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Inception meeting for the pilot-study project on sustainable management of long-lasting insecticidal nets throughout their life-cycle

Geneva, Switzerland, 10–12 August 2010

REPORT

World Health Organization

This publication contains the report of the Inception meeting for the pilot-study project on sustainable management of long-lasting insecticidal nets (LLINs) throughout their life cycle, Geneva, Switzerland, 10–12 August 2010, and does not necessarily represent the decisions or policies of the World Health Organization.

CONTENTS

ACRONYMS

AI	Active ingredient
AMP	Alliance for Malaria Prevention
ANC	Antenatal care
BCC	Behaviour change communication
BEP	Best environmental practices
DANIDA	Danish International Development Agency
EOL	End-of-life
EPI	Expanded Programme on Immunization
ESM	Environmentally sound management
FAO	Food and Agriculture Organization of the United Nations
GF	Global Fund to Fight AIDS, Tuberculosis and Malaria
FGD	Focus group discussions
GMP	Global Malaria Programme
IEC	Information, education and communication
IIC	Intelligent Insect Control
LLIN	Long-lasting insecticidal nets
NCE	No cost extension
NGO	Nongovernmental organization
NMCP	National Malaria Control Programme
NRI	Natural Resources Institute
NTD	Neglected tropical diseases
PE	Polyethylene
PES	Polyester
PET	Separate polyester
SAICM	Strategic Approach to International Chemicals Management
SIHD	Shawnee International Health and Development
UC	Universal coverage
UNEP	United Nations Environment Programme
VCP	Vector control and prevention
USAID/PMI	United States Agency for International Development, Presidential Malaria Initiative
WB	The World Bank
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme

1. INTRODUCTION

The Global Malaria Programme of the World Health Organization (WHO/GMP) recommends universal coverage with effective vector control interventions for all populations at risk of malaria. In the case of long-lasting insecticidal nets (LLINs) this means full coverage of the targeted communities.[1] LLINs need to be replaced every few years, and so sustaining universal LLIN coverage in Africa will require annual distribution of approximately 100 million LLINs. This raises the following question: what should be done with the expired LLINs after they have been replaced? There is growing awareness of the need to consider the environmental impact that these nets may have during their life-cycle, initially when they are used for protection while sleeping, then when the old netting may be re-used for other purposes, and finally as waste.

LLINs contain pyrethroids in polyethylene (PE), polyester (PES) and polypropylene (PP),[2] and their packaging creates insecticide-tainted plastic waste. The options for managing the nets at their end-of-life (EOL) through environmentally sound management (ESM) – re-use, recycling, energy recovery or disposal – will need to take into account both the plastic net material as well as the residual pesticides.

The possibility must also be considered that the netting from old LLINs may be used for alternative purposes ("domestic reuse"), and the implications of this for human health and the environment must also be taken into account. Such uses may have economic or public health benefits (e.g. window screening, crop protection, eve curtains), but they may also have deleterious environmental effects. This raises the question of whether health information should encourage some forms of re-use and discourage others.

Sociocultural, legal and ethical issues must also be taken into consideration. Any proposal that malaria control agencies should collect and remove old LLINs must address the question of legal ownership: in most cases, these nets have been given unconditionally to users, and agencies would need the owners' permission to collect them.

To begin to address these concerns, two pilot projects have been funded to identify and assess the feasibility of environmentally sound options for collection, recycling or disposal of LLINs in Kenya, Madagascar and the United Republic of Tanzania. The World Bank – Canada Pops Trust – has funded a joint Kenya/United Republic of Tanzania project, and the UNEP Strategic Approach to International Chemicals Management (SAICM) has funded a very similar project in Madagascar. These pilot projects are structured into three lines of investigation (work streams): community, logistics and technical. Analysis across these three domains aims to identify preferred options for LLIN EOL management, and to provide evidence for WHO to make recommendations for policies, protocols and guidelines. This preliminary research is not expected to answer all the questions, and the results are expected to frame a follow-up multi-country study for further investigation of identified options.

An inception meeting, held on 10–12 August 2010 in Geneva, Switzerland, at WHO headquarters, brought together country teams, project coordinators and interested constituencies to develop a harmonized framework for identifying research objectives on community, technical and logistics aspects to be achieved during the pilot project, and to conclude with a list of required guidelines, protocols and policies for the sustainable management of LLINs. This meeting report summarizes the key points and discussion topics arising from the presentations, working groups and plenary sessions, and the conclusions reached on setting research priorities and identifying gaps in guidelines, protocols and policies.

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[1] WHO Global Malaria Programme. *Position statement on insecticide-treated mosquito nets* (http://www.who.int/malaria/publications/atoz/itnspospaperfinal.pdf).

[2] Currently, WHOPES LLINs are made of polyester and/or polyethylene and polypropylene with a coated or incorporated pyrethroid insecticide (http://www.who.int/whopes/en/).

2. MEETING BACKGROUND

Participants at the inception meeting were from international organizations, nongovernmental organizations (NGOs), country programmes (Kenya, Madagascar, United Republic of Tanzania), the donor community, LLIN industry, and the WHO Secretariat (*see* Annex 1). They arrived with a diverse set of assumptions and perspectives, partly reflecting their various backgrounds (e.g. private sector, LLIN implementation, environmental management). On the one hand, some argued that leaving old LLINs in the community would be likely to have negative consequences of one kind or another, justifying the collection and recycling, energy-recovery or disposal of old LLINs, which would therefore need to become a routine part of LLIN distribution strategies. On the other hand, others argued that the collection of old nets was not in fact justified by the available evidence, that old netting could be safely and usefully re-used within the community, and that collecting the old nets would in any case be permissible only with the assent of the users who are the legal owners. There was therefore not only a lack of consensus about the central question (what should be done with old nets), but also a wide diversity of views about the underlying issues to be considered, and the evidence needed to answer it.

Despite these differences in perspective, the objectives of the meeting were to set the research agenda for the pilot studies, and to identify the evidence necessary in order to develop guidelines, protocols and policies.

Additional difficulties related to expiration of funding. The projects were to close in December 2010. One no-cost extension was considered for the Madagascar pilot project. Therefore, across all the pilot projects, both time constraints and funding availability were factored into determining the most pertinent research activities.

3. MEETING OBJECTIVES

The aim of the meeting was to identify the issues to be addressed and the information needed in order to develop evidence-based policy recommendations for the end-of-life management of LLINs. The objectives of the meeting were to define the pilot project research agenda, to develop country-specific work plans (Kenya, Madagascar, United Republic of Tanzania), and to conclude with a final listing of specific data needed to inform guidelines, protocols and policies on the sustainable management of LLINs. This was to be done by means of: presenting an overview on the current situation regarding net use and options for safe disposal/recycling/energy recovery; receiving an update on recent initiatives and findings; presenting the initial plans for country pilot projects (*see* Annex 3); and using work streams (community, logistics and technical) to identify the research required to fill the gaps in guidelines, protocols and policies.

The objectives of the meeting were considered on the basis of the three project work streams that were established to investigate research priorities:

1. *Community work stream*. To understand the lifespan of mosquito nets from the community point of view, and the evolving ways that nets may be used as they get older, from initial distribution and use for sleeping, to various alternative uses, to waste. Further to this, to understand the attitudes of the community towards the possible collection of LLINs.
2. *Logistics work stream*. To look at the logistics and feasibility of collection of old LLINs, *assuming* that they are to be collected, through existing distribution systems or alternative options.

3. *Technical work stream.* To evaluate the environmental impact of current local disposal and reuse practices of LLINs, and to evaluate the technical aspects for the safe recycling/disposal/ energy recovery of LLINs.

