Abuja Summit in 2000, 44 African countries committed to the goal of providing protective measures, including insecticide-treated nets (ITNs), to 60 percent of the at-risk population by 2005, especially the population of children under five and pregnant women. To meet this challenge, Roll Back Malaria (RBM) includes ITNs as part of their "prevention intervention strategy."

ITNs are effective in preventing malaria, but have several drawbacks. They require re-impregnation with insecticide on a regular basis to maintain their efficacy. This constraint requires that net users be educated about the importance of re-impregnation and that campaigns be organized to ensure this occurs. Carrying out these campaigns on a large scale is expensive and logistically demanding, and current re-impregnation rates are poor, particularly when ITN users are asked to pay for re-impregnation.

However, the development of technologies within the textile and the chemical industries permitting the durable impregnation of fiber with insecticide has led to several possibilities for making LLINs that can retain repellent efficacy throughout the normal life span of the netting material itself. Today, only one type of LLIN is available on the market, and production capacity covers only a tiny fraction of the need. Expanding LLIN development, production, and availability to make the nets a useful malaria control tool requires: (1) having a good knowledge of the net market; (2) identifying technical, financial, and regulatory obstacles to the development and production of LLINs, particularly in SSA; (3) identifying the roles (financial, technological, regulatory, and logistical) of the different stakeholders involved; and (4) outlining the strategic orientations needed to make this expansion possible.

This business plan was developed in three stages—

- A market assessment to look at the following: (1) the patterns of demand for nets; (2) the distribution channels through which nets reach end-users; (3) the roles of governments, multilateral and bilateral institutions, and nongovernmental organizations (NGOs); (4) the varied approaches of social marketing initiatives; and (5) the proportion of the population that does not have the capacity to pay for LLINs, which are likely to be more expensive than ITNs. To undertake this assessment, a methodology was developed to calculate the proportion of the population that cannot afford nets at expected retail prices and will need financial assistance to buy LLINs.

- A producer analysis focused on: (1) the status of LLIN technologies either available or under development; and (2) the identification of the issues relevant to the production of LLINs in SSA, including taxes and tariffs on the raw materials and equipment needed; the challenges of ensuring quality control; worker safety and

environmental requirements; and the role of the WHO Pesticide Evaluation Scheme (WHOPES) evaluation process.

- A strategy development plan including: (1) a comparison of the estimates of the number of nets that will be distributed over the next few years with the number of LLINs that would be needed to scale up coverage to reach the Abuja Summit targets; (2) a simulation of the financial impact of the substitution of LLINs for ITNs to achieve the Abuja targets; (3) an analysis of the elements that are relevant to the competitive position of net manufacturers; and (4) an outline of the strategic ways in which stakeholders can promote the development, production, and distribution of LLINs.

Market Assessment

The market in the sub-Saharan African region is far from homogeneous: It covers several monetary and economic zones (the Common Market for Eastern and Southern Africa [COMESA], the West African Economic and Monetary Union [WAEMU], etc.); there is wide disparity in gross national income (GNI) per capita (100 to 3,100 U.S. dollars [USD]); several official languages are used (60 percent English, 32 percent French, etc.); levels of urbanization vary widely (9 percent to 81 percent); and malaria prevalence is variable (38 percent to 100 percent). Overall purchasing power is very low; 65 percent of individuals live on less than USD 0.60 per day.

Endemic malaria affects 521 million people, or 80 percent of the total population. Of these, 120 million are children under five and pregnant women. These figures translate into a need for over 50 million nets and 20 million ITNs per year to reach the Abuja targets within five years, if the need for replacement nets is accounted for along with the distribution of nets to new users.

By contrast, according to available data, an estimated 20 million nets of all types will be distributed in 2003. Of these, 80 percent will be bought by governments and institutions for either free or heavily subsidized distribution through a variety of channels, while available data indicate that 20 percent will pass through commercial channels without subsidies. At the current cost, insurance, and freight (CIF) price of USD 2 for untreated nets, this corresponds to sales of USD 40 million for net manufacturers, distribution revenues within the private sector of USD 8 million, institutional expenditures of USD 56 million for nets and distribution, and USD 40 million of expenditures by households. These estimates do not include either insecticide costs, which would add another USD 0.80 per year per net, or re-impregnation campaign costs, which would add another USD 1.20 per year per net.

The socioeconomic diversity of this region is reflected in the relative importance of the two main categories of distribution. In English-speaking countries, it appears that commercial channels, both with and without social marketing support, are predominately used, while in non-English-speaking countries, it appears that governments, multilateral and bilateral institutions, and NGOs participate in the bulk of net distribution efforts. Of the dozens of organizations that are engaged in net distribution throughout Africa, the efforts of UNICEF, NetMark Plus, Population Services International (PSI), and the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) stand out for their size and scope. The distribution strategies employed through these partners are adapted to fit the local context throughout the

countries they work in. However, in 12 sub-Saharan countries, the majority of which are non-English-speaking, there are currently no net distribution activities related to NetMark Plus, PSI, or the Global Fund.

When household expenditures are analyzed across sub-Saharan Africa, it appears that close to 40 percent of households will have to consecrate more than one month of their non-food-related discretionary income in order to purchase an LLIN that retails for USD 5. This lack of purchasing power means that efforts to subsidize LLINs will need to be developed and sustained to ensure equity in their distribution.

While the partners and specialists associated with RBM generally agree that LLINs are more desirable than ITNs as a tool for the prevention of malaria, this is not necessarily the case for consumers, who will not be able to see or feel the difference between an LLIN and an ITN; therefore, Information, Education, and Communication (IEC) campaigns will be needed to sensitize consumers to the benefits of LLINs.

Producer Analysis

LLINs are made of one of several types of synthetic fiber, such as polyester, polyethylene, or polypropylene. The insecticide is integrated either directly into the fiber itself at the moment of extrusion or fixed to the fiber during the production process to give the final net its long-lasting properties. In general, net production can be broken down into four steps:
(1) derivatives from the oil industry are used to make material for extrusion into fiber; (2) this raw material is extruded into yarn; (3) yarn is warped, knitted, and heat-stretched (stented), if needed, to make netting material; and (4) netting material is cut and sewn into nets.

These diverse steps involve the activities of firms across several specialties, including the oil, chemical, and textile industries. While complex, these steps are independent, and this imparts a high degree of flexibility to the net production process. Net manufacturers can engage in all of these steps or just one or two, and it is therefore possible to classify them into three categories:

- Vertically integrated manufacturers who may have the capacity to extrude yarn from chips (Steps 1 or 2 through 4)
- Industrial-scale manufacturers who have the equipment necessary to process yarn through netting material into finished nets (Steps 3 and 4)
- Tailoring firms that cut and sew netting material bought elsewhere into finished nets (Step 4)

The three largest companies that distribute nets in sub-Saharan Africa are A to Z Textile Mills in Tanzania, which is installing high-density polyethylene (HDPE) yarn extrusion capacity to make the Olyset (category 1); Siam Dutch Mosquito Netting in Thailand (category 1); and Vestergaard Frandsen A/S, which has facilities in Thailand and Vietnam (category 2). Most net producers in sub-Saharan Africa are tailoring firms (category 3).

LLINs are being developed by a diverse set of organizations ranging from university laboratories to multinational chemical companies. These technologies can be classified into three categories—

- **Category 1.** Fiber-based, comprising the development of a durable, impregnated yarn that can then be knitted into nets; companies working on or considering this approach include Sumitomo (developer of the Olyset), Sasol, Clariant, BMD Textiles, BASF, Dow, SPCI, and Syngenta.

- **Category 2.** Industrial, consisting of processes that are applied at the factory during net production; Vestergaard Frandsen (developer of the Permanet) and Delft University of Technology have chosen this approach.

- **Category 3.** Field, including processes that are applied to a finished untreated net to transform it into an LLIN; these processes are being developed by Bayer Environmental Science A.S., Syngenta, T.S. Bio, and BASF.

Beyond the technological hurdles imposed by the challenge of developing LLINs, three factors are critical to manufacturers who wish to enter LLIN production. These factors are quality standards, quality control and safety, and taxes and tariffs.

- **Quality standards.** The variation among the processes that are used to make LLINs creates a need to have common standards that can be used by both manufacturers and consumers. WHO is working on developing a suitable standard through WHOPES. A WHOPES standard for LLINs poses the risk that the availability of LLINs will be delayed because they have to go through the evaluation process; on the other hand, WHOPES data is accepted in many African countries as part of their own regulatory approval processes, and WHOPES testing protocols could be used to guide the development of quality control (QC) procedures for use by both LLIN manufacturers and governmental or institutional buyers. The cost of a WHOPES evaluation is approximately USD 64,000, and an interim recommendation can be issued in one to two years.

  Two company currently working on LLINs have an obtained an interim WHOPES recommendation: Sumitomo, for the Olyset; and Vestergaard Frandsen for Permanet 2.

- **Quality control and safety.** Moving from the development and evaluation of an LLIN to production will require that: (1) manufacturers enhance their QC capacity for monitoring the quality of their production; and (2) manufacturers invest in equipment and procedures to protect their workers and the environment from the concentrated doses of insecticide that will be used during the LLIN manufacturing process.

- **Taxes and tariffs.** When the cost structure of a net is examined, and average tax and tariff rates on the inputs are included, it appears that these additional charges can add as much as USD 1 to the cost of an LLIN, which is more than the price of the yarn itself. Besides making it more difficult for consumers to have access to LLINs, taxes and tariffs can impose a burden on sub-Saharan African manufacturers who have to import the materials needed to make LLINs, such as yarn and insecticide. This

situation varies across economic zones and is more favorable toward domestic net producers in certain countries than in others.

When these three factors are taken into consideration along with development costs, it is likely that LLINs will be more expensive to produce than ITNs. It is too early to know exactly what the price differential will be, but private sector decisions alone will not completely determine the price of LLINs. Governments have an important role to play by lowering taxes and tariffs, not only to make LLINs more affordable, but also to promote the local manufacturing of LLINs.

Strategic Analysis

When all of the approaches to producing LLINs are considered, as well as the additional investments needed for equipment, worker safety, environmental protection, and QC, it appears that the cost of a new factory that could produce one million LLINs per year may exceed USD 2.5 million. Calculations of the number of LLINs per year needed to reach the coverage level for the entire at-risk population as specified at Abuja within five years indicate that over 50 million LLINs per year must be produced to both reach new users and to provide for replacements. With baseline yearly LLIN production in 2003 estimated at less than two million, scaling up LLIN production to meet the levels called for in Abuja could require investments totaling close to USD 130 million, if new factories are built throughout SSA. This total could be less if existing factories are converted to LLIN production, but the size of this capacity is not known with certainty.

To develop strategies for focusing external financial assistance from donors on those areas where it could have the most impact, the baseline analysis of untreated net production costs indicates that there is a high degree of competition on the basis of price among net manufacturers; quoted net prices, particularly from Asia, do not take into account the costs of production equipment that has already been amortized. In turn, this implies that a sub-Saharan African net producer who decides to invest in new manufacturing facilities could be at a significant cost disadvantage compared to most of the Asian producers for two main reasons: (1) the installed base of production equipment in Africa is much smaller than that in Asia, which means that capital investment in warping, knitting, and stenting equipment will be needed; and (2) the tariffs and taxes on imported raw materials increase production costs. Therefore, creative approaches to financing the needed investment in production capacity are needed in addition to government action on taxes and tariffs.

To put these expenditures in perspective, it appears that LLINs could provide significant cost savings to net buyers, whether institutions or individual consumers. When compared to the costs of ITNs on a per-year basis, an LLIN lasting five years could cost as much as USD 1.50 less per year for providing the same degree of protection, when the costs of re-impregnation are included. If 50 million LLINs are distributed per year in place of ITNs, this amounts to a global annual savings of USD 75 million per year to provide equally good or better protection against malaria for the populations at risk.

Although institutional buyers will be able to appreciate these savings, the higher initial cost of purchasing an LLIN means that existing net distribution mechanisms will continue to be needed and reinforced, including: (1) free or heavily subsidized distribution through public health–oriented approaches, especially those used by governments and by UNICEF; (2)

social marketing approaches using varying levels of subsidy; (3) voucher distribution, which will have to be expanded to include the rural areas where a majority of the sub-Saharan African population lives; (4) institutional interventions to strengthen the commercial distribution network; and (5) distribution through the independent marketing efforts of the net manufacturers.

Conclusion and Recommendations

The issues addressed during the development of the strategic plan point to the need to have the active participation of a diverse group of stakeholders representing both the public and private sectors in order to make LLINs an integral part of the preventive measures for the control of malaria in sub-Saharan Africa. The coordination of activities both within this group and with other malaria-related activities elsewhere necessitates a mechanism for focusing these efforts. The existing ITN Working Group already represents many of the same partners, who are concerned about the issues that will be encountered if LLINs are to be made available to all who need them.

The ITN Working Group should be mandated to address these issues. First, the group should add experts in the areas of textile technology, economics and finance, and sociology. Second, the expanded group should focus on specific tasks across the following areas: (1) technical; (2) economic and political; (3) production; (4) IEC; and (5) coordination.

Technical

One high-priority objective is to work with WHOPES to rapidly develop a norm for LLINs, which will cover the different materials and technologies. Once this norm is established, the group should make a push to—

- Include this norm in the International Standards Organization (ISO)
- Define a way to categorize LLINs so that they have the same status as an essential drug
- Define testing protocols that can be used for QC
- Look for ways to provide technical assistance in enhancing local laboratory capacity in SSA for QC-related testing

Economic and Political

Tackling issues related to the business environment in SSA will necessitate dialogue with different ministries (including Ministries of Health, Finance, and Agriculture) within governments across SSA, with discussions focused on—

- Identifying possibilities for eliminating taxes and tariffs on both the raw materials needed to make LLINs (similar to the process used for essential drug production in the WAEMU) and on LLINs themselves (consistent with the rates on essential drugs in many countries)
- Standardizing and enabling transparency for regulatory approval processes for LLINs

- Promoting the recognition of WHOPES evaluations for insecticide formulations that are used for public health

Production

Net manufacturers in SSA may be hesitant to take the risk of investing in producing a new product in an environment where commercial interest rates are high and the market for the product is uncertain. The ITN Working Group should address some of these concerns by—

- Working with institutional buyers and funding sources, including UNICEF and the Global Fund to offer renewable, long-term, multiyear contracts for net manufacturers and to maintain incentives, such as a price differential, that will encourage regional purchasing of LLINs made in Africa

- Identifying sources for low-cost, long-term loans to enable risk-sharing with net manufacturers who invest in LLIN production lines

- Proposing strategies for creating financial incentives, such as export processing zones, for entrepreneurs to invest in LLIN manufacturing

Information, Education, and Communication

Convincing the populations within SSA of the importance and value of using LLINs instead of ITNs will require creative approaches to IEC. The inclusion of experts in sociology and anthropology would enable the Working Group to develop strategies for IEC that could be implemented by partners such as PSI and NetMark Plus.

Coordination

The ITN Working Group has a central role to play in coordination. The group should continue to maintain communication, organize meetings, and provide progress reports on LLIN development, while also—

- Expanding relationships with companies and universities to generate interest in developing LLIN technology

- Developing and maintaining performance charts to monitor progress and provide timely information to other partners on tax and tariff levels and regulatory requirements throughout SSA

PART 1. MARKET ANALYSIS

Malaria is recognized as a major public health problem in sub-Saharan Africa (SSA). It causes an estimated one million deaths per year and is the leading cause of mortality in children under five. These facts, combined with the increasing resistance to antimalarial drugs, have made it imperative to develop more effective prevention strategies.

Mosquito nets are an effective means of prevention. Until recently, nets were used without insecticide treatment, and the majority of commercially available nets are untreated. When nets are treated with insecticide, their ability to protect humans against mosquito bites is enhanced, and insecticide-treated nets (ITNs) have been shown to decrease childhood mortality by 15 to 63 percent[1] and malaria episodes by 50 percent.[2] Although untreated nets also provide protection against malaria, at best an untreated net provides only half the level of protection afforded by an ITN.[3]

ITNs have the drawback of requiring the reapplication of insecticide every 6 to 12 months. Reapplication can be done at home, but it is cumbersome, requiring up to 13 steps and the use of protective equipment such as gloves.[4] In addition, commercially available retreatment kits are expensive, costing as much as 25 to 50 percent of the retail price of a new net.[5] Communal retreatment has also been found to be unsuccessful, mostly because of cultural taboos against displaying bed linen in public. Retreatment rates are low in Africa, reaching only 30 percent, even under optimal conditions where there are intensive social marketing activities promoting proper use of ITNs.[6]

Estimates of net use show a great deal of disparity across SSA, but typically reveal that 10 to 30 percent of the population uses untreated nets[7,8]; the percentage who use ITNs is much lower. Enormous progress is still needed to reach the 60 percent coverage goal for vulnerable populations, which was set at the Roll Back Malaria (RBM) summit in Abuja, Nigeria, in April 2000.

Long-lasting insecticidal nets (LLINs) incorporate insecticide during production and should not require the reapplication of insecticide during the life span of the net, thus offering the possibility of avoiding the retreatment problem. Various technologies for LLINs have been under development since the early 1990s.[9] The World Health Organization (WHO) has developed an evaluation scheme for testing LLINs within the framework of the existing

[1] D'Alessandro, U. 2001. Insecticide Treated Bed Nets to Prevent Malaria. *British Medical Journal* 322:249–50.
[2] Roll Back Malaria (RBM). 2002. *Scaling-Up Insecticide-Treated Netting Programmes in Africa: A Strategic Framework for Coordinated National Action*. Revision 8. Geneva: RBM.
[3] Guyatt, H., and R. Snow. 2002. The Cost of Not Treating Bed Nets. *Trends in Parasitology* 18:12–16.
[4] World Health Organization (WHO). 2002. *Instructions for Treatment and Use of Insecticide-Treated Mosquito Nets.* Geneva: WHO.
[5] Simon, J., B. Larson, and M. Fox. 2002. Understanding the Retail Supply and Pricing of Insecticide-Treated Bed Nets in sub-Saharan Africa. Boston: Center for International Health, Boston University School of Public Health.
[6] Schellenberg, J. R., S. Abdulla, R. Nathan, et al. 2001. Effect of Large-Scale Social Marketing of Insecticide-Treated Nets on Child Survival in Rural Tanzania. *Lancet* 357:1241–47.
[7] Simon, J., B. Larson, S. Rosen, A. Zusman. 2001. *Reducing Tariffs and Taxes on Insecticide-Treated Bednets: Background Paper for Africa Malaria Day, April 25, 2001*. Geneva: Roll Back Malaria.
[8] Wardlaw, T. Monitoring Malaria Goals: UNICEF MICS Surveys, 1999–2001. Presentation.
[9] World Health Organization (WHO). 2001. *Report of the Fifth WHOPES Working Group Meeting.* Geneva: WHO.

WHO Pesticide Evaluation Scheme (WHOPES), which was started in 1960. Of the LLINs that have been tested by WHOPES, only the Olyset net has passed, although other technologies are either undergoing or are about to be submitted for WHOPES testing. Representatives of RBM and their partners feel that long-term success in the distribution of LLINs will require strategies to encourage the role of the private sector and to lay out the roles that commercial partners, United Nations (UN) agencies, nongovernmental organizations (NGOs), and governments can play to help meet the 60 percent coverage goal. To meet the need for such strategies, Management Sciences for Health (MSH) was asked to develop a business plan.

For the first part of this strategic plan, a market analysis was conducted addressing the following areas—

- **Industry structure.** The paths by which nets are currently delivered and paid for is described, and available data on quantities is presented.
- **Characteristics of end-user market.** From a "macro" perspective, the potential net user market across sub-Saharan Africa can be characterized by language, participation in a trading bloc, degree of urbanization, and presence of a major initiative for net distribution.
- **Ability to pay versus willingness to pay.** Opinion is divided on how much people can really afford to pay and who can afford to pay. This issue has an impact in two ways: on the choice of marketing strategy and distribution channels for LLINs, and on the accessibility of nets to significant sectors of the population.
- **Buyer characteristics.** Institutional buyers, such as the United Nations Children's Fund (UNICEF) and WHO, buy the majority of nets that are distributed in Africa. As such, they have an important influence not only on establishing a "net culture," but also on the behavior and business strategies of the net manufacturers.
- **LLIN technology.** The introduction of these new technologies will require manufacturers to invest in new equipment, potentially increasing the cost of nets and shifting the forces that shape the net-making industry.

Industry Structure (How Nets Get to People)

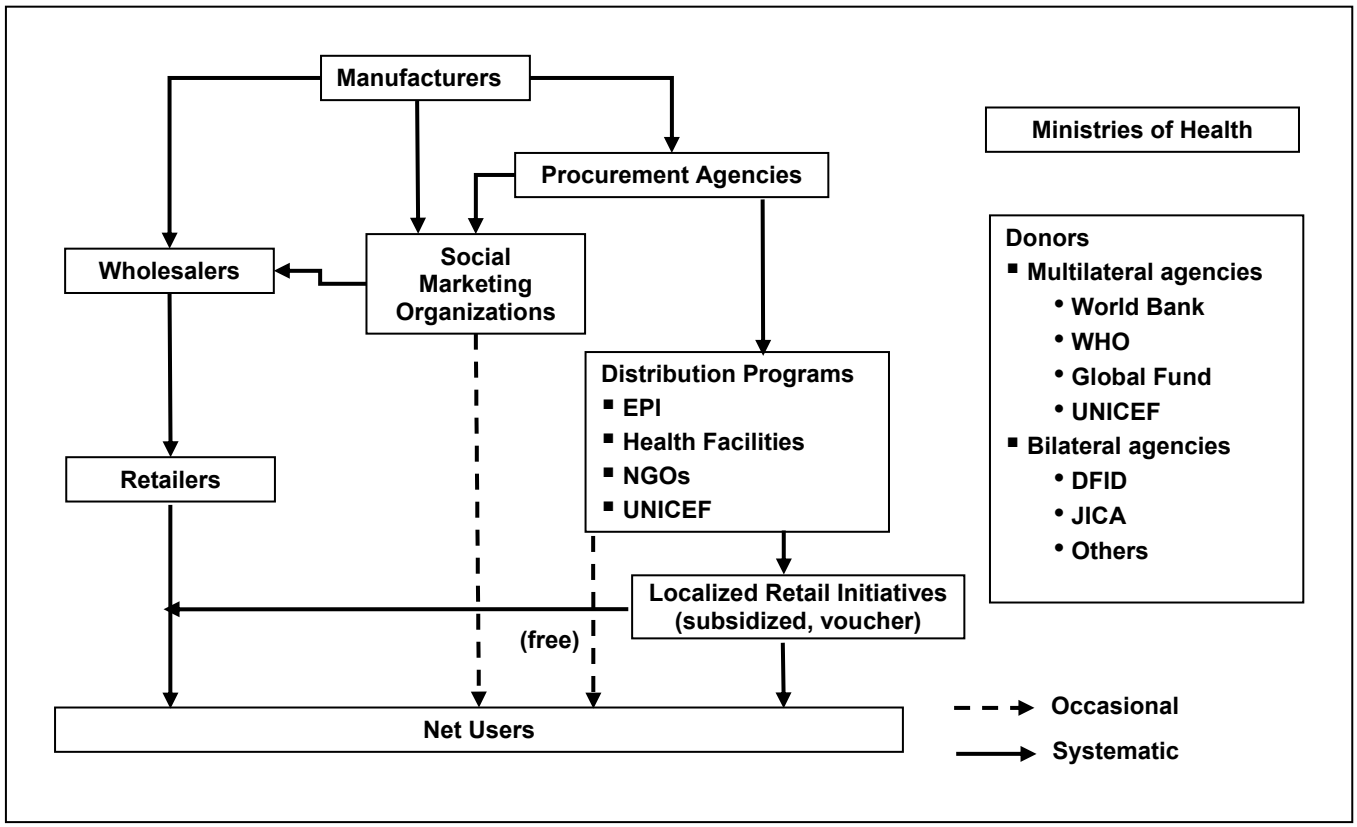
To develop strategies that will stimulate the net market and industry, it is essential to understand how nets get to the people who use them and how they are paid for. The following analysis applies to the three categories of nets that are most commonly sold: untreated nets, pretreated nets, and untreated nets packaged with insecticide.

Because of the importance of nets as a public health measure, numerous programs have been set up to get nets to people through free or subsidized distribution, while, in parallel, nets are also available on the commercial market. This complexity in the net market requires two different ways of looking at the structure of the net industry: (1) through the physical movement of nets and (2) through the financing of nets. Mapping these aspects separately helps show where and how the different stakeholders participate in the net industry. Later sections discuss in more detail some of the major efforts to distribute nets in Africa.

Physical Flow of Nets

The delivery of nets to users can be categorized in three ways: (1) through the purely private commercial channel; (2) through social marketing initiatives that use the retail distribution system to sell nets at various subsidy levels; and (3) through direct public health initiatives, such as through routine immunization contacts (such as through the Expanded Programme on Immunization [EPI]), immunization campaigns (such as measles campaigns), or through prenatal clinics.

The physical flow is diagrammed in Figure 1.



Source: Interviews and documents from UNICEF, WHO, PSI, NetMark, London School of Tropical Medicine and Hygiene, net manufacturers.

Figure 1. Physical Movement of Nets

Getting firm data on the quantities of nets that are delivered through the channels shown in Figure 1 is difficult because of the multitude of actors involved across the more than 40 countries in sub-Saharan Africa. Manufacturers vary in size from "cottage" manufacturers, who sew and cut netting material bought elsewhere into nets for local sale, to large international manufacturers that control the whole process from polyester chips to the finished, packaged goods and that actively market in many countries. Available data is summarized in Table 1. This table includes estimates for countries when available as well as direct purchase data from several institutional buyers.

Table 1. Net Distribution—Quantities x 1,000

Main Language of Country	Commercial Channels	Social Marketing Initiatives	Public Health Initiatives	UNICEF	WHO	PSI
English	2,000	3,000	2,200			
French	120	30	1,000			
Portuguese or Spanish	130	10	410			
Total	2,250	3,040	3,610	4,400[a]	1,000[a]	2,000[a]

Notes: UNICEF = United Nations Children's Fund; WHO = World Health Organization; PSI = Population Services International. Data available as of March 2003. Double counting possible because data often aggregated by organizations.
[a]Figures for UNICEF, WHO, and PSI are not broken down by country language.

One way to estimate total volume of the net market across SSA is to add the known quantities purchased by UN agencies, NGOs, and other large institutional buyers, and then add a maximum figure representing commercial activity. This maximum figure represents a ceiling; actual commercial activity is likely to be lower than this figure, but it is useful to establish a benchmark for commercial sales across SSA. To establish this benchmark, estimates for Nigeria were used, where there is strong evidence of an active net market that has developed in the absence of large-scale net projects. This data includes surveys done by Nigerbus and NetMark, as well as on-site market visits to the Idumagbo market.[10] Based on this evidence, an estimated three million nets are already in use in Nigeria, which implies annual sales of close to one million nets per year. In SSA countries where nets are distributed without the participation of social marketing or other initiatives to stimulate the commercial sector, it is likely that commercial sales are proportionally lower than they are in Nigeria, and therefore it seems safe to use the level of estimated commercial sales in Nigeria to estimate a maximum level for commercial sales elsewhere. Using these assumptions, and adding the data for Tanzania (where there have been social marketing projects) separately, it can be estimated that, at most, 14 million nets per year are reaching sub-Saharan Africa.

