Institution: London School of Hygiene & Tropical Medicine (LSHTM)

Unit of Assessment: UoA2 – Public Health, Health Services & Primary Care

Title of case study: Scaling up insecticide treated net coverage: evidence to support strategic policy decisions and investment

1. Summary of the impact

A comprehensive body of research into the effectiveness, cost and distribution of long-lasting insecticidal nets (LLINs) by LSHTM has made a major contribution to the reduction of malaria-related mortality between 2008 and 2013, especially among children in Africa. The research formed the basis of a radically altered strategic approach to combating malaria by WHO and other agencies, and led to the roll-out of malaria campaigns based around LLINs in several African countries. LSHTM research into the technology of LLINs, which also contributed to these developments, is described in a separate case study.

2. Underpinning research

This case study traces LSHTM contributions to the evidence that justified the scaling-up of investment and large-scale distribution of insecticide-treated nets (ITNs) to control malaria. Lead researchers included Jo Lines, Reader in Malaria Control and Vector Biology, at LSHTM since 1984 (seconded to WHO 2008–2011); Christian Lengeler, LSHTM Trial Coordinator and Research Fellow 1992–1995; Peter Smith, Professor of Tropical Epidemiology, at LSHTM since 1979; Chris Curtis, Professor of Medical Entomology, at LSHTM from 1976 until his death in 2008; Mark Rowland, Professor of Medical Entomology, at LSHTM since 2000, and Anne Mills and Kara Hanson, Professors of Health Economics, at LSHTM since 1979 and 1990. Due to the number of LSHTM researchers contributing to research into ITNs, work contributing to the technological development of LLINs is described in a separate case study.

By 1993, the first major field trial of insecticide-treated nets (ITNs) in Africa (in The Gambia) had shown a remarkably large reduction in all-cause child mortality. However, to justify large-scale roll-out of nets, replication across the range of eco-epidemiological conditions in the region was needed. Lengeler, Smith and country researchers carried out a series of field trials (in Burkina Faso, Kenya, The Gambia and Ghana) between 1993 and 1996. The Ghana findings – similar to those in the other countries – showed a reduction in all-cause child mortality of 17%.[3.1] Supporting evidence on cost-effectiveness gathered by Mills and country economists showed that ITNs were extremely cost-effective.[3.2]

A subsequent influential 2004 Cochrane review and meta-analysis by Lengeler concluded that ITN coverage for a cohort of 1,000 children will on average prevent 5.5 deaths per year across a wide range of epidemiological settings in rural Africa. Further LSHTM epidemiological trials conducted between 1995 and 2005 and included in the Cochrane review confirmed that ITNs are effective against both falciparum and vivax malaria in regions where the vector mosquito species are different (e.g. the Amazon Basin and South Asia) but where mortality rates are lower, and when deployed through other methods of implementation.

Also during 1993 and 1998, small-scale Tanzanian trials by Lines and Curtis confirmed the entomological mode of action of ITNs, by recording reductions in sporozoite rates in mosquitoes. This confirmed the underlying mechanism of the 'mass effect',[3.3] which occurs when the insecticide kills so many of the mosquitoes trying to feed through the net that the transmission capacity of the local mosquito population as a whole is reduced, protecting the whole community rather than just the individual sleeper. The researchers argued that in order to obtain the necessary levels of coverage, nets should be distributed free of charge to everyone.[3.4]

In 2001–2005, LSHTM researchers conducted a series of detailed studies to examine the role of local commercial markets in delivering mosquito nets to end users, and showed that the coverage achieved by commercial markets in nets is more equitable than that achieved by the sale of subsidised nets by public health systems and projects.[3.5] Further work in 2010–2011 demonstrated

the epidemiological advantages of free distribution of nets directly to pregnant women and infants through routine antenatal and immunisation services.[3.6]

3. References to the research

3.1 Binka, FN, Kubaje, A, Adjuik, M, Williams, LA, Lengeler, C, Maude, GH, Armah, GE, Kajihara, B, Adiamah, JH and Smith, PG (1996) Impact of permethrin impregnated bednets on child mortality in Kassena-Nankana district, Ghana: a randomized controlled trial, *Tropical Medicine & International Health*, 1(2): 147–154, doi: 10.1111/j.1365-3156.1996.tb00020.x. Citation count: 241.

3.2 Goodman, C, Coleman, P and Mills, A (1999) Cost-effectiveness of malaria control in sub-Saharan Africa, *Lancet*, 354(9176): 378–385, doi: 10.1016/S0140-6736(99)02141-8. Citation count: 138.

3.3 Hill, J, Lines, J and Rowland, M (2006) Insecticide-treated nets, *Advances in Parasitology*, 61: 77–128, doi: 10.1016/S0065-308X(05)61003-2. Citation count: 40.

