Institution: Durham University

Unit of Assessment: UoA5

Title of case study: Integrated Vector Management for the Control of Vector Borne Diseases

1. Summary of the impact (indicative maximum 100 words)

Integrated Vector Management (IVM) was developed by the World Health Organisation to control vector borne diseases using combinations of interventions. Professor Steve Lindsay and his team have contributed to the development and assessment of many of the tools used for vector control, including insecticide-treated bed nets (ITNs), larval source management and house screening for malaria control. This research has influenced international policy on the control of malaria and other important diseases. It is estimated that 294 million ITNs have been purchased for malaria control, and have helped save 1.1 million lives over the past decade.

2. Underpinning research (indicative maximum 500 words)

IVM has lacked evidence about many of the potential tools that could be used for vector control and there has been little evidence supporting the use of combinations of tools for the control of VBDs. Prof Lindsay and colleagues have carried out studies in Africa to measure the efficacy of a range of vector control tools against malaria and other major VBDs, and his teams carried out 3 of the 4 major recent trials of microbial larvicides in Africa. These studies have provided important evidence required for making policy decisions for disease control. Importantly, unusually and in-line with the IVM strategy, some of these tools, such as screened housing, can be used by development agencies outside the health sector[1].

Prof. Lindsay was a member of the team which first demonstrated that insecticide treated bednets (ITNs) reduced deaths from malaria in African children[2]. Since treated nets and indoor residual spraying of insecticides target only indoor mosquitoes, further reductions in transmission were proposed to be achieved by targeting outdoor biting mosquitoes. This led to the group carrying out large-scale field trials of microbial larvicides to control both indoor and outdoor biting vector mosquitoes in Kenya, Tanzania and The Gambia[3]. This work demonstrated that (1) larval control could reduce malaria transmission in Africa, which challenged the accepted dogma, and (2) larviciding by ground teams failed to work in areas with extensive breeding sites. Of particular note was the field trial conducted in the Western Kenyan Highlands where long-lasting insecticidal nets were combined with larval control which demonstrated for the first time that combinations of interventions can provide additional protection against malaria infection in children[3]. The importance of larval source management for malaria control was also highlighted by Lindsay's recent meta-analysis for the Cochrane Library[4]. These studies are internationally recognised as being the strongest evidence for assessing the efficacy of any health intervention.

In recent years we have seen a rise in mosquitoes resistant to insecticides used on nets or walls, and in the future we may lack effective insecticides for malaria control threatening the hard-won gains made over the past 10 years. The Durham team therefore carried out a randomised controlled trial in The Gambia to determine whether house screening, with no insecticides, would protect children against malaria. It found that house screening reduced anaemia in children by half[5]. Since anaemia is a major killer of children under two years old, house screening is also likely to protect young children from dying from malaria. This work has strengthened the hypothesis that socio-economic development should be considered as a 'health intervention'. A systematic review and meta-analysis published in The Lancet[1] demonstrated that the poorest were twice as likely to have malaria than the less poor, implying that development may well act as an effective long-term intervention against malaria.

The Durham group also studies fly-borne diseases, and was the first to demonstrate that the human face fly, *Musca sorbens*, transmitted trachoma an important cause of blindness in the world. Importantly they showed that fly control by space spraying insecticides or installing pit latrines could reduce trachoma in African children (Emerson, Lindsay)[6].

3. References to the research (indicative maximum of six references)

1. Tusting L, Willey B, Lucas H, Thompson J, Kafy HT, Smith R, Lindsay SW (2013) Is socio-economic development the most cost-effective 'intervention' against malaria? *The Lancet* 382: 963-72. DOI:10.1016/S0140-6736(13)60851-X

2. Alonso PL, Lindsay SW, Armstrong Schellenberg JRM, Gomez, P, Hill, AG, David, PH, Fegan, G, Cham, K & Greenwood, B.M. (1993) A malaria control trial using insecticide-treated bed nets and targeted chemoprophylaxis in a rural area of The Gambia, West Africa. 2. Mortality and morbidity from malaria in the study area. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 87, supplement 2: 13-8. DOI: 10.1016/0035-9203(93)90170-U.