Paying for Nets

Because nets have historically been expensive for many households in sub-Saharan Africa, there has been active participation in the net market by many government agencies, NGOs, and social marketing organizations, which buy nets on behalf of those who need them. These purchases are often carried out by procurement agencies, particularly UNICEF, which negotiate and manage net purchases for the organizations that eventually distribute them to the end users. Figure 2 shows the flow of financing for nets.

[10] Lines, J., and S. Vyas. 2002. "Recent Changes and Possible Trends in the Net Market in Nigeria." <http://www.lshtm.ac.uk/dfid/malaria/Acrobat%20documents/Trends_in_Nigeria_net_market_march_2003.pdf> (accessed Jan. 12, 2004).

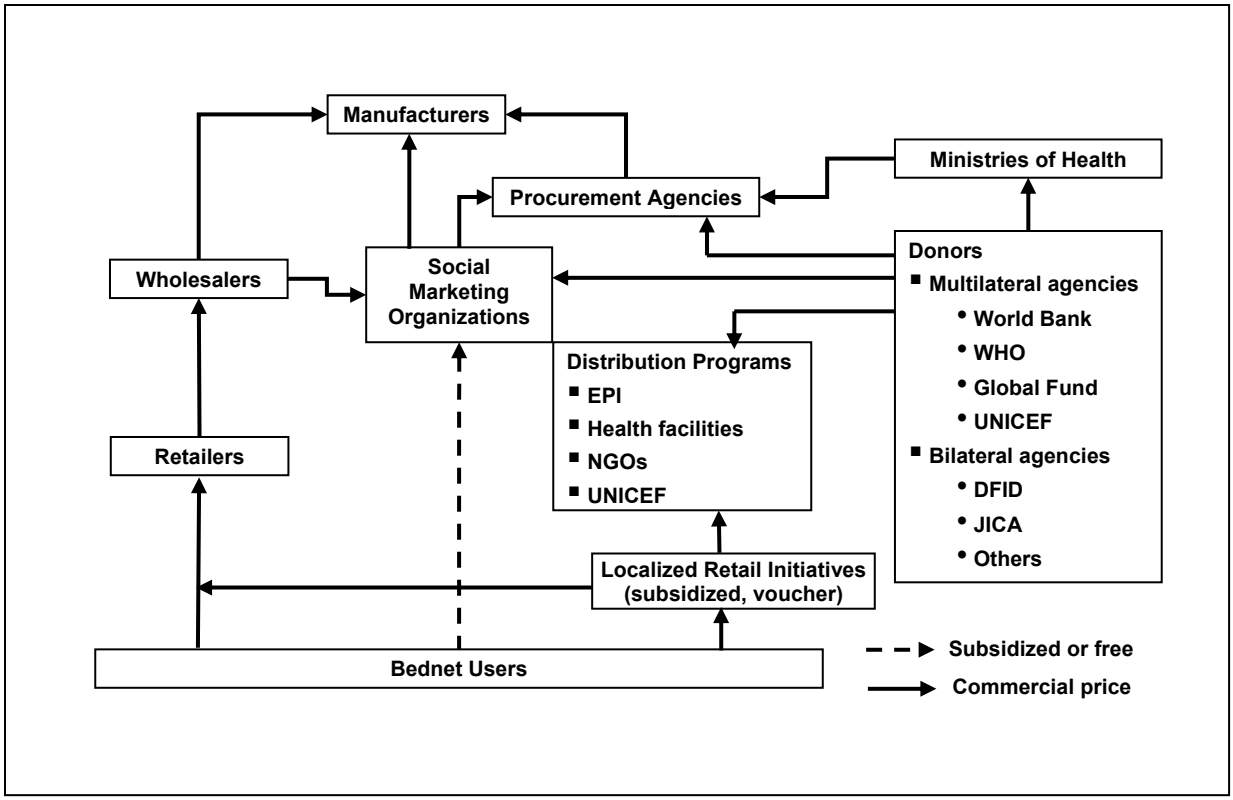


Figure 2. How Nets Are Paid For

Little data is available on the totals for cash flows; the major net manufacturers are privately held companies and are understandably somewhat hesitant about divulging sales information. One major manufacturer acknowledges 2002 sales of approximately 9 million U.S. dollars (USD) to Africa. UNICEF spent USD 9.5 million in 2002 on procuring 4.4 million nets for African countries. This includes USD 2.2 million spent on purchases of Olyset and Permanet nets. UNICEF has the advantage of being able to buy in bulk; the average order size was 54,000 nets, and the largest order was 799,000 nets.[11] It should be noted that UNICEF also had to order more than 30 different types of nets, which somewhat limited their negotiating leverage with the manufacturers. Currently, UNICEF is accumulating a stock of 300,000 nets in the three or four most commonly ordered sizes. This stock will enable a more rapid response to procurement requests, as government agencies and NGOs often expect to receive large quantities of nets within weeks of placing an order.

Characteristics of End-User Market

Of the 680 million people who live in 44 countries of sub-Saharan Africa, 521 million are considered to be "at risk" for endemic malaria.[12,13] Of these, approximately 126 million are in the vulnerable groups—children under five and pregnant women. Calculation of the number of nets needed can be done in a variety of ways. Based on these population figures, and assuming a four-year life span for a polyester net and two people sharing a net, reaching a

[11] UNICEF data and information courtesy of M. Lainejoko.
[12] UNICEF. *Global ITN Estimates 190802* (unpublished document).
[13] Roll Back Malaria Web site < http://mosquito.who.int/cgi-bin/rbm/dhome_rbm.jsp?ts=3250840205&service=rbm&com=gen&lang=en>.

goal of 60 percent coverage of the at-risk population would require 40 million nets per year. On a household basis, it has been estimated that there are 86 million households in sub-Saharan Africa. Assuming that each household has two nets, and again assuming a four-year life span for a net, 43 million nets per year will be required to provide reasonable net coverage to all of the households in sub-Saharan Africa.

Current utilization data is available from a variety of sources, including multiple indicator cluster surveys (MICSs) by UNICEF, NetMark surveys, and various studies and household surveys; the data has been summarized elsewhere.[14] It is important to note that there can be wide disparities in net usage rates even within one country, depending on local culture, so it is impossible to get an accurate idea of net use across all of sub-Saharan Africa. However, it is probably safe to conclude that net utilization rates across sub-Saharan Africa as a whole are probably no higher than around 15 percent, even taking into account intracountry variability.

Strategies for developing the LLIN market have to take the variety of mechanisms by which nets are bought and sold into consideration. However, the purpose of this business plan is not to do an evaluation of existing programs, but to highlight their presence and influence on the commercial market for LLINs.

Of the 2,500 or so partners[15] identified by RBM, two (Population Services International [PSI] and NetMark Plus) run projects that span several countries and focus specifically on net sales and promotion activities. A large scaling up of activities by government agencies is starting as money becomes available from the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund).

Despite the complexities and individual variations between countries, it is possible to make some general characterizations that could be useful for potential manufacturers who wish to enter the net market. These characteristics include—

- Breakdown by language
- Grouping by trading bloc (tariffs and taxes)
- Degree of urbanization (as commercial distribution is generally easier in urban than in rural areas)
- The presence of NetMark, PSI, or a planned Global Fund–financed intervention

In addition to outlining a description of the market for nets along these lines, it is crucial to address the controversial issue of willingness versus ability to pay. While an in-depth discussion of this area is beyond the scope of the business plan, it is possible to estimate what a net purchase might signify in terms of the discretionary income available to the poorer strata of people and households in sub-Saharan Africa.

[14] Simon, J., B. Larson, S. Rosen, A. Zusman. 2001. *Reducing Tariffs and Taxes on Insecticide-Treated Bednets: Background Paper for Africa Malaria Day, April 25, 2001*. Geneva: Roll Back Malaria.
[15] Dr. M. Kawano, World Health Organization, personal communication, 2001.

Breakdown by Language

The three main languages inherited from the colonial era are English, French, and Portuguese. Although ultimately, marketing efforts will require materials and strategies tailored to each of the hundreds of local dialects and languages, the categorization of countries by language is still useful because it correlates with per capita gross national income (GNI) and also shows that non-English-speaking countries were less successful in getting Global Fund money from Rounds 1 and 2 for malaria.

The distribution of the population at risk among the 44 countries, by language, is not homogeneous (Table 2): 62 percent of the at-risk population live in the English-speaking countries, which represent 66 percent of the total population, while 32 percent and 6 percent of the at-risk population live in French-speaking and Portuguese-speaking countries, respectively, representing 29 percent and 5 percent of the total population. This is described in greater detail below.

Table 2. Distribution of At-Risk Populations by Language—Population Figures x 1,000

Main Language of Country	Number of Countries	Population at Risk for Malaria		Estimated Population of Children Under Five and Pregnant Women		Gross National Income per Capita (Weighted, in USD)
English	20	360,739	62.0%	75,758	60.2%	535
French	19	188,634	32.4%	42,662	33.9%	307
Portuguese	5	32,595	5.6%	7,426	5.9%	333
Total	44	581,968	100%	125,846	100%	459

Membership in Trading Bloc

There are nine trading blocs across Africa.[16] Within these blocs, there are plans to create tariff-free zones, and variable progress has been made toward this goal. Knowing the potential size of the target market, as well as average per capita income, could be useful for a manufacturer or investor who is deciding where to set up a net-making facility. Of these nine blocs, the three most important in terms of share of total world exports are the Economic Community of West African States (ECOWAS), the Southern African Development Community (SADC), and the Common Market for Eastern and Southern Africa (COMESA). Within these three blocs, the size of the at-risk population is 206 million, 133 million, and 241 million, respectively. More detail can be found in Annex 1.

Tariff and Tax Structure

In the Abuja Declaration on Roll Back Malaria in Africa (April 2000),[17] pledges were made to reduce taxes and tariffs on mosquito nets, insecticides, and antimalarial drugs. Although some progress has been made in eliminating tariffs on imported nets, most notably by Tanzania, implementation of these pledges has been uneven and, in some cases, even

[16] Data drawn from MBendi Web site <www.mbendi.co.za> (accessed March 2003).
[17] Roll Back Malaria (RBM) Partnership Secretariat. 2000. *The Abuja Declaration and the Plan of Action*. Geneva: RBM. <http://mosquito.who.int/docs/abuja_declaration.pdf>.

reversed, as in the case of Nigeria, where tariffs were recently raised to 75 percent.[18] In addition, despite the progress that some countries have made on reducing tariffs on finished nets, in many countries tariffs remain in place on the polyester yarn and polyester chips that are required for net production. These anomalies can inadvertently create strong disincentives for local net production and hinder the competition that would help increase net availability and lower prices.

Degree of Urbanization

In 12 countries, the percentage of the population living in urban areas is less than 30 percent, and all 12 have a per capita GNI of less than USD 350. In these countries, commercial distribution and marketing campaigns will have different requirements than in countries that have a greater degree of urbanization. PSI is working in six of these countries. A breakdown of countries by urbanization and per capita GNI can be found in Annex 2.

Presence or Planned Intervention by Publicly Funded Programs

Net distribution is promoted and carried out in sub-Saharan Africa by numerous organizations and governments. This section highlights four efforts that merit discussion because of their size, scope, and differing approaches. These are NetMark Plus, PSI, UNICEF, and the Global Fund.

NetMark Plus

NetMark Plus is an eight-year, USD 65 million, USAID-funded project being implemented by the Academy for Educational Development. The original NetMark program was launched in 1999, covering four countries; in 2002, it was renamed NetMark Plus and expanded to cover as many countries as possible. Originally, the project's focus was on commercial expansion of ITN markets, but the project seeks to expand ITN use in SSA by supporting all of the following three components of the RBM strategic framework for scaling up—

- **Long-Term Targeted Subsidies.** For many years to come, a large segment of the sub-Saharan population will be at high risk from malaria and too poor to purchase an ITN at any commercial price. NetMark works to ensure that ITNs are available through partial or full subsidies that are targeted specifically to those who most need them. The project helps Ministries of Health, NGOs, and donors to expand equity programs. Examples of how NetMark supports targeted subsidy approaches include Senegal and Zambia, where coupons are distributed to pregnant women through prenatal clinics to enable them to purchase ITNs from retailers at a discounted price. Additional partners for these projects include UNICEF and ExxonMobil.

- **Short-Term Subsidies to Encourage Market Growth.** In countries or regions where ITN awareness and acceptance is particularly low and/or commercial activities are very weak, NetMark makes strategic, time-limited investments intended to stimulate interest in and use of ITNs among an "early adopter" segment of the population. In addition to stimulating demand for ITNs, this kind of market priming effort also

[18] Hanlin, R. 2002. *ITN Scaling Up in Nigeria: Situational Update Dec. 2002*. New York: UNICEF.

introduces local distributors and retailers to ITNs as a potentially viable commercial product; it may even convince a local manufacturer to produce ITNs. For example, the Zambia targeted subsidy activity described above also serves to generate interest in selling ITNs among distributors and retailers. However, NetMark's approach includes planning an exit strategy so that servicing of its successful efforts can gradually be shifted to the commercial sector for the long term. NetMark supports market priming interventions in Nigeria by helping to strengthen local manufacturing capacity. The project is also helping to strengthen distribution and retail networks in all target countries.

- **Unsubsidized Commercial Expansion for Sustainability.** To ensure access to ITNs for all segments of the population on a sustainable basis, the participation of the private commercial sector is critical. NetMark seeks to engage the commercial sector in promoting and selling ITNs to those who can afford to pay, thus enabling the limited resources available in the public sector to be used to subsidize ITNs for those who truly cannot afford to pay. Competition is encouraged among these commercial partners to ensure customer access to higher quality and more affordable products. NetMark supports the efforts of over 15 multinational and locally based private sector partners in various countries to make ITNs available commercially.

In addition to these target areas, NetMark Plus also works to create a favorable environment for sustainable commercial expansion through the advocacy for the reduction in taxes and tariffs on ITNs. NetMark technical staff provides assistance to national malaria control programs in the development of malaria strategies consistent with the RBM framework. NetMark is also interested in making strategic investments and developing partnerships that will lead to the rapid introduction of new long-lasting technologies throughout SSA.
An analysis of NetMark's activities, using language as a criterion, shows that English-speaking countries represent the majority of the population at risk that is covered by NetMark Plus: 82 percent live in English-speaking countries and 18 percent in French-speaking countries (Table 3). The instability in Côte d'Ivoire prevented NetMark from starting activities there.

Table 3. NetMark Plus Countries Sorted by Language—Population Figures x 1,000

Main Language of Country	Number of Countries	Total Population		Population at Risk for Malaria		Gross National Income per Capita (Weighted, in USD)
English	5	213,399	83.3%	191,590	82.0%	298
French	4	42,755	16.7%	41,885	18.0%	422
Portuguese	0	0	0.0%	0	0.0%	0
Total	9	256,154	100%	233,474	100%	318

Note: Data as of March 2003

Population Services International

PSI is a nonprofit group active in social marketing projects in 70 countries. Initially, PSI focused on family planning products, but it is now significantly involved with net distribution programs. For these programs, PSI works with the commercial sector but focuses on "priming the market" by selling products at subsidized prices, in conjunction with a social marketing campaign. Unlike NetMark, PSI invests in developing its own brand to help create a "net culture" in the countries it serves and to stimulate competition among manufacturers to lower the prices of their own brands. PSI is active in 15 African countries as of 2002. PSI has played a significant role in Tanzania, a country that today has an active commercial market in nets.

A comparison of countries served by these two initiatives shows that compared with NetMark, PSI is active in poorer, less urbanized countries. PSI also serves proportionately more non-English-speaking countries: 50 percent of the at-risk population in all of the countries they cover live in English-speaking countries, compared to 42 percent in French-speaking and 7 percent in Portuguese-speaking countries (Table 4). More information can be found in Annex 3.

Table 4. PSI Countries Sorted by Language—Population Figures x 1,000

Main Language of Country	Number of Countries	Total Population		Population At Risk for Malaria		Gross National Income per Capita (Weighted, in USD)
English	7	123,399	50.4%	115,361	50.1%	331
French	7	103,456	42.2%	96,807	42.0%	189
Portuguese	1	18,292	7.4%	18,292	7.0%	210
Total	15	244,926	100%	212,484	100%	318

Note: Data as of March 2003.

PSI and NetMark Plus LLIN-Related Activities

Both NetMark Plus and PSI have expressed concerns about consumer acceptance of the Olyset net, but market research activities have been delayed due to the lack of widespread availability of the Olyset. Market acceptability studies are being carried out by WHO, and there was some feedback following a UNICEF distribution of 50,000 Olyset nets in Rwanda, but these results are not yet widely available. NetMark Plus is working with A to Z Textile Mills to conduct consumer testing in Uganda. In addition to the issue of acceptability, there is concern that the Olyset net will be too expensive to be supported by the commercial market.

While representatives from both organizations agree with the longer term goal of making LLINs the standard for nets in Africa, an immediate priority is the creation of a "net culture" in Africa, because people must accept the concept of using nets before they will be willing to pay for them. PSI uses a strategy of social marketing, price subsidies, and the introduction of a PSI-branded net, while NetMark does not always overbrand nets but works with partners to reinforce existing brands or to develop new brands, and to strengthen distribution networks.

UNICEF

The distribution and procurement activities of UNICEF merit special mention because of their scale and target. In terms of scale, the UNICEF has been and will continue to be a major purchaser of nets, as reflected in the figures for UNICEF purchases given in an earlier section. As an example of the amounts of funding involved, about USD 7 million was recently released to eight UNICEF country offices in Africa for public sector distribution of subsidized ITNs. UNICEF is particularly focused on "sustained equity provision" and uses carefully targeted subsidies and distribution mechanisms to reach pregnant women, children under five, and the very poor. These mechanisms include free or highly subsidized nets for pregnant women and young children, social marketing through health facilities, free distribution in emergencies, and subsidized distribution in association with EPI activities. In addition, UNICEF will be organizing retreatment campaigns in 2003 as part of their Accelerated Child Survival and Development (ACSD) program in West and Central Africa.

There has been some concern that these kinds of highly subsidized or free programs undermine the commercial sector by bringing nets that are priced below cost into the market, but a number of surveys by UNICEF suggest that actual leakage rates are quite low. In Mozambique, 10 months after 200,000 nets were distributed to flood victims, it was found that 96 percent of people who stated that they had received nets were still in possession of them.[19] (This was verified by direct observation.) Similarly in Kenya, out of a donation of 70,000 to pregnant women, almost no nets had been sold. This type of evidence should reassure the stakeholders in the private sector who may have legitimate concerns about the reliability of the commercial market based on anecdotal, but unquantified, reports of net leakage from public health–related initiatives.

Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria

The Global Fund has recently accepted proposals for combating malaria from 22 countries for funding Rounds 1 and 2, for a total of USD 413 million[20] in approved proposals that include a malaria component. Distribution of nets is included in almost all of these proposals. In some cases, the mechanism has not been defined, while in others, partners have been chosen for social marketing and for other approaches, such as vouchers.

While the amount of money allocated to fight malaria is considerable, a closer examination of how the money will be distributed reveals some inequities. For example, a comparison of the allocation of Global Fund money for malaria against the countries where PSI and NetMark have projects shows that 27 percent of the Global Fund total is allocated to only four countries where both PSI and NetMark will be or are already working, while 38 percent will be shared among eight countries where neither program is active.

In addition, as noted earlier, French-speaking countries lag far behind English-speaking countries for Global Fund allocations. For Rounds 1 and 2, 81 percent of the approved Global Fund proposals, or USD 336 million, has been slated for 14 English-speaking countries compared to 11 percent, or USD 48 million, for 7 French-speaking countries.

[19] Renshaw, M. 2001. *Summary of Malaria Interventions in ESARO* (unpublished document for UNICEF).
[20] Rounds 1 and 2 funding data from Global Fund Web site <http://www.theglobalfund.org/en/> (accessed March 2003).

Our analysis also reveals 13 countries, with an at-risk population of 46 million, where there are no NetMark, PSI, or Global Fund activities as of early 2003. These 13 countries are—

- Angola
- Botswana
- Chad
- Republic of the Congo
- Equatorial Guinea
- Gabon
- Gambia
- Guinea-Bisseau
- Liberia
- Sierra Leone
- South Africa
- Djibouti
- São Tomé and Príncipe

Of these, eight are non-English-speaking, and this suggests that perhaps more external intervention is needed in these countries to increase net availability and to implement other antimalaria initiatives.

Ability to Pay vs. Willingness to Pay

When assessing the potential size of the commercial market for LLINs, it would be helpful to have a precise assessment of what proportion of the at-risk population could afford to buy nets versus how many will require subsidized or free nets. This subject is controversial among those who work in the field. Evidence has been produced showing that in two districts with a population of 350,000 in rural Tanzania, a majority of the population appears capable of buying a USD 5 net,[21][22] while other studies have suggested that it would be less expensive to provide free nets than to make the substantial investments required for a successful social marketing program.[23] On the other hand, PSI found that to reach a target population of pregnant women and children under five in Malawi, the price of the net had to be around USD 1. At this price, PSI successfully distributed over 300,000 nets in 2002 and expects to sell over 500,000 in 2003.

It should not be forgotten that the daily median expenditure per person for private consumption across the 44 countries is USD 0.63.[24] An analysis of available World Bank data on income distribution in several selected countries allows an estimation of the cost of nets relative to **individual** discretionary income. The details of this analysis of individual discretionary income can be found in Annex 4. This report focuses on two countries, Burkina Faso and Cameroon, for which direct **household** expenditure data was available. This data

[21] C. Lengeler, personal communication, March 2003.
[22] Schellenberg, J. R., S. Abdulla, R. Nathan, et al. 2001. Effect of Large-Scale Social Marketing of Insecticide-Treated Nets on Child Survival in Rural Tanzania. *Lancet* 357:1241–47.
[23] Guyatt, H., M. Gotink, S. Ochala, R. Snow. 2002. Free Bed Nets to Pregnant Women through Antenatal Clinics in Kenya: A Cheap, Simple and Equitable Approach to Delivery. *Tropical Medicine and International Health* 7(5):409–20.
[24] World Bank. 2001. *World Development Indicators 2001*. Washington, D.C.: World Bank.

shows that between 8.6 and 11.5 percent of household income is available for discretionary spending, including health, leisure, and other goods and services. Figure 3 shows the results of these analyses.

In Burkina Faso, where 48 percent of households in rural areas have less than 300,000 Communauté Financière Africaine (CFA) francs per year in total monetary income (USD 484, assuming an exchange rate of USD 1.00 to 602.79 CFA francs), these results suggest that those households (representing 33 percent of all households in Burkina Faso), have USD 39.60 per year available for net purchases (assuming that any of their "discretionary" income can be used to purchase a net). In Cameroon, the poorest 20 percent of the population would have USD 61 per year available for net purchases. Based on these results, it is reasonable to assume that purchasing a net for USD 5 represents one to two months of discretionary income for a significant proportion of the population, ranging from 20 percent to as high as 40 percent across sub-Saharan Africa. Purchase of a net has to compete with other demands that sub-Saharan households have on their discretionary income, such as treatment for acute illnesses and other unforeseen needs.

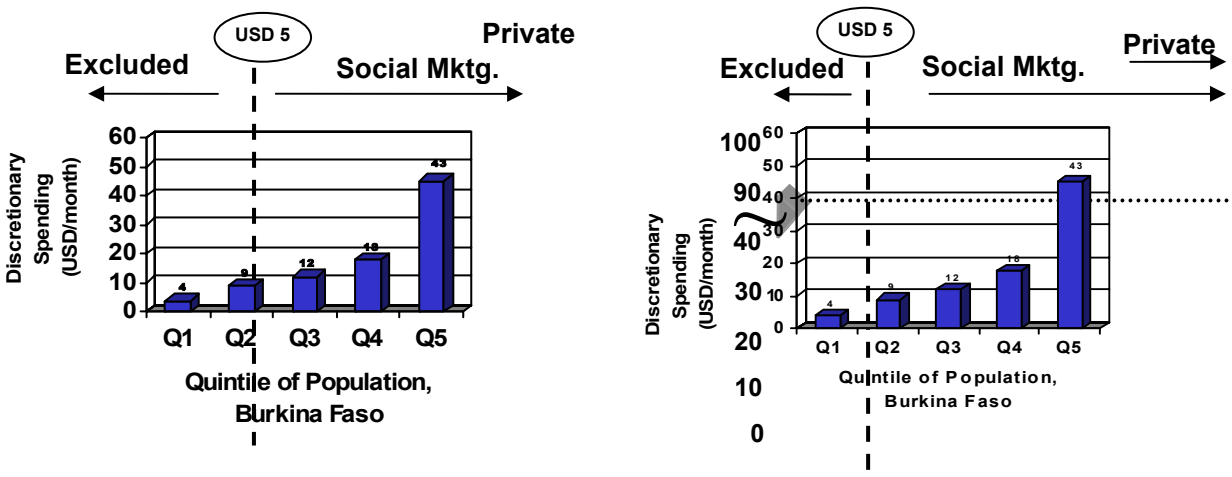


Figure 3. Discretionary Spending for Burkina Faso and Cameroon

In addition to directly subsidizing net prices through social marketing programs, voucher programs may have a role to play. NetMark will be running experimental programs in Zambia and Senegal, while the Mennonite Economic Development Associates (MEDA) has recently completed the design for a voucher program to be administered by the Government of Uganda. UNICEF will be testing a voucher program to reach pregnant women in two districts in Tanzania as part of the Tanzanian Global Fund proposal.

Maximizing net coverage through the commercial sector will require robust marketing campaigns and efficient distribution systems. For example, in Tanzania, it has been shown that as net coverage improved through the intervention of a series of social marketing projects, both the ratio and absolute differences in net coverage actually decreased as

coverage rates went up when compared across quartiles of household wealth.[25] However, the cost of delivering a net through social marketing programs has been estimated to be between USD 3 and USD 15 (these costs are calculated differently between programs). PSI has found that these costs can vary substantially depending on procurement costs and actual cost recovery. In Malawi, PSI found that donor cost per net dropped over time from USD 3.56 from 1998 to 2001 to as low as USD 2.06 at the current time.[26] It remains unclear how sustainable the commercial market for nets will be once the support for social marketing is withdrawn.

Building Brand Recognition

Understanding the effect of social marketing programs on the commercial market requires a consideration of how the transition between these time-limited interventions and a self-sustaining commercial market can occur. Several net manufacturers have expressed concern that the strong brand recognition built up through social marketing programs makes it difficult for them to phase in their products. This issue will become particularly acute with the long-lasting nets, because LLINs are physically indistinguishable from nontreated nets, and consumers will have to rely on the packaging to know what they are buying. To counter this, a number of strategies have been proposed—

- **Seal of quality.** NetMark has created a "seal of quality" for nets with WHO-approved insecticides that are marketed by their partners. As this is a very recent initiative, the effectiveness of this approach will not be known for some time. Receiving this "seal of quality" requires acceptance as a NetMark partner, which may be difficult for smaller manufacturers to obtain. In addition, WHO has its own WHOPES approval process for LLINs, and although this has not been used for marketing purposes, a decision to do so could potentially create confusion in the minds of consumers.

- **Alliance with multiple commercial partners.** In NetMark's experience, some of the distributors who were initially chosen did not live up to commitments in terms of number of ITNs imported and geographic coverage. Therefore, NetMark is actively pursuing new partners to complement existing ones, enforcing more stringent requirements for partners in terms of marketing development, and setting up sales teams to support the efforts of companies with limited resources until the market achieves a level at which these companies can be absorbed into the existing commercial structure.