It was emphasized that the objective of the meeting was not for the group of experts to reach conclusions on interim recommendations or policy positions. Rather it was to reach consensus on the information that was needed in order to reach such conclusions, and thus to define the research questions for the pilot studies (*see* Annexes 2 & 4).

4. DISCUSSIONS ON PROJECT RESEARCH PRIORITIES

The starting point for identification of research priorities was to discuss net use, and trace the life-cycle of an old mosquito net from the time it ends its useful life as a public health tool until it is considered waste (*see* Fig. 1). The possible paths of the mosquito net until its end-of-life is roughly understood, but at each step beyond its use as a "bednet", questions arise as to the need for intervention, especially whether it is better to collect nets from the community, or leave them there.

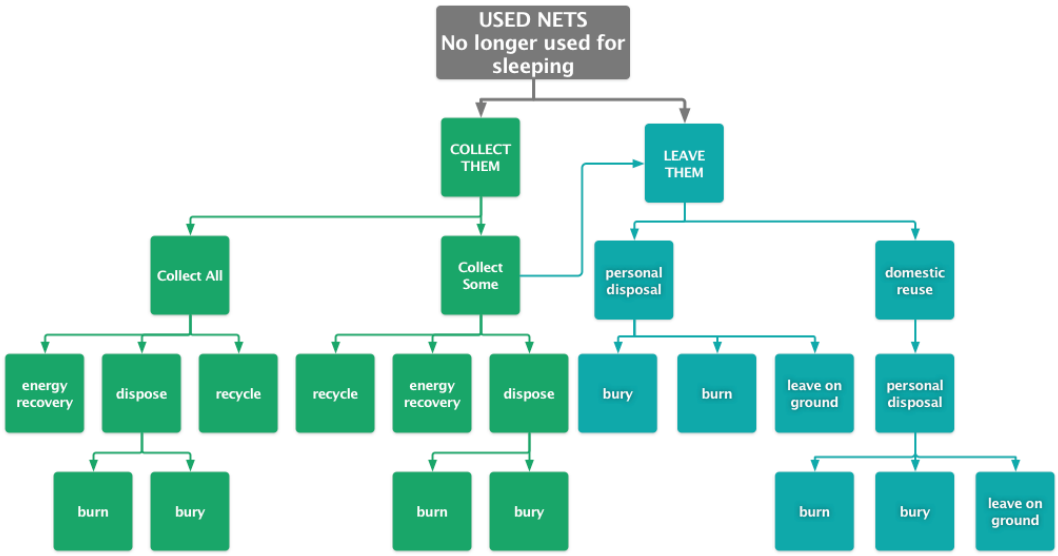

Figure 1. Flowchart of used LLINs

There were several lines of argument related to these two main options: to leave old LLINs in the community or to take them away. These included:

- LLINs pose a hazard to the environment and/or human health, and so should be removed.
- We have distributed these nets, so it is our responsibility, through good stewardship, to ensure their proper disposal.
- LLINs are already being be re-used in and around the household, and these uses are of genuine value to extremely poor people.
- While a few of these uses may be environmentally undesirable, most of them pose no health risks and some may have significant health benefits.

- What proportion of the total plastic waste in target communities do LLINs represent, and should we consider disposal of LLINs as part of the overall plastic waste issue?

Further questions and arguments arose from the "take them" or "leave them" points of view, and in considering the flowchart, another series of discussions raised important research questions that were useful in setting the research agenda. It was eventually agreed among participants that: the decisions made for EOL management of LLINs, at the minimum, should consider the country-specific context, the importance of maintaining and increasing LLIN coverage and usage, the ability to minimize environmental impact, the relative cost-effectiveness, and community acceptability; and that research priorities should consider these aspects. The following sections describe the main points addressed by presentations, and deemed by the work streams "community, logistics, technical" to be the priority research areas for the sustainable management of LLIN pilot projects:

1. Definition and identification of LLIN status: LLIN condition, use and materials.
2. Environmental and public health impact.
3. Ethical and legal issues.
4. Mechanisms for LLIN collection, storage and transport.
5. Options for recycling, energy recovery and disposal.
6. LLINs in the larger waste picture.
7. Management of LLIN packaging.
8. Funding mechanisms.

See *Annex 4.*

4.1 Definitions and identification of net status

Several expressions are already used to describe the physical status of LLINs, however these are rather arbitrary and lack clear definitions and accurate methods of measurement. Establishing a common terminology for an LLIN's status in its life-cycle, including physical condition and use, will become essential for stakeholders when decisions are being made on when and how in their lifespan they should handled. This will help to answer the following question: "Which nets that have reached EOL could be considered for collection from households?".

4.1.1 Net condition

Since the meeting, WHO has issued the Guidelines on monitoring durability of LLINs under operational conditions[3], which defines standardized methods for measuring the physical integrity of net. However, at the time of the meeting these standards were not yet available.

Many terms can be used to explain the process of physical wear and tear that limits the useful life of a net. "Useful life" is a term used to describe a net from the point of distribution to the point where it is no longer being used to sleep under or should be considered no longer useful to sleep under, based on its condition and ability to provide personal protection. A Venn diagram (*see* Fig. 2) was developed and proposed during discussions to define the terms commonly used in describing net condition and use in LLIN operations: damaged nets, expired nets, retired nets, ineffective nets. Although measurable thresholds remain to be determined (TBD), suggested definitions for commonly-used terms were:

- *Used nets.* Nets that are being used or have been used. This term includes all of the net categories described below.

[3] http://whqlibdoc.who.int/publications/2011/9789241501705_eng.pdf

- *Damaged nets.* Nets that are being used or have been used, and have a TBD minimum amount of holing.

- *Ineffective nets.* Nets that are being used or have been used, and are no longer providing personal protection. The threshold of holing and insecticidal availability TBD.

- *Expired nets.* Nets that are older than the TBD recommended lifespan.

- *Retired net.* A net that is no longer being used for sleeping under. It may be used for an alternative purpose, stored away or have been discarded.

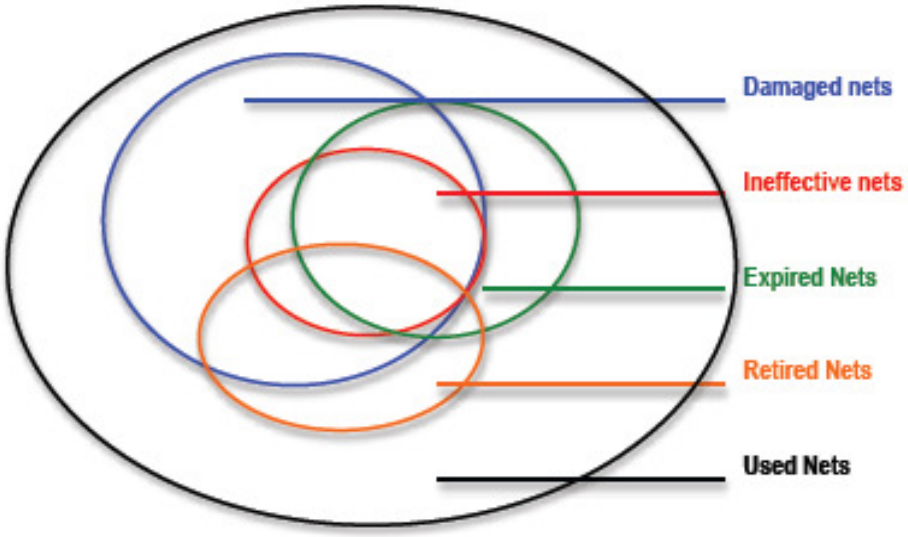

Figure 2. Venn diagram of LLIN physical condition

It should be noted that the term "used nets" encompasses all of the terms for net condition proposed, and that nets may be defined by all or some of the other net conditions. The relative proportion of net-condition status, as indicated by the size of the ovals, is arbitrary and likely to change based on country-specific distribution and usage profiles.

