UNITED NATIONS

SC

UNEP/POPS/COP.7/INF/5

Distr.: General
16 February 2015

English only

Stockholm Convention on Persistent Organic Pollutants

Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants
Seventh meeting
Geneva, 4–15 May 2015
Item 5 (a) (ii) of the provisional agenda*

Matters related to the implementation of the Convention: measures to reduce or eliminate releases from intentional production and use: DDT

DDT expert group and its report on the assessment of scientific, technical, environmental and economic information on the production and use of DDT and its alternatives for disease vector control

Note by the Secretariat

1. As referred to in the note by the Secretariat on the evaluation of the continued need for DDT for disease vector control and promotion of alternatives to DDT (UNEP/POPS/COP.7/5), the DDT expert group assessed the information on production and use of DDT and prepared a report for the consideration of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants at its seventh meeting.

2. Annex I to the present note contains the report of the DDT expert group on the assessment of the production and use of DDT and its alternatives for disease vector control. Annex II to the present note sets out the list of current members of the DDT expert group. The terms of office of the members nominated by parties will expire on 1 September 2015.

3. The present note, including its annexes, has not been formally edited.

* UNEP/POPS/COP.7/1.

060315

Annex I

Report of the DDT expert group on the assessment of the production and use of DDT and its alternatives for disease vector control

12 November 2014
Geneva

Stockholm Convention on Persistent Organic Pollutants

Acronyms and Abbreviations

BMGF	Bill & Melinda Gates Foundation
COP	Conference of the Parties
CS	Capsule suspensions
DDT	Dichloro-diphenyl-trichloroethane
DFID	Department for International Development
DSS	Decision support system
EC	Emulsifiable concentrate
EU	European Union
FAO	Food and Agricultural Organization
GEF	Global Environment Facility
GFATM	Global Fund to Fight AIDS, Tuberculosis and Malaria
IRS	Indoor residual spraying
IRD	Institute for Research and Development, France
IRM	Insecticide resistance management
IVCC	Innovative vector control consortium
IVM	Integrated vector management
LLINs	Long-lasting insecticidal nets
MOH	Ministry of Health
MT	Metric Tonnes
NIPs	National implementation plans
NMCPs	National malaria control programs
PMI	President's Malaria Initiative
PHP	Public health pesticides
POP	Persistent Organic Pollutants
POPRC	Persistent Organic Pollutants Review Committee
SC	Suspension Concentrate
TDR	Special Programme for Research and Training in Tropical Diseases
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme
WP	Wettable powder

Contents

List of Tables

I. Introduction

1. The Stockholm Convention has listed dichloro-diphenyl-trichloroethane (DDT) in its Annex B with production and use of DDT for disease vector control in accordance with Part II of the annex, as an acceptable purpose. Such production and use, as provided in paragraph 2 of part II of Annex B, is restricted to World Health Organization recommendations and guidelines on the use of DDT and when locally safe, effective and affordable alternatives are not available the Party in question. Availability of DDT under the Convention as an acceptable purpose for disease vector control use has no time limitation.

2. Paragraph 6 of part II of Annex B of the Stockholm Convention on Persistent Organic Pollutants require that commencing at its first meeting and at least every three years thereafter, the Conference of the Parties (COP) shall, in consultation with the World Health Organization, evaluate the continued need for dichloro-diphenyl-trichloroethane (DDT) for disease vector control on the basis of available scientific, technical, environmental and economic information. Due to the fact that the COP now has ordinary meetings every two years, by its decision SC-3/2[1], it undertakes the evaluation of the continued need for DDT for disease vector control at each ordinary meeting, as provided in the revised process for DDT reporting, assessment and evaluation contained in Annex I to that decision.

3. The process adapted by the above decision DC-3/2 for the reporting on and assessment and evaluation of the continued need for DDT for disease vector control has established an expert group to analyse the data gathered with the following Terms of Reference:

(a) Undertake a situational analysis on the production and use of DDT and the conditions for such use, including a review of the responses by countries to the questionnaire;

(b) Evaluate the availability, suitability and implementation of alternative products, methods and strategies for Parties using DDT;

(c) Evaluate the progress in strengthening the capacity of countries to shift in a safe fashion to reliable or suitable alternative products, methods and strategies based on a review of the opportunities and needs in countries for sustainable transition;

(d) Make recommendations on the evaluation and reporting mechanisms set out in paragraphs 4 and 6 of Part II of Annex B of the Convention;

(e) Consider and assess the actions being taken by Parties to accomplish the following:

(i) Development of regulatory and other mechanisms to ensure that DDT use is restricted to disease vector control;

(ii) Implementation of suitable alternative products, methods and strategies including resistance management strategies to ensure the continuing effectiveness of such alternatives;

(iii) Measures to strengthen health care and to reduce the incidence of the disease being controlled with DDT;

(iv) Promotion of research and development of safe alternative chemical and non-chemical products, methods and strategies for Parties using DDT, relevant to the conditions of those countries with the goal of decreasing the human and economic burden of disease. Factors to be promoted when considering alternatives or combination of alternatives shall include the human health risks and environmental implications of such alternatives. Viable alternatives to DDT shall pose less risk to human health and the environment, be suitable for disease control based on conditions in the Parties in question and be supported by monitoring data;

(f) Make recommendations to the Conference of the Parties on the continued need for DDT for disease vector control and on any actions deemed necessary to reduce the reliance on DDT in the light of the assessments undertaken pursuant to subparagraphs (a) to (e) above.