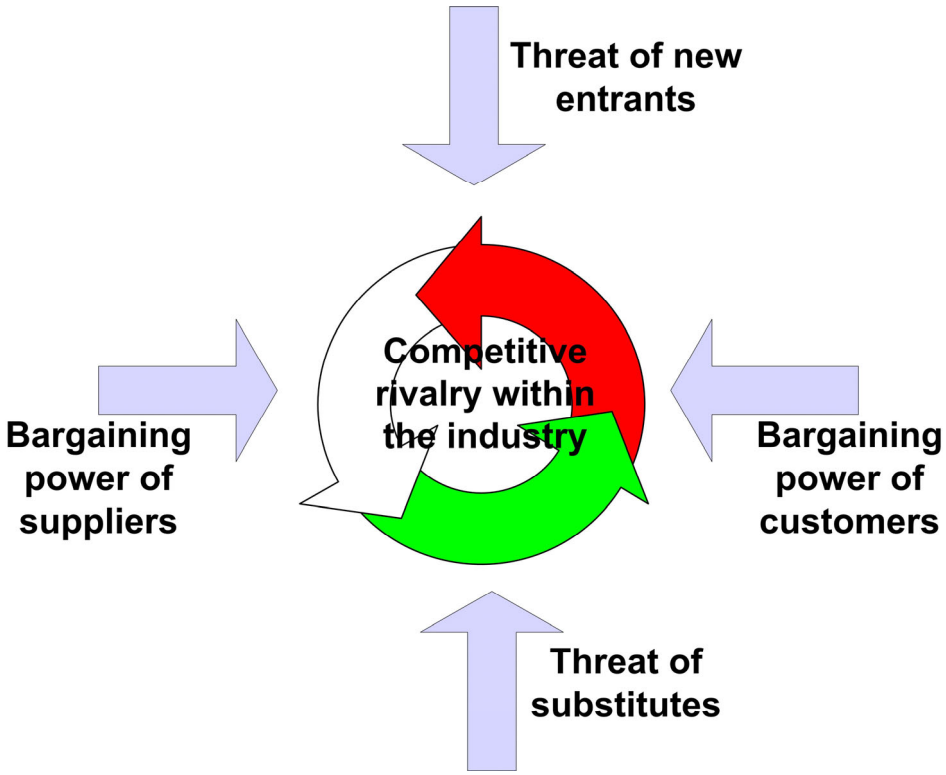
- **Licensing brands.** PSI has expressed an interest in licensing their brand names to suitable commercial partners. This licensing could be done at no or low cost, provided that the commercial partners will provide good "stewardship" of the brand names that consumers have come to trust.

[25] Hanson, K., N. Kikumbih, J. R. Schellenberg, et al. 2003. Cost-Effectiveness of Social Marketing of Insecticide-Treated Nets in the United Republic of Tanzania. *Bulletin of the World Health Organization* 81(4):269–76. (Draft provided courtesy of Dr. Jo Lines.)
[26] Smith, B. R., D. C. Chavasse, C. Mkandala, and J. Miller.. 2003. *Using social marketing to cost-effectively target malaria risk groups with insecticide treated nets.* Washington, D.C.: Population Services International.

- **Collaboration between NetMark and PSI.** Discussions with officials of both NetMark and PSI show a high degree of awareness of the branding issue,[27] and the two organizations will be increasing their efforts to work together. A collaborative framework was defined in 2002 and a joint workplan developed in Mali in 2003.

Current State of Competition in the Net Industry

The "five forces" framework (Figure 4) was developed by Michael Porter of the Harvard Business School in 1980 and has since become a widely applied tool for analyzing competition and business strategies across many companies and industries. A brief description of this framework can be found in Annex 5. For the purposes of this business plan—and keeping in mind the objective of fostering an active, commercially viable market in LLINs—it is important for the stakeholders to understand the factors that make the industry attractive or unattractive. Clearly, new manufacturers will not enter this industry if it does not offer a reasonable chance of earning sustained profits. It is also clear that the new LLIN technology and increasing demand for nets will reshape the industry, and the five forces framework could be helpful in understanding the potential obstacles that firms might face and in pointing the way to interventions that will increase the viability of the LLIN industry.



Source: Porter, M. E. 1985. *Competitive Strategy: Techniques for Analyzing Industries and Competitors.* New York: Free Press. Reprinted with permission.

Figure 4. The Five Competitive Forces

[27] Dr. Susan Zimicki, Academy for Educational Development, and Mr. Brian Smith, Population Services International, personal communication, April 2003.

Using this framework, the current industry for untreated and pretreated nets shows the following five characteristics—

1. **Bargaining power of customers.** The large institutional buyers account for over half of the purchases from the large, internationally based manufacturers.[28] As a result, manufacturers have experienced intense pressure on their profit margins and are at a disadvantage compared with their principal customers. In a handful of countries, consumer actions did have some influence on the shape, color, and size of net.

2. **Threat of new entrants (barriers to entry).** Variable government policies, including tariff and tax structures, often make it difficult for manufacturers to enter a market and to stay in business there. For example, in Tanzania, there is no tariff on imported nets but there is a 25 percent tariff on polyester yarn, effectively discouraging local manufacture. In Nigeria, as noted earlier, tariffs have fluctuated considerably, creating an environment that could wreak havoc with a manufacturer's sales and production plans.

   In addition, net distribution in most countries in Africa requires a close relationship with wholesalers, and it is often difficult for newcomers, especially outsiders, to enter the distribution channels in a given country. This may be one of the problems encountered in Kenya, for example, where prices for untreated nets are higher than prices in Tanzania despite a VAT (value-added tax) exclusion for nets.[29]

   Another obstacle to entry may have been unintentionally created by the large-scale buying activities of major international procurement agencies. Competing for these orders may be difficult for new entrants who may lack the manufacturing capacity, an established manufacturing track record, and the other requirements needed to successfully compete in the international bidding process. Profit margins have been decreasing over the past few years, and this, coupled with the uncertainty of long-term orders, has been a deterrent to manufacturers. On the other hand, the technical specifications and testing procedures of the procurement agencies have had a spillover effect in stimulating improvement in the quality of nets sold in the private commercial market.

   The establishment of social marketing brands by social marketing organizations can also make it difficult for new brands to enter the market, as consumers come to recognize and prefer the socially marketed brand at the expense of other brands that are not subsidized.

3. **Bargaining power of suppliers.** Most nets for sale are untreated, which means that polyester is the most important raw material. Because polyester is a commodity and, in theory, net manufacturers can easily switch suppliers, one would not expect that polyester suppliers exert much pressure on net manufacturers. There is an important exception to this in India, where 80 percent of the polyester market is controlled by one supplier and prices of polyester are high. This has been cited as one of the reasons that there are no major Indian net manufacturers.[30] In contrast, both Vietnam and

[28] Representative of a large manufacturer, personal communication. February 2003
[29] Larson, B., and S. Rosen. 2002. *The Retail Market for Bednets in Kenya: How Well Is It Working?* Health and Development Discussion Paper Series. Boston, MA: Boston University School of Public Health.
[30] Representative of Vestergaard-Frandsen, personal communication, February 2003.

Thailand are home to large-scale net manufacturers. Insecticide is usually packaged separately from nets, and therefore it does not have a major impact on the cost of the net itself.

4. **Threat of substitutes.** Products that are used for vector control, such as sprays and coils, are a real threat to net manufacturers. The worldwide market for such products in 2001 was USD 2 billion at the retail level[31] and was backed by the aggressive marketing campaigns of large, multinational chemical companies. Repeated studies have shown that many African households purchase coils and sprays, even though the aggregate cost of these methods for mosquito control often exceeds the cost of a net.[32]

5. **Competitive rivalry.** The type of competition that occurs between net manufacturers tends to depend on the context in which the manufacturers compete. In Tanzania, Sunflag, the first major manufacturer, eventually lost market share in the late 1990s as its competitors increased innovation by producing nets in different colors and sizes, developed greater willingness to negotiate and better service to institutions, and lowered their prices. Consumers benefited both from lower prices and more choices.

   However, competition for the very large orders from international procurement agencies tends to be on the basis of price, and only those manufacturers who have sufficient net-making capacity can compete. This may change with the introduction of LLIN technologies that will introduce competition on the basis of innovation, but it is not clear how much negotiating power manufacturers will have if one institutional buyer dominates the market. Over the long run, forcing manufacturers to compete purely on the basis of price could undermine future improvements in net technology because manufacturers will focus on cost efficiency rather than on innovation and smaller net manufacturers will exit the business.

The overall balance between these competitive forces is influenced by two factors outside the well-known five forces framework: government policies and donor decisions. As noted earlier, tariffs and taxes can alter the barriers to entry, but other government policies, such as regulatory policies and procurement procedures, could also have an impact on the decisions that businesses make because these policies simultaneously affect several of the forces. Donors can also affect the balance, as the availability of large amounts of money for malaria programs could make it more attractive for new firms to start making nets.

In conclusion, while it is difficult to generalize across the many countries in sub-Saharan Africa, it is reasonable to conclude that in the current market for untreated nets, there are high barriers to entry and a high degree of competition based primarily on price. The confluence of these factors is not favorable to new manufacturers who may want to enter the business.

Potential Impact of Long-Lasting Technologies on the Net Industry

While the various available approaches to producing LLINs differ significantly and will impose different requirements in terms of investment and infrastructure, it is possible to

[31] World Health Organization (WHO). 1998. *Draft Specifications for Household Insecticide Products. Report of Informal Consultation Feb 3–6, 1998*. CTD/WHOPES/IC/98.3. Geneva: WHO.
[32] Goodman, C., P. Coleman, and A. Mills. 2000. *Economic Analysis of Malaria Control in sub-Saharan Africa*. Geneva: Global Forum for Health Research.

assess some of the effects that this new technology will have on industry structure. Initially, LLINs will be differentiated from other nets because they provide protection against mosquitoes and do not have to be retreated. Even those nets that have not yet passed the WHOPES testing process, such as the Permanet, appear to retain their insecticidal properties for a longer time than do conventionally treated nets.

In theory, these advantages should allow LLIN manufacturers to command a price premium, but this will be true only if purchasers value the additional protection against mosquitoes provided by the long-lasting insecticide. The purchasers who value the extra protection would include the large institutional buyers who are informed about the public health benefits and who will make it a priority to provide LLINs to the programs they serve. However, it is not clear that the consumers who buy nets in the commercial market will understand the extra value provided by the long-lasting insecticide; it is impossible to discern the difference between an LLIN and an untreated net. Aside from the label, there is no way for consumers to know that they are getting a different product. It will therefore be incumbent upon the manufacturers of LLINs to establish the presence of their brands and to build up consumer trust. At the minimum, this could require an extensive marketing campaign, but undertaking such a campaign might be difficult for manufacturers just entering the LLIN market. While a number of projects provide assistance with marketing, such as the MEDA program in Uganda, the largest such project, NetMark, has so far chosen the strongest firms as partners, which could make it difficult for new, less established firms to enter the market.

If the added value provided by LLINs is not perceived by those who buy nets, whether end users, procurement agencies, institutions, or governments, then the threat of substitutes is real. Buyers will prefer to spend their money on an untreated net at a price of USD 5, which has a USD 2 or less factory gate price, rather than the more expensive LLIN that has a USD 5 factory gate price and a correspondingly higher retail price. In the near term, possible solutions could include—

- Establishment of a WHOPES "seal of quality" to help consumers to distinguish LLINs from ordinary nets
- Work with marketing partners to develop campaigns to educate consumers about the advantages of LLINs
- Support initiatives that are willing to provide market support to a variety of commercial partners, rather than those limited to only one or two (such as NetMark)
- Explore ways to subsidize the cost of LLINs so that, at least initially, these nets will be available at prices comparable to those of untreated nets

In Part 2 of this business plan, a survey of existing and potential LLIN technologies will be conducted and financial models will be developed to permit not only a determination of the capital investment requirements needed for the different technologies, but also the type of donor support that might be needed to bring LLINs to the market at prices comparable to those of untreated nets. The barriers that net producers face in terms of technology transfer, registration, quality control, and distribution will also be examined.

PART 2. PRODUCER ANALYSIS

How a Net is Produced

Choosing a Fiber

Nets are currently made out of polyester, cotton, or polyethylene. In Africa, most of the nets that are industrially produced are made out of polyester, while the Olyset net is made out of polyethylene. Cotton nets are generally produced on an ad-hoc basis for local use in a number of West African countries.

A more detailed comparison of the advantages and disadvantages of the different fibers for making nets can be found elsewhere,[33] but in summary, multifilament polyester is more durable, better at holding insecticide, and easier to control for quality than cotton. Polyethylene was previously considered a second choice because of possible lack of resistance to sunlight, but the feasibility of the incorporation of insecticide into polyethylene to make a long-lasting fiber, along with positive results from field tests in West Africa, have established it in the marketplace of long-lasting nets.

Remaining fiber possibilities include polypropylene and polyamide fibers such as nylon. WHO does not consider polyamides to be a choice material for making nets.[34] Polypropylene holds potential, but of the 30 million tons of polypropylene produced worldwide each year, it is estimated that only 15,000 tons at most are produced in a filament form suitable for net production[35] and that these facilities are already at 100 percent capacity. This could create a bottleneck if the demand for polypropylene increased, as it would if it was used for more nets.

Production of a Polyester, Polypropylene, or Polyethylene Net

This section includes a description of the production steps for transforming polyester or polyethylene chips into a conventional net. These steps involve activities across the oil, chemical, and textile industries. These descriptions will provide the background against which LLIN technologies can be categorized.

Polyester net manufacturing begins with derivatives from the oil industry and is followed by several steps that can be carried out either by one vertically integrated manufacturer or by different manufacturers who are specialized (Figure 5). Polypropylene nets are not yet widely manufactured, but their production uses the same steps as those for polyester nets.

[33] World Health Organization (WHO). 2001. *Specifications for Netting Materials*. *Report of an Informal Consultation WHO, Geneva, 8-9 June 2000*. WHO/CDS/RBM/2001.28. Geneva: WHO
[34] Ibid.
[35] R. Moissonnier, Global Industry Leader Fibers, Clariant Corporation, personal communication, March 2003.

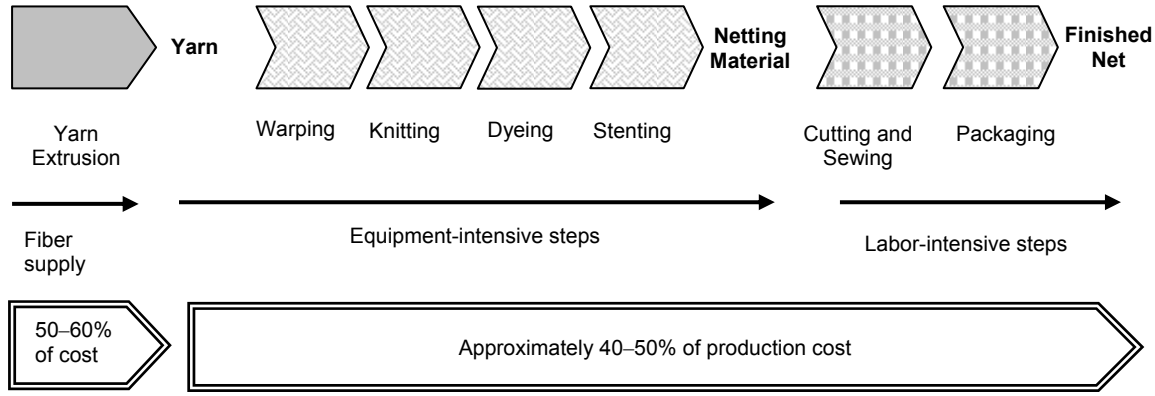


Figure 5. Polyester/Polypropylene Net Production

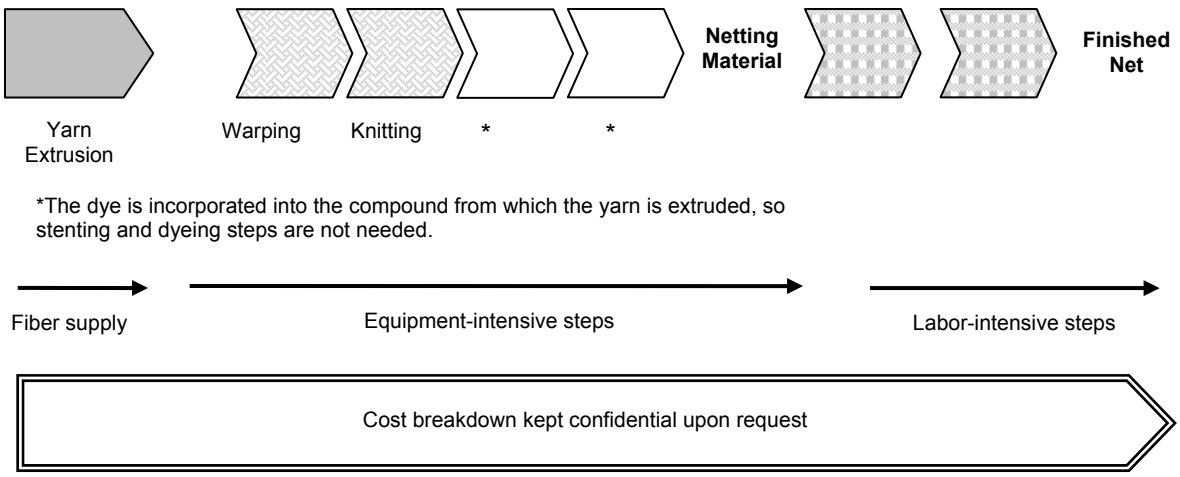
Within this production chain, the most labor-intensive step is the sewing, which is done by hand on sewing machines. For example, at one manufacturer, approximately 10 people are employed to operate the warping, knitting, dyeing, and stenting machines, while over 50 people work on the sewing, cutting, and packaging to transform the netting material into a finished product. High capital costs are incurred when installing extrusion capacity or knitting and stenting capacity; one African net manufacturer[36] estimates the cost for setting up a factory for transforming yarn into netting material at USD 2 million. Today, sub-Saharan African net manufacturers' capacity for polyester yarn extrusion is almost nonexistent, so the steps outlined above are often carried out in different places. Yarn, which is mostly imported from Asia, is bought by a manufacturer equipped to transform it into netting material. In turn, this manufacturer may go on to produce the finished net, or sell all or part of the netting material to smaller manufacturers who will do the cutting, sewing, and packaging.

Most net producers in sub-Saharan Africa are limited to the last two stages of net production. They cut, sew, and package netting material bought from a supplier because they do not have the resources needed to establish a knitting facility. These labor-intensive steps provide many jobs but require a low degree of technological sophistication. However, if netting material is available, it is relatively easy for these net producers to expand capacity.

Production of a Polyethylene Net

Polyethylene net production also involves several steps, but unlike polyester net production, the production steps from yarn extrusion through the production of the finished net are carried out within a single manufacturer's facilities (Figure 6).

[36] Director of an African net manufacturer, confidential personal communication, April 2003.



Source: Sumitomo Chemical Co., A to Z Textile Mills

Figure 6. Polyethylene Net Production

The Olyset net was developed by Sumitomo Chemical Co. of Japan, and production is subcontracted to a Chinese company. Sumitomo has agreed to make this technology available on a non-exclusive basis to other net producers, and A to Z Textile Mills in Tanzania is currently working to install production capacity for the Olyset net. All of the production steps will take place in-house. A to Z anticipates has been producing Olyset nets since September 2003. This project is an outstanding example of a public-private cooperative effort and is more fully described in Annex 6. It is our hope that this description could be used as a guide for other technology transfer projects.

The Cost Structure of Nets

Production Costs

Getting a detailed cost breakdown is difficult for two reasons: (1) manufacturing information is often confidential; and (2) net manufacturers generally do not have cost accounting systems in place that would permit an accurate cost analysis. The breakdown of costs varies slightly from manufacturer to manufacturer, but is estimated as shown in Table 5 by two different net manufacturers (per finished untreated net, ex-factory price).

Table 5. Price Breakdown by Two Manufacturers of Conventional Nets

Item	Manufacturer #1	Manufacturer #2
Yarn	USD 1.00	—
Machinery and labor (machine operators)	USD 0.80	—
Netting material	USD 1.80	USD 2.06
Labor (cutting, sewing, and packaging)	USD 0.60	USD 0.25
Other costs (including packaging and tricot border)	USD 0.72	USD 0.39
Cost of goods	USD 3.12	USD 2.70
Gross profit margin of 20%	USD 0.62	USD 0.54
Ex-Factory Price	**USD 3.74**	**USD 3.24**

Note: — = not applicable.

Although this was data given to us by the manufacturers, it is not consistent with the prices obtained by large institutional buyers, which can be USD 2 or lower per net (free on board [FOB] price). This price breakdown also does not include information on infrastructure costs such as electricity and utilities, nor is machinery cost broken down by amortization and operating costs. A profit margin of 20 percent is assumed, which may seem high but is reasonable given the risks and obstacles that are associated with operating in Africa, where financing is expensive and companies are exposed to political risks in addition to market risks.

The discrepancy between the ex-factory prices noted above and the institutional buyer prices could be explained by the lack of accurate cost accounting data from the manufacturers, or could be due to the manufacturers' attempt to keep the real figures confidential by quoting inflated costs.

Upon analyzing the components of the cost structure, assuming that the relative breakdown of costs is correct, it was concluded that labor costs account for between 10 and 20 percent of the cost of making a net, while netting material accounts for 60–75 percent of the cost. The third part of the business plan will include some data on manufacturing costs in Asia as well as a discussion of the intangible differences between manufacturing in Africa versus Asia.

Distribution Costs

Getting a net from the factory to the retail store adds considerably to its price, particularly if VAT is obligatory. What happens to the price of a conventional, untreated net as it goes through the private commercial distribution chain is illustrated using the following assumptions—

- Ex-factory price of untreated net: USD 2
- Net producer profit margin: 25 percent[37]
- Wholesale markup: 15 percent
- Retail markup: 25 percent

The USD 2 ex-factory price can be considered to be a rough average, as there is a considerable range of prices between those for small rectangular nets and those for conical nets. The net producer margin was calculated separately, as this figure may be less for sales to large institutional buyers but more for sales to the commercial sector. For the wholesale and retail markups, the assumed figures are based on those for pharmaceutical products; the

[37] Representative of an East African net manufacturer, personal communication, April 2003.

wholesale markups in Africa are generally around 25 percent, and the retail markups are as high as 50 percent or more.[38] Although nets are usually sold outside of pharmacies in retail settings next to fast-moving items such as soda or soap, where markups may be lower than for medicines, their slower turnover increases inventory costs. Because of this, wholesalers and retailers are still likely to require high markups, so these assumptions on retail and wholesaler markups are on the conservative side.

In the analysis of distribution costs shown in Table 6, the cost of a net increases by over 40 percent as it moves through the commercial channel, even without taking into consideration the effect of VAT. The cost of treatment (impregnation with insecticide) is not included here, as the objective is simply to show the effect of distribution costs on net prices.

Table 6. Distribution Costs for Conventional Untreated Net

	Without VAT	
	Price	**Markup/Margin**
Cost of goods	1.60	
Net producer profit margin (25%)		0.53
Ex-factory price (corresponds to large institutional buyer price)	**2.13**	
Wholesale markup (15%)		0.32
Wholesale price	**2.45**	
Retail markup (25%)		0.61
Retail price	**3.07**	
Multiplier between ex-factory price and retail price	1.44	

The 44 percent increase in the price of a net as it moves from the factory to the retail outlet seems a high burden to inflict on the consumers of nets, but previous experiences with pharmaceutical products have shown that trying to force wholesalers and retailers to operate with reduced margins has ultimately resulted in a lack of availability of products in retail outlets.[39] This outcome would be counterproductive to the objectives of attaining increased distribution of nets.

Taxes and Tariffs

Taxes and tariffs affect both the retail prices of nets and the price competitiveness of domestic net production against imported nets. In many African countries, tariffs on mosquito nets have been lowered following the pledges made in Abuja, but tariffs on the inputs needed to make nets, including polyester chips, yarn, netting material, and insecticides, remain high. For example, as of late 2002, polyester yarn carried a tariff of 25 percent for import into Nigeria, while netting material carried a tariff of 20 percent in Senegal.[40] These added costs are passed on to the consumer of the final product; however, an imported net made in a country where no tariff was paid on the inputs will not carry these added costs. Thus, an imported net will have a price advantage over a domestically made net that had to factor in

[38] Director of Sustainable Healthcare Enterprise Foundation, Kenya, personal communication, April 2003.
[39] Director of Cosmos, Kenya, personal communication, April 2003.
[40] Starling, M., and R. Njau. 2002. *Review of the Processes and Nature of Effective Policy Change for Tax and Tariff Rationalisation on Nets, Netting and Insecticides in Ghana, Senegal, Mali, Nigeria & Tanzania.* London: Malaria Consortium.

tariff costs on the inputs. This imbalance will tend to discourage local net production. An additional difficulty facing net producers is the difficulty in getting up-to-date and reliable tariff information, as highlighted in Annex 7.

Impact of Tariffs on Retail Prices

The impact on retail prices of reducing tariffs has been previously analyzed in a study[41] using economic models that used different hypotheses for net production and distribution and for tariff rates. Three different tariff rates, ranging from 25 to 40 percent across differing price elasticities of demand, were tested on 12 models. The four hypotheses for net production and distribution included consideration of imported nets as well as domestic net production. Over all of these, the maximum expected reduction in net prices was 29 percent. The maximum corresponding increase in demand (assuming all other factors remained equal) was 14.5 percent, which would be significant but remains far from the gap that needs to be closed to reach the Abuja targets.

Impact of Taxes and Tariffs on Domestic Net Production

In contrast to the effect on retail prices, relative tariff levels on the inputs for net production and on finished nets factor heavily in the decisions of net producers. These tariffs even seem more of a concern than other business-related taxes such as corporate income taxes, which generally range from 35 to 40 percent in sub-Saharan Africa.[42]

For example, Nigeria has kept the tariff on polyester yarns and netting at 25 percent, while the tariff on nets went as low as 5 percent after the Abuja conference (it has since fluctuated, going as high as 75 percent).[43] By contrast, Tanzanian customs duties on insecticides, dyes, chemicals, and finished nets are 0 percent. This discrepancy may be part of the reason why net production in Nigeria, a country with an active textile industry and a population almost four times greater than that of Tanzania, is three times lower than that of Tanzania.[44]

Impact of VAT on Net Prices

Based on the model for distribution costs above (cf. Table 6), some projections were made to enable a retail price comparison, with and without VAT, between conventional nets that are bundled with a treatment kit (USD 0.60) and LLINs. Two different hypotheses are used to calculate the price of an LLIN: (1) an additional cost of USD 1, which is the midpoint of a range of expected costs for LLIN processes based on one set of estimates provided; and (2) the price point of USD 5 that has been chosen as an indicative price for LLINs by WHO and UNICEF. This analysis, shown in Table 7 below, includes the estimated cost of a treatment kit to permit a more realistic comparison among the choices that would face a consumer who wants a treated net but is confronted with different products in the marketplace.