It was pointed out that there is surprisingly little information on how the epidemiological protection given by an LLIN declines as it gets older, gaining holes and losing insecticide. There is also no official or agreed threshold of wear of tear, beyond which it can be assumed that a net is useless. There is anecdotal evidence that users vary in their perceptions of when a net has become useless, and the point at which the net is considered no longer fit to be used on the bed: in some places nets with just a few holes may be discarded, while elsewhere badly-shredded nets are often seen in use on the bed. It was pointed out that even an untreated net with holes gives a slight but detectable degree of protection compared to the use of no net at all. Hence, WHO suggests that the default advice to users should be "do not give up using your old LLIN, however poor its condition, until you have a new and better net to sleep under." All this suggests that an appropriate functional way to classify a net's condition needs to be developed.

As suggested in figure 1, one possible strategy is to collect some but not all of the old nets, leaving those that are still in good condition in the community. The question then arises as to who will decide which nets are to be collected and which should be left behind, and how this decision should be made. Developing a method for measuring and defining net condition is complex; as mentioned

above, there is currently a dearth of published data on LLIN performance and durability in field conditions, and on the threshold of damage (number of holes and insecticide availability) at which it will no longer confer adequate personal protection.[4]

It was also pointed out by WHO that although WHOPES-recommended LLIN products have a nominal lifespan of 3 years, recent data from the field suggests that in practice there is much variation around this figure. In all situations, the process of net wear and tear is gradual and continues over a long period, but the speed of this process varies widely between settings. There are also differences between products, such that in one setting product X may be much more durable than product Y, while in another setting this ran king may be reversed. This variance is seen not just between brands, but in nets used by different individuals, households, districts and countries, and may be influenced by a number of sociocultural factors and environmental conditions, presumably because the factors causing net wear and tear also vary between settings.[5]

4.1.2 Net material

There may be technical issues in the ESM management of net waste that differ between the materials used to produce nets. LLINs are currently produced in PE and PES,[6] and conventional nets in PES and other materials. The identification of material type for separation may also be critical for waste-management processes, such as recycling.

4.1.3 Net purchased

It is normally safe to assume that conventional untreated nets have been purchased by the user, as generally only LLINs are distributed in national mass and routine distributions; such nets will not normally be considered as candidates for collection. In some settings, however, the same brands of LLIN may be both distributed free by public health systems and sold by the commercial sector, which makes distinguishing a purchased from a given net difficult. It could be argued that removal of a net that a household has bought for itself requires more justification than removal of a net that was previously donated by the same project that is now trying to recover it. This is discussed in greater detail under section 4.3, *Ethical and legal issues*.

4.1.4 Net labelling

Recommendations were made for ways to overcome the challenge of identifying net condition, net-use status, material, and years in use. One suggestion is to evaluate methods of labelling LLINs through tagging, bar-coding, micro-chipping or colour-coding to identify and track LLINs. Standardizing the information recorded, method of labelling and materials used, as well as how the data produced are managed, could ease the identification of LLINs that have reached the limit of their useful lifespan as a malaria control tool. Manufacturers have indicated that current LLIN labelling has at minimum the date of production and batch number, however this information is limited in value given wide variability between the date of manufacture and date of distribution. This is further challenged by the lack of permanence of the information on the currently-used tags owing to variability in the quality of the label material, the inks for printing, and how the LLINs are handled in actual field use.

[4] Kilian A. How long does a long-lasting insecticidal net last in the field? *Public Health Journal,* 2010 (21):43-47.
[5] Killian A. *LLIN durability presentation*. Atlanta, Georgia, 2010 (ASTMH, 3–7 November).
[6] Bayer has a polypropylene LLIN (Lifenet) that has just been approved by WHOPES approval process.

4.2 Environmental and public health impact

4.2.1 Environmental impact of old LLINs

An LLIN that has reached the end of its useful life still contains insecticides, whether it is still being used to sleep under, is being re-used for another domestic purpose, or has been discarded as waste. LLINs are not considered as hazardous waste under the Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal.[7] Nevertheless, it has been proposed that LLINs that have reached their EOL should be considered as "pesticide containers", and managed using the same principles, in order to minimize the environmental risk. In the end, there was no firm conclusion on the question of whether and how much old LLINs should be viewed as carrying an environmental risk. However, there was broad agreement that there may be environmental (toxicity to terrestrial and aquatic life) and human health risks related to net usage and local LLIN waste management, i.e. when burned, buried or left in the environment (*see* Fig. 1). It was agreed that the research team should determined exactly which LLIN re-use and disposal scenarios should be considered in order to evaluate environmental and public health risks.

When an LLIN is used as a net to sleep under, the risk for the environment is low. However the risks arising from the re-use of old LLIN material for other domestic "non-design" purposes have not been assessed. To quantify these risks, one would need a greater understanding of the different uses. It was agreed that a full risk assessment would be outside the scope of the preliminary research study, which should focus instead on identifying scenarios and developing models as a basis for these risk assessments.

4.2.2 Public health impact of old LLINs

It was argued that there may be a public health benefit from leaving the LLINs in the community. If an LLIN in good condition is not available, then sleeping under a used or worn out LLIN is certainly better than not using a net at all. The protection given by an old LLIN presumably depends on (a) the size and number of holes and (b) on insecticide levels.[8]

LLINs used as eave curtains or window coverings may contribute to malaria vector control.[9] Common domestic reuses for economic activities, including covering of crops and enclosure of livestock, may improve economic outputs and hence the livelihood and health of the household. For example, treated netting has been shown to be effective at improving cabbage production in smallholdings in Benin[10]. There is anecdotal evidence that old netting is being re-used for purposes other than sleeping, however the range and frequency of such forms of domestic reuse have not been fully documented. Studies have shown nets being used for a range of outdoor purposes, including: fishing and drying fish in Kenya;[11] prawn fishing in the Solomon Islands[12], protecting seedlings and garden crops, as the walls of a chicken coop, plaited into string to tie cattle in Ethiopia[13], and as washing sponges in Liberia[14]. A range of indoor uses have also been reported, with netting being used as a ceiling, a room-divider, curtains on window, door or eave, bed covers,

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7 Basel Convention 6th Conference of the Parties. *Technical guidelines for the identification and environmentally sound management of plastic wastes and for their disposal*. Geneva, UNEP, 2002.

8 Rehman AM et al. *How much does malaria vector control quality matter: the epidemiological impact of holed nets and inadequate indoor residual spraying*. PloS one 6(4), 2011.

9 Lengeler C. *Insecticide-treated bednets and curtains for preventing malaria*. Cochrane Database Syst Rev., 2004.

10 T. Martin, F. Assogba-Komlan, T. Houndete, J. M. Hougard, and F. Chandre (2006) Efficacy of Mosquito Netting for Sustainable **Small** Holders' Cabbage Production in Africa. *Journal of Economic Entomology* 99(2):450-454.

11 Minakawa N et al. Unforeseen misuses of bednets in fishing villages along Lake Victoria. *Malaria Journal*, 2008, 7(1):165.

12 Atkinson J et al. A qualitative study on the acceptability and preference of three types of long-lasting insecticide-treated bednets in Solomon Islands: implications for malaria elimination. *Malaria Journal*, 2009, 8(1):119.