4. The COP in its evaluation of continued need for DDT for disease vector control at its sixth meeting held in 2013, in its decision SC-6/1, concluded that countries that are relying on DDT for disease vector control may need to continue such use until locally safe, effective, affordable and environmentally sound alternatives are available for a sustainable transition away from DDT.

[1] UNEP/POPS/COP.3/30, Annex I, Decision SC-3/2.

5. By the same above decision, the COP decided to evaluate the continued need for DDT for disease vector control, on the basis of scientific, technical, environmental and economic information, including that provided by the DDT expert group with the objective of accelerating the identification and development of locally appropriate, cost-effective and safe alternatives.

6. The COP also invited the United Nations Environment Programme, in consultation with the World Health Organization, the DDT expert group and the Secretariat, to prepare a road map for the development of alternatives to DDT, and to present it to the COP at its seventh meeting.

7. The DDT expert group, in collaboration with the WHO, conducted an assessment of available scientific, technical, environmental and economic information related to the production and use of DDT for disease vector control.

8. To facilitate the process of compiling the above information, the DDT Expert Group met through various channels including the Stockholm Convention POPs Webinars, online meetings and emails to discuss and agree on the format and outline of the preliminary report that forms the framework for the expert group to report to the COP for its consideration during its seventh meeting.

9. The inter-sessional discussions held by the Group agreed to analyse the following key issues:

(a) Situation analysis of the production and use of DDT;

(b) Availability, suitability and implementation of alternatives to DDT;

(c) Implementation of vector control products, methods and strategies;

(d) Capacities for countries to transit from DDT to other alternatives for vector control;

(e) Action taken by Parties/Partners to reduce reliance on use of DDT for vector control.

II. Situation Analysis of the Production and Use of DDT

10. Paragraph 4 of Part II, of Annex B of the Convention requires Parties registered to use DDT for acceptable purposes to provide to the Secretariat and World Health Organization information, every three years, on the amount used, the conditions of such use and its relevance to the Party's disease management strategy. The DDT expert group undertake assessments every two years in parallel to the meetings of the COP. The information on production and use was last provided by Parties for the period 2009 to 2011 and was considered by the DDT expert group in its assessment for the sixth meeting of the COP. As notification of production and use information by Parties for the next cycle (2012-14) is due in 2016 the information will not be available for the 2014 assessment by the DDT Expert Group. However, information from the 2009 to 2011 reporting period and limited additional information obtained from producers and key users will be summarized in this section of the report.

1.1 Sources and amounts of DDT production and distribution in 2009-2011 and 2012-14

11. The Secretariat to the Stockholm Convention distributed the adopted DDT questionnaire to the 178 Parties to facilitate providing information on production and use of DDT for disease vector control covering the 2009-2011 reporting cycle. As reported by the DDT expert group in its assessment of November 2012, a total of 24 Parties responded to the DDT questionnaire for the reporting cycle 2009-2011. Included in these respondents were 12 Parties out of 18 registered for acceptable use/production of DDT. Of the 12 Parties, seven reported use of DDT for vector control. These were India, South Africa, Eritrea, Swaziland, Mauritius, Zambia and Mozambique. As in the previous reporting cycle (2006-2008) Gambia, which has not notified the DDT Register of acceptable purposes, reported that it has continued to use DDT. The six other countries in the DDT Register that had not submitted their DDT questionnaires for the 2009-2011 reporting cycle included Botswana, China, Marshall Islands, Namibia, Senegal and Venezuela. China has stopped production and use DDT since 2010 and will give up the right for re-use of DDT for malaria outbreak in accordance to the Chinese national malaria elimination plan (2010-2020)[2].

1.1.1 Global production

12. The information provided by the Parties to the questionnaires covering the 2009 to 2011 reporting cycle showed that India was the only producer of DDT and that the trend of global DDT production for the years 2009, 2010 and 2011 was more or less steady at 3,415; 3,610 and 3,192 Metric Tonnes (MT) of technical grade material (98-99% active ingredient, a.i.), respectively. The

[2] Reported by the member of the DDT expert group from China.

annual DDT production during the 2009-2011 reporting cycle closely matched the reported annual global use of DDT.

13. The DDT Expert Group members from India have provided information on DDT production and export for the periods[3] of 2012-13 and 2013-14, following consultation with Hindustan Insecticide Ltd., the only producer of DDT identified. This includes the production of 3,872.4 MT and 2,786.0 MT of technical grade material (98-99% a.i) for 2012-13 and 2013-14, respectively. The technical grade material was used to prepare DDT formulations for export as well as domestic sale. The total production sold on the market in India in 2012-2013 and 2013-1014 was 2,934.500 MT and 3,091.500 MT of technical grade material (98-99% a.i), respectively. The amount of DDT exported from India in 2012-2013 and 2013-1014 was 287.337 MT and 75.284 MT of technical grade material (98-99% a.i), respectively.