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[41] Simon, J., B. Larson, S. Rosen, A. Zusman. 2001. *Reducing Tariffs and Taxes on Insecticide-Treated Bednets: Background Paper for Africa Malaria Day, April 25, 2001*. Geneva: Roll Back Malaria.
[42] Ernst & Young. 2002. *Worldwide Corporate Tax Guide.* New York: Ernst & Young Global Limited.
[43] Hanlin, R. 2002. *ITN Scaling Up in Nigeria: Situational Update Dec. 2002.* New York: UNICEF.
[44] Lines, J., and S. Vyas. 2002. "Recent Changes and Possible Trends in the Net Market in Nigeria." <http://www.lshtm.ac.uk/dfid/malaria/Acrobat%20documents/Trends_in_Nigeria_net_market_march_2003.pdf> (accessed Jan. 12, 2004).

Table 7. VAT Effect on LLIN Prices	Conventional Net (with treatment)		Long-Lasting Insecticidal Net		USD 5 Long-Lasting Net	
Price Element	**With VAT**	**Without VAT**	**With VAT**	**Without VAT**	**With VAT**	**Without VAT**
Production cost of untreated net	1.60	1.60	1.60	1.60		
Treatment kit for conventional net	0.60	0.60				
Cost of LLIN process			1.00	1.00		
Cost of goods at producer level	**2.20**	**2.20**	**2.60**	**2.60**	**3.75**	**3.75**
Net producer profit margin (25%)	0.73	0.73	0.87	0.87	1.25	1.25
VAT (20%)	0.59	0.00	0.69	0.00	1.00	0.00
Ex-factory price with VAT*	**3.52**	**2.93**	**4.16**	**3.47**	**6.00**	**5.00**
Wholesale markup (15%)	0.53	0.44	0.62	0.52	0.90	0.75
VAT (20%)	0.11	0.00	0.12	0.00	0.18	0.00
Wholesale price	**4.15**	**3.37**	**4.91**	**3.99**	**7.08**	**5.75**
Retail markup (25%)	1.04	0.84	1.23	1.00	1.77	1.44
VAT (20%)	0.21	0.00	0.25	0.00	0.35	0.00
Retail price	**5.40**	**4.22**	**6.38**	**4.98**	**9.20**	**7.19**
Multiplier between ex-factory and retail prices	1.53	1.44	1.53	1.44	1.53	1.44

*This price would correspond to the large institutional buyer price, although the net producer's margin might be less.

The inclusion of VAT will raise the price of a net by over 50 percent as it moves through the commercial distribution chain, with a resulting price 22 percent higher (e.g., USD 5.40 vs. USD 4.22) than if VAT is not added at each step. By contrast, an LLIN process that costs USD 1 could add close to USD 1 to the final price of a net. However, if the hypothetical VAT is lowered to 0 percent from 20 percent at the same time, this LLIN will cost less (e.g., USD 4.98 vs. USD 5.40) than a conventional net bundled with a treatment kit to which VAT is applied. This point is made to show that a government decision to exempt nets from VAT could offset the additional cost of producing an LLIN.

However, an LLIN that costs USD 5 ex-factory will carry a price increase of almost 100 percent compared to the retail price of an ITN (e.g., USD 7.19 vs. USD 4.22) even if VAT is removed. This LLIN will then be too expensive at the retail level for the poorest section of the population. Ability to pay was discussed in Part 1 of this business plan, and Part 3 will look at the amounts of subsidies that would be required to make LLINs competitive in price with conventional nets.

Improving the Tax and Tariff Incentives

Changing the tax and tariff structure to provide better incentives to domestic producers will require the involvement of multiple stakeholders. Possible strategies that could improve incentives for domestic net production include—

- **Establishment of an export zone (EPZ).** The favorable tax and tariff incentives generally accorded to production facilities in an EPZ can be an attractive option to net producers who find that expansion into external markets will be necessary to achieve better economies of scale in production. In these zones, companies can benefit from tax breaks and exemptions from import and export duties, but produce mainly for export. Sub-Saharan countries that have set up EPZs include Madagascar, Kenya, and

Tanzania, among others. The track record of EPZs in Africa is mixed,[45] and there have been accusations of unfair labor practices within these zones.[46] However, UNICEF will continue to be a major buyer of nets and can have a role to play in ensuring fair labor conditions, while at the same time net manufacturers could benefit from the tariff exemption to be able to compete against nets imported from Asia. There is at least one net manufacturer who is setting up a knitting facility in an EPZ in East Africa; another sees the benefit in terms of paperwork reduction in Tanzania, even though tariff rates are relatively low in that country.

Executing this strategy will still require investment on the part of the net producers, and before relocating to an export processing zone and investing in net production, they will need to see that there is a consistent demand for nets.

- **Selective removal of VAT and tariffs on inputs used for net production.** This can be done via a refund or an upfront exemption.

    - In Tanzania, net manufacturers are refunded the 10 percent tariff for that portion of imported polyester yarn that is used in making nets for the export market. The refund arrives two to three months after the necessary documentation is submitted.

    - Within the West African Economic and Monetary Union (WAEMU), an effort is being made to exempt untreated mosquito nets that are used as inputs by companies that dip them in insecticide and sell them as treated nets. A system is already in place for pharmaceutical companies that are exempt from payment of all inputs used to make pharmaceuticals. Retroactively, these companies must be able to prove that these inputs were actually used as intended. To be eligible, the company must be registered with the national authorities as a pharmaceutical manufacturer.

    - Although this strategy sounds straightforward, work on standardizing tariff nomenclature for nets and their inputs, including yarns, dyes, and other chemicals, will be required, as well as developing a definition to establish which companies can be classified as net producers.

In summary, taxes and tariffs can have an important effect on retail net prices, but they have a critical impact on the decisions of net producers. Stimulating net production in Africa will require further changes in taxes and tariffs, and RBM is to be acknowledged for consistently highlighting the importance of this issue over the years. Within African countries, Ministries of Health need to highlight the importance of nets for malaria prevention within national health policy. If they do so, then Ministries of Finance may be willing to offer the same types of tax and tariff exemptions that have been helpful in some countries for stimulating the local pharmaceutical industry. Net producers also have a role to play in lobbying governments and participating in stakeholder meetings. In the five countries studied in the Malaria Consortium

[45] Watson, P. October 2001. *Export Processing Zones in sub-Saharan Africa* (*Findings* 193). Washington, D.C.: World Bank Group. <http://www.worldbank.org/afr/findings/english/find193.pdf>
[46] International Labour Organization. 1998. "Export Processing Zones Growing Steadily, Providing a Major Source of Job Creation." Press Release. <http://www.ilo.org/public/english/bureau/inf/pr/1998/34.htm> (accessed January 2004).

report,[47] it took from one to four years to achieve an initial round of tax and tariff reductions. Similarly, the WAEMU countries were eventually successful in implementing the tax exemptions for pharmaceutical inputs.

Landscaping of LLIN Technologies

Before proceeding to a description of the LLIN technologies that are available and those still in the research and development stage, some background information is presented on WHOPES and the insecticides that have been recommended for mosquito net use. Although those already involved in the production of insecticides and mosquito nets may be familiar with this information, it is included for the benefit of stakeholders who may not be as familiar with the field. WHOPES will have an important role to play as specifications are being developed for LLINs.

WHOPES Specifications

The WHO Pesticide Evaluation Scheme was set up in 1960 to promote and coordinate the testing and evaluation of pesticides for public health use. It was designed to provide these services because of the lack of established, internationally accepted standards for pesticide use. WHOPES functions in close collaboration with industry, national disease and pest control programs, pesticide registration authorities, and WHO Collaborating Centres and research institutions, as well as other WHO programs, notably the International Programme on Chemical Safety.

WHOPES testing involves the safety, efficacy, and acceptability (e.g., ease of use) of pesticide products for public health use and comprises four phases: (1) laboratory testing; (2) small-scale field-testing; (3) large-scale field-testing; and (4) development of specifications for quality control and international trade.

Typically, a pesticide manufacturer will approach WHOPES with a product for testing, and, in turn, WHOPES will solicit proposals from the Collaborating Centres for testing. Industry will then usually fund the testing, as well as submit thorough product data documentation. Results are collated and then reviewed by a WHOPES-convened committee of experts, which meets once a year.

Prior to 1999, a WHOPES recommendation could be issued for any product that was nominally similar to an existing, previously approved compound. However, in 1999, WHO decided to harmonize the development of specifications with the U.N. Food and Agriculture Organization (FAO). Under the new procedures, a joint FAO/WHO recommendation can be issued only after a manufacturer submits a data package for a specific active ingredient. In particular, assessments of the manufacturing process and the impurity profile must be carried out before this compound can be deemed equivalent to a previously approved compound and receive a recommendation. After an interim period established by WHO that will precede the implementation of the new recommendations, this will limit the number of generic products that are WHOPES-recommended, as generic manufacturers may be less willing than innovator brand manufacturers to assemble a data safety package for submission. On the

[47] Starling, M., and R. Njau. 2002. *Review of the Processes and Nature of Effective Policy Change for Tax and Tariff Rationalisation on Nets, Netting and Insecticides in Ghana, Senegal, Mali, Nigeria & Tanzania.* London: Malaria Consortium.

other hand, the stricter requirements of the new procedures provide better safeguards for public health.

Insecticides for Mosquito Net Impregnation and LLIN Production

Seven pyrethroid insecticide products (six compounds) have been approved by WHOPES under the old procedures for the impregnation of mosquito nets. There are differences between the pyrethroids in terms of skin irritation, required dosage, and patent status. Pyrethroids that are more irritating will have greater requirements for worker safety, while those that require higher doses may be more difficult to incorporate into a long-lasting process. Knowing patent status is helpful because a generic may be available; however, so far, few generic producers have submitted the product safety documentation required by the new WHOPES procedures. The pyrethroids are compared in Table 8 according to physical side effects, patent status, and required dosage. Some of the other concerns relating to pyrethroid insecticides and the WHOPES process are discussed in Annex 8.

Table 8. Comparison of the Six Pyrethroid Insecticides Currently Recommended by WHO for Impregnation of Mosquito Nets

Insecticide	Trade Name	Skin and Mucous Membrane Irritant	Patent Status	Dosage Required for Effectiveness
Alpha-cypermethrin	Fendona	++	Generic	++
Cyfluthrin	Solfac	++	Generic	++
Deltamethrin	K-Othrin	++	Generic	+
Etofenprox	Vectron	+	Patent still valid	+++
Lambdacyhalothrin	Icon	++	Generic	+
Permethrin	Peripel	+	Generic	+++

Note: + = Low; ++ = Intermediate; +++ = High.

LLIN Specifications

In the case of an LLIN, an interim recommendation may be issued upon its successful testing and evaluation in laboratory and small-scale field studies, if a WHO-recommended insecticide has been used in their manufacture. WHOPES Phase I and II testing of LLINs normally takes one to two years and costs an estimated USD 50,000 to USD 80,000, which must be paid by the company that is submitting the net for testing.

The variation among technological approaches to making LLINs makes it necessary to develop a standard definition of an LLIN to guide the manufacturers and developers of LLINs. Currently, LLINs are defined as "a ready-to-use pretreated mosquito net, which requires no further retreatment during its expected life span (4-5 years)."[48] The early state of these technologies poses particular challenges to WHOPES efforts to develop a rigorous set of specifications and will require extensive consultation with industry and independent experts. WHOPES is actively working on this new set of specifications. So far, an interim WHOPES specification for polyethylene monofilament-based nets incorporating Permethrin, based on the experience with Olyset, has been published, and manufacturers are encouraged

[48] WHOPES draft guidelines in progress, courtesy of M. Zaim, WHO.

to submit new LLINs for WHOPES testing even though the new set of LLIN specifications is not yet available.

UN agencies have expressed a preference for buying WHOPES-approved nets, but they have been confronted with two difficulties: (1) As of June 2003, only the Olyset has received an interim WHOPES recommendation, and (2) the lack of supply of Olyset nets has meant that UN agencies have had to buy LLINs that are not approved by WHOPES as "pretreated" nets.

The thoroughness of the WHOPES evaluation process will be valuable for developing an objective standard for LLINs and helpful for institutional buyers who would not have the technical resources nor the time to evaluate nets themselves. However, there are several limitations to the WHOPES process—

- A WHOPES recommendation will not help the consumer who buys an LLIN in the retail market, because this information will not be available in the retail environment.
- The WHOPES evaluation process can be costly and time-consuming for small organizations, which could discourage them from continuing development of LLINs. This cost will also be reflected in the cost of LLINs.
- WHOPES is not a substitute for external verification of the quality of an LLIN. Without a specified enforcement mechanism, institutional buyers that purchase nets on behalf of end-users such as Ministries of Health, UN agencies, and NGOs will still have to test and inspect the LLINs that they buy.

In conclusion, developers of LLIN technology will have to carefully choose their insecticide based on several criteria: (1) the potential to ensure the safety of workers who could be handling impregnated materials; (2) the relative quantity required for efficacy; and (3) WHOPES recommendations. WHO technical experts are available for consultation and can play a valuable role in guiding developers.

Description of LLIN Technologies

We have divided the companies and organizations that are making or developing long-lasting nets into four categories: (1) companies currently selling nets that are durably impregnated (both WHOPES recommended and non-WHOPES recommended); (2) multinational chemical and agrochemical companies; (3) textile companies; and (4) startup companies and university research laboratories. These categories are pertinent because they are indicative of the amount of resources that an organization can devote to the development of an LLIN, as well as to whether the organization will actually sell the finished nets. An alternative classification is presented at the end of this section to highlight the relationship of these actors to the actual production process of nets.

Companies Currently Selling LLINs (both WHOPES recommended and non-WHOPES recommended)

- ***Sumitomo Chemical Co. Ltd. in partnership with A to Z (Tanzania) and ExxonMobil Corporation***

The Olyset net is the only WHOPES-recommended long-lasting net currently available. It is made out of high-density polyethylene, which comes from the oil industry. In Sumitomo's process, Permethrin is incorporated at 2 percent weight per weight (wt/wt) with HDPE and other ingredients, including stabilizers, into a compound. The compound is then passed through an extrusion process to make a monofilament yarn from which the net is made. Sumitomo plans to supply a 12 percent wt/wt concentration "masterbatch" that will be combined with HDPE from ExxonMobil at the A to Z factory for extrusion into monofilament yarn.

The process was developed by the chemical division of Sumitomo in Japan, and the Olyset net is currently produced under contract to Sumitomo in China. Capacity in China is limited to 30,000 nets per week, so to improve production capacity, a project to establish manufacturing capacity in partnership with A to Z Textile Mills of Tanzania was started in 2001, and production of the Olyset type net by A to Z started in September 2003. A fuller description of this project and the issues that had to be overcome for the transfer of technology is described in Annex 6. It is expected that other firms will be interested in acquiring the Olyset technology and in producing Olyset-type nets.

- ***Vestergaard Frandsen A/S***

Permanet is the brand name of a mosquito net sold by Vestergaard Frandsen, a private company based in Denmark. The Permanet has not yet been WHOPES approved, but it is undergoing WHOPES trials, with results for Phase II expected by early December 2003. If approved, this would make Permanet eligible for a provisional recommendation.

This net is made using a process in which insecticide is mixed with a wash-resistant agent and then applied to the netting material. The netting is then dried so that it can be cut, stitched, and packaged into a finished net. Vestergaard uses deltamethrin at a concentration of 50 mg/m^2, which required the installation of protective measures for workers in their manufacturing partner's facility in Hanoi. The company has also developed the Zero Fly Plastic Shelter, which is deltamethrin-impregnated polyethylene sheeting for use in temporary shelters in emergency situations.

Even while waiting for the WHOPES recommendation, Vestergaard has been active in promoting the Permanet, with total sales in Africa estimated at close to three million to date.

- ***SiamDutch***

SiamDutch has developed an LLIN that is marketed as the Dawa net. The Dawa net is currently undergoing laboratory and field trials, after which the formulation will be submitted to WHOPES. The company is focusing its efforts on a process and formulation that can be used in the field as well as in a factory setting, which would make it possible to convert

existing nets into LLINs. In addition, alternative formulations are being considered, such as using an impregnated yarn.

Multinational Chemical and Agrochemical Companies

- ***Bayer CropScience AG***

Bayer Environmental Science (Bayer ES), a company based in France under the roof of Bayer CropSciences and one of the four companies of the Bayer Holding, is a major supplier of pyrethroid insecticides for the impregnation of mosquito nets in the African market. Following the acquisition of Aventis CropScience, Bayer now has ownership of the deltamethrin range of products (K-O, K-Othrine), in addition to the original Solfac insecticides (which contain cyfluthrin) for impregnating nets.

Consistent with their commitment to the African market, Bayer ES is working with a number of partners to develop technologies for the production of long-lasting nets and anticipates being able to submit one or more for WHOPES testing in 2004. Two different categories of processes are being researched: an industrial process to take place during net manufacturing and a field process that can be applied to finished nets. It is anticipated that the additional cost of producing nets using these technologies will be 10–15 percent of the cost of an untreated net.

Furthermore, Bayer ES plans to support their net manufacturing partners with the demand creation process and the distribution of long-lasting nets.

- ***Syngenta International Ag***

Syngenta was formed by the merger of the agribusiness division of Novartis and the agrochemical division of Zeneca in 2000. For the impregnation of mosquito nets, the company produces lambda-cyhalothrin, which is marketed under the brand name of Iconet. Awareness of the need for an improved solution for nets has led to a research effort focused on several axes for providing long-lasting protection: 1) incorporation of the insecticide into polyester fiber; 2) a process for treating netting material, either before or after sewing; 3) a field process that can be applied to a finished net with a minimum of equipment. The company expects to be able to submit one of these to the WHOPES evaluation process before the end of 2004.

- ***Sasol Limited***

Sasol Limited is a large, diversified conglomerate based in South Africa that produces fuel and fuel-related chemicals. Within the Sasol Wax Division, a polyethylene fiber that incorporates insecticide is being actively developed.

- ***Clariant International Ltd.***

Clariant International Ltd. is a large, multinational firm that was formerly part of Sandoz. Of its five divisions, the Masterbatch Division is a world leader in the production of color and additive masterbatches. Using their expertise in additives, Clariant is working on a process for incorporating insecticide in polypropylene and polyester fiber. If successful, this process would enable a yarn producer to produce yarn suitable for knitting into long-lasting

insecticide-treated netting material. In turn, this material could be cut and sewn into LLINs by the same manufacturer who did the knitting, or sold to other manufacturers who would do the cutting, sewing, and packaging to make the final product.

- ***Dow Chemical Company***

Dow has expertise in chemical, plastic, and agricultural products and is present in more than 170 countries around the world. The company is leveraging this expertise to develop ways to incorporate insecticides into plastic polymers without using high temperatures. One of the polymers it is especially interested in is a biodegradable compound based on plant carbons that is being developed in a joint venture with Cargill. The use of this compound in combination with a biodegradable insecticide offers a potential solution to the problem of net disposal. The insecticide, which is in the organophosphate class, has been submitted to WHOPES for evaluation. The company emphasizes its commitment to the principles of Responsible Care (cf. Annex 8) and will consider the transfer of its technology, once developed, only under conditions that respect these principles.

- ***BASF***

BASF is a large, multinational chemical company that currently manufactures the Fendona brand of alpha-cypermethrin for impregnating mosquito nets. Its product line includes many other high-value-added chemicals, plastics, colorants and pigments, dispersions, automotive and industrial coatings, crop-protection agents, fine chemicals, oil, and gas. In its work on developing long-lasting nets, the company has considered several approaches including the development of a reinforced nylon, incorporation of insecticide into raw materials, and a field-type process that could be applied toward the end of the net production process or to a finished net in the field. Because of its concerns over net costs and acceptability, it is favoring the field-type process, while recognizing that this approach will allow a larger number of net producers in Africa to make LLINs. BASF is committed to Responsible Care principles (cf. Annex 8).

Textile Companies

- ***BMD Textiles***

BMD is based in Cape Town, South Africa, and the company has the in-house capability to do everything from warping, warp knitting, and weft knitting to dying, printing, and finishing. For several years they have been working with various fibers, including polyester, polypropylene, and HDPE, to develop a long-lasting net in partnership with various Japanese companies. The main developments have been with polyester and, most recently, with multifilament, fine-denier polypropylene. BMD has been using WHOPES-approved insecticides and fiber that conforms to WHO specifications. Once the company has an established product, it anticipates that it will use the yarn, which will be made in Japan, to produce netting material that will be sold to the net manufacturers who will produce the final net.

- ***Rhovyl***

Rhovyl makes a polyvinyl chloride (PVC)–based fiber capable of holding additives such as antimicrobial products and anti–dust mite chemicals. The company has shown interest in the

long-lasting net market in the past but did not respond to information requests during the writing of this business plan.

Private Companies and University-Based Research Labs

- ***Delft University of Technology***

Professor Jan Marijnissen of Delft University of Technology in the Netherlands is a particle technologist and has established a world-class aerosol lab at the university. His technology permits the deposition of extremely fine aerosolized particles on a number of surfaces, including fiber. Dr. Marijnissen is committed to making his technology available for developing countries, but will need to do further research on using WHO-recommended insecticides and on testing wash resistance.

- ***T.S. Bio***

T.S. Bio has inherited from Athanor, a former textile firm, a process that can attach a bioreactive molecule, such as an insecticide molecule, to a number of surfaces. Results using high-performance liquid chromatography (HPLC) to quantify the insecticide show that insecticide will remain despite repeated washings. The company has tried this process on nets from several different net manufacturers.

- ***SPCI***

SPCI is a small company that has been active in biotextiles for over 10 years. This company was the first to develop industrial processes to treat textile material with biocides. With their partners, SPCI was able to supply nets and clothing treated for protection against insect vectors (mosquitoes, etc.) to the French army.

Since 1998, the company has been working on a process to prolong the insecticidal effects of the chosen polymer by incorporating insecticide either directly into fiber or into a polymer prior to extrusion. SPCI has submitted samples for efficacy testing to an independent laboratory and expects the full results before the end of 2003.

Classification of LLIN Developers by Principal Activity

This classification, shown in Table 9, indicates the diversity of backgrounds and expertise among the various developers of LLIN technology. Although many of these companies have multiple divisions across a number of specialties, only those activities pertaining to the net production process are included.

Table 9. Principal Activity of LLIN Developers

Main Type of Business	Company Name	Nets/ Netting Material	Insecticide	Inputs for Polyester or Polyethylene Yarn	Polyester or Poly-propylene Yarn	Textile Processing
Insecticide Manufacturers	Bayer		x			
	Syngenta		x			
	Dow		x			
	BASF		x			
	Sumitomo		x			
Other Chemical Companies	Clariant			x		
	Sasol			x		
Textile Companies	BMD	x				
	Rhovyl				(PVC yarn)	
Net Manufacturers	A to Z	x				
	Vestergaard	x				
	SiamDutch	x				
Private Companies	SPCI			x		
	T.S. Bio					x
University-Affiliated Research Laboratories	Delft					x

x = Company or organization's principal involvement in net production process

This table also highlights the dominance of insecticide manufacturers in the LLIN development effort. These companies are also often able to leverage expertise across a number of divisions, including plastics and textile expertise in some cases. However, research and development of LLINs must compete with other priorities within these companies, while the smaller companies have the advantages of focus and flexibility. It is therefore impossible to predict which technology will be the next to market, and WHO and UNICEF have wisely continued to maintain an open dialogue with all of these developers.

Summary of LLIN Technologies

These LLIN technologies have been classified into three categories: (1) fiber-based processes that produce an impregnated yarn that can then be knitted, cut, and sewn into an LLIN; (2) industrial processes that are applied in the factory during net production to make an LLIN; and (3) field processes that can be applied at the end of the production cycle or to a finished net to transform it into an LLIN. These distinctions are useful for understanding the constraints facing the transfer of these technologies and the potential impact on the LLIN market. How these processes are used in making nets is illustrated in Figure 7.

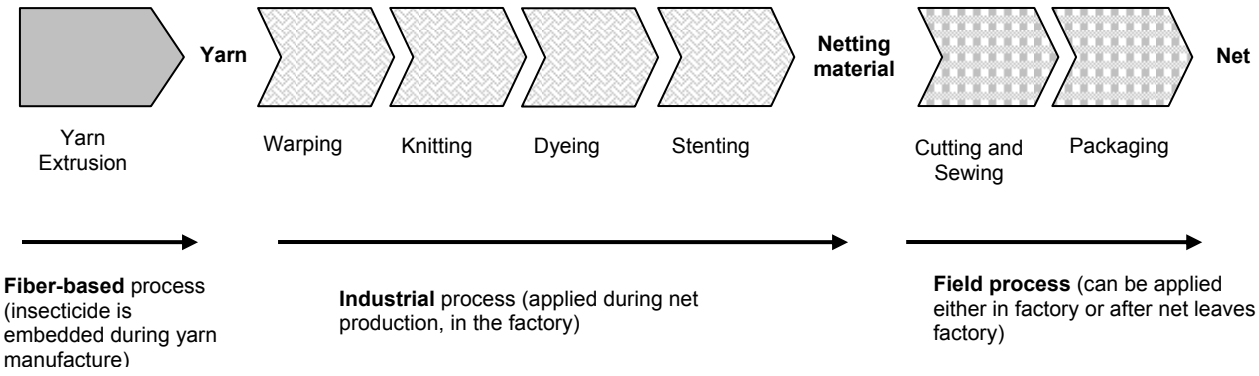


Figure 7. Classification of LLIN Processes

Table 10 provides a summary of the categories to which these LLIN technologies belong as well as their development status.

Table 10. Classification of LLIN Technologies

Type of Company	Developer	WHOPES Approved	Commercially Available	Expected Time Frame for WHOPES Submission	Type of Process (Fiber-Based, Industrial, Field)
Companies with Existing LLIN Technologies	Sumitomo	Yes	Yes	Has provisional recommendation	Fiber-based
	Vestergaard Frandsen	Pending	Yes	Under evaluation	Industrial
	SiamDutch	No	Yes	1 year	Unknown
Multinational Companies	Bayer	No	No	1 year	Industrial and Field
	Syngenta	No	No	1 year	Industrial and Field
	Sasol	No	No	1 year	Fiber-based
	Dow	No	No	Unknown	Fiber-based
	BASF	No	No	Unknown	Field
Textile Companies	Clariant	No	No	1 year	Fiber-based
	BMD	No	No	Unknown	Fiber-based
	Rhovyl	No	No	Unknown	Fiber-based
Small Companies and Research Laboratories	Delft	No	No	Unknown	Industrial
	SPCI	No	No	1 year	Fiber-based
	T.S. Bio	No	No	Unknown	Field

From this summary, it is clear that a variety of approaches are being tried to create LLINs without a clear dominance by any one approach. It is also likely that LLIN buyers will have a wide choice of processes, although they will have to wait a year or more until more of these technologies are commercialized. The classification of LLIN technologies into fiber-based, industrial, and field processes is used in the following discussion of the principal issues that will arise for the implementation and transfer of these technologies to net producers in Africa. Some of the technical issues that relate to insecticide use but are less directly related to technology transfer issues are addressed in Annex 8.

The issues that will arise in implementing and transferring LLIN technologies include—

1. **Manufacturing Quality Control (QC).** Many net producers will need technical assistance to establish manufacturing QC for long-lasting nets because of the additional complexity of the product.

   For fiber-based processes, net producers may need QC procedures for incoming raw materials to ensure that the fiber meets the requirements for making a long-lasting net. Ideally, producers should have ways to measure the quantity of insecticide and its bioavailability in the fiber that they will be using to make the long-lasting net. However, implementation of a rigorous documentation and labeling system could enable smaller net manufacturers to share the burden of quality control with institutional buyers, who would only have to: (1) verify the quality of the long-lasting yarn from a relatively small number of yarn producers, and (2) verify that long-lasting yarn was actually used by checking the appropriate documentation from the net producer.