13 Baume C, Reithinger R, Woldehanna S. Factors associated with use and non-use of mosquito nets owned in Oromia and Amhara Regional States, Ethiopia. *Malaria Journal*, 2009, 8(1):264.

14 Banek K, Kilian A, Allan R. Evaluation of Interceptor long-lasting insecticidal nets in eight communities in Liberia. *Malaria Journal*, 2010, 9(1):84.

padding under a sleeping mat, tablecloths, and even as garments in Sudan.[15] There is a need to further characterize and document such alternative uses and to clarify to what extent and in what condition nets are being put to such alternative purposes.

Identification of domestic reuses, the relative frequency of the reuses, and the perceived condition of the nets when they are transferred to reuse or to waste, and how waste is managed, will be a priority for community research, as well as assessing the perceptions of the public health and environmental risk of nets. These results will assist the technical work stream to develop environmental and human health risk models in the pilot project.

Questions were raised as to whether trace amounts of insecticides in the netting may increase pressure resulting in insecticide resistance. If so, this would be important in the light of reported pyrethroid resistance in Africa. WHO staff pointed out that old netting could only have this kind of effect if it is re-used in a location where mosquitoes that serve as human malaria vectors come into contact with it. This is very unlikely with all of the outdoor uses listed above. Previous experimental hut studies with netting used as a curtain suggest that there is likely to be both some contact with mosquitoes, and (if the netting still has some insecticide) some protective repellent/deterrent effect against mosquitoes. The same would be expected if the fabric is used as a ceiling or room divider. In other words, re-use of old netting will produce extra selection for insecticide resistance if and only if it also produces some protection against biting. For consideration of this question was considered beyond the scope of this study.

Other than the issue of environmental damage, one of the most frequently-suggested arguments for collecting up old nets is as a precaution during an LLIN distribution campaign, in order to prevent the old nets from blocking the use of the new ones. However, it was agreed that so far, there is no evidence that this happens in practice. Indeed, the opposite argument can also be suggested: usage of the new nets may be improved if the old nets are left behind, since families will be less tempted to divert the new nets to such unintended uses because the old ones are available instead. Moreover, there are anecdotal reports that when a net-user gets a new replacement net, their old net may, if it is still in moderately good condition, handed on to a relative or friend (perhaps living elsewhere) who up to that time has had no net. Clearly, this is a practice that leads to greater overall coverage, and it would not be possible if all old nets were collected. What happens in practice with these various possibilities is therefore an important question for the research agenda. Ultimately, EOL management options should maintain or increase coverage to have an impact on malaria control.

Finally, another issue is related to community concerns about the safety of the pesticides in LLINs. The question is whether the collection of old nets might confirm and draw attention to these fears about chemical safety, and thus exacerbate them. This could be especially relevant for pregnant women and children who, according to qualitative research, are perceived by the community to be more susceptible to possible side-effects of the insecticide.

4.3 Ethical and legal issues

There are legal and ethical limitations and conditions attached to the collection of nets by projects and local authorities. Questions that will be considered during the pilot project and longer-term research include:

1. If field-worker asks a householder to give up a net that has been given to or purchased by the household, what the legal status of that request?
2. Who legally owns the net if it has been distributed to the individual by the Ministry of Health? If there is no contract, and if no statement about the ownership of the net was given orally or in writing to the recipient when the net was handed over, should it be assumed as a default that the net is a gift? Or can it be argued that this is a loan, and that the nets remains the property of the

[15] The MENTOR Initiative. *Malaria control in humanitarian crisis training*. Photo and PPT presentation, 2010.

Ministry of Health, even in the absence of any explicit statement to this effect? If collection of nets is voluntary, would IEC help to persuade owners to give in their nets? What degree of persuasion or social pressure would be justified/ethical in order to obtain "increased LLIN coverage"?

3. If an LLIN exchange scheme is set up, so that one new LLIN is given out in exchange for every worn-out LLIN given in by a user, how will newcomers to the area obtain a net? What about residents who have no net to give in, because the old one has been stolen or completely destroyed?
4. If there are some strategies for EOL management that would avoid or mitigate some environmental damage, but on the other hand would risk decreasing the coverage of LLINs, is there an appropriate way to balance between these negative and positive effects, and how can this balance be found?
5. Will the discussion of risks of environmental impact of LLINs adversely affect LLIN ownership and usage? Is it ethical to use fear-messaging on the environmental impact to promote LLIN EOL management? With limited funds for investment in malaria control, what is ethically the better investment of funds? Should the task of mitigating environmental risks be supported only by additional non-health sources of money, or is it justified to use some proportion of public health funds for this purpose (even if this reduces the number of LLINs that can be purchased)?
6. Should net preference (size, shape, colour, fabric) be considered when planning an exchange of nets, if there is evidence that usage will be affected, even if the cost per LLIN is increased?

Participants expressed the opinion that in order for activities to continue towards the targets adopted for universal coverage of LLINs, putting in place policies on receiving a new LLIN only by exchange of an old one would jeopardize maintaining and increasing LLIN coverage levels. There was also concern that the policy of exchange may encourage people not to take care of their nets, because they would know this to be the means of receiving a new one. It may even encourage them to tear them into pieces, claiming "more nets" for exchange and ultimately resulting in penalizing those who have properly cared for and maintained their LLINs.

The community work stream will be responsible for investigating these legal and ethical questions, although all work streams should be considering these during the course of the pilot project. It is accepted that many of the issues will not be resolved during the pilot project, and other organizational bodies may be required to make decisions on these legal and ethical issues.

4.4 Mechanisms for net collection, storage and transport

Although it is not yet clear whether the collection of old LLINs will be common or rare, it is likely that there will some occasions when it happens, and so there is a need to assess the options for logistic operations for handling the collection, storage and transport of old LLINs. Current country LLIN distribution mechanisms (e.g. mass campaign, ANC, EPI) will be investigated to assess options for reverse logistics, but options for alternative collection strategies will be proposed, which may or may not be linked to another commodity that is being collected. The subsequent management options should be developed on the basis of national policies, resources and constraints.

The logistics aspects provide the link between community feasibility and technical possibilities (*see* Fig. 3). Although this area of research will be primarily the responsibility of the logistics work stream, the results of community and technical research will also be important in determining optimal strategies.

Decisions on mechanisms for collection, storage and transportation should consider:

1. current LLIN distribution mechanisms and the possibility of reverse logistics for universal coverage campaigns, ANC/EPI, private-sector sales, emergency distributions;

2. quantity (volume) of nets collected;
3. preference of the community for where, when and how nets are to be collected;
4. transportation infrastructure;
5. laws and conventions;
6. other costs (taxes for storage, insurance costs);
7. methods of monitoring of the system; and
8. storage facilities.

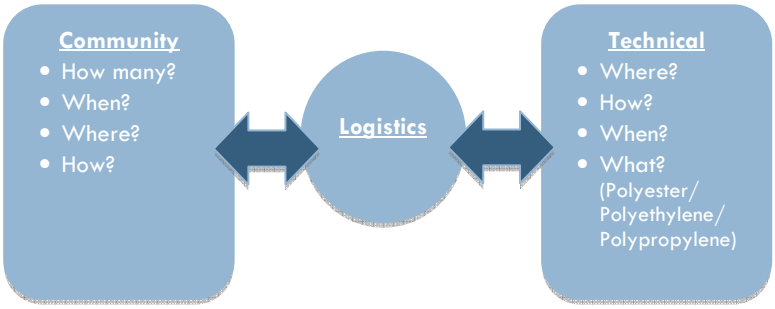

Figure 3. Linking of the three research areas

4.5 Options for recycling, energy recovery or disposal

According to conventional environmental principles, waste-management options may be ranked in order, from most preferred to least preferred, as: reuse, recycle, energy recovery, and disposal. The choice between these options is further influenced by the proximity principle, that is, it is generally better to manage waste close to its point of generation. It was agreed that these options, and this rank order preference, should be taken as starting points for evaluating country-specific LLIN waste management options *(see* Fig. 4*).* It is however important to recognize that these general approaches may be overruled by project-specific considerations such as environmental and health impacts (as discussed in section 4.2), cost, ethical and legal issues (as discussed in section 4.3), availability and access to waste-management infrastructure.