14. Overall, the total global production of DDT has remained relatively constant over the period 2009 to 2014 but with some variations from year to year. The amount of DDT produced for export, by Hindustan Insecticide Ltd, in 2012-13 equalled 9.8% and in 2013-14 equalled 2.4% of the amount produced for the Indian market.

1.1.2 Export of DDT

15. According to the last reporting period of the Parties, India is the only country with an export of DDT products directly from the factory, namely from the Hindustan Insecticide Ltd. The number of countries to import DDT from India was reduced from five to two between years 2012-13 and 2013-14, with a drop in the amount of exported DDT from 286.23 MT to 76.46 MT of technical grade material (98-99% a.i) for the same period. The countries to discontinue the import of DDT in 2013-14 included Botswana, Myanmar and Namibia, whereas South Africa and Zimbabwe maintained their DDT import albeit at reduced levels (Table 1).

Table 1: Global export of DDT reported in metric tonnes (MT) of technical grade material (98-99% active ingredient)[4]

Source	Country	Export of DDT in MT	
		2012-13[b]	2013-14[b]
India	Botswana	22.50	-
	Myanmar	8.85	
	Namibia	57.45	-
	S. Africa	33.10	30.79
	Zimbabwe[a]	164.33	45.67
Total		***286.23***	***76.46***

[a] *Zimbabwe United Nations Development Programme*
[b] *Reporting period: April 1st to March 31st*

1.2 Trends in DDT use

16. For the reporting period 2009-2011, malaria was the primary disease targeted in all the respondent countries followed by leishmaniasis control in India. According to the questionnaires, India was the only country that reported using DDT for both malaria and leishmaniasis vector control, while Mauritius reported using DDT for malaria vectors in addition to control of *Aedes albopictus*, the vector of the chikungunya and dengue viruses. A review of information published during the period 2012 to 2014 indicates that DDT is still used by government departments in India against mosquito and sand fly vectors. Notably, DDT is used for indoor residual spraying (IRS) in 60% of all malaria high risk areas in India. Overall, the use of DDT in India for malaria control has been reduced steadily every year from 2009 (2847 MT technical grade material (98-99% a.i.) to 2014 (1757 MT) whereas the use of DDT for leishmaniasis control has seen a steady increase every year from 2009 (500 MT) to 2014 (1335 MT).

1.3 Existing mechanisms on purchase, quality control and use of DDT

17. The importation, packaging, registration, transportation, storage and disposal of DDT and other public health pesticides is based on WHO Pesticide Management and WHO IRS guidelines and within country rules and regulations. In some countries where disease vector control programmes are

[3] Financial year: April 1st to March 31st; [2] Used for preparation of 75% and 50% DDT formulations.

[4] Source: Hindustan Insecticide Ltd, India.

supported by development partners such as PMI, the spray operators of insecticides are trained in safe use, mixing, handling and disposal, to minimize human exposure and environmental contamination in accordance with WHO guidelines. Such programmes also include quality assurance on application of insecticide by follow-up bio-efficacy verifications. For countries where facilities are inadequate to undertake product quality assurance of insecticides used, including DDT, options are available to send the samples abroad for quality testing to places such as India, South Africa and Europe.

18. WHO has published Guidelines on Procuring Public Health Pesticides that elaborate on purchase requirements and quality control (WHO 2012). The objective of the guidelines is to provide guidance in the procurement of appropriate high quality public health products. The manual promotes fairness, transparency, integrity, accountability and quality assurance in procurement. The document is meant to assist the governments and stakeholders in preparing their own local standard operating procedure on procurement and quality control of pesticides.

19. As highlighted in the previous report by the DDT Expert Group, India has developed and implemented an Environmental Management Plan (EMP) with support from the World Bank. The EMP has six codes of practices, namely, i) transport of insecticides for IRS activities, ii) storage and management of insecticide stocks, iii) community responsibility during IRS activities, iv) use and maintenance of personal protective equipment, v) indoor residual spraying, and vi) disposal of waste water, empty bags/containers and biomedical wastes.

1.4 Hazards related to misuse and environmental contamination

20. According to the country responses for the reporting period 2009-2011, the eight DDT using countries, except Eritrea and Mauritius, reported to have community awareness programmes in place to raise awareness on human and environmental safety issues relating to DDT use. However, only three of the countries (India, Gambia and Uganda) report having a system in place for monitoring exposure to DDT. The agencies in charge of assessing the risks are the Health and Environment ministries.

21. In 2011 WHO published an update of the 2001 Joint FAO/WHO meeting report on Pesticide Residue on Human Health focusing on DDT use in IRS in order to provide specific advice to the Conference of the Parties. The report highlighted issues relating to hazard assessment, exposure assessment and risk characterization on use of DDT in disease vector control. A detailed analysis of the human health risks is available in the WHO (2011a) report.