3.4 Curtis, C, Maxwell, C, Lemnge, M, Kilama, WL, Steketee, RW, Hawley, WA, Bergevin, Y, Campbell CC, Sachs, J, Teklehaimanot, A, Ochola, S, Guyatt, H and Snow, RW (2003) Scaling-up coverage with insecticide-treated nets against malaria in Africa: who should pay?, *Lancet Infectious Diseases*, 3(5): 304–307, doi: 10.1016/S1473-3099(03)00612-1. Citation count: 81.

3.5 Webster, J, Lines, J, Bruce, J, Schellenberg, JRA and Hanson, K (2005) Which delivery systems reach the poor? A review of equity of coverage of ever-treated nets, never-treated nets, and immunisation to reduce child mortality in Africa, *Lancet Infectious Diseases*, 5(11): 709–717, doi: 10.1016/S1473-3099(05)70269-3. Citation count: 32.

3.6 Okell, LC, Paintain, LS, Webster, J, Hanson, K and Lines, J (2012) From intervention to impact: modelling the potential mortality impact achievable by different long-lasting, insecticide-treated net delivery strategies, *Malaria Journal*, 11(327), doi: 10.1186/1475-2875-11-327. Citation count: 3.

Key grants

Mills, Economic Evaluation of National Impregnated Bednet Programme, The Gambia, WHO-TDR, 1992–1994, $275,000.
Mills, Workshop on Cost-effectiveness Analysis of Impregnated bednets, WHO-TDR, 1996, $7,500.
Mills, Lines, Hanson, Scaling Up ITN Coverage in Tanzania, Understanding the Contribution and Limitations of the Private Sector, Gates Malaria Partnership, 2002–2005, £366,833.
Porter, Lines, Godfrey-Faussett, TARGETS: Team for Applied Research Generating Effective Tools and Strategies: Proposal for a Research Programme Consortium in Communicable Diseases, DFID, 1/4/2005–31/3/2010, £5,082,631.

4. Details of the impact

The research carried out by LSHTM has made an important contribution towards reducing the number of deaths from malaria. Using WHO methods of estimation, it can be estimated that approximately 1m malaria-related deaths were prevented by LLINs between 2008 and 2013, mostly among African children.[5.1] This impact was brought about by net distribution operations and investment decisions during the impact assessment period (mostly in 2009–2010). The WHO policy that led to these operations, which explicitly cites LSHTM research as supporting evidence, was first drafted and announced shortly before the impact assessment period (in 2007). Nevertheless, it is clear that the operations putting this policy into practice did take place during the assessment period, and were equally influenced and justified by the same research, as were the subsequent WHO statements repeating and amplifying the initial policy announcement.

Following a very limited emphasis on vector control by WHO and leading agencies in the 1990s, the late 2000s marked a strategic sea change. Since 2006, and supported by the evidence accumulated through the research, WHO has been recommending **ITNs/LLINs as the default**

vector control intervention for Africa, with indoor residual spraying (IRS) as a possible alternative that might be preferable in some settings. The relevant WHO report, *Malaria Vector Control and Personal Protection*[5.2] acknowledges Curtis' work on the Study Group that produced it, as well as Rowland's written contribution. It also cites numerous relevant LSHTM outputs. This document set the scene for further strategic emphasis on malaria prevention through ITNs/LLINs.

In 2008, The Roll Back Malaria partnership (RBM) – the global framework for coordinated action against malaria – **made ITNs and LLINs the lead intervention** in its Global Malaria Action Plan.[5.3] The plan acknowledges the contributions of no fewer than six LSHTM researchers and quotes a December 2007 briefing produced by Lines and colleagues for the Department for International Development (DFID), which was based on 3.1 and 3.3 and itself highlighted LLINs as a central plank in the quest to eradicate malaria.[5.4] As part of the 2008 Global Malaria Action Plan, 'SUFI' (Scaling-Up For Impact) was proclaimed as a goal – aiming to rapidly reach universal coverage for all populations at risk with locally appropriate malaria control interventions, with **730m LLINs to be distributed globally** (about 350m in Africa) (5.3, p. 14). The impact paper in Pakistan and the implementation research that followed led to the LLIN strategy adopted by the Global Fund for South Asia (e.g. Pakistan and Afghanistan) [5.3] and by WHO for conflict induced emergencies [5.5].