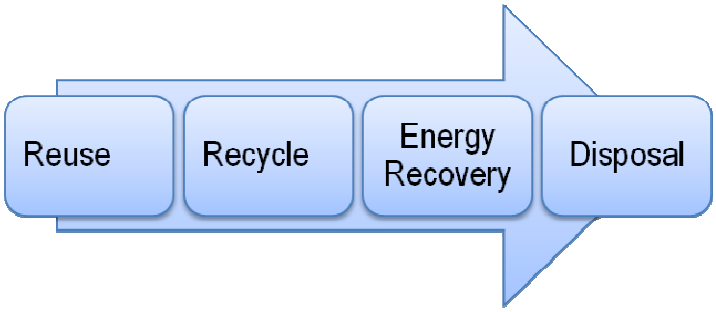

Figure 4. Waste-management hierarchy and proximity principle

4.5.1 Reuse

Reuse options have been discussed above, while addressing the environmental and public health impact of the topic of "domestic reuse" in section 4.2, *Environmental and public health impact*. If the decision is to leave nets in the community, the relative environmental, public health and economic impacts of the various domestic reuses should be evaluated. It is hypothesized that some alternative uses, such as window screening and eave curtains, may have a health benefit by continuing to function as a vector-control tool, while others may serve a purpose in economic

activities. Certain domestic reuses that may benefit the community in one way or another (and that do not involve a significant health or environmental risk) may be worth promoting. Conversely, it may be necessary to advise against others that may pose an environmental risk. One suggestion was that a manufacturer of an LLIN could never recommend any usage other than protection against insect bites while sleeping, and the question was raised as to whether the same limitations would also apply to others, including WHO.

4.5.2 Recycling

If the decision is taken that the LLINs must be collected, recycling options should be considered. When considering recycling of LLINs, it is important to take into account composition (materials of the nets, e.g. PES, PE), scenario selection and safety with respect to residual pesticide and the recycling process. It is assumed that the volume of LLINs to be collected will depend on the number of nets distributed and the collection strategies proposed, which may vary significantly between countries, and this relative volume will be important for selecting the appropriate scale of the recycling operation and suitable recycling plant technology. The scenario needs to be economically viable, and the process and economies of scale may differ significantly between a larger and a smaller plant, and depend on the number of LLINs to be recycled.

The cost of reprocessing the LLINs, the logistics costs and the value of the output (product) should be optimized to make this option financially attractive. Although there is an established international market for recovered polymers for reprocessing into products, the presence of residual pesticides from LLINs is expected to be significant and may potentially limit second-life opportunities. The residual pesticides would be likely to require additional health and safety safeguards during reprocessing, and as a result require a "chain of custody" to ensure segregation of recovered LLIN material from the general recovered plastic waste stream. The optimum scenario, from the perspective of chain-of-custody and economics, would be to see the entire process to a "second life" product take place within a country and at the same location. Ultimately "closed loop" recycling, converting end-of-life LLINs back into LLINs would be the most elegant solution.

Making use of lessons learned from similar disposal/recycling/energy-recovery initiatives will be helpful in the pilot project. There are pesticide-container recycling programmes that are well established in the United States, European Union and Brazil, that produce products such as pallets, railroad ties, irrigation piping and battery boxes. Intelligent Insect Control (IIC) is running its own trials on the processing of PE LLINs and possible secondary products that could be developed. It plans to produce and test plastic squatting-boards for pit-latrines to be used in humanitarian aid interventions, in partnership with University of Copenhagen researchers and with DANIDA funding.

4.5.3 Energy recovery There are many examples of energy recovery where waste is converted to energy either in the form of heat or electricity, which can take place at both a national and local level. The most common form of energy recovery is incineration, although it can also be done as "disposal" without any energy recovery (*see* section 4.5.4, *Disposal*). Incinerators are common in cement plants and for medical waste, and may be available in the pilot countries. Other energy-recovery technologies to be assessed include: a combustion laboratory that takes plastic and turns it into pearled polymer beads that are then fed into high-oxidation combustion burners to produce energy; a coarse solid-fuel burner, where it is not even necessary to process the plastic and it just requires a starter fuel; and solid burners for energy recovery at village level.

4.5.4 Disposal

In relation to waste-management disposal practices, there is already guidance on the management of pesticide-containing materials developed by FAO, the Secretariats of the Basel and Stockholm Conventions, WHO/UNEP, WHOPES, and the American Society of Agricultural and Biological Engineers, among others. These documents provide theoretical guidance for the management of LLINs[16], but do not provide practical guidance for individuals or national malaria control programmes.

Two disposal options are available: *i)* land-filling, where the environmental fate of the residual insecticide was identified as an issue requiring further investigation; and *ii)* incineration, which requires sufficiently high temperatures following the conditions for proper incineration of materials, available under the Basel Convention.

Local disposal practices of LLINs and their packaging need further investigation. Anecdotal evidence suggests that households are either burying or burning garbage in household or community pits, or throwing waste into the environment. The environmental and health risks of these practices, including measurement of emissions from local burning of LLINs and their packaging and the leaching of insecticides in burial practices, are currently undocumented.

4.6 LLINs in the larger-scale waste picture

Policies developed for EOL management of LLINs should consider the broader context of solid-waste management and specifically that of plastic. It is currently unknown to what extent expired LLINs and their packaging actually contribute to waste in the community. As mentioned in section 2, one opinion is that, if LLINs represent only a small proportion of the overall waste or of the plastic waste, the question arises whether the most appropriate solution is a specific intervention to collect only LLINs or a broad effort to deal with the plastic waste as a whole. It will therefore be essential to uncover whether old nets form a large or small proportion of plastic waste in a community, to what extent this plastic waste is retained within the household, used for other purposes, or disposed of in the environment and whichever the case, whether or not the nets and packaging are perceived as a major waste issue.

4.7 Management of LLIN packaging

A frequent and urgent request from agencies and countries managing LLIN distribution has been for guidance on how to manage the waste created by LLIN packaging during mass distribution campaigns. Distribution policy in campaigns, and sometimes during routine delivery systems, is often to take LLINs out of their individual packaging to reduce the likelihood of resale, to encourage hang-up of nets and in some cases to assist in marking the LLINs. A significant amount of insecticide-tainted packaging, including bailing materials, is produced at the distribution site. This waste is often handled by either open-air burning in piles, or by dumping in landfills. In some instances, there are reports of agencies encouraging the reuse of LLIN packaging to carry items including foodstuffs.[17] Currently no guidelines exist on best practices for managing packaging waste[18].