1.5 Stockpiles of DDT

22. According to the country responses for the reporting period 2009-2011, only five out of 24 countries reported on the stockpiles of DDT. Parties that reported having stockpiles of DDT included: South Africa with 36.0 tonnes of DDT 75% wettable powder (WP) that is stocked at secure dedicated facilities; India with 2,046.0 tonnes of DDT 50% WP; Jordan with 25 tonnes of DDT 75% WP stored at the MoH warehouses; Gambia with 14 tonnes of 75% WP in good and usable condition; and Mauritius with 5 tonnes of technical grade DDT (98-99% a.i.). Swaziland reported that it had unspecified stocks of obsolete DDT in need of disposal.

23. The national implementation plans (NIPs) submitted to the Stockholm Convention requires that countries provide indications of the quantity, quality and location of DDT stockpiles and obsolete DDT in their countries. They are also required to address illegal trafficking and use of DDT for purposes other than public health vector control. Operations are ongoing to clean up and safely dispose of obsolete pesticide stocks under the auspices of the Africa Stockpiles Programme (ASP 2010). A research article on DDT substitutes indicates that Bangladesh has 602 MT of obsolete DDT stockpiled in storage facilities that are inadequate, resulting in seepage, pilferage, weathering and misuse, leading to environment contamination and health hazards¨ (Rahman, 2012). There also may be other countries not reporting.

1.6 Repackaging and disposal of DDT stockpiles

24. An ongoing UNEP-GEF EMRO-project has reported the destruction of the majority of waste DDT identified in the eight participating countries during the project. This includes 23.8 tonnes of DDT and other obsolete stocks in Jordan and 41.2 tonnes of concentrated DDT in Morocco. An additional 28.7 tonnes of DDT in Iran have been repacked and are set for destruction by September 2014 (WHO, 2014a).

III. Availability and suitability of alternative products, methods and strategies to DDT

2.1 Availability and accessibility of alternatives to DDT for indoor residual spraying

25. The WHO has recommended 12 insecticides, including DDT, for use in IRS in malaria control programmes. The recommended IRS products fall within four different classes of insecticides with products available in all four classes. The alternative classes of insecticides to DDT are the organophosphates, pyrethroids and carbamates. See the WHOPES homepage for the 12 recommended insecticides for IRS - (http://www.who.int/whopes/Insecticides_IRS_Malaria_09.pdf). Only six of the 11 chemicals recommended as alternatives to DDT are commonly used. However, the choice of any of these alternatives depends on the susceptibility of vector populations, the length of the disease transmission season, the type of surfaces to be sprayed, the commercial availability and the ability of the governments to procure and handle the insecticide. Importantly, most of the recommended alternatives to DDT do not have the desired residual persistency of more than 6 months and therefore require more than one round of application per year.

26. The first choice for most countries when they consider IRS is to use one of the different formulations of the pyrethroid class of insecticides because of their low cost, low toxicity to mammals, effectiveness and community compliance. The shift to carbamates such as bendiocarb and organophosphates has been necessitated by development of pyrethroid resistance and also to preserve the effectiveness of long-lasting insecticidal nets (LLINs) that use the same class of insecticide. The introduction of insecticides of another class should always be preceded by appropriate susceptibility assessment. New formulations that provide long insecticide residual on walls have recently been approved for IRS by WHOPES which include microencapsulated organophosphate, pirimiphos-methyl CS (capsule suspension) and the pyrethroid formulations, lambda-cyhalothrin CS and deltamethrin WG (wettable granules) (WHO, 2010a). Research is also carried out to re-purpose existing chemicals for use in insecticide based vector control, as for example chlorphenapyr (BASF).

27. Micro-encapsulated pirimiphos-methyl CS (Actellic 300 CS) has been assessed in several trials and is now established as a long lasting (6-9 months) alternative insecticide for IRS. However, the high cost of this product (which is about 4 times and 2 times more expensive than pyrethroids and carbamates respectively) makes it prohibitive for most endemic countries (Tangena *et al.,* 2013; Rowland *et al.*, 2013; Tchicaya *et al*., 2014; Chanda *et al*., 2013a; Oxborough *et al.*, 2014; WHO, 2014a). In addition, a recent study conducted in Sarawak, Malaysia demonstrated long-lasting effect of deltamethrin-WG against *An. maculatus* (Rohani, *et al.,* 2014). Research in Morocco has found IRS with α-cypermethrin plus SoC-EM an effective and cost-effective approach for the prevention of cutaneous leishmaniasis (Faraj *et al.*, submitted).

28. Due to the high cost of current alternatives to DDT an approach with increasingly targeted (focal) use of IRS is seen as a way of reducing cost and improving quality of spray operations. However, targeted IRS will often require high quality and updated epidemiological and entomological information. For example, in low transmission countries IRS is often conducted in places where there are no malaria but spray programs have insufficient data to withdraw spraying for fear of leaving populations unprotected.