   Industrial and field processes will require net producers to develop the in-house capacity to test their final product. One major net manufacturer has an eight-person team that performs HPLC on several samples of netting per day and a bioassay test on one sample per day. A small manufacturer would be unlikely to have an in-house unit with this kind of capacity, and would have to depend on outsourcing the testing of the long-lasting properties of their manufactured nets, with testing costs estimated to be as high as USD 1,000 per sample.

   External technical assistance and support will most likely be needed to meet the QC requirements for any of the three types of LLIN processes. A Crown Agents study of QC for conventional nets found that net sizes varied considerably from one producer to another, that color varied between batches of nets from the same producer, and that one major net producer lacked a Quality Assurance Department. Although these issues were successfully resolved, the experience suggests that other stakeholders in LLIN development will have a role to play in ensuring that LLINs are produced to high standards. This role could be in the form of donor support for training or WHO support in establishing collaborating testing centers close to net producers who may lack sophisticated testing equipment. These testing centers could not only serve the needs of manufacturers for internal QC but also respond to the needs of national malaria control program managers who need to test the quality of the LLINs that they will be buying.

2. **Required Investment.** Because many of the LLIN technologies are still under development, it is difficult to predict the amount of money that will be required to upgrade or add production capacity to make LLINs. However, based on the categorization of LLIN technology into fiber-based, industrial, and field processes, it is possible to make a tentative cost estimate.

   Fiber-based and field processes are likely to require the least amount of investment by most net manufacturers because the LLIN technology is either already in the yarn when it arrives at the factory to be knitted into nets or applied to a finished net by impregnation. Those few manufacturers who do extrude their yarn may have to make a larger investment if extra equipment such as a masterbatch dosing apparatus is needed.

Industrial processes will require the installation of additional equipment in the net production line. For example, one long-lasting process uses a treatment that is applied to netting material after it comes out of the stenter but before it is cut and sewed into nets. Installing additional equipment also means additional hiring and training costs. Net manufacturers are likely to require concrete evidence of the viability of the long-lasting net market before making this kind of investment. Donors could have an important role to play as a source of low-cost financing for net producers who are willing to upgrade their capacity to make LLINs but who want a partner to share the risk.

3. **Intellectual Property Protection.** Many of the multinational insecticide and chemical companies interviewed have experience with establishing production facilities in developing countries and with tactics to protect their intellectual property. It appears that fiber-based and field processes will be easiest to protect because the critical formulas and steps do not have to be shared with each net producer, whereas implementing an industrial process will require a greater degree of knowledge-sharing between the inventor of an LLIN technology and the net producer.

   The nascent state of LLIN technology does not permit a definitive solution to be presented in this document, but discussions with one of the smaller companies suggest that the involvement of multiple stakeholders, including selected net producers, could lead to creative solutions for this issue.

4. **Knowledge Transfer.** Besides simply enabling the manufacture of LLINs in Africa, African companies should also develop the capacity to participate in the evolution of LLIN technology, but this goal will have to be balanced against other considerations. It appears that the industrial processes are most likely to provide opportunities for African net producers to innovate or to improve an LLIN process because of the hands-on involvement needed for these kinds of processes.

5. **Worker Safety and Environmental Protection.** The multinational companies interviewed have highlighted worker safety and environmental protection as particular concerns because of the high social profile of the effort to introduce LLINs in Africa. To date, field experience has varied between net producers: There have been no reports of complaints from the Chinese manufacturing facility where the Olyset is produced, while Vestergaard Frandsen had to install workstation-based ventilation systems as well as air conditioning in their factories in Southeast Asia.

   Potential buyers of LLINs will have to recognize the additional costs that will be incurred to provide proper monitoring and procedures. For example, A to Z Textile Mills will install a forced ventilation system in their factory, hire a full-time nurse to record and evaluate worker complaints, and provide gloves and uniforms for their workers on the production line for their Olyset net. Institutions such as UNICEF and organizations such as PSI and NetMark Plus that are supporting private sector activities also have a moral responsibility to ensure that the LLINs they buy are made in workplaces that respect standards such as Social Accountability 8000, which was established by Social Accountability International to ensure decent working conditions throughout the supply chain.

Additional reflection will be required to address environmental concerns. Neither polyester nor HDPE degrade naturally, and discarded plastic bags already litter the streets of many African cities. Besides the possibility of using a biodegradable fiber, as proposed by Dow, enlarging the group of stakeholders to include companies such as soda manufacturers, who are accustomed to recycling glass bottles, could contribute to finding a viable solution to the problem of net disposal.

6. **Cost.** The additional production costs to make an LLIN are difficult to predict at this time because most of the technologies are still in the research phase. Bayer has estimated that the additional costs of producing an LLIN will add 10–15 percent to net production costs, but the rest of the companies interviewed were unable to provide cost estimates. A preliminary estimate of relative costs between the different classes of LLIN technology revealed that a field process involving the impregnation of a conventional net to transform it into an LLIN is likely to be the most costly because it is done on a net-by-net basis. This estimate will require confirmation as the relevant LLIN technologies move into the industrial scale-up phase. At present it is not possible to classify relative cost differentials between fiber-based and industrial processes.

   It is clear that developers of LLIN technology will want to recoup their development costs. Although the large, multinational, specialty chemical companies appreciate the social value of developing an LLIN, and the development costs appear small when compared to the annual research budget at any one of these companies, recovery of these costs is needed for the companies to internally justify their research efforts. Estimates of research and development costs range from USD 1 million to USD 4 million[49,50] with a desired payback period of three years or less.

7. **Accessibility in Remote Areas.** Most Africans live in rural areas, where roads are questionable and transport is difficult. A field-based process, administered by the local health structures or a local NGO, could be a feasible way to improve end-user access to LLINs.

These seven considerations are summarized across the classifications of LLIN processes in Table 11.

[49] Global business manager of an insecticide company, personal communication, August 2003.
[50] Senior officer of a net manufacturing company, personal communication, August 2003.

Table 11. Implementation Issues for LLIN Technologies

LLIN Process	Level of Difficulty in Establishing Quality Control	Investment Required	Ease of Protecting Intellectual Property	Potential for Knowledge Transfer	Worker Safety and Environmental Considerations	Cost	Application in Remote Areas
Fiber-based	Medium	Low	High	Low	Depends on choice of insecticide and specifics of process	Unknown	Nets have to be transported from factory
Industrial	High	High	Low	High		Unknown	
Field	High	Medium	High	Medium		Likely to be highest	Could be applied locally

None of these potential approaches to making LLINs stand out as an ideal way to ensure that LLINs are produced in Africa. Little data on costs exists, as most of the LLIN technologies have not yet been scaled up for industrial production. Nevertheless, this discussion could be useful to stakeholders in the LLIN effort as they consider the potential tradeoffs that may have to be made between developing technical capacity in Africa and ensuring that many net producers are able to enter the LLIN market. For potential producers, a fiber-based solution that can be used without requiring additional equipment and special arrangements to protect intellectual property would be ideal. Alternatively, if developers are concerned about protecting their intellectual property, then alternative strategies for technology transfer will have to be found, and developing these could require technical assistance and study by partners, such as foundations, that are not directly involved in the commercial transactions.

Financing the Production of LLINs

Accessing capital is frequently difficult for African companies because of the low levels of private investment in Africa.[51] When available, investments often carry high interest rates and short payback periods; commercial bank rates in Kenya were recently over 20 percent.

Donor participation in facilitating access to low-cost funding will increase the opportunities for African net producers to make the investments that might be needed to access LLIN technologies. A to Z Textile Mills has thus been able to benefit from the support of the Acumen Fund through a loan to set up the manufacturing capacity for the Olyset net, and ideally other African net producers will also have the opportunity to work with financing institutions to increase LLIN manufacturing capacity.

This business plan is expected to help investors become better informed of the opportunities that are posed by the development of the market in long-lasting nets, and better prepared to identify and to work with potential partners.

[51] Hernandez-Cata, E. June 2001. *Raising Growth and Investment in Sub-Saharan Africa* (*Findings* 185). Washington, D.C.: World Bank Group. <http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000094946_01082304074145>

Demand Creation and Distribution

Sustainability of LLIN manufacturing will require the development of a viable private commercial market in long-lasting nets. The work being done by UNICEF, NetMark Plus, and PSI in building a net culture in Africa was discussed in the first part of this business plan. In summary, UNICEF's activities focus on distribution of nets to the most vulnerable segments of the population (children under five and pregnant women), PSI is using innovative social marketing strategies to make nets available and affordable to a broader segment of the population, and NetMark Plus has continued to work on strengthening the commercial sector and has added components to their program directed toward equity in net distribution. In addition to these three multicountry efforts, GFATM money is being made available to many countries for use in malaria programs. Preliminary estimates of the number of nets that will be purchased using Global Fund money from Rounds 1 and 2 indicate that 6.7 million nets will be distributed in Year 1, 15.1 million by Year 2, and a total of 27.0 million by Year 5.

The third part of this business plan will compile the estimated number of net purchases for the next few years from these sources and look further at distribution strategies, including the use of vouchers that can also contribute to building the commercial market in LLINs.

Conclusion

It is impossible to select a definite "winner" for LLIN technology. The field is evolving rapidly, and outside stakeholders are also dealing with shifting priorities. In closing, the following five key takeaway points should be highlighted—

1. Only one LLIN technology (Olyset) is both recommended by WHOPES and currently available as of mid-2003, but there is insufficient capacity to meet projected demand. A second technology (Permanet) will be re-evaluated at the end of 2003, but alternative technologies are at least one to two years away in terms of technical development and passing the WHOPES testing process.

2. Manufacturing quality control for LLIN production is likely to be a technical challenge that will require external support, especially for smaller net manufacturers who may be still learning the basics of quality control for conventional net production.

3. While active research and development efforts are ongoing at a spectrum of companies and organizations, several of these companies have highlighted worker safety and environmental concerns that need to be addressed.

4. Tax and tariff rates make it difficult for African net producers to compete against importers.

5. LLIN costs cannot be definitively predicted at this time, so a comparison of the advantages and disadvantages of manufacturing in Asia versus in Africa could be helpful in focusing LLIN development efforts.

Successfully getting LLINs to sub-Sahara Africa will require addressing the issues highlighted in this analysis. As LLIN technology matures, net producers will have to be encouraged to enter LLIN production. Meeting the potential demand for LLINs with nets produced in Africa would necessitate an enormous scale-up of capacity on the continent, requiring the equivalent of eight producers the size of A to Z, the largest net producer in Africa, each with the capacity to process roughly 70 million square meters of netting per year into five million finished nets. To achieve this will require the removal of the obstacles manufacturers currently face, especially in the context of strong competition from Asian producers. The complexity of LLIN technology means that the smaller net producers are likely to need external support in the form of low-cost financing, technical assistance with quality control, or both. Each stakeholder will have a role to play: governments in rationalizing taxes and tariffs; WHO in developing specifications for LLINs and in providing technical expertise; UNICEF in ensuring that the nets it buys are made by net producers who respect worker and environmental safety standards; donors in facilitating low-cost financing; and the private sector in continuing development of viable LLIN technologies.

This business plan is meant to serve as a living document that can be updated as the field situation changes and LLIN technologies continue to develop. The market for LLINs is expected to grow rapidly as UNICEF scales up its purchases, Global Fund money becomes available, and the efforts of NetMark and PSI expand. This growth will mean that there will continue to be a place for new LLIN technologies to enter the market. The summary of LLIN technologies provided here may become rapidly out of date as the field evolves; nevertheless, the framework outlined for categorizing these technologies should still be useful for policy makers, institutions, NGOs, and private sector organizations working to get LLINs into Africa.

The third part of this business plan will bring the different themes explored in the first two parts together as the strategies that will be needed to move forward are considered.

PART 3. STRATEGIC ANALYSIS AND RECOMMENDATIONS

Planned Distribution of Nets

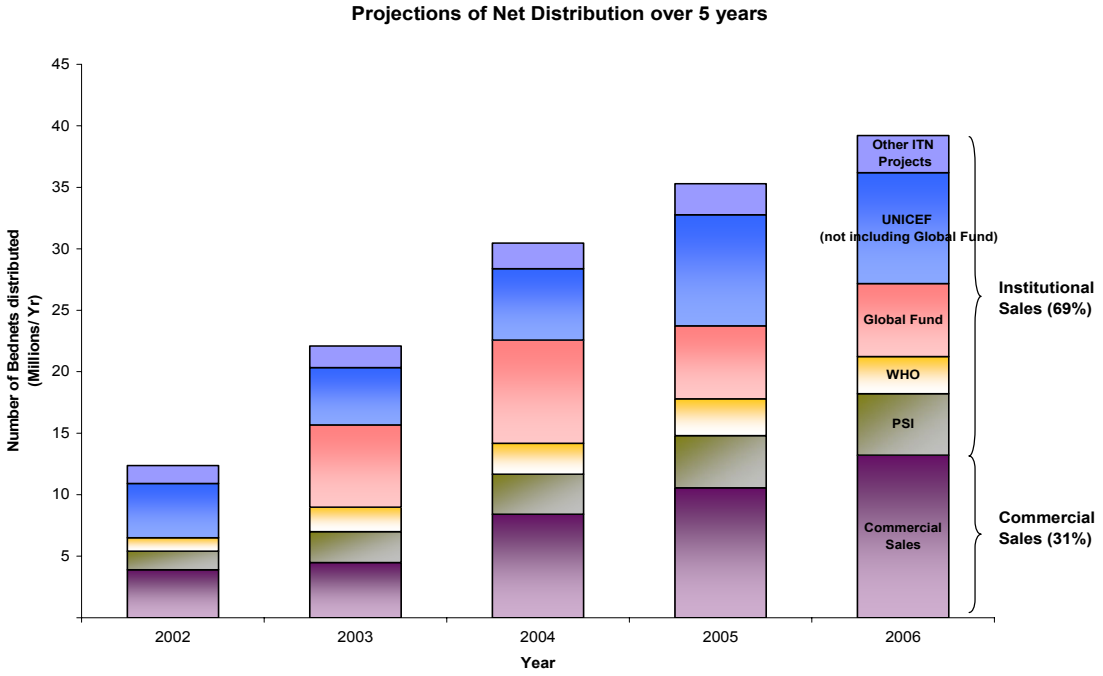
Cumulative estimates for the number of nets distributed per year are 35 million nets by 2004 and 42 million nets by 2006. Over the period of 2002 through 2006, this will add up to an estimated 152 million nets. These figures could be much higher as existing initiatives expand their reach, the Global Fund continues to support new country proposals, and the commercial market develops. For example, the rapid evolution of commercial sales in Tanzania, where there was a steady 20 percent growth in net sales from 1994 to the present,[52] suggests that there could be similarly rapid growth of commercial sales in other countries if a "net culture" is developed. Therefore, the number of nets that will be distributed by 2006 could be much higher than 42 million.

The estimates shown in Figure 8 include information from the following sources—

- Global Fund proposals from Rounds 1 and 2[53]
- UNICEF Supply Division estimates[54]
- Estimates from PSI[55]
- Data on ITN projects compiled by WHO with an assumed 20 percent growth rate over the next five years[56]
- Estimates of commercial sales based on previous data with an assumed 20 percent growth rate, combined with data from NetMark Plus partners[57]

The numbers for purchases by WHO are estimates based on the relative size of these procurements compared to those of UNICEF for 2002. The UNICEF figures as originally supplied were modified downward to account for the possibility that Global Fund–related procurement may take place through the Supply Division and to reduce the risk of double counting. Numbers for LLIN sales are not counted separately because the LLINs' recent arrival on the market and their limited availability make it impossible to make independent projections of their future distribution.

[52] Dr. Jo Lines, London School of Tropical Medicine and Hygiene, personal communication, February 2003.
[53] Global Fund proposals available at <http://www.theglobalfund.org/search/default.aspx?lang=en>.
[54] Courtesy of M. Lainejoko, UNICEF Supply Division.
[55] Courtesy of B. Smith, PSI.
[56] Courtesy of Dr. M. Kawano, WHO.
[57] Courtesy of D. McGuire, Director, NetMark Plus.



Sources: UNICEF, PSI, Global Fund Rounds 1 and 2 proposals, WHO, NetMark Plus, London School of Hygiene and Tropical Medicine studies
Note: Commercial sales include NetMark Plus and other estimates

Figure 8. Growth in Net Distribution (All Types)

The estimates in Figure 5 suggest that institutional purchases will continue to make up the bulk of net purchases over the next few years. Although these estimates do not distinguish between LLINs and conventional nets, all of the RBM partners contacted have stated their commitment to including LLINs in their programs as they become more available. Therefore, it appears that there will be sufficient demand for LLINs, based on the currently available information, to justify an investment in LLIN manufacturing capacity on the part of net manufacturers. If LLINs are available in sufficient quantity, demand should grow very rapidly when compared to a baseline estimate of combined Olyset and Permanet sales of 4.5 million during 2002.

Distribution of Nets

Several different mechanisms for distribution are currently used, and innovative approaches are being developed to enable the distribution of a large number of nets while ensuring equity. A country-by-country description of these mechanisms is not possible here, but they generally fall into one of four categories—

1. **Free or heavily subsidized distribution through public health–oriented approaches.** UNICEF, among other partners, has been focusing on children under five and pregnant women, using a variety of approaches allied with public health initiatives such as Integrated Management of Childhood Illness (IMCI); EPI and other vaccination campaigns; information, education, and communication (IEC) campaigns; and community development activities. In Zambia, for example, UNICEF has supplied nets both to locally based programs that sell them at subsidized prices in

rural clinics and to district health management teams for community-based distribution. For Africa Malaria Day in 2001, UNICEF supplied 70,000 nets in Kenya for free distribution to pregnant women in 35 districts. It was able to do this at a cost of USD 3.81 per net.[58] Across West and Central Africa, UNICEF integrates the distribution of free or highly subsidized nets within IMCI plus as part of its overall Accelerated Child Survival and Development strategy.

In addition, UNICEF has provided many free nets in emergency situations, such as after the floods in Mozambique in 2000.

2. **Social marketing.** This approach uses commercial marketing strategies for the promotion of public health goods and is used in a number of innovative ways to distribute nets. PSI has been one of the pioneers of this approach, which is having great success in a number of countries, such as Malawi, where PSI, in partnership with UNICEF, sells green rectangular nets at highly subsidized prices (USD 1–1.50 per net) to mothers and children attending prenatal clinics. In parallel, blue conical nets are sold through commercial sector channels at less subsidized prices (USD 5.60 for the consumer), and revenues from these sales are used to cross-subsidize the cheaper nets. This program has continued to expand and is on track to sell 500,000 nets in 2003, equal to the entire amount sold from 1998 to 2001, and subsidized prices for the green nets are now below USD 1, due to economies of scale and other efficiencies. The current cost to donors per net delivered through PSI's project in Malawi is estimated at only slightly over USD 2 per net.[59]

3. **Subsidizing net purchases through use of vouchers.** Initiatives that use this approach distribute vouchers to a selected target population, which, in turn, uses the vouchers to get a fixed discount on nets that are purchased from commercial outlets. An innovative approach using bar-coded vouchers combined with a computerized management information system (MIS) has been proposed for the Uganda National Voucher Scheme by MEDA.[60,61] A number of features of this system should reduce the risks of counterfeits and leakage that are often problematic with voucher schemes; these features include the use of vouchers that are hard to reproduce; fixed expiry dates; the use of bar-code stickers that are applied to the ITNs in a secure warehouse; and the deployment of a two-part voucher to enable monitoring and evaluation.

   In Tanzania, Global Fund money will also be used to develop a national-scale voucher system for net purchases.

   Although vouchers hold great appeal as a demand-side subsidy system, some reservations exist about their wholesale adoption.

[58] Guyatt, H., S. K. Corlett, T. P. Robinson, S. A. Ochola, R. W. Snow. 2002. Malaria Prevention in Highland Kenya: Indoor Residual House-Spraying vs. Insecticide-Treated Bednets. *Tropical Medicine and International Health* 7(4):298–303.
[59] U. Gilpin, Population Services International, personal communication, April 2003.
[60] Langi, P. 2003. *Uganda National Voucher Scheme for Accessing Subsidized ITNs to Vulnerable Groups*. Presentation at Workshop for Mapping Models for Delivering ITNs through Targeted Subsidies, May 13–15, Lusaka, Zambia.
[61] Mennonite Economic Development Associates (MEDA). 2003. *Design of a National Voucher Scheme for Insecticide-Treated Mosquito Nets in Uganda*. Winnipeg, Manitoba: MEDA.

4. **Stimulating the commercial sector.** NetMark Plus has taken the lead in strengthening the commercial sector under its expanded range of activities, which include market priming activities and targeted subsidies. Market research is used to develop consumer-focused generic marketing campaigns. NetMark Plus activities also include support for distribution networks in places where there has often been a reluctance to make the investments needed to move nets to retail outlets.

5. **Independent commercial sector.** There is activity in the commercial sector in several countries, unsupported by any programs. To expand this, net manufacturers will have to actively market their products, which will require them to establish representation in multiple countries across sub-Saharan Africa. While some net manufacturers have been quite active in setting up field offices and representatives in many locations, other manufacturers have preferred to focus their efforts on the institutional procurement market and have been slower to invest in marketing for the private retail market. To increase sales in the private sector, net manufacturers will need to establish marketing strategies to expand their sales of LLINs to consumers through commercial distribution channels.

In summary, most of these approaches to distributing nets require some level of subsidy, whether it is directed toward the cost of the net itself or toward indirect support for marketing campaigns and distribution. For the near future, this means that LLIN distribution will be dependent on donor support. Over the longer term, exit strategies will have to be developed as net use increases, although the poorer and more vulnerable segments of the population will likely continue to need some type of subsidy to enable them to get an LLIN. Detailed descriptions of several projects using targeted subsidies are available elsewhere.[62]

No single approach has emerged as the universal solution to ensuring the equitable distribution of nets, although a voucher system has been used in several projects. While there are strong arguments, and some evidence, in favor of this demand-side type of approach to subsidies, the current voucher programs may not solve the equity issues posed by LLINs for the following reasons—

- **Lack of support for LLIN purchases.** The schemes planned on a national scale for Tanzania and Uganda will use a voucher that gives a fixed discount amount toward the purchase of any type of net; this voucher scheme is similar to the one piloted in Zambia.[63] With this type of nonselective voucher, LLINs will remain more expensive for consumers than untreated nets and conventional ITNs because the "starting" price for LLINs is likely to be higher than the prices for the other kinds of nets. Therefore, it is quite likely that consumers will apply their vouchers to buying conventional nets instead of LLINs, and LLIN uptake will be slow.

- **Leakage costs.** With the large number of nets that will be subsidized, even low levels of leakage could be quite costly to donor agencies. Monitoring systems will have to be robust to minimize problems that could arise, such as the re-sale of vouchers, and this monitoring system will add to overhead expenses.

[62] ITN Working Group. *Workshop on Mapping Models for Delivering ITNs through Targeted Subsidies*. Summaries available at <http://mosquito.who.int/cmc_upload/0/000/016/562/lusaka.htm> (accessed Sept. 4, 2003).
[63] Chimumbwa, J., and H. A. Mwenesi. 2003. *ITN Targeted Subsidies in Zambia*. Presentation at Workshop on Mapping Models for Delivering ITNs through Targeted Subsidies, May 13–15, Lusaka, Zambia.

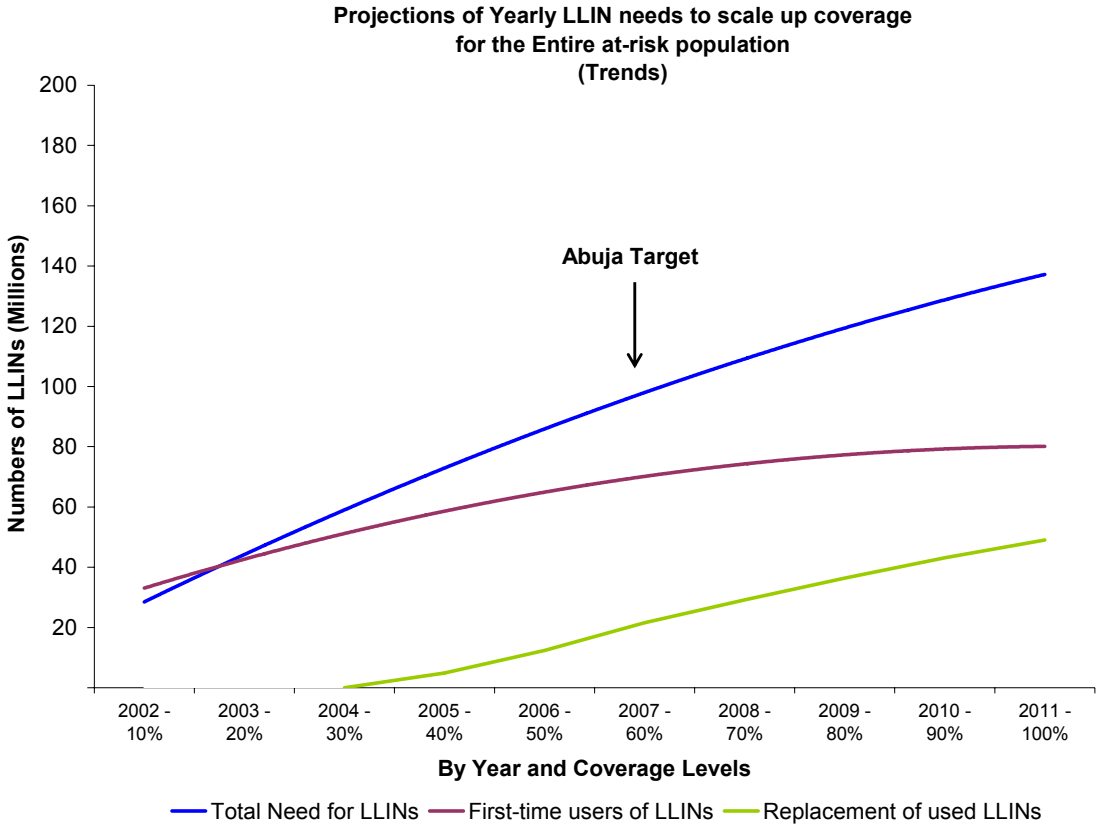
- **Increased costs to cover rural areas as programs are scaled up.** A national scaling-up, as planned by Uganda and Tanzania in their Global Fund proposals, will require coverage of rural areas, where a majority of the population lives. This will require that redemption procedures for both consumers and retailers be made accessible, in terms of paperwork and geography. For retailers in rural areas to develop trust in the system, redemption centers must be located nearby and be capable of handling the cash conversion process in a timely fashion. Communication campaigns will be needed to inform retailers and consumers about the voucher scheme and how it works. If retailers have difficulty redeeming their vouchers for cash, retailer participation will lag and, in turn, consumers could see little benefit from the voucher scheme. The increased transaction costs associated with implementing the scheme in rural areas could make free distribution of LLINs more attractive.

In conclusion, vouchers are attractive because they allow consumer choice and can encourage participation by the retail sector in net distribution, but they should not be seen as the only choice for targeted subsidies. Continued evaluation and development of alternative methods of providing targeted subsidies are needed.