In 2008, following a series of publications arguing that the impact of ITNs would be maximised only if they were given free to everyone in the community (because of the 'mass effect' demonstrated by Lines et al.[3.3, 3.4]), the UN Secretary-General announced a **vision of universal coverage** to end malaria deaths.[5.6] His message was that LLINs, along with indoor residual spraying, would be made available to all people at risk, especially women and children in Africa. It was based on a WHO position statement on *Insecticide-Treated Mosquito Nets* which was first published in 2007 and remained the standard WHO policy position throughout the 2008–2013 period.[5.7] The position statement explains the reasons for this shift to universal coverage through the use of ITNs, citing several LSHTM outputs as well as Lengeler's Cochrane review of the earlier mortality trials. Subsequently, and following these WHO recommendations, ITN distribution campaigns have mostly been standalone and designed to provide nets for entire populations, with one net provided for every two people (eg Uganda). The contributions of LSHTM research and staff are acknowledged by the WHO unit responsible for global WHO policy on this topic.[5.8]

Largely as a result of the strategic initiatives described, **expenditure** on malaria control as a whole is expected to exceed $1bn throughout 2008–2013[5.1, 5.2] with some 40% to 60% of this being spent on vector control (mostly nets).

Not all countries wish to rely on externally funded and free distribution of all nets, and some prefer to develop approaches more readily sustainable over the longer term. LSHTM research findings on the public health value of **commercial markets** as a distribution mechanism for ITNs, and their importance in achieving overall coverage levels, encouraged several countries to promote a diverse and complementary mixture of distribution channels. Examples include Kenya, Ghana, Tanzania, Pakistan and Afghanistan, who are encouraging **mixed distribution systems** operating in parallel, including not only mass campaigns but also distribution of free nets through routine public health systems (especially antenatal and immunisation services) and unsubsidised commercial markets.[5.9, 5.10]

5. Sources to corroborate the impact

5.1 Number of deaths prevented 2008-13 calculated from: WHO (2012) *World Malaria Report*. Geneva: WHO, http://www.who.int/malaria/publications/world_malaria_report_2012/en/ (accessed 14 November 2013) (pp. 59–61); Roll Back Malaria Partnership (2011) *A Decade of Partnership and Results,* Progress & Impact Series, no. 7, September. Geneva: WHO, http://www.rbm.who.int/ProgressImpactSeries/docs/report8-en.pdf (accessed 11 November 2013) (pp. 18, 68–69); Roll Back Malaria (2010) *World Malaria Day 2010: Africa Update,* Progress & Impact Series, no. 2, April. Geneva: WHO, http://www.rbm.who.int/ProgressImpactSeries/docs/wmd2010report-en.pdf (accessed 11 November 2013) (p. 38).

5.2 WHO (2006) *Malaria Vector Control and Personal Protection: Report of a WHO Study Group*, WHO Technical Report Series, no. 936, http://whqlibdoc.who.int/trs/WHO_TRS_936_eng.pdf (accessed 14 November 2013).

5.3 Roll Back Malaria (2008) *The Global Malaria Action Plan: For a Malaria-free World*. Geneva: WHO, http://www.rbm.who.int/gmap/gmap.pdf (accessed 14 November 2013).

5.4 Lines, J, Whitty, CJM and Hanson, K (2007) *Prospects for Eradication and Elimination of Malaria: A Technical Briefing for DFID*. London: DFID Health Resource Centre, http://r4d.dfid.gov.uk/PDF/Outputs/Targets_RPC/HD205-DFID-final-2007-20_2_.pdf (accessed 14 November 2013).

5.5 WHO (2013) *Malaria control in humanitarian emergencies: an inter-agency field handbook*, 2nd edition, WHO, Geneva, http://apps.who.int/iris/bitstream/10665/90556/1/9789241548656_eng.pdf (accessed 25 November 2013).

5.6 Ki-moon, B (2008) UN Secretary-General's video message on World Malaria Day – announcing vision for universal coverage to end malaria deaths, statement, 25 April. New York: UN, http://www.un.org/sg/statements/index.asp?nid=3118 (accessed 14 November 2014).

5.7 WHO (2007) *Insecticide-treated Mosquito Nets: a WHO Position Statement*. Geneva: WHO, http://www.who.int/malaria/publications/atoz/itnspospaperfinal/en/index.html (accessed 14 November 2014) (remains the primary WHO policy document on this issue).

5.8 See paragraph 4 of letter from Coordinator of the Vector Control Unit at the Global Malaria Programme, WHO. Available upon request.

5.9 Njau, RJA, de Savigny, D, Gilson, L, Mwageni, E and Mosha, FW (2009) Implementation of an insecticide-treated net subsidy scheme under a public-private partnership for malaria control in Tanzania – challenges in implementation, *Malaria Journal*, 8(201), doi: 10.1186/1475-2875-8-201.

5.10 Kolaczinski, JH, Muhammad, N, Khan, QS, Jan, Z, Rehman, N, Leslie, TJ and Rowland, M (2004) Subsidized sales of insecticide-treated nets in Afghan refugee camps demonstrate the feasibility of a transition from humanitarian aid towards sustainability, *Malaria Journal*, 3(15), doi: 10.1186/1475-2875-3-15