29. To deploy insecticides more effectively in transmission ‘hotspots’, high quality reliable case surveillance systems need to be in place. Case data need to be used in planning and directing IRS operations. Currently GEF funded trials are planned in Senegal and Namibia to demonstrate the feasibility of combining targeted IRS with targeted parasite reduction and elimination.

2.2 Recent developments in chemical and non-chemical products and strategy used to reduce reliance on DDT and progress on introducing new alternative vector control products

30. Significant changes in land-use, economic developments, or malaria elimination may reduce the geographic area in which IRS needs to be deployed and thus the reliance on DDT.

31. Information on the applicability and cost-effectiveness of alternatives has been limited, thus, not allowing the countries to effectively design application of alternatives in local environmental, epidemiological and socio-economic settings. Furthermore, limited national capacity has led to inadequate analysis of available alternatives, insufficient consideration of alternatives in national policy and a lack of coherent and integrated approaches to vector control including the concept of integrated vector management (IVM).

32. IVM, defined as "a rational decision making process for the optimal use of resources for vector control" can help countries make evidence-based decisions on the use of pesticides, including DDT. A GEF funded initiative in Mexico and Central America reduced their reliance on pesticides, including DDT, by implementing alternative strategies against vector populations based mainly on environmental management and community participation. IVM provides the appropriate framework for more judicious use of pesticides, including DDT and alternatives and use of evidence-based vector control interventions.

2.2.1 Chemical control

33. As part of the Global Malaria Action Plan, universal coverage of LLINs (defined as one net for every two persons) is recommended for all populations at risk of malaria. All current generation LLINs are treated with pyrethroids, but vector resistance to this class of insecticides has increased exponentially in the past few years, particularly in Africa, and may limit their effectiveness. Furthermore, recent studies indicate that LLINs remain effective for substantially shorter periods than the expected 3 to 4 years due to physical deterioration. It is encouraging to note that there are currently at least eight LLIN products submitted by various companies to WHOPES for laboratory and field evaluation prior to market launch. New generation LLINs (e.g. Permanet 3, Olyset plus, Olyset duo) that may prove effective against pyrethroid resistant vectors are under development.

34. In some malaria areas, LLINs and IRS have been combined in an attempt to interrupt transmission. The evidence from trials assessing the combined effect of LLINs and IRS has so far been inconclusive with some trials showing significant added impact (West *et al* 2014) whilst others show no evidence of additional protection due to the combination (Corbel *et al*., 2012). WHO guidelines have recently been issued (WHO, 2014b). Recent studies have indicated that some vectors have the tendency to feed and rest outdoors (exophagic, exophilic) in the early part of the night (Reddy *et al.,* 2011; Smithuis *et al.,* 2013), which may render LLINs and IRS relatively ineffective against them. The impact of either LLINs or IRS is also dependent on the outdoor behaviour of human populations (Bradley *et al.,* 2012) Vector behaviour should be considered as part of the planning of IRS and LLIN programmes.

35. Chemical larviciding with organophosphates such as Temephos is used by a few countries to control mosquito larvae. This includes the urban malaria scheme implemented in several Indian cities, where granules formulation of Temephos is used to control *An. stephensi* and *Aedes* mosquitoes. In settings where breeding sites of *Anopheles* spp. are "few, fixed and findable", anti-larval activities with chemical and non-chemical methods should be explored as a supplementary measure to IRS and LLINs, provided there is evidence that this is a cost-effective, sustainable and operationally feasible measure. For resistance management purposes, if an organophosphate is used for larviciding, a different class of insecticide should be used for adult control.

2.2.2 Non-chemical control

36. Larval source management, which includes environmental management, microbiocides and biological control, aims to suppress vector population size and subsequently human-vector contact. Before the introduction of DDT, engineering and environment-based interventions contributed to the prevention of malaria, especially in Asia. Studies indicate that environmental management approaches can be cost-effective components to add to integrated control programmes, if there are sufficient resources and technical capacity to plan, implement and evaluate the intervention (Konradsen *et al.,* 2004; Pedercini *et al.,* 2011). Most of these methods have been documented to be effective in reducing malaria transmission in those specific settings where conditions were appropriate for their use (Killeen *et al.,* 2002; Keiser *et al.,* 2005; Fillinger and Lindsay, 2011). The Roll Back Malaria larval source management work-stream 2012 has supported case study reports on larval source management in urban areas in Mauritius, Sudan, India and Tanzania. Environmental management for larval vector control may be most feasible in urban areas or in particular agricultural settings where the management of water can be controlled through engineering approaches or infrastructural investments.

37. Another strategy has been the use of microbiocides, including the bacterial larvicides *Baccillus thuringiensis israelensis* (Bti) and Baccilus sphaericus (BSph). A pilot study in Kenya has demonstrated the effectiveness of Bti in reducing malaria morbidity (Fillinger, *et al.*, 2009) while studies in the Gambia, Mauritius, Swaziland and India reported variable success. A study to assess the effectiveness of a community-based microbial larviciding intervention in Tanzania found the intervention to be effective in reducing the prevalence of malaria infection in urban Dar es Salaam with the highest effectiveness during dry seasons (Maheu-Giroux and Castro, 2013).