3. Fillinger U, Ndenga B, Githeko A, Lindsay SW (2009). Integrated malaria vector control with microbial larvicides and insecticide-treated nets in western Kenya: A controlled trial. *Bulletion of the World Health Organization*; 87: 655-65. DOI: 10.2471/BLT.08.055632

4. Tusting L, Thwing J, Sinclair D, Fillinger U, Gimnig J, Bonner KE, Bottomley C, Lindsay SW (2013) Mosquito larval source management for controlling malaria (Review). *The Cochrane Library* 8: DOI: 10.1002/14651858.CD008923.pub2.

5. Kirby MJ, Ameh D, Bottomley C, Green C, Jawara M, Milligan PJ, Snell PC, Conway DJ, Lindsay S. W. (2009) Effect of two different house screening interventions on exposure to malaria vectors and on anaemia in children in The Gambia: a randomised controlled trial. *The Lancet*; 374: 998-1009. DOI: 10.1016/S0140-6736(09)60871-0.

6. Emerson PM, Lindsay SW, Alexander N, Bah M, Dibba SM, Faal HB, Lowe K, McAdam KPWJ, Ratcliffe AA, Walraven GEL, Bailey RL (2004). Role of flies and provision of latrines in trachoma control: cluster-randomised controlled trial. *The Lancet* 363: 1093-8. http://dx.doi.org/10.1016/S0140-6736(04)15891-1

Grants supporting the research described above.

UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR). A malaria control trial using insecticide-treated bed nets and targeted chemoprphylaxis in a rural area of The Gambia, West Africa. 1988-1990.

Edna McConnell Clarke Foundation. A community randomised intervention against house flies for the control of trachoma and diarrhoea. £95,808. August 1999-July 2002.

Department for International Development. Health and Population Division (R7448, RD567). Trachoma and diarrhoea transmission by synanthropic flies with the development of sustainable strategies for fly control. £324,867. August 1999- July 2002.

Environmental Health Project, United States Agency for International Development. Field Studies of Anti-larval Methods for Malaria Control in Africa. $359,027. January 2003-August 2004 (R020411).

National Institutes of Health, USA. Anti-larval measures for malaria control in The Gambia. $2,090,895. September 2003-August 2008.

Medical Research Council. House screening against malaria. £534,000. 1st May 2005-31st October 2008 (R020583).

Bill & Melinda Gates Foundation Framework for Integrated Vector Control. $1M. 1st September 2012- 28th February 2014.

4. Details of the impact (indicative maximum 750 words)

The research trial described in Section 2 led to the World Health Organisation (WHO) carrying out

further studies across sub-Saharan Africa which confirmed the results, demonstrating that using insecticide-treated nets (ITNs) resulted in a 20% fall in mortality in children under five years old [7]. Today treated nets are the major tool used for reducing malaria in Africa and many parts of the tropics [8]. They are cheap and cost only US$1.39 per person per year of protection (www.rbm.who.int/keyfacts.html, accessed 25th April 2013). It is estimated that 294 million nets were purchased for malaria control between 2008 and 2010, enough to cover 73% of the 800 million people living at risk of malaria [8]. As a consequence the percentage of households with at least one ITN in sub-Saharan Africa has risen from 3% in 2000 to 53% in 2012 [9]. It is estimated that the massive roll-out of ITNs and, to a lesser extent, indoor residual spraying, has saved 1.1 million lives [9].

Over the last 10 years Lindsay's teams carried out 3 of the 4 major recent trials of microbial larvicides in Africa: in Kenya [3], Tanzania [10] and The Gambia [11]. The results from this trial provided WHO with much needed information on the protective efficacy of this intervention and led to larval source management being recognised by WHO in an 'Interim Position Statement on the role of larviciding for malaria control in sub-Saharan Africa' that references this work [12]. For the first time Larval Source Management was included in the World Malaria Report in 2012, which is a statement of support for this intervention.

In recent years the interest in larval control for malaria control has grown and there are presently 27 malaria endemic countries using larval control for malaria control, including 9 in Africa, 5 in the Americas, 3 in the Eastern Mediterranean, 6 in Europe, 2 in South-East Asia and 2 in the Western Pacific [9]. Since these countries look to WHO for advice on malaria control, the work done by Lindsay and colleagues has significantly influenced the uptake of this intervention, providing the evidence that larval control is an effective intervention against malaria.