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[16] Food and Agriculture Organization of the United Nations. *FAO pesticide disposal series* (http://www.fao.org/ag/AGP/AGPP/Pesticid/Disposal/en/103194/index.html); and *Plant Production and Protection Division* (http://www.fao.org/agriculture/crops/core-themes/theme/pests/en/); World Health Organization/United Nations Environment Programme. *Pesticide-related activities at UNEP Chemicals* (http://www.chem.unep.ch/Pesticides/default.htm); Stockholm Convention. (http://chm.pops.int/Implementation/WasteStockpiles/Overview/tabid/446/language/en-GB/Default.aspx); American Society of Agricultural and Biological Engineers. *Recycling plastic containers from pesticides and pesticide-related products*. ASABE, 2006 (http://asae.frymulti.com/abstract.asp?aid=22228&t=1).

[17] Guidance from AMP BCC work stream.

[18] The WHO Global Malaria Programme will release interim recommendations on packaging in late 2011.

It is unknown how much insecticide remains on the various packaging materials used by LLIN manufacturers once the LLIN has been removed. This waste could be treated either as normal solid waste or as insecticide-tainted material, but to decide on how it should be handled, an assessment of the amount and type of residual insecticides left on the packaging, and a listing of the different packaging materials used, is considered necessary. This information, along with the recommendations on waste management of pesticides from the Basel Convention, should assist in drafting guidance to countries on the environmentally-sound management of LLIN packaging. Further to this discussion, the question remains of whether individual packaging is even required, and whether LLINs could be bundled only in bailing materials, which would reduce the costs incurred by additional packaging and eliminate the generation of waste. Producing evidence to answer these questions will be the task of the technical work stream during this pilot project. Additional investigation into environmentally-friendly alternatives for packaging is also relevant to this area of research, although it should be taken on by the manufacturers, and in the large-scale project proposal.

4.8 Funding mechanisms

Who will pay for strategies involving the collection, transport and recycling or disposal of old LLINs from households? Is this a viable business proposition that investors would take on with loans for start-up? With reverse logistics, would the funding mechanism already be built into the distribution cost? Would the primary donors (Global Fund, World Bank, USAID/PMI) be willing to cover additional costs related to these activities? From a stewardship perspective, is it the role of manufacturers or distributors , to pay for and manage this?

A cost-analysis of the EOL options is needed to determine whether they are financially viable activities that would require a first-time capital input versus a recurring cost. It is important for determining whether this is a role for the entrepreneur, donor or manufacturer. As some donors are accustomed to adding in budget to cover the costs of similar activities such as the sound management of medical waste, there may be funds to cover ESM of LLINs if the evidence is provided that these are the recommended actions for the management of LLINs. If this were stipulated as a "must do", donors would be more likely to respond.

Of concern however was how much additional cost per net would a donor be willing to pay, and what ceiling would there be? This margin is something that should be quantified if this downstream process is to be taken into consideration in funding LLIN distribution and/or LLIN procurement. Certainly, if manufacturers were asked to be responsible for the cost of recovering their LLINs and processing them, this would affect the price per LLIN. With insecure funding, it is unknown whether major donors have the budget capacity to respond to increases in the price and operational cost of EOL management of LLINs. If funds are not available, the question remains of where will the funds come from?

It is possible that long-term product stewardship, including EOL management of LLINs, is the responsibility of the LLIN industry, with resulting implications for manufacturers. There are several challenges to this approach as it would be difficult for a manufacturer to take responsibility in one country, since many different brands of LLINs are distributed and are likely to be collected at the same time. Once an LLIN is delivered to a country, the manufacturer loses control of it. Product stewardship is however a possibility, and the topic is being discussed among LLIN manufacturers in the CROPLIFE forum.[19]

When considering funding issues, it should be noted that EOL management of similar products has succeeded. In the case of insecticide containers, California has legislated that all pesticide

[19] Within CROPLIFE LN, manufacturers have begun discussions on product stewardship; however neither a statement nor a position has been formulated to date.

containers have an additional tax added to cover the cost of recycling the container. It was suggested that this might be a possible solution for LLINs, if it had political backing. But before the funding issue can be addressed, having an established set of guidelines and protocols on EOL management of LLINs will be necessary for investors, donors and manufacturers to calculate costs and risks involved in these activities. Without these, the risk and cost implications cannot be readily estimated, and may prevent partners from developing opportunities in the management of used LLINs.

5. CONCLUSIONS

In identifying priorities for the research to be carried out in the pilot study, participants tried to address the questions that would help move to drafting essential guidelines, protocols and policies on the sustainable management of LLINs. Some knowledge gaps were identified as being of lower priority and appropriate to be addressed through later and larger-scale studies. Participants concluded that the following areas should be considered as the main questions and outputs for the pilot research study:[20]

1. The effects of removal or non-removal of LLINs from the community:
   a. What are the relative stages of wear and tear that LLINs go through as they progress from use as a net (perhaps by a series of users), then domestic reuse and eventual waste?
   b. On the usage of LLINs: when new LLINs are distributed, which option leaves better eventual overall use-coverage: taking the old nets away or leaving them there ?
   c. What are the attitudes of net owners/communities towards keeping or giving back LLINs?
   d. What are the current non-design uses for LLINs and the netting from LLINs (i.e. "domestic reuse")?
   e. What are the human health benefits and risks, environmental risks, and insecticide-resistance risks associated with "domestic reuse" and local disposal?

2. Protocols to assess the logistic options of collecting, segregating, transporting, storing and monitoring of nets/netting and packaging material for:
   a. recycling;
   b. energy recovery;
   c. disposal.

3. Protocols to assess options for conditions under which LLINs are:
   a. reused;
   b. recycled;
   c. used for energy recovery;
   d. discarded.

4. Review of the labelling standards on what information is required on all tags of WHOPES-approved LLINs for tracking purposes, and identification of material, age of net, etc. Policy made on what methods, type of materials, sewing procedures and printing are required to ensure the durability of the label and the information on it.

5. Evidence-based guidelines for individual packaging requirements for LLINs. Guidelines on how to manage the resulting waste from LLIN packaging (e.g. specifications for biodegradable products and guidance on secondary utilization of bags).

6. Standardization of terminology and definitions for the terms used to describe LLIN status related to net condition and net use. Establishment of measurements and thresholds to define net-condition terms.

7. Guidelines for field-level evaluation of net use and net condition.

[20] There was no consensus among participants that eventual policy should be made on which of the types of "domestic reuse" of LLINs would be advisable or inadvisable. Representatives at the meeting explained that manufacturers are not willing to recommend any unintended, unregistered or non-labelled use of their LLIN products. Although it may be feasible to provide a position on uses that are inadvisable, in order to advise for possible reuse the issuing body would have had to demonstrate that there would be no negative impact. Participants felt that it may be easier to identify non-design uses which are ***not*** recommended, as this would only require determining that a clear risk to human health or the environment existed.