38. For at least 35 years, the WHO has promoted the use of larvivorous fish as an environmentally friendly alternative to insecticide-based interventions for malaria control. Biological larval control

using larvivorous fish is feasible in certain ecotypes and settings and is propagated in India as a supportive intervention to control vector breeding. An additional benefit from the use of larvivorous fish is the ability by certain species in particular, *Gambusia affinis,* to reduce DDT contamination in the water and sediment as well as edible fish of rural ponds (Dua *et al.*, 1999).

39. Dedicated housing and homestead improvements, for example insect screens on windows and doors aimed at reducing indoor vector densities, and interventions to make the homestead environment less conducive for vector breeding have been shown to reduce vector-borne diseases in particular settings (Atieli *et al.*, 2009; Kirby *et al.*, 2009; Bradley *et al.,* 2013). However, the evidence of housing modifications needs further documentation (Anderson *et al.*, 2014).

40. A series of demonstration projects for alternative vector control methods funded by the Global Environment Facility (GEF) and co-ordinated by WHO/EMRO are nearing completion. These include i) the comparison of pyrethroid IRS, LLINs and environmental management for protection against cutaneous leishmaniasis in Morocco; and ii) the combined use of LLINs and IRS with bendiocarb, compared to LLINs alone, in Sudan and Yemen. The results will help advance the evidence base on the combination of IRS and LLINs and alternative vector control approaches. Similar demonstration projects are in the early planning stage for the WHO/AFRO region.

41. The use of insect growth regulators (IGR) has been incorporated in integrated approach to malaria and dengue vector control, but more studies are required to assess the impact.

2.3 New paradigms and research prospects on alternative products and strategies for vector control

42. A number of organizations such as the Innovative Vector Control Consortium (IVCC) which is a product development partnership have ongoing research projects to develop novel insecticides to overcome resistance and reduce application costs of insecticides, as well as to develop information systems and tools that allow effective use of insecticides. According to the IVCC[5], it is in the process of developing four promising active ingredients that could augment the current classes of insecticides for IRS but require further research before being ready for field testing.

43. Other specific products currently undergoing efficacy trials include durable wall linings that may protect entire households (Messenger *et al.,* 2012; Ngufor *et al.*, 2014). Insecticidal paint products are also, under development. These are being evaluated and large-scale systematic trials and cost-effectiveness studies need to be completed (Amelotti *et al.,* 2009; Mosqueira *et al*., 2010a, 2010b).

44. Several research groups have focused on the possibility of using modified mosquito releases to reduce vector populations or to render them incapable of transmitting the pathogens for malaria and dengue. Examples of these are, genetically modified mosquitoes and Wolbachia infected *Aedes aegypti* (Olivaa *et al.,* 2014). However, the large scale impact of such technologies is still lacking in evidence, although modelling studies indicate that they have considerable potential, and public acceptance of some of the technologies is still in question.

45. Ongoing research points towards the potential of the development of entomopathogenic fungi, ovitraps, adult traps, monolayer surface agents (oil), spinosad, fabric repellents and toxic sugar baits for disease vector control.

46. New paradigm vector control methods are being reviewed and guided by the WHO Vector Control Advisory Group (VCAG), and one of the IVCC committees (ESAC 3). Examples of new paradigms are: new generation LLINs and IRS insecticides that restore effectiveness against pyrethroid resistant mosquitoes; spatial repellents; topical repellents; insecticide treated eaves screening; lethal mosquito attractants (WHO second VCAG report 2014).The efficacy of these new approaches has currently not been sufficiently evaluated for policy recommendation, but ongoing studies indicate a promising potential for successful development.

47. IVCC has recently issued a call for funding of new paradigms specifically addressing the problem of residual transmission that is not covered by IRS and LLINs. UNEP/GEF, UNIDO, WHO, TDR, Global Alliance, BMGF, USAID, DFID, Wellcome Trust, and EU are some of other key donors that fund vector control research.

[5] A presentation made to the DDT Expert Group by Dr. Robert Sloss of IVCC.

IV. Implementation of Vector Control Products, Methods and Strategies

3.1 Vector control capacities, policies and guidelines at national level

48. As most malaria affected countries are in the control phase of the malaria elimination continuum, it is essential that effective vector control and surveillance are developed and maintained, as part of the preventive interventions of this phase. However, many national malaria control programs (NMCPs) still have inadequate human capacity and infrastructure at all levels for implementing, managing, monitoring and quality assuring vector control and surveillance activities. There is a need to reinforce the in-country institutional capacity to educate and train skilled staff to ensure the necessary pool of vector control and surveillance expertise within NMCPs. There is also a need to bridge the gap between national policy and guideline development and the implementation of control and surveillance activities at field level. The WHO Global Malaria Programme recently issued guidance for capacity building in entomology and vector control with key recommendations for countries as well as national and international partners (WHO, 2013).

49. In the absence of national policies and regulatory measures, each country must adapt the relevant recommendations and directives of the WHO, FAO and the Secretariat of the Stockholm Convention.