Lindsay is presently the Chair of the Larval Source Management workstream for the Roll Back Malaria Partnership, a global framework for coordinated action against malaria that informs international policy. This workstream provides the technical support for WHO and national malaria control managers around the world by providing the evidence required for decision making. Lindsay and his team, supported by WHO, have (1) carried out the analysis and written the Cochrane review on Larval Source Management [1], which provides the evidence that this intervention is protective and (2) led and written the WHO manual on larval source management that shows national control managers how to implement this intervention [13]. Thus the work of this team has contributed to larval source management being supported by WHO and have provided material that assists national malaria control programme managers around the world.

The team also demonstrated for the first time that *Musca sorbens*, the face fly of humans, transmits trachoma, the second cause of preventative blindness in the world. This is recognised by WHO (http://www.who.int/topics/trachoma/en/) and the International Coalition for Trachoma Control (http://www.trachomacoalition.org/about-trachoma/transmission-routes). The Carter Center had planned to construct 10,000 latrines in rural Ethiopia to improve sanitation by reducing face fly breeding in surface faeces. The program was so successful more than 90,000 latrines were ultimately constructed. This activity was directly related to our demonstration that face flies transmit trachoma (http://www.cartercenter.org/news/documents/doc2198.html). Latrines reduce fly numbers because these flies do not enter latrines to breed.

Because of Prof Lindsay's expertise in the development of new tools for vector control he has been

invited to participate and chair several meetings helping to shape WHO's policy on IVM and contributed to the 'Report of the WHO consultation on integrated vector management (IVM)' [14] and 'Development of a global action plan for integrated vector management (IVM) Report of a WHO Consultation' [15] which led to WHO adopting this policy [16] and producing a handbook on IVM [17] which references some of his team's research. He also provides support to the Bill and Melinda Gates Foundation, advising on funding vector control research and has recently joined WHO's Vector Control Advisory Group (VCAG) on New Tools. His work on health and development also influences policy at the highest international level and his work [1] is referenced repeatedly in the recent policy document produced by Roll Back Malaria/UNDP entitled 'Multisectoral Action Framework for Malaria' [18] which represents a new approach to global malaria control.

5. Sources to corroborate the impact (indicative maximum of 10 references)

7. Lengeler C. Insecticide-treated bed nets and curtains for preventing malaria. The Cochrane Database of Systematic Reviews. 2004; (2): CD000363 pub2. DOI: 10.1002/146.
8. WHO. World Malaria Report 2011. Geneva: World Health Organization; 2011. http://www.who.int/malaria/publications/atoz/9789241564403/en/index.html
9. WHO. World malaria report. 2012. Geneva: World Health Organization; 2012. http://www.who.int/malaria/publications/world_malaria_report_2012/wmr2012_full_report.pdf
10. Geissbühler Y, Kannady K, Chaki PP, Emidi B, Govella NJ, Mayagaya V, et al. Microbial larvicide application by a large-scale, community-based program reduces malaria infection prevalence in urban Dar Es Salaam, Tanzania. *PLoS ONE*. 2009; **4**(3). doi:10.1371/journal.pone.0005107
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12. WHO. Interim Position Statement: The role of larviciding for malaria control in sub-Saharan Africa. Geneva: World Health Organization; 2012. http://www.who.int/malaria/publications/atoz/interim_position_statement_larviciding_sub_saharan_africa.pdf
13. WHO. Larval Source Management. A supplement ary measure for malaria vector control. Geneva: WHO; 2013. http://apps.who.int/iris/bitstream/10665/85379/1/9789241505604_eng.pdf
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15. WHO. Development of a global action plan for integrated vector management (IVM) Report of a WHO Consultation. Geneva: World Health Organization; 2008. http://whqlibdoc.who.int/hq/2009/WHO_HTM_NTD_VEM_2009.1_eng.pdf
16. WHO. WHO position statement on integrated vector management. *Wkly Epidemiol Rec*. 2008; **83**(20): 177-81. http://www.unboundmedicine.com/harrietlane/ub/citation/18488269/WHO_position_statement_on_integrated_vector_management_
17. WHO. Handbook on Integrated Vector Management (IVM). Geneva: World Health Organization; 2010. p. 78 http://whqlibdoc.who.int/publications/2012/9789241502801_eng.pdf
18. RBM/UNDP. Multisectoral action framework for malaria Geneva, Switzerland: UNDP and RBM; 2013. http://reliefweb.int/sites/reliefweb.int/files/resources/Multisectoral-Action-Framework-for-Malaria.pdf