Analysis of the Remaining Gap in Coverage and the Investment Needed to Cover It

While this analysis indicates that there will be a significant increase in the number of nets that are planned for distribution over the next few years to the populations of sub-Saharan Africa, significant gaps will remain to reach the Abuja target of 60 percent coverage. To quantify the size of this gap, the number of LLINs that will be needed to scale up the coverage of two different target populations was calculated; first, the entire at-risk population (Figure 9), and second, the population of children under five and pregnant women. Conservative assumptions were chosen for the calculations, including: (1) an average life span of three years for a net;[64] (2) an average population growth of 2.3 percent per year; and (3) a linear increase in coverage rates over 10 years to reach 100 percent of the population. To permit users to input their own assumptions, the model used to make these calculations will be made available separately from this strategic plan.

[64] The number of years that a polyester net will last is controversial; much of the literature says they will last five years, but there are reports of nets lasting only one to two years in rural areas.

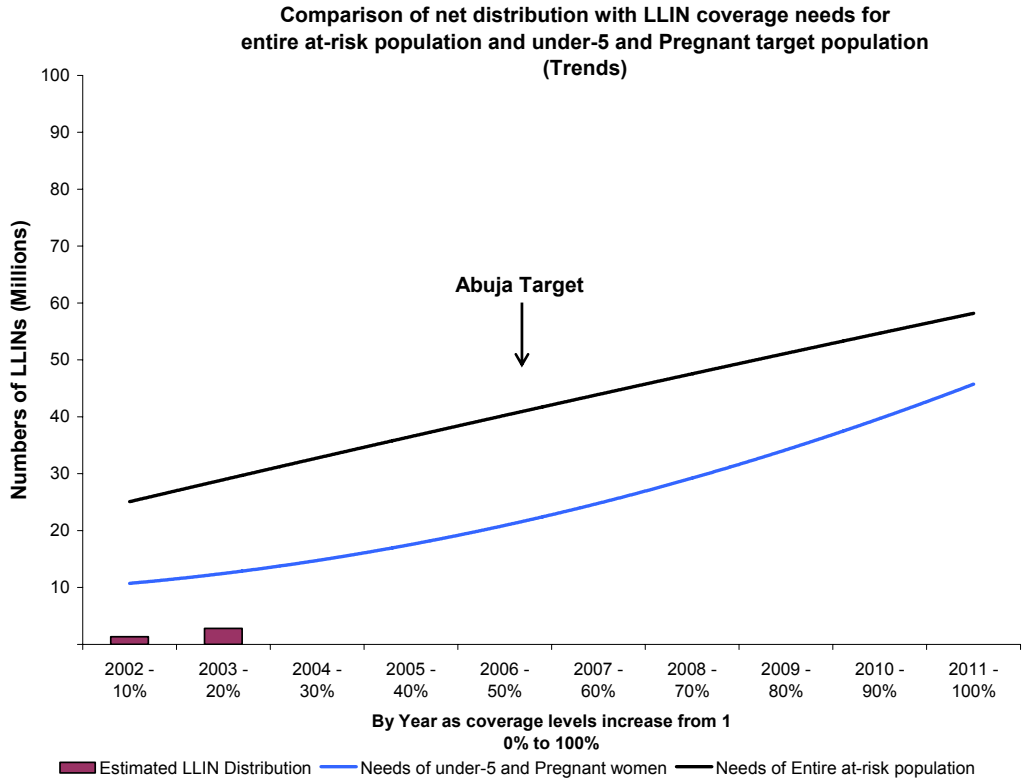


Source: United Nations Population Division

Figure 9. Structure of Demand for LLINs

From this analysis, it is evident that the demand for replacement nets will become an important part of overall demand for LLINs even as coverage rates continue to increase. This shift in demand from the distribution of nets to first-time users to the distribution of replacement nets could present the opportunity to achieve other goals, such as protection of the environment or the reinforcement of public health strategies directed at children. For example, strategies for replacing nets could include a component that would ensure proper disposal of used nets as they are exchanged for new ones, or that would provide a new LLIN in the context of an IMCI-related visit.

The analysis also indicates that current plans for distributing nets will barely meet the needs for coverage of children under five and pregnant women, even if all these nets are LLINs, and will fall far short of meeting the needs for coverage of the entire at-risk population (Figure 10).



Source: United Nations Population Division. Estimates of projected distribution from Figure 1.

Figure 10. Net Distribution vs. LLIN Needs

A large increase in the manufacturing capacity of LLINs will be needed, as well as extensive participation by donors and public agencies, in order to make LLINs accessible to those who need them, regardless of ability to pay.

The Costs of Scaling Up Production to Meet Needs

Some estimates of the size of investment that would be needed to scale up net production are listed in Table 12, which includes the costs of the machinery needed to set up a line capable of producing 1–1.5 million nets per year, both for conventional polyester nets and Olyset-type polyethylene nets.

Table 12. Machinery Costs for Net Production from Raw Material

Net Production (from compatible yarns, including polyester and propylene)		Polyethylene Net Production (from compound)	
MACHINERY	INVESTMENT	MACHINERY	INVESTMENT
Warp Knitting Machine x 4	$580,000	Extruder	$150,000
Warping Set	$395,000	Warping Set	$395,000
Stenter	$500,000	Warp Knitting Machine x 4	$580,000
Sewing Line (50 machines)	$200,000	Sewing Line (50 machines)	$200,000
TOTAL	$1,675,000	TOTAL	$1,325,000

Sources: Estimates furnished by Karl Mayer GmbH, A to Z Textile Mills, UNICEF

The costs in Table 12 are for equipment alone. Besides these equipment costs, LLIN production may require additional equipment, depending on the process used. Factory overhead costs, training costs, and the extra costs of establishing QC facilities and procedures would also have to be included.

Taking into account these supplementary costs, it is estimated that an investment of USD 2 million to USD 2.5 million will be needed to install a new facility capable of manufacturing 1.2 million LLINs per year (100,000 per month). To cover the needs of the population of children under five and pregnant women alone (Figure 10) would require an investment in new facilities of close to USD 50 million, even taking into account planned production of the Olyset and Permanet nets. Meeting the needs of the entire at-risk population could require an investment as high as USD 150 million. Large as these investments may seem, calculations suggest that the overall savings made possible by the use of LLINs in place of conventional nets will outweigh these costs.

Potential Cost Savings of Using LLINs Instead of ITNs

This section presents a further analysis of the costs of providing access to LLINs across sub-Saharan Africa to both the population of children under five and pregnant women as well as to the poorer segments of the population. First, the per-year costs of providing LLINs are compared with the costs of providing ITNs and retreatment campaigns. For this analysis, a number of assumptions were made regarding the life span of a net, the number of insecticide retreatments per year, and the purchase cost of a conventional net and an LLIN (Table 13). The costs of a retreatment campaign are based on those of existing retreatment programs.[65] A spreadsheet model that accompanies this report will permit readers to enter their own assumptions and to arrive at their own cost estimates, as firm data concerning the life span of a net is lacking and there is a variety of numbers currently being used.

[65] Dr. P. Guillet, WHO, personal communication, August 2003.

Table 13. Assumptions for Cost Comparison between Conventional Nets and LLINs (3-year net life span)

Cost per net for conventional net and retreatment (in USD):		Cost per net for LLIN (in USD)	
Initial Cost of Net and Treatment Kit		**Initial Cost of Net**	
Untreated net	1.60	LLIN	5.00
Delivery to clinic	0.22	Delivery to clinic	0.22
Freight/customs	0.11	Freight/customs	0.11
Insecticide kit if bundled with net	0.40	Insecticide kit if bundled with net	N/A
= Cost to deliver net + 1 treatment kit	**$2.33**	**= Cost to deliver 1 LLIN**	**$5.33**
Retreatment Costs		**Retreatment Costs**	
Insecticide	0.40	Insecticide	0.00
Retreatment campaign (per net)	0.80	Retreatment campaign (per net)	0.00
Total cost of 1 retreatment	**$1.20**	**Total cost of 1 retreatment**	**$0.00**
Life span of a net in years	3	Life span of a net in years	3
Retreatments per year	2	Retreatments per year	0
# of additional retreatments over lifetime of net	**5**	# of retreatments over lifetime of net	**0**
= Retreatment costs of lifetime of net (5 x $1.20)	**$6.00**		**$0.00**
= Lifetime cost of conventional net	**$8.33**	**= Lifetime cost of LLIN**	**$5.33**
= Per-year cost of conventional ITN (over 3 years)		**= Per-year cost of LLIN (over 3 years)**	

Sources: UNICEF report; WHO.
Notes: Cost of untreated net and insecticide kit are based on recent institutional procurement cost figures. Costs of delivery to clinics and freight/customs are based on August 2001 report of UNICEF-funded distribution of free nets. Retreatment costs are based on the estimated cost per net of a retreatment campaign. LLIN price is based on indicator price set by UNICEF.

The underlying model used to make these calculations will be available separately from the business plan. With these assumptions, it appears that the cost per year of providing coverage with an LLIN could be as much as 36 percent less expensive than providing coverage with a conventional net. This saving becomes significantly larger as the life span of a net increases (Figure 11).

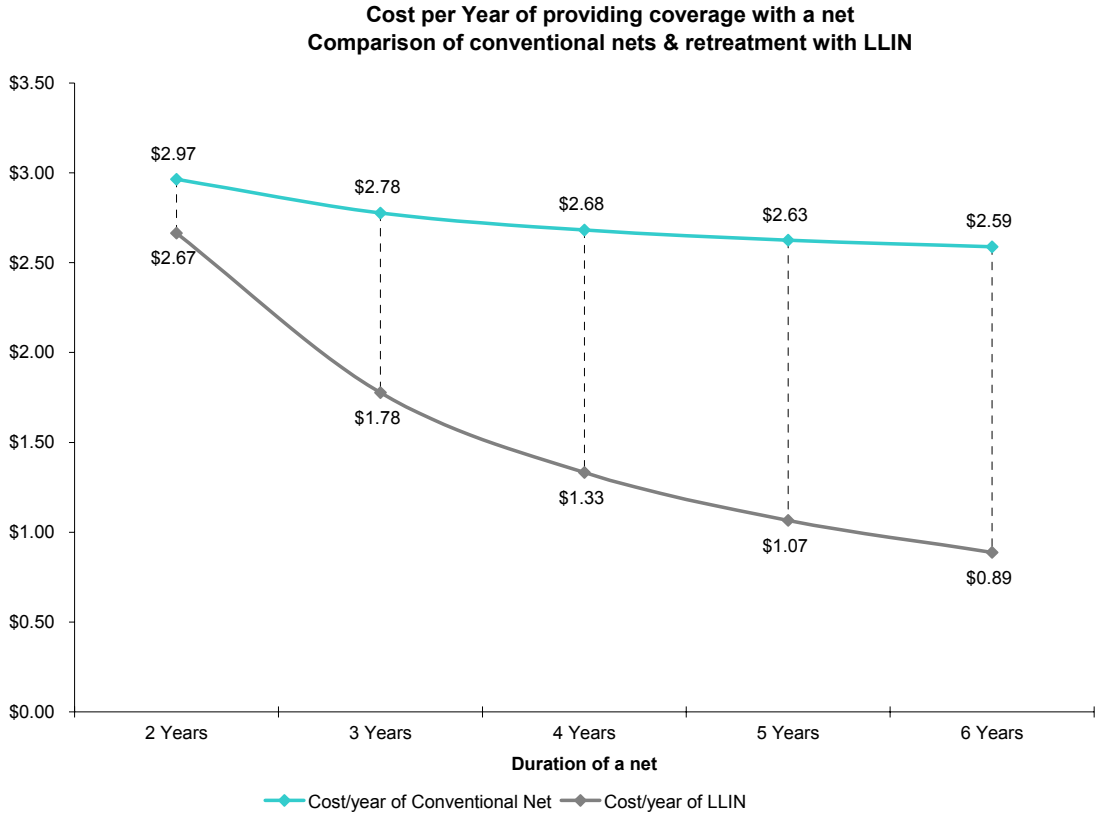


Figure 11. Comparison of Cost per Year of Providing Coverage with a Conventional Net Requiring Retreatment vs. LLIN

These savings are theoretical because they assume that follow-up retreatments of the ITNs are actually done. This may be possible if retreatment is free, but it would require considerable organizational and logistical effort to carry out retreatment campaigns on a large scale. In actual practice, retreatment rates are low (typically below 20 percent), even when intensive efforts are made to educate the population. LLINs are thus more cost-effective on a per-year basis not only when considering comparable protective efficacy, but also on a practical basis because retreatment is not required. When the cost savings above for an individual net are extrapolated to a population basis, the global cost savings possible becomes quite large (Table 14). These calculations for the total costs of providing ITNs and LLINs to selected target populations do not take into account existing net distribution initiatives or the contribution of users, but are intended to give an idea of the magnitude both of the cost of providing nets and of the potential savings if LLINs are used. The number of nets per person that was chosen for the model assumes the following: (1) to ensure coverage of the children under five and pregnant population, it is necessary to count one net per person, even if the net is actually shared by mother and child, because of the probability that someone else in the house may also need a net; (2) for coverage of the general population, it can be assumed that a net will be shared by two persons. In this analysis, the economically vulnerable population was defined as that segment of the population living in households for whom the purchase of an LLIN, priced at USD 5.33, would exceed one month's worth of discretionary expenditures. This methodology for defining the capacity of individuals and households to

purchase health-related goods has been developed elsewhere[66] and was described previously in Part 1 of the business plan.

Table 14. Costs of Ensuring Equity in Net Distribution

	Cost of Providing 60% Coverage of—		
Factor	**Children Under Five and Pregnant Women**	**Economically Vulnerable Population**	**Entire At-Risk Population**
Number of Nets per Person	**1**	**2**	**2**
Number of Nets (in millions)	80.3	59.0	174.8
ITNs with Retreatment (in USD millions)	$222.9	$163.9	$485.4
LLINs (in USD millions)	$142.6	$104.8	$310.6
Cost Savings with LLINs	$80.3	$59.0	$174.8

Sources: UN Population Division data, UNICEF distribution costs
Notes: Total costs were calculated using the per-year costs of ITNs and LLINs for three-year life span of a net. See text for explanation of how number of nets per person was selected.

The data in the table above permit certain conclusions. First, providing nets, whether they are LLINs or ITNs that have to be retreated, will cost anywhere from USD 140 million to as high as USD 485 million depending on the target population selected. As noted above, this does not take into account user contributions; it is unlikely that international donors would cover all of these costs in order to distribute nets to the entire at-risk population, although they have demonstrated a commitment to the provision of free or heavily subsidized nets to those at biological risk (through UNICEF and other programs) and those at economic risk (through support for social marketing programs that sell nets at cost). Therefore, ensuring coverage for the entire at-risk population will require the significant expansion of the private commercial distribution of nets.

Second, the projected savings made possible by using LLINs to cover the target populations highlighted above appears to offset the investments in LLIN manufacturing capacity that will be required to meet these needs. However, these two aspects of LLIN scaling up are interdependent. Financing agencies or investors who provide funding for LLIN manufacturing capacity are likely to do so only if these projects are financially viable. In turn, these projects will be viable only if there is sufficient demand for LLINs. This demand in turn will depend on donor support for institutions and projects that subsidize LLIN distribution, as unsubsidized retail prices are likely to be beyond the reach of large segments of the population.

Nevertheless, distinguishing between the needs of net producers and the needs of net consumers allows different stakeholders within the RBM partnership to contribute in specific ways that are adapted to the strengths that each one brings to the table. Some organizations will continue to focus on supporting net distribution, while others, particularly those with the capacity to make soft loans, will hopefully support the financing needed to scale up LLIN production once they see that commitments have been made toward supporting the nets' distribution.

[66] Guimier, J. M., D. Candau, M. Garenne, and L. Teulières. 2002. *Pourquoi le prix des médicaments est élévé dans les pays d'Afrique sub-saharienne*. Paris, France.

This section has established the economies of using LLINs instead of ITNs and the need to support LLIN manufacturing in order to achieve the scaling-up of LLIN use in Africa; the elements that are necessary for the cost-efficient manufacturing of nets are discussed in the following section.

Elements of Competitiveness in Net Manufacturing

To win bids for international procurement orders, a net manufacturer has to be able to meet the demands for quality, low prices, and rapid delivery time. The limited resources that most households in Africa can dedicate to purchasing a net make it imperative that LLINs be available at prices that are affordable yet at the same time attractive enough to justify an investment in LLIN production on the part of net manufacturers and other potential entrants, which might include other firms in the textile industry.

In this section, the price structure of the manufacturing process of untreated nets is examined. This analysis is important to an understanding of how the implementation of LLIN technologies will affect net manufacturing costs and, by extension, the prices of LLINs. The net-making business has become extremely cost competitive. Ten to fifteen years ago, nets were selling for USD 10 or more (FOB price), but current prices for untreated nets are often below USD 2. Profit margins have declined along with prices as worldwide capacity has expanded. Therefore, a cost differential of only a few cents per net can make the difference between winning and losing a bid and between a profit and a loss for a net manufacturer (assuming that other factors such as quality and delivery time are equivalent between competing bids).

Although the factors examined here are important, a net manufacturer's own management skills and company business strategy are also needed for success. For example, Tanzania may not appear to offer a very favorable environment for making nets because of high transportation costs and difficulties with infrastructure, such as poor roads and unreliable electricity, but nevertheless A to Z Textile Mills has grown from its base in Arusha to become one of the world's largest net manufacturers and has taken the lead in pioneering the production of LLINs in Africa.

The information presented here came primarily from discussions with net manufacturers, with supporting data gathered from research on the Internet.

Choice of Manufacturing Location

The vast majority of nets in use today in Africa are made in Africa or in Asia. While individual differences in the business environment between countries make it impossible to state definitively which country or countries are the best locations for net manufacturing, available data on tariff rates and the costs of equipment permit different scenarios for the production of untreated nets to be modeled (Table 15). These costs are used as a starting point to understand the cost aspects of competitive net manufacturing, and their application to the manufacturing of LLINs is discussed below.

The model presented is a simulation of net manufacturing cost structures under several scenarios: (1) an existing Asian manufacturer who uses equipment that is already amortized,

or paid for; (2) an African manufacturer who is trying to sell nets at the same price as nets from Asia; and (3) an African producer who is pricing nets in a way that permits a sustainable business.

The assumptions made are—

- High-quality German machinery is used to set up the production line.
- A soft loan is available at a 5 percent interest rate over a period of 60 months to cover the financing for new equipment.
- Tariff rates on imported yarn are only 10 percent (in many African countries, they are higher).
- Yarn is available on the domestic market in Asian countries where there is sufficient yarn extrusion capacity, while it is imported into Africa where yarn extrusion capacity is minimal.[67]

Additionally, producer efficiency is assumed to be similar between manufacturers. The underlying model accompanying this business plan will allow users to input their own assumptions about costs.

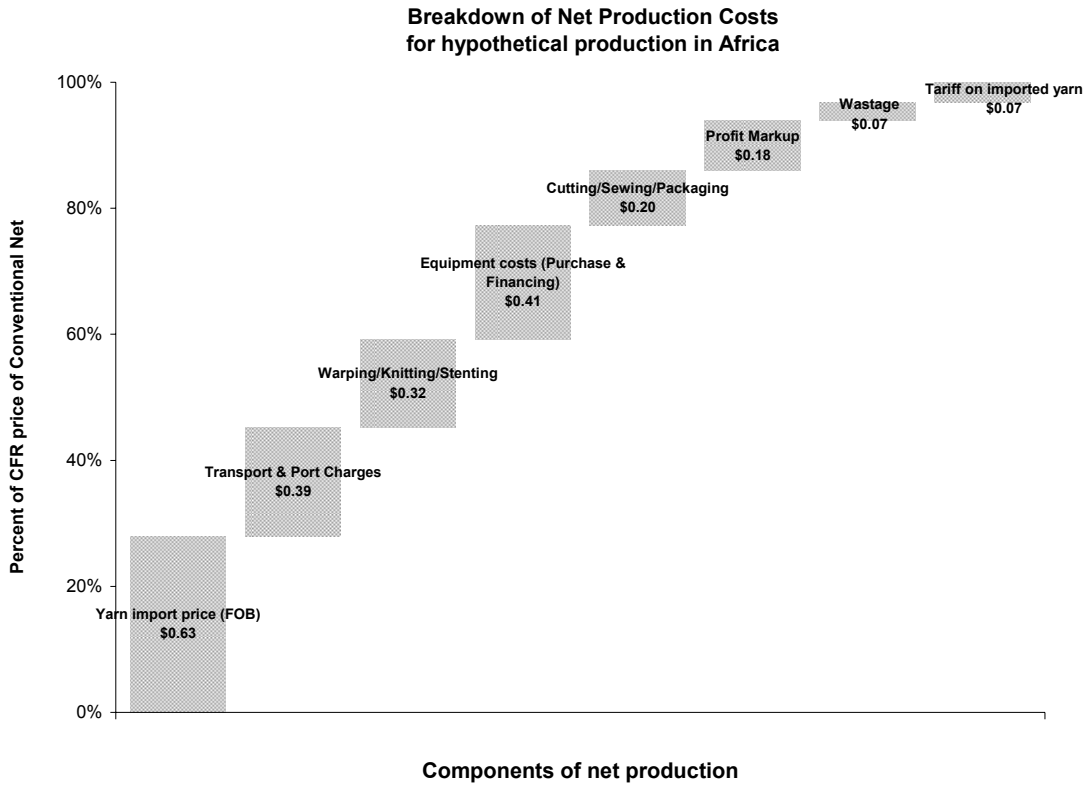
[67] Mr. René Moissonnier, Global Industry Leader, Clariant Corporation, personal communication, June 2003.

Table 15. Comparative Costs for Net Manufacturing

The user of the Excel model can modify the parameters which are shown below.	(1) Vietnamese producer making conventional nets using **existing equipment**, local labor, and yarn that is purchased on local market	(2) African producer making conventional nets with **new equipment, imported yarn**, and production conditions identical with Vietnam, and selling at price competitive with Vietnamese production	(3) African producer making conventional nets with **new equipment, imported yarn,** and selling at commercially sustainable price
Step 1.			
Yarn or Compound import price (FOB)	0.63	0.63	0.63
Sea Freight (Asia to Africa)	N/A	0.06	0.06
Transit Agent Fees and Insurance	N/A	0.01	0.01
Yarn or Compound price (CIF)	**0.63**	**0.71**	**0.71**
Step 2.			
Tariff on imported yarn	N/A	0.07	0.07
Transport from port and associated charges	N/A	0.02	0.02
Warping/Knitting/Stenting **(W/K/S)**	0.35	0.35	0.32
Other Charges-			
Equipment Depreciation	*0.00*	*0.15*	*0.15*
Loan Repayment	*0.00*	*0.26*	*0.26*
Profit markup (Netting Production Steps)	Included in W/K/S	Included in W/K/S	0.15
Cost of producing netting material from yarn	**0.35**	**0.85**	**0.97**
Step 3.			
Cutting/Sewing/Packaging **(C/S/P)**	0.22	0.22	0.20
Wastage (4% of netting material)	0.04	0.06	0.07
Profit markup (Cutting and Sewing Steps)	Included in C/S/P	Included in C/S/P	0.03
Cost of producing net from netting material	**0.26**	**0.28**	**0.29**
EXW Price (Add totals from Steps 1-3):	**1.24**	**Set at 1.24**	**1.97**
Step 4.			
Transport to port and associated charges	0.09	0.09	0.09
Sea freight (Vietnam to Africa)	0.20		
Sea Freight (from African port to African port)		0.20	0.20
CFR Price	**1.53**	**Sold at 1.53**	**2.26**
Net Manufacturer's Total Profit:	**Included above**	**-0.61**	**0.18**
Variable Parameters to be set by user of Excel model.			
Theoretical maximum net production/yr:		1,500,000	1,500,000
Machinery utilization rate (cover downtime):		80%	80%
Effective annual net production capacity:		1,200,000	1,200,000
Equipment Capital Cost:		$1,400,000	$1,400,000
Equipment Depreciation Life (Yrs)		8	8
Wastage		4%	4%
Loan Type (Commercial or Soft):		Soft	Soft
Loan Amount:		$1,400,000	$1,400,000
Interest Rate (annual):		5%	5%
Loan Maturity (Months):		60	60
Cost of Credit:		185,184	185,184
Start of Payback period (mth):		0	0
Assumed profit markup of Vietnamese producer		10%	10%
Net Manufacturer's Profit Markup:		10%	10%
Tariff Rate (Imported Yarn or Compound):		10%	10%
VAT (Locally Produced Netting):		0%	0%

Source: Interview with net manufacturers (names held confidential upon request)
Notes: CFR = Cost and Freight (Incoterm)

According to this analysis, an African manufacturer who sets up a brand-new facility and who has to borrow in order to finance his or her equipment, and who subsequently tries to sell an untreated net at a cost and freight (CFR) price competitive with that of a Vietnamese producer, can only do so at a significant loss (USD 0.61 per net). At a more realistic price (USD 2.26 per net), his or her nets are 47 percent more expensive to an institutional buyer who buys at the CFR price. To develop additional insight into the cost structure of the manufacture of untreated nets, the costs that would be faced by an African manufacturer are categorized in Figure 12.



Source: Personal communication with various net manufacturers (kept confidential upon request)
Notes: Cost breakdown assumes—
(1) Imported polyester yarn is used.
(2) Import tariff on yarn is 10 percent (in many countries, the tariff is higher).
(3) Transport and port charges include those for importing yarn and sending final net by sea.
(4) Loan to finance equipment is at 5 percent over five years.
(5) Equipment costs are USD 1.2 million, depreciated over eight years.
(6) Production costs are based on those from Asia, taking into account a 10 percent profit margin.

Figure 12. Breakdown of Costs in Untreated Net Manufacturing

The four most important factors, in decreasing order of cost, are raw materials; transportation and associated services; the transformation of yarn into netting material through warping, knitting, and stenting; and equipment (including financing). These factors and others, such as those related to the business environment, are discussed in more depth in Annex 9 while the relative importance of the principal elements is summarized above. The majority of these factors are beyond the direct control of the net manufacturer: Yarn and equipment costs are determined on the world market; financing costs depend on available financing; and tariffs are determined by governments. A manufacturer does have a choice of location, which can affect transport-related charges; systems to improve production efficiency; and what profit

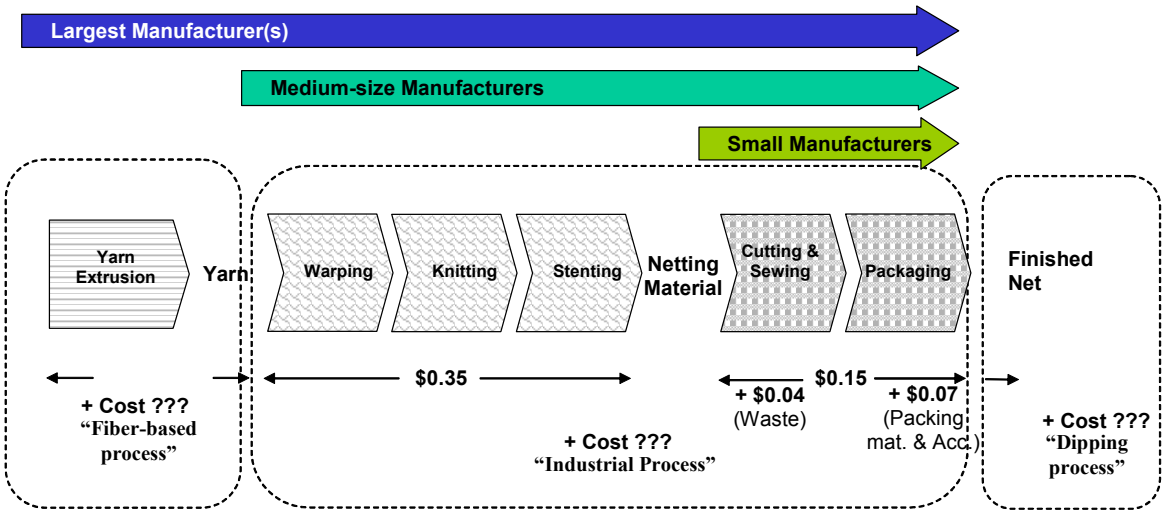
markup to add at the end, but these decisions will have only minor impact on the cost structure shown in Figure 12. The primary sources of the cost differential between African and Asian nets include equipment-related costs for depreciation and financing, and tariffs on the imported yarn.