3.2 Insecticide resistance management (DDT and alternatives)

50. All vector control programs must be based on proactive resistance monitoring and surveillance. To date, Anopheline resistance has been identified for all major chemical classes used for vector control, i.e. pyrethroids, organochlorines, carbamates and organophosphates (Corbel & N'Guessan, 2013). The direct link between program failure and insecticide resistance has been demonstrated in South Africa (Hargreaves et al., 2000) and strong evidence is available from Zimbabwe and Zambia (Choi et al., 2014). The emergence of insecticide resistance in malaria vectors should therefore be regarded as a serious threat to vector control programmes that are reliant on insecticide-based indoor interventions (LLINs and IRS).

51. Resistance is generally recognised in the form of physiological changes, mainly target-site and metabolic resistance. Target-site resistance may not confer operational failure of vector control on its own, but could pose a major threat in concert with metabolic resistance (Hemingway *et al.*, 2013) Resistance in the form of behavioural changes in the vector, such as shifts from indoor to outdoors biting and resting is a third and increasingly recognised form of insecticide resistance (Sokhna *et al*., 2013).

52. In recent years the use of pyrethroids as the insecticide class of choice for IRS has decreased significantly because of resistance and reduced funding for control programs. Currently, all LLINs products are impregnated with pyrethroids as regulated by the WHOPES. The widespread use of pyrethroids in public health as well as agriculture and the increasing selection for the mechanisms that confer metabolic resistance to pyrethroids are recognised as the main challenge to effective vector control (Hemingway, 2014). Notably, the shift from complete pyrethroid susceptibility to country wide metabolic resistance can occur over the space of less than 12 months, as recently observed in Malawi (Hemingway, 2014).

53. Control failure may be curtailed if national resistance management strategies and vector control options are guided by timely evidence of insecticide susceptibility for local vector populations. Thus, it is critical that routine monitoring and surveillance of physiological and behavioural resistance are in place in the affected countries. This includes monitoring of cross and multiple resistance between pyrethroids and the alternative chemical classes for use in IRS, including DDT.

54. Standard bioassays remain the core methods for resistance monitoring by many surveillance programs. Molecular markers of resistance, however, are increasingly used to complement conventional bioassays for early tracking of resistance development. Markers are well established for target site resistance, but are still inadequately characterised for metabolic resistance and are completely lacking for behavioural resistance. Thus, it may still be premature to rely on molecular markers as the sole tool for comprehensive resistance monitoring (Riveron *et al.*, 2014).

55. The 2012 Situation Analysis reported insecticide resistance monitoring in all of eight countries with reported use of DDT at the time of the analysis. The monitoring was based on the WHO bioassay revealing wide variability in resistance levels depending on the insecticide class, location and species tested (2012 DDT EG Report).

56. A recent study in Uganda revealed significant differences in the resistance profiles to pyrethroids, organochlorines and carbamates of sympatric populations of *An. parensis* and *An. funestus* s.s, with the more exophilic, exophagic *An. parensis* displaying high susceptibility to most of the tested insecticides as opposed to the predominantly endophilic *An. funestus* s.s. This suggests that the level of insecticide resistance of *An. funestus* may have been under estimated by previous monitoring activities due to dilution from the susceptible *An. parensis* population (Mulamba, 2014).The finding underscores the importance of accurate species detection and understanding of behavioural patterns for successful vector control.

57. The use of different insecticides with separate modes of action either in rotation or combination is proposed as a strategy to mitigate or delay insecticide resistance. However, a recent study in China suggests that long-term use of various classes of insecticides may in fact select for multiple-resistance due to high selection pressure. The study reported high metabolic resistance to the four main insecticide classes for *An. sinensis* in areas with prolonged and extensive use of each insecticide class for control of agricultural pests as well as public health disease vectors (Chang *et al*., 2014). This argues for timely resistance monitoring to guide selection of insecticide class.

58. The potential impact of agricultural activities on insecticide resistance has also been reported from African countries including Tanzania and Sudan, where resistance studies suggest correlation between use of agricultural insecticides and resistance selection in Anopheline vectors (Nkya *et al.*, 2014; Abuelmaali, 2013). These observations stress the importance that in relevant regions, NMCPs reflect the coordinated action between the Ministries of Health and Agriculture.

59. In the absence of new insecticides approved for vector control, it is critical that NMCPs develop efficient insecticide resistance management (IRM) strategies that are based on timely data on vector susceptibility to the available insecticides. IRM strategies should be implemented as soon as there is a change in national vector control policies. The Presidents Malaria Initiative supports many of the IRS programmes in Africa and has invested in building capacity for monitoring of insecticide resistance in order to enable better decision-making on the appropriate choice of insecticides. In addition, the WHO Global Malaria Programme has developed a Global Plan for Insecticide Resistance Management (GPRIM) in malaria vectors to provide guidance to countries for developing effective management of insecticide resistance (WHO, 2012a; World Malaria Report 2013). The implementation of GPRIM has been initiated in some countries, but is yet to achieve wider traction.