ANNEX 1

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ANNEX 2

Agenda

	Time	***Activity***	***Lead***
DAY 1	08.30	Assemble and register	
Session 1	09.00	Opening remarks with objectives and expected outcomes	Jo Lines
	09.15	Introduction of participants	All
	09.30	Election of Chairperson and Rapporteur	Jo Lines
	09.45	Current situation in the regions	Jo Lines
	10.00	Country presentation – Kenya	Kenya team
	10.45	Country presentation – Madagascar	Madagascar team
	11.30	*Coffee*	
Session 2	11.45	Country presentation – United Republic of Tanzania	U.R. Tanzania team
	12.30	A coherent research approach	Jerry Cooper
	13.00	*Lunch*	
Session 3	14.00	Environmental safety, technical aspects and challenges to safe disposal/recycling	Kevin Munn
	14.30	Plastics, recycling – issues to consider	David Smith
	15.30	*Coffee*	
Session 4	16.00	Community and ethics issues	Michael Albert
	16.30	Logistics/economics	Gaël du Châtellier
	17.00	Plenary discussions	Chair
	18.00	Housecleaning and closure	Jo Lines and Chair
DAY 2	09.00	*Review of day 1*	*Rapporteur*
Session 5	09.20	Presentations by Industry	Industry representatives
	10.40	Plenary discussions	Plenary
	11.00	*Coffee*	
Session 6	11.20	Funding mechanisms	Plenary
	11.45	Plenary discussions	Plenary
	12.00	Introduction to the groups	Chair
	12.15	A coherent research approach – community, logistics, technical aspects and product stewardship	Working groups
	12.30	*Working lunch*	
Session 7	13.30	Working groups (cont'd)	Working groups
	15.45	*Coffee*	
	16.00	Plenary discussions /combining the three aspects	Plenary
	18.00	Closure	Chair
DAY 3	09.00	Planning agenda for day 3	Stephanie Guillaneux
	10.45	*Coffee*	
Session 8	11.00	Working groups by country	Working groups
		Plenary discussions	Plenary
	13.00	*Working lunch*	
		Working groups by country	Working groups
Session 9	14h30	Future work plan for Kenya	Plenary
	15.00	*Coffee*	
		Future work plan for United Republic of Tanzania	Plenary
		Future work plan for Madagascar	Plenary
Session 10		Setting the agenda and timetable for the future: Who does what and when? How do we coordinate efforts? When do we need to meet and where?	Plenary
Session 11		Discussion of conclusions to be included in the meeting report	Plenary

ANNEX 3

Country profiles

KENYA

Five districts were initially chosen for the pilot project based on differences in epidemiology of malaria, LLIN use and distribution strategies. These districts are:

- *Bondo*. Western Kenya along lake Victoria, hyperendemic, planned for 2010 UC campaign.
- *Kisii*. Western Kenya, mesoendemic, planned for 2010 UC campaign.
- *Kiriniyaga*. Central Kenya, hypoendemic/seasonal transmission, routine distribution only.
- *Makueni*. Central Kenya, hypoendemic/seasonal transmission, routine distribution only.
- *Kwale*. Coastal Kenya, hyperendemic, planned for 2010 UC campaign.

Data from 2009 district health surveys show that ownership by household of at least one LLIN was 58% in urban areas and 55% in rural areas. Past campaigns have focused on social marketing, free LLINs for ANC services and campaigns targeting children under 5. The national strategy for LLINs now targets UC campaigns in districts of high transmission and only routine delivery though ANC and EPI in other districts. A UC campaign was planned for 2010, with routine delivery to sustain coverage until another UC campaign in 2014.

Of concern was what to do with the bags of the LLINs, as well as the LLINs themselves when considering recycling/disposal issues including a pilot in the upcoming campaign.

MADAGASCAR

Madagascar began its project in February 2010 with an inception meeting on 16–17 March, and a trial of an exchange for old LLINs in three communes in the district of St Marie Island. IEC/BCC materials and messages were developed for this activity *(see* Annex 5*)*. Preliminary research was done with focus group discussions and household questionnaires (non-probability sample). Further questions were added to a post-campaign household survey in May 2010. Results from these studies indicate that in some areas as many as 90% would exchange an old LLIN for a new one (St Marie questionnaire) while in the post-campaign survey only 39.3% would consider taking the LLIN for disposal.

Madagascar has already distributed 1 739 000 LLINs to approximately 3.6 million persons in 19 districts during a 2010 UC campaign. In November 2010 the remaining 72 districts were to receive a total of 5.6 million LLINs for 10.2 million people to achieve universal coverage by the end of 2010. Madagascar has two different projects funded to address LLIN sustainability:

1. SAICM – five districts where community-based research will occur. Districts were selected based on endemicity, seasonality of transmission, cultural profile, and differences in accessibility.
2. PMI/DELIVER exchange of LLIN programme in six districts – November 2010 (south). They would attempt to collect 60 000 LLINs. The programme was to look at recycling in and out of the country.

Note: one district overlaps in the two project areas in the south.

Madagascar would like to assess differences between the two intervention areas – distribution with exchange and distribution "stand-alone". Additional analysis and cross-tabulation of the post-campaign May 2010 data is recommended to elicit descriptive data on those who were willing to dispose of their LLINs no longer used to sleep under.

UNITED REPUBLIC OF TANZANIA

Distributions in the United Republic of Tanzania were originally targeted to children under 5 and pregnant women through a voucher system, however in Global Fund round 8 sleeping spaces were registered and a UC campaign was envisaged. This is part of a larger vector-control programme that involves indoor residual spraying (IRS) in epidemic-prone areas and larviciding in urban areas. The country has an established LLIN manufacturing company in-country – A to Z textiles – that produces Olyset net® of Sumitomo Chemicals, which currently produces 10 million nets a year, with a capacity that will double in 2011. With regard to recycling/disposal capacities**,** several initiatives have been identified in the United Republic of Tanzania, including:

- the project on sound management of pesticides funded by the Bill and Melinda Gates Foundation;
- 21 private plastic companies;
- ongoing recycling of PET bottles;
- a programme for shredding syringes and recycling them at the Tanzania Industrial Research and Development Organisation (TIRDO);
- an incinerator for medical waste;
- the availability of three cement kilns.

The country team has selected five districts for the pilot study. These districts have been chosen based on differences in their history of LLIN use, disease burden, level of LLIN coverage, urban vs rural and accessibility.

The following are the districts selected:

Kyele/Mbeya

1. Kigoma rural
2. Mtwara rural
3. Kilombero
4. Muheza
5. Kyela

Technical support from the three lead researchers (community, logistics, technical) is planned to assist the teams to reach project objectives.

ANNEX 4

Working-group outputs

Each of the three working groups completed a plan indicating:
1. Decision points/policy areas to be addressed in the research.
2. Evidence required to make these policy decisions.
3. Methods of data collection.

TECHNICAL GROUP

The outputs and arguments of the technical group concerning decisions points were made in the context/assumption that:

i. new nets are recommended to be used only for sleeping until they are retired;
ii. after nets are retired they can be collected, but if not, should not be reused in any way that could have negative impacts on health and/or the environment;
iii. as a general principle, acceptable *local* solutions should be sought for all retired nets and packaging.

Proposed acceptable options for the management of retired nets are, in order of preference, based on the waste-management hierarchy.

Domestic reuse

Although reuse cannot currently be recommended, it is recognized that old nets are sometimes used for purposes other than sleeping. There is therefore a need to determine the different ways nets are being used in order to make a careful assessment of risks. Supporting evidence in assessing risk would include dermal, oral and inhalation exposures, impacts on susceptible species, and insecticide-resistance issues.

Decision point	Potential recommendations	Evidence required	Method of data collection
How should retired nets be managed?	After the nets are retired they can be collected but should not be reused in ways that have negative impacts on human health and/or the environment	Assessment for alternative uses (cost/benefit/risk).	Based on community survey outcomes (indicating common uses), perform risk/benefit analysis of these uses. Supporting evidence would include dermal, oral and inhalation exposures, impacts on susceptible species, and insecticide-resistance issues.
What are the best ways to manage collected nets/packaging?	1. Recycling (preferred where suitable infrastructure and volumes exist)	Are acceptable infrastructure and processes identified?	Develop standards for performance, material handling, chain of custody, acceptable and sustainable recycling practices (OSH, environmental management).
		Evaluation of acceptable recycled products.	Identify or develop criteria for evaluation of potential recycled products, including major exposure pathways and accounting for previous lessons learned in similar activities.
	2. Energy recovery/incineration	Are acceptable infrastructure and processes identified?	Develop protocols and possible procedures for using existing incineration and energy-production facilities (e.g. power plants, cement kilns**,** etc.).
			Develop projects to potentially use LLINs for energy recovery in new installations (including small-scale facilities).
	3. Disposal	Are acceptable infrastructure and processes identified?	Develop guidance for local burial and disposal practices in the event that recommendations 1 and 2 are not feasible options.
	4. Packaging guidance (development of minimum standards)	Packaging should be the minimum to maintain the full integrity of the product prior to use. Tenders/buyers demonstrate that they adopt this guidance.	