It may seem surprising that there appears to be little comparative advantage to local manufacturing, but this can be explained by several reasons: (1) transport costs between African countries are as high as those between Asia and Africa, whether by sea or by land; (2) polyester yarn has to be imported into Africa, which incurs additional transport costs, as well as tariffs and taxes; (3) there is little customization for the local market, which often can be advantageous to producers who are located near consumer markets but does not appear to be so for nets, where general parameters such as choice of size and color do not require close interaction with customers.

Before the ways in which various actions by governments and other stakeholders can ameliorate some of these obstacles to African production are analyzed, the relevance of the cost analysis for untreated net manufacturing to that of the eventual production of LLINs must be explained.

Cost Elements of LLIN Manufacturing

Understanding the manufacturing process of untreated nets is important because several of the LLIN technologies under development will result in processes that are used either as inputs to the net manufacturing chain ("fiber-based") or as applications at the output stage of the net manufacturing chain ("dipping process") (Figure 13).



Sources: Interviews with net manufacturers; on-site visit to net manufacturer (names held confidential upon request); and interviews with organizations developing LLIN technology

Figure 13. LLIN Technologies

The companies working on LLIN technologies have focused primarily on these two development strategies so that minimal investment on the part of the net manufacturers will be needed to make the shift from conventional net production to LLIN production. However, this could also mean that manufacturers based in Africa will still face a cost disadvantage compared to those based in Asia because they will still be faced with the issues highlighted earlier regarding tariffs and the investment costs associated with setting up production lines. This is a theoretical concern, given that most LLIN technologies are still under development, but it is worthy of consideration if there is a desire to ensure significant participation by African manufacturers in future LLIN production. To accomplish this, African governments, donors, financing institutions and institutional buyers will have particularly important roles to play, as will the net manufacturers themselves.

LLIN Production and Distribution in Africa

This section, the conclusion of the business plan, starts with two concrete examples of how action by governments and financing institutions could be effective in reducing the cost disadvantage faced by African manufacturers. It concludes with a discussion of the specific ways in which all the stakeholders can contribute to the shared goal of increasing the production and distribution of LLINs in Africa; the role of a coordinating mechanism is also outlined.

Examples of Ways to Reduce Manufacturing Cost Disadvantages in Africa

Reducing tariffs on the inputs for making nets and reducing capital investment–related expenses can significantly reduce the final production cost of an untreated net (Figure 14).

The user of the Excel model can modify the parameters which are shown below.	(3) African producer making conventional nets with new equipment, imported yarn, and selling at commercially sustainable price	(3) African producer making conventional nets with new equipment, imported yarn, and selling at commercially sustainable price
Step 1.		
Yarn or Compound import price (FOB)	0.63	0.63
Sea Freight (Asia to Africa)	0.06	0.06
Transit Agent Fees and Insurance	0.01	0.01
Yarn or Compound price (CIF)	**0.71**	**0.71**
Step 2.		
Tariff on imported yarn	0.07	0.00
Transport from port and associated charges	0.02	0.02
Warping/Knitting/Stenting (W/K/S)	0.32	0.32
Other Charges-		
Equipment Depreciation	*0.15*	*0.15*
Loan Repayment	*0.26*	*0.15*
Profit markup (Netting Production Steps)	0.15	0.13
Cost of producing netting material from yarn	**0.97**	**0.77**
Step 3.		
Cutting/Sewing/Packaging (C/S/P)	0.20	0.20
Wastage (4% of netting material)	0.07	0.06
Profit markup (Cutting and Sewing Steps)	0.03	0.03
Cost of producing net from netting material	**0.29**	**0.28**
EXW Price (Add totals from Steps 1-3):	**1.97**	**1.76**
Step 4.		
Transport to port and associated charges	0.09	0.09
Sea freight (Vietnam to Africa)		
Sea Freight (from African port to African port)	0.20	0.20
CFR Price	**2.26**	**2.05**

Source: Model used in Table 15

Figure 14. Possible Interventions to Improve the Competitiveness of African Net Producers

In the first case, reducing the tariff on imported yarn from 10 percent to 0 percent would reduce the production cost of an untreated net by USD 0.07, which, in turn, would lead to savings that could be passed on to consumers. This tariff reduction is possible if Ministries of Health, local net manufacturers, and other partners work together to convince the respective Ministries of Finance of the importance of doing so for public health. A description of how the political process has transpired in several African countries is available elsewhere.[68]

[68] Starling, M., and R. Njau. 2002. *Review of ITN Taxes and Tariffs*. London: Malaria Consortium.

In the second case, a reduction in the amount of the soft loan (which may be possible if a stake in equity is offered by an investor in place of part of the loan) results in a further USD 0.11 reduction in the production cost of an untreated net.

Together, these two interventions would result in a USD 0.19 reduction in the CFR price of an untreated net if it is assumed that the net manufacturer reduces his or her markup to take into account the reductions in the cost of production.

To go beyond these interventions for the production of untreated nets, and to enlarge the discussion to include wide-reaching strategies for promoting LLIN production and distribution, more stakeholders will have to be involved. The list below is a starting point for further discussions and planning by the RBM partners.

Stakeholder Actions for Promoting the Development, Production, and Distribution of LLINs

Governments

- Beyond previous recommendations and promises to lower tariffs and taxes on mosquito nets and insecticide,[69] developing local production of LLINs will also mean that tariffs and taxes are lowered for the inputs needed to make mosquito nets, such as polyester yarn.

- Regulatory approval processes should be streamlined. Accepting a WHOPES provisional recommendation and minimizing or eliminating the need for in-country testing will lead to quicker availability of LLINs in the country concerned.

Donors

- On the demand side, donors should continue working with RBM partners who will be distributing LLINs to ensure equity through targeted subsidies and free distribution to selected vulnerable populations. Donor input will also be needed to continue to develop and pilot new ways of providing targeted subsidies.

- On the supply side, low-cost, long-term financing will be needed to enable African firms to invest in LLIN manufacturing facilities. Technical assistance with developing business plans may also be needed for some firms that have been producing nets on a small scale and will require external support to scale up LLIN production, with its added complexity and requirements for rigorous QC.

- The possibility of developing a technology "trust" should be explored. This would be a strategy to use public or institutional funding to buy licensing rights or to underwrite the development of LLIN technologies. These technologies could then be licensed or transferred at low or no cost to net manufacturers.

[69] Roll Back Malaria Cabinet Project. 2000. *Part I: The African Summit on Roll Back Malaria*, *Abuja, Nigeria.* Geneva: World Health Organization.

Institutional Buyers

- As the buyers of the majority of LLINs both now and in the near future, institutional buyers will have to develop procurement policies that will support African manufacturers. These policies could include procurement from regional sources or, in the case of open procurement cycles, permitting a price differential in favor of African manufacturers. Strategies such as these have already been used by UNICEF to ensure supplier diversification for drugs and vaccines.

Manufacturers

- Manufacturers should take the risks of investing in LLIN manufacturing capacity and in seeking out partners with whom they could develop this capacity. Many of the multinational companies contacted during the writing of this business plan have expressed an interest in finding potential African partners.

- The potential availability of low-cost financing will enable manufacturers to share the risks of a new venture.

- Active marketing efforts will be needed to increase LLIN penetration in private commercial distribution networks. NetMark Plus could be a potential partner in several countries for developing brand awareness while both NetMark Plus and PSI are working on priming markets.

NetMark Plus, PSI, and Other Organizations Working in the Field

- Organizations working in the field should cooperate to find areas where their complementary expertise can increase the overall penetration of LLINs by targeting specific market segments.

- These organizations should contribute to market research to learn how LLINs will need to be adapted to meet consumer preferences.

- They should continue to innovate and explore ways of ensuring equity through, but not limited to, the distribution mechanisms discussed earlier.

- They should consider further expansion in French-speaking countries that are currently underserved by existing net distribution initiatives.

Global Fund

- The Global Fund should encourage future malaria-related proposals to focus on the distribution of LLINs rather than untreated nets or ITNs. This would be in line with the RBM strategy of promoting LLINs.

- It should develop recommendations for the procurement of LLINs that will favor a diverse supplier base and encourage African manufacturing of LLINs.

- It should work with the non-English-speaking countries of sub-Saharan Africa to increase access to Global Fund disbursements. In the first part of this business plan, it was noted that approved Rounds 1 and 2 proposals for French-speaking countries,

where 32 percent of the at-risk population lives, accounted for only 18 percent of the total funding approved for malaria-related programs. Technical assistance may be needed for these countries to prepare the documentation needed for submitting a proposal.

UNICEF—Program Division and Supply Division

- UNICEF should work with governments and other institutions to improve their procurement capacity.
- It should support the development of shared resources for providing external quality control of LLINs. Ministries of Health and other institutions and agencies that will buy LLINs will need reliable testing facilities.
- When possible, UNICEF should use regional suppliers for supplying nets to African clients.
- It should continue expanding the distribution of LLINs through the programs it supports, including free distribution in emergencies and for pregnant women, subsidized net delivery through health facilities, and community-based distribution.

WHO

- Through WHOPES, WHO should: (1) develop a comprehensive standard for LLINs that developers of LLIN technologies and manufacturers can use to guide their research and development efforts, to include details such as the number and type of washing cycles, the type of soap that should be used, and so on; (2) promulgate standards for QC; and (3) provide recommendations and advice to other stakeholders regarding technical aspects of LLINs.
- WHO should encourage and stimulate the development of regional testing reference centers in Africa that could be used both by the buyers of LLINs and, possibly, by manufacturers, to ensure quality.
- In its own procurement efforts, WHO should promote the purchase of LLINs.
- It should coordinate the presentation and collection of all relevant studies. For example, excellent information on ITN-related projects, including geographical information on location and on numbers of nets distributed, has been compiled separately but is quite complementary to understanding the market structure of nets. In addition, an online database was developed two years ago to facilitate the gathering of real-time data on retail net prices, but it appears underused.
- WHO should continue to provide support to all stakeholders by providing technical advice and expertise.
- It should advocate and promote efforts to scale up LLIN use throughout sub-Saharan Africa.

RBM Partnership

- The RBM partnership should refine the strategic framework to reflect the evolution of the market for nets and the development of additional LLIN technologies as they become available.
- It should mobilize and encourage contact between partners to work toward shared goals.
- Through the regional and country representative offices, the partnership should: (1) develop and maintain contacts with local net manufacturers; (2) collect data on net distribution; (3) collect data on tax and tariff levels on nets and on their inputs, including yarn and insecticide; (4) lobby Finance Ministries to reduce these taxes and tariffs where possible; and (5) collect price data on nets.

Organizations and Institutions That Are Developing LLIN Technology

- Although the LLIN market may be small compared to other markets that companies may be active in, overcoming the technological hurdles involved in making long-lasting impregnated nets could lead to breakthroughs in other related areas where profit potential will be greater. The public health importance of LLINs to Africa and the correspondingly high profile of the effort to bring LLINs to Africa can be strong motivators to researchers working on LLIN-related projects.
- It should be recognized that the potential size and rapid growth in demand expected for LLINs will allow room for additional LLIN technologies besides Olyset and Permanet.
- Organizations working on LLIN technology should enter into partnerships with net manufacturers and work with them to resolve implementation and quality control issues.
- These organizations should license or make available their LLIN technology, when developed, on a nonexclusive basis to net manufacturers.
- They should continue dialogue with WHO to refine standards for LLINs and to contribute to knowledge of LLIN technology.

Other Companies and Organizations within the RBM Partnership

- RBM partners need to work closely with other partners such as net manufacturers to define the ways in which they can contribute.
- They should remain alert to internal resources, especially within the large multinational companies, that may have been previously overlooked but which could contribute to the development of LLINs.

Developing a Coordination Mechanism

In view of the multiple ways in which stakeholder actions will have to be coordinated to reach the final goal, a mechanism should be established to maintain contacts between stakeholders on a regular basis. These contacts will require regular discussions between a variety of organizations within both the private and public sectors. While there are important and useful meetings that are held on a regular basis (ITN Working Group Meeting, WHOPES Working Group Meeting, and other RBM-hosted workshops), maintaining the momentum toward implementing the overall LLIN strategy will require interactions between stakeholders outside of these meetings. This is especially necessary because the rapid pace of developments in LLIN technology means that the landscape is constantly changing and that new opportunities will develop.

While various individuals within RBM have played important roles in facilitating the communication between organizations that is leading to the transfer of Olyset technology to Africa, it is likely that other issues may arise as other LLIN technologies that are beyond the public health–related expertise of WHO are developed. These issues, some of which have been touched on above, include—

- Negotiating the establishment of a technology "trust." Through this strategy, introduced above, LLIN technology could be made available at much lower cost to manufacturers who wish to acquire it.

- Facilitating partnership agreements between companies developing LLIN technology, net manufacturers, and public health–related organizations in ways that will address the needs of all stakeholders.

- Identifying new partners. While it is hoped that this business plan will demonstrate the viability of the LLIN market to those already interested in this initiative, further discussions may be needed with potential partners to engage their commitment to LLINs. Potential partners could include textile firms across Africa that are not currently manufacturing nets but have industry-related experience that would be an advantage in setting up LLIN manufacturing facilities. An additional suggestion would be to find ways to engage other university-related research labs in doing LLIN research, perhaps through setting up an international competition.

- Facilitating contact with potential sources of low-cost financing for LLIN manufacturing. The Acumen Fund, through its relationship with the Rockefeller Foundation, is an example of the type of organization that could work with net manufacturers to finance their investment in LLIN capacity. While the number of these financing sources is limited, it may be possible to find additional partners in this domain through research and interviews.

- Developing net procurement recommendations for the Global Fund. During the writing of this business plan, the Global Fund requested input on writing these guidelines for their use. This represents an opportunity to inform the procurement process that Global Fund recipients will be using in a way that will foster the uptake of LLINs.

- Providing technical assistance for governments that wish to lower tariffs on net inputs. It was described earlier how, in the WAEMU countries, it has been possible to exempt the inputs needed for manufacturing pharmaceuticals from tariffs. It should be possible to do the same for the inputs needed to manufacture LLINs. If direct technical assistance is not possible, a detailed case study of the WAEMU procedure could be useful as an example.

Conclusion

In conclusion, this business plan has covered the different aspects of what is needed to scale up the production and distribution of LLINs in sub-Saharan Africa. From a public health standpoint, there is an overwhelming need for LLINs; from a business standpoint, it is possible and feasible to address this need if stakeholders work together. This plan has outlined some of the ways in which each stakeholder can contribute, and it is hoped that it will play a role in the continuing discussions and work that will be needed to get LLINs into the possession of all those in sub-Saharan Africa who are at risk of malaria.

APPENDIX 1. MEMBERSHIP IN TRADING BLOCS

Table A1-1. Trading Bloc Membership

	ECOWAS	SADC	EMCCA	COMESA[a]
	Togo	Zimbabwe	Equatorial Guinea	Zimbabwe
	Sierra Leone	Zambia	Gabon	Zambia
	Senegal	Tanzania	Republic of the Congo	Sudan (North)
	Nigeria	Swaziland	Chad	Malawi
	Niger	South Africa	Central African Republic	Madagascar
	Mali	Namibia	Cameroon	Djibouti
	Liberia	Mozambique		Kenya
	Guinea-Bissau	Malawi		Rwanda
	Guinea	Democratic Republic of the Congo		Uganda
	Ghana	Botswana		Eritrea
	Gambia	Angola		Ethiopia
	Côte d'Ivoire			Angola
	Burkina Faso			Democratic Republic of the Congo
	Benin			
Number of countries (out of 44 on Roll Back Malaria list)	14	11	6	13
Total population (millions)	239	200	32	280
Population at risk (millions)	206	133	26	241
Gross national income per capita (weighted)	307	870	560	234
% urbanized	41.1%	34.1%	34.4%	38.1%

[a] Not all countries listed in the COMESA bloc have implemented the 0 percent tariff rate for trading within the bloc.
Note: ECOWAS = Economic Community of West African States; SADC = Southern African Development Community; EMCCA = Economic and Monetary Community of Central Africa; COMESA = Common Market for Eastern and Southern Africa.

APPENDIX 2. URBANIZATION DATA

Table A2-1. Urbanization Data for African Countries, 2001

Country	% Urbanized	GNI per Capita (USD)	Population at Risk
Angola	34.2	500	9,926,201
Benin	42.3	360	5,395,491
Botswana	50.3	3,630	456,118
Burkina Faso	18.5	210	10,479,000
Burundi	9.0	100	4,190,602
Cameroon	48.9	570	12,560,466
Central African Republic	41.2	270	3,273,000
Chad	23.8	200	6,129,962
Republic of the Congo	62.5	700	2,593,000
Democratic Republic of the Congo	30.3	124	41,742,839
Côte d'Ivoire	62.5	630	13,691,405
Equatorial Guinea	48.2	700	393,355
Eritrea	18.7	190	2,931,477
Ethiopia	17.6	100	22,238,623
Gabon	81.4	3,160	1,032,563
Gambia	32.5	330	1,111,000
Ghana	38.4	290	17,202,593
Guinea	32.8	400	7,347,838
Guinea-Bissau	32.8	160	992,350
Kenya	33.1	340	14,632,895
Liberia	44.9	100	2,123,000
Madagascar	29.6	260	13,228,980
Malawi	24.9	170	9,380,303
Mali	30.0	210	10,709,811
Mauritania	30.0	350	1,316,948
Mozambique	40.2	210	17,194,157
Namibia	30.9	1,960	614,046
Niger	20.6	170	8,857,159
Nigeria	44.0	290	111,701,036
Rwanda	6.2	220	2,938,455
Senegal	47.4	480	8,311,999
Sierra Leone	36.6	140	4,194,723
Somalia	36.6	100	1,788,952
South Africa	50.4	2,900	8,381,647
Sudan	36.1	330	26,261,060
Sudan (South)	36.1	330	9,000,000
Swaziland	36.1	1,300	662,024
Tanzania	36.1	270	28,160,059
Togo	33.3	270	4,085,000
Uganda	14.2	280	17,769,241
Zambia	39.6	320	7,777,425
Zimbabwe	35.3	480	9,294,101

APPENDIX 3. DATA FOR NETMARK AND PSI COUNTRIES

Table A3-1. Data for Countries Where NetMark and PSI Work

NetMark	PSI	Countries	Population at Risk	GNI per Capita	% Urbanized
Yes	No	Ghana	19,154,860	290	38.4
Yes	No	Nigeria	113,850,638	290	44.0
Yes	No	Senegal	9,420,518	480	47.4
Yes	Yes	Benin	6,256,068	360	42.3
Yes	Yes	Cameroon	14,163,385	570	48.9
Yes	Yes	Kenya	16,545,240	340	33.1
Yes	Yes	Mali	11,261,224	210	30.0
Yes	Yes	Uganda	22,234,606	280	14.2
Yes	Yes	Zambia	10,387,739	320	39.6
No	Yes	Burkina Faso	11,535,072	210	18.5
No	Yes	Burundi	4,392,566	100	9.0
No	Yes	Central African Republic	3,717,293	270	41.2
No	Yes	Democratic Republic of the Congo	46,789,520	124	30.3
No	Yes	Madagascar	14,410,853	260	29.6
No	Yes	Malawi	10,986,070	170	24.9
No	Yes	Mozambique	18,238,520	210	40.2
No	Yes	Namibia	690,821	1,960	30.9
No	Yes	Rwanda	4,320,189	220	6.2
No	Yes	Tanzania	34,437,844	270	36.1
No	Yes	Togo	4,526,972	270	33.3
No	Yes	Zimbabwe	10,490,902	480	35.3
NetMark		9 countries	223,274,279	318	39.1
PSI		18 countries	245,384,886	273	30.7
Both NetMark and PSI		6 countries	80,848,263	346	32.1

APPENDIX 4. ESTIMATING DISCRETIONARY INCOME FOR BUYING NETS

Data was taken from the World Development Indicators report for 2002, using (1) size of the economy to determine gross national income per capita data; (2) distribution of income or consumption to calculate percentage shares of income/consumption by quintiles of population; and (3) structure of demand to obtain the percentage of gross national income represented by private consumption (the remainder typically represents government expenditures). Then annual expenditures were estimated both per individual and per quintile of the population (with separate figures for the lowest 10 percent and the highest 10 percent) by combining these three classes of data for the 22 African countries where data was available. These annual expenditures correspond to money that individuals in these quintiles have available for spending on necessities like food and housing per year. This data is shown in Table A4-1.

For example, an individual in the lowest 20 percent of the population by income living in Burundi has USD 51.15 per year to live on for all his or her expenses, or USD 4.26 per month. Most of this sum will be required to buy food and most of the rest for paying housing costs, transport, and so on. Even when aggregated across a household (as net purchases are usually done on a household basis), it is clear that a net that costs USD 5 will represent a significant investment for this quintile of households in Burundi.

For the analysis of Burkina Faso and Cameroon, more detailed information on household expenditures was available, which allowed a more precise quantification of the impact that the purchase of a net would have on household finances.[70,71] The analyses based on data from Burkina Faso and Cameroon are shown in Tables A4-2, A4-3, and A4-4.

[70] Commeyras, C. 2003. Etude de l'Accessibilité et des Déterminants de Recours aux Soins et aux Médicaments au Cameroun. *XXVI^{emes} Journées des Economistes Français de la Santé.*

[71] Institut National de la Statistique et de la Démographie (INSD). 1998. *Analyse des résultats de l'enquête prioritaire sure les conditions de vie des ménages en 1998.* Paris, France.

Table A4-1. Distribution of Household Consumption

Country	Percentage of Income Used for Private Consumption	GNI per Capita (USD)	Percentage of Total Spending, by Lowest Decile and All Quintiles						Expenditures on Private Consumption (USD)				
			Lowest 10%	Lowest 20%	Second 20%	Third 20%	Fourth 20%	Highest 20%	Lowest 20%	Second 20%	Third 20%	Fourth 20%	Highest 20%
Burkina Faso	76%	210	2.0	4.6	7.2	10.8	17.1	60.4	**36.71**	**57.46**	**86.18**	**136.46**	**481.99**
Burundi	93%	110	1.8	10	15.1	16.1	21.5	48.0	**51.15**	**77.24**	**82.35**	**109.97**	**245.52**
Central African Republic	81%	280	0.7	2	4.9	9.6	18.5	65.0	**22.68**	**55.57**	**108.86**	**209.79**	**737.10**
Côte d'Ivoire	71%	600	3.1	7.1	11.2	15.6	21.9	44.3	**151.23**	**238.56**	**332.28**	**466.47**	**943.59**
Ethiopia	78%	100	3.0	7.1	10.9	14.5	19.8	47.7	**27.69**	**42.51**	**56.55**	**77.22**	**186.03**
Ghana	81%	340	2.2	5.6	10.0	15.1	22.6	46.7	**77.11**	**137.70**	**207.93**	**311.20**	**643.06**
Guinea	77%	450	2.6	6.4	10.4	14.8	21.2	47.2	**110.88**	**180.18**	**256.41**	**367.29**	**817.74**
Kenya	76%	350	2.4	5.6	9.3	13.6	20.3	51.2	**74.48**	**123.69**	**180.88**	**269.99**	**680.96**
Madagascar	87%	250	2.8	6.4	10.7	15.6	22.5	44.9	**69.60**	**116.36**	**169.65**	**244.69**	**488.29**
Mali	79%	240	1.8	4.6	8.0	11.9	19.3	56.2	**43.61**	**75.84**	**112.81**	**182.96**	**532.78**
Mauritania	68%	370	2.5	6.4	11.2	16.0	22.4	44.1	**80.51**	**140.90**	**201.28**	**281.79**	**554.78**
Mozambique	79%	210	2.5	6.5	10.8	15.1	21.1	46.5	**53.92**	**89.59**	**125.25**	**175.02**	**385.72**
Niger	84%	180	0.8	2.6	7.1	13.9	23.1	53.3	**19.66**	**53.68**	**105.08**	**34.93**	**80.59**
Nigeria	88%	260	1.6	4.4	8.2	12.5	19.3	55.7	**50.34**	**93.81**	**143.00**	**220.79**	**637.21**
Rwanda	88%	230	4.2	9.7	13.2	16.5	21.6	39.1	**98.16**	**133.58**	**166.98**	**218.59**	**395.69**
Senegal	79%	490	2.6	6.4	10.3	14.5	20.6	48.2	**123.87**	**199.36**	**280.65**	**398.71**	**932.91**
Sierra Leone	91%	130	0.5	1.1	2.0	9.8	23.7	63.4	**6.51**	**11.83**	**57.97**	**140.19**	**375.01**
South Africa	64%	3020	1.1	2.9	5.5	9.2	17.7	64.8	**280.26**	**531.52**	**889.09**	**1710.53**	**6262.27**
Tanzania	84%	270	2.8	6.8	11.0	15.1	21.6	45.5	**77.11**	**124.74**	**171.23**	**244.94**	**515.97**
Uganda	87%	300	3.0	7.1	11.1	16.4	21.5	44.9	**92.66**	**144.86**	**214.02**	**280.58**	**585.95**
Zambia	86%	300	1.1	3.3	7.6	12.5	20.0	56.6	**42.57**	**98.04**	**161.25**	**258.00**	**730.14**

Sources: World Development Indicators 2002, World Bank Group.

Table A4-2. Burkina Faso Household Expenditures

Monthly Cash Expenditure (agricultural workers)	Monetary Income	Total Income
Food, beverages, and tobacco	63.0%	65.8%
Clothing and footwear	7.4%	4.7%
Housing, water, electricity, and other	4.2%	13.3%
Furniture, household goods	3.7%	2.6%
Education	1.2%	0.8%
Transfers	3.7%	2.3%
Transportation	5.2%	3.3%
Health	5.5%	3.5%
Entertainment	0.1%	0.0%
Other goods and services	5.8%	3.7%
Total amount in CFA francs	335,253	536,826
Percentage of disposable income not needed for essential items	11.4%	
Ratio of monetary to total income	62.5%	

Note: The shaded area denotes discretionary income.

Other data from the same study shows—

- Of those with total revenues less than 300,000 CFA francs, 79 percent are farmers.
- Of farmers, 54 percent have revenues less than 300,000 CFA francs.
- Among rural households, 47.7 percent have revenues less than 300,000 CFA francs.

Based on the ratio of monetary OF income to total income, these 47.7% of households would have a monetary income below 190,000 CFA francs/yr. With a disposable income equal to 11.4% of that amount, these households have, on a monthly basis, € 2.71 per month for spending on health, recreation, and other goods and services.

Furthermore as 77 percent of the 42.5 percent of households with this income are in rural areas, this implies that 33 percent of households in Burkina Faso have € 2.71 or less per month to spend on nets, other health expenses, entertainment, and "other goods and services", thus the purchase of a $5 net for these households requires considerable sacrifice.

Table A4-3. Cameroon Household Survey Data, by Income Quintile (ECAM 2001)

Category of Expenditure	Q1	Q2	Q3	Q4	Q5	Average (CFA francs)
Food	6.4%	11.5%	16.7%	23.9%	41.6%	608,805
Cafés, restaurants	6.8%	10.6%	14.8%	22.8%	44.9%	69,646
Beverages	2.7%	6.3%	10.2%	19.3%	61.4%	21,987
Tobacco	11.3%	13.6%	18.8%	25.6%	30.6%	4,393
Clothing, shoes	4.3%	8.6%	12.6%	21.3%	53.1%	122,975
Housing	6.5%	10.4%	14.4%	21.1%	47.6%	311,776
Household equipment	3.5%	7.3%	10.9%	19.9%	58.4%	108,664
Health	3.4%	7.1%	12.0%	18.9%	58.6%	136,869
Transportation/communication	1.8%	4.1%	7.1%	12.4%	73.6%	249,105
Education	1.6%	4.4%	9.8%	21.3%	62.9%	103,682
Personal care	3.7%	7.7%	13.2%	23.5%	52.0%	44,442
Entertainment	1.0%	3.4%	7.1%	14.6%	73.9%	35,588
Goods and services	4.3%	8.8%	12.5%	25.2%	49.3%	21,243
Total Expenses						**1,839,175**

Note: ECAM = Enquête Camerounaise auprès des Ménages
The shaded areas denote discretionary income.

The percentages in Table A4-3 represent the percentages of the total amount spent within the different quintiles, that is, 6.4 percent of national expenditures on food are spent by those households within the lowest quintile (Q1), 11.5 percent by those within the second lowest quintile (Q2), and so on. This data can be transposed to calculate the percentage of household expenditures spent on different categories **within** each quintile, as shown in the table.

Table A4-4. Cameroon Household Expenditures, by Income Quintile

Category of Expenditure	Q1	Q2	Q3	Q4	Q5
Food	44.3%	43.4%	41.9%	38.3%	26.2%
Cafés, restaurants	5.4%	4.6%	4.2%	4.2%	3.2%
Beverages	0.7%	0.9%	0.9%	1.1%	1.4%
Tobacco	0.6%	0.4%	0.3%	0.3%	0.1%
Clothing, shoes	6.0%	6.6%	6.4%	6.9%	6.8%
Housing	23.1%	20.1%	18.5%	17.3%	15.4%
Household equipment	4.3%	4.9%	4.9%	5.7%	6.6%
Transportation/communication	5.1%	6.3%	7.3%	8.1%	19.0%
Education	1.9%	2.8%	4.2%	5.8%	6.8%
Health	5.3%	6.0%	6.8%	6.8%	8.3%
Personal care	1.9%	2.1%	2.4%	2.7%	2.4%
Entertainment	0.4%	0.8%	1.0%	1.4%	2.7%
Goods and services	1.0%	1.2%	1.1%	1.4%	1.1%
Total % of income that is discretionary	**8.6%**	**10.1%**	**11.3%**	**12.3%**	**14.5%**
Discretionary income per household/year (USD)	**61**	**130**	**220**	**375**	**1,121**
Discretionary income per household/month (USD)	**5.05**	**10.82**	**18.32**	**31.25**	**93.43**

Note: The shaded areas denote discretionary income expenses.

APPENDIX 5. THE FIVE FORCES

The "five forces" framework for understanding the dynamics that drive industries and competitors was first outlined by Michael E. Porter of the Harvard Business School in his book *Competitive Strategy: Techniques for Analyzing Industries and Competitors* (Free Press, 1985). According to Porter, strategic choices are made by companies based on two central themes: (1) the potential of an industry for long-term profitability; and (2) the attempt to improve relative competitive position within an industry. In turn, the long-term profitability of any industry, whether a product or a service is produced, is determined by five competitive forces: the potential for new entrants, the threat of substitute products or services, the relative bargaining strength of suppliers, the relative bargaining strength of buyers, and rivalry among existing firms within the industry.

The reader is referred to Porter's *Competitive Strategy: Techniques for Analyzing Industries and Competitors,* as mentioned above, and his *Competitive Advantage: Creating and Sustaining Superior Performance* (Free Press, 1985); for a deeper discussion, beyond the scope of this business plan, see *On Competition* by the same author (Harvard Business School Press, 1998).

Briefly, the types of questions that arise when using Porter's framework to analyze an industry can be summarized as follows—

1. **Threat of new entrants (barriers to entry)**

    - Economies of scale—if these are significant, a new entrant who starts off with low volume will have difficulty competing with established, large-volume producers
      Brand identity—strong loyalty to an established brand will make it difficult for new brands to move in (think Coca-Cola vs. generic colas)
      Capital requirements—the need for a large initial investment will discourage new entrants
      Access to distribution channels
      Government policies—for example, tax and tariff policies that would make it difficult for new manufacturers to set up shop

    - Capacity of existing firms to retaliate against the new entrant

2. **Threat of substitutes**

    - Relative price performance of substitutes
    - Switching costs on the part of the buyer
    - Buyer propensity to substitute

3. **Bargaining power of buyers**

    - Bargaining leverage
    - Buyer volume—buyers who buy large quantities have more clout
    - Buyer switching costs relative to firm switching costs—if using the product does not require specific accessories or equipment, buyers can go elsewhere
    - Buyer information
    - Availability of substitute products
    - Price sensitivity—buyers who are sensitive to price will be more motivated to force down prices

4. **Bargaining power of suppliers**

    - Presence of substitute inputs
    - Supplier concentration—for example, a needed input might be available from many suppliers
    - Cost relative to total purchases in the industry—if the price of the input is high, the firm will be more motivated to bargain with suppliers
    - Threat of forward integration relative to threat of backward integration by firms in the industry

5. **Rivalry among existing firms**

    - Industry growth—a rapidly growing market will focus companies' efforts on keeping up with demand, rather than trying to gain market share from rivals
    - Fixed (or storage costs) relative to value added—if fixed costs are high, firms will be forced to compete harder to maintain sufficient sales volume to cover these costs
    - Brand identity—a generic product or commodity will increase rivalry as firms end up competing on price
    - Exit barriers—if the installed equipment base cannot be converted to making other products, firms are forced to compete fiercely for business.

Industry structure can be subject to frequent changes. Technological advances can shift the status quo, as computer makers discovered when PCs became popular. A particular firm's actions can also serve to shift industry structure. In other instances, a dominant firm may act to preserve industry structure rather than to seek an incremental advantage, because it may be better off in the presence of weak rivals than with no rivals at all.

ANNEX 6. CASE STUDY ON THE PRODUCTION OF LLINs IN TANZANIA

This project is an example of how coordination between private sector partners, UN agencies, NGOs, and donors is making possible the production of one type of long-lasting net in Africa.

History of Olyset Project

A process for incorporating permethrin into polyethylene fiber was developed 15 years ago by Dr. T. Itoh at Sumitomo Chemical Co., Ltd., in Osaka, Japan. This process enables permethrin to be embedded into a masterbatch with high-density polyethylene (HDPE), from which an insecticide-impregnated yarn can be extruded. Net production using this process was started under contract with a Chinese manufacturer, and field tests showing positive results had been done by the early 1990s. Over the past few years, WHO has also become interested in finding a process for making long-lasting nets, and two years ago the organization made inquiries to Sumitomo as the RBM/WHO partnership was developing a policy for introducing long-lasting nets into Africa. Although Sumitomo had initiated net production in China, the company had expressed an interest in finding net manufacturing partners in Africa. Along with several other African net manufacturers, A to Z Textile Mills of Arusha, Tanzania, expressed an interest in the possibility of manufacturing the Olyset; however, A to Z stood out for its leadership in the net market and for the strength of its management team. A third company, ExxonMobil Corporation, was already aware of RBM from its corporate involvement and support for malaria control projects at its work sites in Africa.

From this set of relationships, the idea arose to use HDPE for the masterbatch from ExxonMobil's facility in Saudi Arabia. HDPE will be mixed with a concentrated masterbatch shipped from Japan to create a final compound that is to be used for extruding the polyethylene yarn to make the Olyset-type net. By shipping HDPE from Saudi Arabia instead of from Japan, this proposed modification of the supply chain offers the possibility of reducing production costs and, therefore, net prices. In addition, Sumitomo is able to protect its intellectual property because the concentrated masterbatch, which contains the insecticide and other needed additives, is manufactured on its premises.

Description of Olyset Project

The following organizations have participated in this coalition of partners to make this project possible—

- **A to Z Textile Mills.** This company is the largest net producer in Africa and will be the first to produce the Olyset-type net in Africa. A to Z has a large plant in Arusha, Tanzania, and plans are under way to set up additional plants in Dar es Salaam, Tanzania; Cameroon; and Nigeria.

- **ExxonMobil Corporation.** One of the world's largest producers of HDPE, this company's presence in Africa makes it a logical choice to be the supplier of HDPE for Olyset-type net production by A to Z. After testing by Sumitomo, the HDPE from

ExxonMobil appears suitable for use in net production. Revenues from sales of HDPE to A to Z (which will be at market price) will be donated by ExxonMobil to ensure that nets are available to vulnerable segments of the population.

- **World Health Organization.** WHO has played a facilitating role in coordinating ongoing discussions and in providing technical expertise.

- **UNICEF.** As a major purchaser of nets, UNICEF's plans to distribute LLINs in Africa and interest in seeing production of LLINs in Africa has also played an essential role in encouraging the project to go forward and in convincing the other partners of the viability of the demand for long-lasting nets.

- **Acumen Fund.** Acumen Fund is a nonprofit organization that provides financial and technical assistance to support innovations that address current issues in both the for-profit and nonprofit worlds. The fund is making a USD 400,000 loan to A to Z to support the production of the Olyset-type net, effectively sharing some of the business risk.

- **Population Services International.** PSI, a nonprofit organization, is a leader in the development of social marketing programs and well-known for its efforts in marketing family planning products. It is active in the social marketing of nets as well, with programs in 16 African countries. In Tanzania, PSI has covered all 114 districts, with a recent end-of-project survey showing net coverage rates as high as 80 percent in urban areas and 50 percent in rural areas.

- **Sumitomo Chemical Co., Ltd.** The inventor and developer of the Olyset technology, Sumitomo has proved a willing partner in adapting its process to use HDPE from ExxonMobil and will assume initial responsibility for quality control of the A to Z product.

As of June 2003, A to Z is proceeding with the installation of the machinery from China for the knitting of polyethylene. This machinery is required because heavier-weight polyethylene fiber cannot be used on conventional polyester knitting machines. Technical assistance and training for operating the extruder and the knitting machinery will be provided by the Chinese manufacturer.

Sumitomo will initially assume responsibility for quality control of the A to Z nets. Net samples will be sent to Japan on a regular basis to ensure that the A to Z nets meet the standards set by Sumitomo. Worker protection will be ensured by the use of gloves, a forced air ventilation system that will renew work-space air regularly, and the on-site presence of a medical professional to record and treat work-related complaints. Air quality will be monitored for the presence of insecticide vapor and particulates.

Environmental protection measures will include a sand filter bed through which insecticide-contaminated water will pass before discharge into the environment. The discharge water will be monitored, and, if needed, a second step using the addition of sodium hydroxide will ensure that any remaining insecticide in the water is broken down.

Target date for initial production is late August 2003, with final modification of the supply chain to ship ExxonMobil HDPE directly to A to Z anticipated for January 2004. A to Z Textile Mills is confident in the viability of this project; with the knowledge that institutional

purchasers will be committed to buying long-lasting nets and that the private commercial market will also be growing.

ANNEX 7. TARIFF LEVELS

Getting reliable, specific tax and tariff data on a country basis is best done by on-site investigation, and even then responses can be contradictory; a recent report noted that the VAT on treated nets in Senegal was stated to be either 18 percent or 0 percent, depending on the respondent.[72]

The limited information available on the Web sites for WAEMU (West African Economic and Monetary Union), CEMAC (Central African Economic and Monetary Community), and COMESA (Common Market for Eastern and Southern Africa) shows the classifications in tariff systems presented in Tables A7-1, A7-2, and A7-3.

Table A7-1. Tariff Categories for West African Monetary Union

WAEMU			
Product Type	**Category**	**Total Tariff and Levies***	
Essential social goods from a limited list	0	**2%**	
Essential goods, basic raw materials, capital goods, specific inputs	1	**7%**	**Insecticide (nonretail)**
Intermediate goods and inputs	2	**12%**	**Polyester yarn**
Final goods and other products not included elsewhere	3	**22%**	**Untreated net (impregnated net is specified at 0%)**

*Includes tariff, statistical royalty, and community levy

Table A7-2. Tariff Categories for Central African Economic and Monetary Community

CEMAC			
Product Type	**Category**	**Tariff**	
Basic goods	I	**5%**	**Insecticide (nonretail, quantities greater than 1 kg)**
Raw materials and capital goods	II	**10%**	**Polyester yarn**
Intermediate goods	III	**20%**	
Consumer and final goods	IV	**30%**	**Mosquito nets (both treated and untreated presumed to be included with window treatments, curtains, and valances)**

[72] Starling, M., and R. Njau. 2002. *Review of the Processes and Nature of Effective Policy Change for Tax and Tariff Rationalisation on Nets, Netting and Insecticides in Ghana, Senegal, Mali, Nigeria & Tanzania.* London: Malaria Consortium. p. 22.

Table A7-3: Tariff Categories for Common Market for Eastern and Southern Africa

COMESA	
Product Type	**Tariff**
Capital goods	**0%**
Raw goods	**5%**
Intermediate goods	**15%**
Final goods	**30%**

Despite what may appear to be a straightforward system for classifying goods into four categories within these trading blocs, the Harmonized System of Tariffs nomenclature has been implemented differently within Africa, as shown in Table A7-4.

Table A7-4. Differences in Tariff Nomenclature

Product	WAEMU	CEMAC	COMESA
Mosquito Nets			Unavailable
Product Code	63.04.91.00.10	6303.12.00	
Tariff	0%	30%	
Insecticide (wholesale)			
Product Code	38.08.10.90.00	3808.10.90	
Tariff	5%	5%	
Yarn			
Product Code	54.02.42.00.00	5402.42.00	
Tariff	10%	10%	

Within the WAEMU, 10 digits are used for classifications, while within CEMAC, 8 digits are used. This is partly because the International Customs Organization specifies nomenclature only through the six-digit level.[73] Furthermore, the tariff levels for polyester yarn are misleading for the WAEMU and CEMAC; the descriptions are similar—"yarn of synthetic filaments, not for retail, of polyester, partially oriented"—but within the WAEMU, yarn is classified in the category for intermediate goods or inputs, while within CEMAC, it is classified in the category for raw goods.

A closer look shows that even within these trading blocs, individual countries may not follow the common policy on tariffs. A study commissioned by the Malaria Consortium[74] notes that decision makers in Mali felt that the country had the right to exercise national sovereignty when confronted with an important public health issue, and therefore both tariffs and taxes were lowered to 0 percent for treated and untreated nets, polyester yarns and netting, and insecticides.

In conclusion, while there has been limited progress toward the pledges made in Abuja in 2000 regarding lowering the tariffs on mosquito nets, there is still much room for

[73] M. Ferrantino, Office of Economics, U.S. International Trade Commission, personal communication.
[74] Starling, M., and R. Njau. 2002. *Review of the Processes and Nature of Effective Policy Change for Tax and Tariff Rationalisation on Nets, Netting and Insecticides in Ghana, Senegal, Mali, Nigeria & Tanzania.* London: Malaria Consortium. p. 30.

governments to take action to support the production of nets in Africa. The Malaria Consortium study, which covers the countries of Ghana, Senegal, Mali, Nigeria, and Tanzania, shows considerable differences among countries in the rate of change in policies affecting taxes and tariffs; that study also shows the need for clearly defining the roles of the key stakeholders within a given country to effect change.

ANNEX 8: PYRETHROIDS AND WHOPES

Pyrethroids prevent sodium channels of the nervous system of mosquitoes from functioning normally, thus disturbing transmission of nerve impulses. Pyrethroids are presently the only group of insecticides recommended by WHO for treatment of mosquito nets due to the chemicals' rapid knock-down effects and high insecticidal potency at low dosages, as well as their relative safety for human contact and domestic handling. The rapid metabolism of pyrethroids lowers the magnitude of the resultant human toxicity. In long-term toxicity studies of pyrethroids recommended for treatment of mosquito nets, no teratogenic, carcinogenic, or mutagenic effects have been detected in experimental animals.

Discussions with private sector partners have revealed the following six areas of concern related to the use of insecticides—

1. **Worker Safety.** The existing technologies for long-lasting nets as well as some of those under development will require the workers who are doing the cutting and sewing to handle impregnated netting material. However, there are no international standards in place for measuring dermal exposure. Acute exposure can result in tingling and burning sensations in the skin, facial swelling, and headache, but these symptoms go away quickly after exposure is stopped. No long-term toxicity is expected, as noted above.

   Manufacturing experience with the Olyset and Permanet nets has shown differing results: With the Olyset (which uses permethrin), no complaints were reported during 10 years of production in China; with the Permanet (which uses deltamethrin), facial and skin irritation was reported immediately when production was started in Hanoi. Vestergaard-Frandsen was obliged to install safety procedures including the use of gloves, masks, aprons, and air conditioning, but after these measures were taken, the incidence of adverse reactions decreased considerably.

   A to Z will install measures to protect and monitor worker safety. These measures are briefly described in Annex 6.

2. **Insecticide Suppliers.** WHO recommends only products that have met the updated joint FAO/WHO specifications. The recommendations are made on a product-specific basis, and to date only large multinational companies have submitted the product safety data package required. Even though five of the six recommended insecticides are off-patent, so far the generic manufacturers have not submitted generic versions of these insecticides for WHOPES study, perhaps because of the time and cost involved in doing so. While there is some reported interest among generic manufacturers in going through the WHOPES recommendation process, at the current time the effective lack of generic competition puts buyers of insecticide at a negotiating disadvantage. There are no "standard" prices for insecticides because prices are negotiated on an individual basis, unlike other products, such as medicines, for which generic versions are available and for which pricing information is available.[75]

[75] Management Sciences for Health. 2002. *International Drug Price Indicator Guide*. Available online at <http://erc.msh.org/mainpage.cfm?file=1.0.htm&id=1&temptitle=Introduction&module=DMP&language=english> (accessed June 18, 2003).

3. **Environmental Considerations.** There are no international standards for handling pyrethroid insecticides. Care should be taken to avoid insecticide contamination of surface water because of the possible toxicity to wildlife. The short activity life of pyrethroid insecticides makes it relatively easy to install environmental protection measures. A to Z will install a water treatment system using a sand filtration bed. As waste water passes through this, most of the insecticide will be absorbed and subsequently broken down by sunlight; the remaining insecticide can be treated with sodium hydroxide, if needed.

4. **Resistance.** There is documented resistance to pyrethroid insecticides dating from the early 1990s, especially in West Africa. At the current time, pyrethroid-impregnated nets are still considered effective by WHO for preventing malaria transmission by mosquitoes. There is ongoing research in using insecticide combinations, either as a mosaic or as a mixture. In a mosaic application, for example, the bottom of the net is treated with a pyrethroid while the top is treated with an alternative insecticide.

   In addition, there is some ongoing basic research to discover a new molecule, and support for research and development of alternative insecticides should remain a priority for both the public and private sectors because of the long lead-time (up to 10 years) and high expenditures (up to USD 200 million) needed to develop a new active ingredient for public health use.

5. **Responsible Care.** Responsible Care is a set of voluntary practices and principles first established in 1988 by the U.S. chemical industry through the American Chemical Council to achieve reductions in environmental pollution and improvements in workplace and community safety.[76] Of the companies developing LLIN technologies listed earlier, Bayer and Dow are listed as Partner Company Sponsors; BASF subscribes to these standards as well. Because of the high profile of the effort to promote LLINs, the large multinational companies will need to ensure that any technology transfer projects will also respect the principles of Responsible Care.

6. **Testing Facilities.** One large company expressed concern over the lack of testing facilities. While quantitative testing using methods such as HPLC is readily available, fewer labs can do bioefficacy testing, and still fewer facilities are able to perform small-scale field testing, which has to be done under carefully controlled conditions. The USD 300,000 fee for the WHOPES testing also represents an expense that will have to be earned back on net sales.

Resolving these issues will require continued discussions between WHO, UNICEF, and the private sector. For example, WHO has relationships with selected collaborating institutions around the world, and it may be possible to increase the number of collaborators by working with the private sector. UNICEF, as a major purchaser of nets, is familiar with net manufacturing facilities throughout Africa and could work with LLIN developers who are looking to partner with net producers to identify those who respect worker and environmental standards in their manufacturing facilities.

[76] Responsible Care Practitioners Site. <http://www.americanchemistry.com/rc.nsf/secondaryprofilesid/lsgs-4dnmdz?opendocument> (accessed June 27, 2003).

ANNEX 9. ELEMENTS OF COMPETITIVENESS RELEVANT TO NET MANUFACTURING

This annex is included with the LLIN business plan to enable further discussion of the factors that companies face when deciding where to set up a net manufacturing facility. These factors can be categorized as quantitative or qualitative. Qualitative factors can be measured and include items such as the costs of inputs, equipment, and so on; quantitative factors are those related to the business environment in which companies operate and are hard to measure.

This list is meant primarily as a guide for discussion; manufacturers and investors will want to do their own research because country-specific factors may come into play that are beyond the scope of this discussion. These could include things such as the presence of an established capable local partner or special incentives such as tax breaks that may be negotiated with local authorities.

Quantitative Factors

Raw Material Costs. The principal raw material for making conventional nets is polyester fiber, and most polyester fiber is produced in Asia, which favors net producers in Thailand and Vietnam if they can buy fiber locally. However, assembling a net also requires additional material for finishing, such as tricot; supports such as rings for conical nets; and a plastic bag to ship it in. A small cost advantage accrues to those net manufacturers, including some in Africa, who have access to these inputs on the domestic market and who can thereby avoid the additional costs associated with importing these materials.

Transportation Costs and Services. Shipping capacity between East and West Africa is limited when compared to shipping from Asia to Africa, even though quoted costs are lower. Low efficiency in African ports[77] and lengthy times to clear customs increases the risk of delivery delays, with the result that freight costs represent close to 13 percent of the total value of imports into Africa, compared to a range of 8 to 9 percent for imports into Asia, the United States, and Europe.[78] Inland transport costs can easily equal or exceed shipping costs, especially in Africa. For example, the cost of moving a 20-foot container 500 kilometers from Mombassa to Nairobi is estimated to be as high as USD 2,975[79]; moving the equivalent volume from Bangkok to Hat Yai, a distance of 935 kilometers, costs USD 462.[80]

Machinery Costs and Availability. The two main sources of machinery for making netting material, including warping and warp knitting equipment, are China and Europe. While prices of European machines are often several times higher than Chinese prices, there are tradeoffs in terms of reliability, quality, and after-sales support. Net manufacturers also have to take into consideration the availability of local service representatives and maintenance

[77] Container Ports: Infrastructural Issues. *Africa Research Bulletin* 2000;40(5):15673.
[78] United Nations Conference on Trade and Development (UNCTAD). 2002. *Review of Maritime Transport*. Geneva: UNCTAD. p. 66
[79] Reichert, H. 2002. *East Africa Region: Enhancing Transportation Management to Foster U.S. Agricultural Trade Opportunities.*
[80] Thailand Board of Investment. 2003. "Cost of Doing Business in Thailand." <http://www.boi.go.th/english/business/costs_transportation.html> (accessed July 25, 2003).

and spare parts costs. The investment in machinery to transform yarn into netting material represents the majority of expenses that are incurred to set up a net manufacturing facility.

Production Efficiency. Cutting, sewing, and packaging nets are labor-intensive steps. Efficiency has two components: waste and productivity. Waste is caused by a lack of worker skill or training; a well-run operation will have wastage rates as low as 4 percent. In Vietnam, it takes an estimated six to eight months before a newly established production line can reach this low level of wastage. Productivity is related to the speed at which workers produce nets.

Economies of Scale. These economies become significant for manufacturers who have installed capacity to make knitting material. This capacity is costly (as high as USD 2 million) and requires minimum volumes (at least 100,000 nets/month), but it lowers production costs by 15–20 percent.

Tax and Tariff Levels. Imposition of taxes and tariffs on the materials needed to produce nets, such as yarn and insecticide, can add considerably to production costs. Taxes and tariffs are discussed in Part 2 of the business plan, where an example of how tariffs directly affect the production cost of a net is given.

Qualitative Factors

Availability of Skilled Labor. In countries where the textile industry is active, it is relatively easy to find the needed human resources. These include Asian countries such as Thailand, where several net producers supply the African market, and African countries where nets are currently produced such as Tanzania, Nigeria, and Kenya. Countries that are active in the textile industry but not in net production include Botswana, Mauritius, Madagascar, and South Africa. Unfortunately, in some African countries such as Kenya, the decline of the textile industry has created a shortage of managerial expertise, making it difficult to find capable personnel to run manufacturing facilities.

Political Climate. It is difficult to sustain any enterprise in a country suffering from political instability.

Unpredictability of the Judiciary and Corruption. These two factors have been important considerations for doing business in Africa in previous surveys,[81,82] although performance varies between countries. In one of these surveys,[83] sub-Saharan Africa was perceived as no worse than other regions, including the Commonwealth of Independent States (CIS) region and Latin America. Furthermore, 16 African governments have signed up for peer review of governance standards under the New Partnership for Africa Development (NEPAD).

Technology Transfer. A comprehensive discussion of the issues involved in technology transfer is not possible here, apart from some general comments. Firms often are not willing to transfer technology to countries where intellectual property protection is perceived as

[81] Pfeffermann, G., and G. Kisunko. 1999. *Perceived Obstacles to Doing Business: Worldwide Survey Results*. Washington, D.C.: International Finance Corporation.
[82] Brunetti, A., G. Kisunko, and B. Weder. 1997. *Institutional Obstacles to Doing Business*. Washington, D.C.: World Bank.
[83] Ibid.

weak.[84] This could present a potential obstacle to transferring LLIN technology to African countries where frameworks to provide protection of intellectual property are still under development.[85] The capacity of recipients to absorb technology must also be taken into consideration.[86] Another study[87] found that African partners participating in joint ventures with northern firms developed competence in operations and quality control but that this learning did not necessarily lead to new innovations. The review of the literature undertaken for this report did not find any one model (e.g., licensing, joint ventures, or direct investment) to be the catch-all solution to technology transfer, so it appears that for LLIN technology a case-by-case approach will be needed.

[84] Mansfield, E. 1994. *Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer*. Washington, D.C.: World Bank and International Finance Corporation.

[85] Maskus, K. E. 1997. *The International Regulation of Intellectual Property*. Paper presented at Internet Engineering Steering Group (IESG) Conference, Regulation of International Trade and Investment, September 12–14, University of Nottingham, U.K.

[86] Saggi, K. 2000. *Trade, Foreign Direct Investment, and International Technology Transfer: A Survey*. Washington, D.C.: World Bank.

[87] Chrysostome, E. V., and Z. Su. 2002. Towards Successful Learning within North-South Joint Ventures Operating in sub-Saharan Africa: An Exploratory Study. *Journal of Comparative International Management* 5(1).