LOGISTICS GROUP

The logistics working group reported their plans based on four areas of research/assessment:

1. Logistics of collection
2. Logistics of transportation
3. Logistics of monitoring
4. Logistics of storage.

1. COLLECTION

Collection method		**Evidence required**	**Method of data collection**
Distribute and collect at distribution point simultaneously	A	Expected quantities (methods of distribution: e.g. mass campaign, door-to-door, date of last distribution, etc.)	Collection of data from ministry of health, government, NGOs, retailers (own study).
	B	Location/accessibility	Distribution plans.
	C	Cost	Field studies.
	D	Human behaviour	Collection of data from ministry of health/NMCP, other government departments, NGOs, retailers. Community assessment.
	E	Must work for all distribution systems: Mass distribution Routine distribution Social marketing Commercial Emergency supplies	Field study.
	F	Available equipments (protection, packaging)	Field study.
	G	Extra human resources	Calculation.
	H	Minimum facilities	Field study.
Collection without distribution		A B C D E F G H	
		Feasibility for adequate communication	Available market research. Focus groups.
Voluntary restitution (collection point)		A B C D E F G H	
Collection with incentive		A B C D E F G H	
Collection of jettisoned nets		A B C D E F G H	

2. TRANSPORTATION

Potential recommendations		**Evidence required**	**Method of data collection**
From user to first storage point	A	Cost (volume, distance, weight)	
	B	Accessibility: - for net owners - for transporter Need for list of required transport means (trucks, flight, boats, walking)	
	C	Who is transporting?	
	D	Availability of free transport means (e.g. from distribution, other)	
	E	Availability of free transport means (e.g. from military)	
From first storage point to intermediate storage A, from A to B and so on		A B C D E	
International transport		A B C D E	
		Existing laws and conventions	Basel Convention Ministry of transport Customs
		Specific packaging and labelling required	
		Insurance	

3. MONITORING

Potential recommendations		**Evidence required**	**Method of data collection**
Collection	A	Who will use this monitoring information?	
	B	Accurate data on population, past/current distributions	
	C	Duration	
	D	Cost	
	E	Areas of population covered	
	F	Partners involved (is monitoring already being done for distribution?)	
	G	Existing monitoring and records (e.g. bill of lading, storebooks, distribution list, etc.)	
	H	Cost	
	I	Existing law for monitoring	
Transport		A, B, C, D, E, F, G, H, I	
Storage		A, B, C, D, E, F, G, H, I	

4. STORAGE

Potential recommendations		**Evidence required**	**Method of data collection**
At collection point	A	Existing facilities: number, capacity, condition (dry, secured, accessible, etc.)	
	B	Cost	
	C	Stewardship	
	D	Security	
In between storages		A, B, C, D	
		Does transport include temporary storage?	
		Existing facilities for net preparation (separation, cleaning, compacting, etc.)	
At customs		A, B, C, D	
		Storage cost at customs	
		Time	
		Taxes	

COMMUNITY GROUP

The community working group prioritized from a large list of decisions and questions that arose from a brainstorming session. Listed below are the main decision points to be addressed in the pilot study research.

Decision point	***Issues***	***Evidence required***	***Method of data collection***
Should any net be removed from the household based on utilization issues (coverage)?	1. Do retired nets still in the household contribute to vector control? 2. Do retired nets block the use of more effective (new) nets? 3. Should non-treated nets be removed?	Do old nets block net coverage?	Randomized community trials: taking away the net and not taking it away.
		Does replacing a net reduce net coverage?	Randomized community trials: taking away the net and not taking it away.
Should retired nets be removed that are being used for "domestic reusing"?	1. Do retired nets still contribute to vector control? 2. Are alternative uses harmful?	What are the retired nets being currently used for?	Qualitative methods: observational, FGD, key informant interviews, etc.
		What are the categories of use (e.g. still hanging in the HH, still present near a sleeping space, agriculture/livelihood, etc.)?	Mixed methods (qualitative and quantitative).
		To what extent (what frequency) are the alternative uses (and their respective categories) occurring?	Quantitative methods: cluster surveys.
		What is the spectrum of the net life-cycle? At what stage in the life-cycle do the nets move on to an alternative use? At what point do they move on to a third use?	Mixed methods: qualitative (defining end-of-life and next phase-of-life points); quantitative: cluster surveys (defining the possibility to generalize these points in a life-cycle).
		What risks are associated with those various uses: risks for health, environment and insecticide resistance?	Risk assessments.
		What is the value associated with the retired net (monetary value and availability)?	Market survey and qualitative and/or quantitative methods for perceived value.

Decision point	***Issues***	***Evidence required***	***Method of data collection***
Will acknowledgement/acceptance of alternative uses (IEC/BCC) increase or decrease the probability of new LLINs being used for alternative purposes?	1. What types of messages are required to ensure that informing the person that you are taking away the net will not reduce coverage? 2. Will the type of distribution affect alternative uses?	Net coverage (utilization) following take-back that includes messages about "acceptability of giving up retired nets".	Randomized community trials: taking away the net and not taking it away, qualitative.
		Net coverage (utilization) following take-back that includes messages about "acceptability of giving up retired nets" through different distribution systems.	Randomized community trials: taking away the net and not taking it away, qualitative.
		Is the interaction/understanding between the HH and the individual health agent doing the collection getting the "right" message across?	Randomized community trials: taking away the net and not taking it away, qualitative.
What are the ethical risks in requiring households to exchange a net to get a new one?	1. If you decide to collect nets, should the take-back be voluntary, required, legislated? 2. If the end-result is increased coverage (utilization) of nets, does it matter whether or not it is ethical? 3. Does the household have the right to a new LLIN independent of the exchange of the LLIN?	Country values on what is considered ethical.	Mixed methods: qualitative to understand ethical considerations; quantitative to achieve a range of opinions
		Is there a long-term hazard to LLINs in the community?	Risk assessment.
		Do households object to net being removed?	Alternative conditions where you would do the exchange-trial?
Do old nets significantly contribute to waste in the community?	1. Is net waste significant? 2. Is net waste comparable to other waste? 3. How many nets have actually been discarded (and how can we be sure that the health agent asking questions about nets no longer present in the home is getting a true response)?	What is the amount of fabric and plastic discarded in the community?	Quantitative: direct observation; cluster survey.
		What is the amount of netting that ends up as waste (discarded) in the community?	Quantitative: direct observation; cluster survey.
		What do communities perceive as their major solid-waste problems?	Quantitative to determine perceptions and frequency.
		Are health agents actually collecting information on discarded nets?	Qualitative methods: FGD.
How does the community feel about giving up their nets?	1. Are community members willing to give back their retired net at no benefit? 2. What are community members' attitudes about recycling/pollution? 3. How much incentive is required to give up their retired net?	What is the monetary value of a retired net?	Mixed methods (qualitative and quantitative).
		Do community members care about plastic pollution?	Qualitative methods.
		Is the interaction between the HH and the health agent asking the questions regarding the households' willingness to give back a net “voluntarily”.	Mixed methods; cluster survey with internal validity checks.