60. The combination of a comprehensive database and online mapping of Anopheline insecticide resistance across the African continent was recently presented in the form of IR mapper (Knox *et al*., 2014). The IR-mapper provides a visual map of the temporal and spatial distribution of resistance. It also specifies the extent of available data highlighting regions where data are lacking. VectorBase (IRBase) also contains a global insecticide resistance database. In addition, the WHO Regional Office for the Eastern Mediterranean (EMRO) is currently developing a comprehensive insecticide resistance database including records from the 1940s to 2012 (UNEP, 2014). The aim is to facilitate data sharing and establish benchmarks on resistance status among malaria vectors in the region.

61. A commonly overlooked factor for use of IRS in vector control is the development of ‘community resistance’. The reluctance by some communities to permit the spraying of houses tends to intensify as the disease burden decreases in the face of successful elimination agendas. As such the use of IRS (with or without DDT) in the final stages of the elimination continuum may be less feasible than planned in some communities.

3.3 Implementation of integrated vector management

62. The WHO Global Strategic Framework for Integrated Vector Management defines IVM as “a strategy to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease vector control. IVM encourages a multi-disease control approach, integration with other disease control measures and the considered and systematic application of a range of interventions, often in combination and synergistically” (WHO, 2004).

63. The IVM strategy comprises several key elements including:

(a) Policy and legislation;

(b) Collaboration within the health sector and with other sectors;

(c) Empowerment and involvement of local communities and other stakeholders;

(d) Integrated approach;

(e) Evidence-based decision making;

(f) Capacity building.

64. The IVM strategy, promoted since 2001, is widely acknowledged and the said target of most malaria endemic countries. Many of the countries transitioning to IVM have obtained increased training on IVM principles and have held operational and structural arrangements within the ministries of health. However, a recent survey on the status of IVM implementation found that most of the countries that claim to implement IVM did not fully understand the IVM principles, suggesting a need for further IVM training and introduction to the WHO Guidelines (WHO 2003, UNEP 2011). The transition to IVM is faced by additional challenges, especially in low income countries, such as lack of policy frameworks to guide and promote the process as well as insufficient finances and operational difficulties (Corbel, 2013, Mutero, 2012). There is a need to ensure that IVM approaches are being implemented and that they are making an impact. NMCPs must strengthen inter-sectorial coordination for implementation of IVM strategies by involving all relevant sectors.

65. The actual number of countries on track for IVM transition is uncertain, but approximately ten African countries are stated to be implementing IVM action plans, while various countries in other regions are developing such plans (WHO, 2014c). Notably, a large number of African NMCPs already incorporate some of the IVM key elements in their control activities (Beier *et al*., 2008). One country to fully embrace the IVM Strategy is Zambia, where for the past 10 years IVM activities have been introduced, consolidated and expanded in a step-wise manner, in accordance with the WHO guidelines (Chanda *et al*., 2008).

66. Documentation of intervention impact in Zambia is achieved through routine monitoring and evaluation activities. The epidemiological impact, as observed in 2008, included a significant reduction in in-patient malaria cases (55%) and deaths (60%) as compared to 2001/2002. Resistance to DDT and pyrethroids was recently detected in both *An. gambiae* s.s. and *An. funestus* s.s leading to immediate discontinuation of DDT usage and concerns of the sustainability of the ongoing control activities (Chanda *et al.,* 2011; Chanda *et al*., 2013b; Choi *et al.,* 2014).

3.4 Possible role of DDT in malaria elimination efforts

67. As malaria transmission continues to decline in many malaria endemic countries, NMCPS should prepare to undergo a paradigm shift as the focus changes from malaria control to actual elimination and continued interruption of transmission. Efforts required for malaria elimination and prevention of re-establishment are fundamentally different from those of malaria control, as case detection and elimination of transmission foci are emphasised (WHO, 2007). DDT could play a continued role as malaria programmes enter the final stages of the malaria elimination continuum if necessary. Examples of countries that have successfully eliminated malaria in the recent past using DDT are Morocco and Mauritius. Some countries such as Mauritius, Botswana, Senegal and Venezuela have opted to keep DDT for emergency purposes. China and Myanmar, however, has opted not to keep DDT for emergency purposes as part of its ongoing national malaria elimination programme.

68. The use of DDT may be justified by a series of observations from Southern Africa. In 1996, South Africa changed from DDT to deltamethrin usage in IRS, allowing for the introduction of pyrethroid resistant *An. funestus*. The reappearance of *An. funestus* after several decades of absence was associated with a severe outbreak of malaria in 1999/2000 compelling the re-introduction of DDT within months. The malaria incidence in South Africa has declined markedly since then (Maharaj et al. 2005, Coetzee *et al.,* 2013) with no reports of epidemic activity and the country is now earmarked for malaria elimination by 2018 (South African DOH 2011). Pyrethroid resistant *An. funestus* was contained in South Africa through the use of a mosaic system (DDT for traditional houses and pyrethroids for cement structures). However, insecticide resistance in *An. funestus* is now widespread across other parts of Africa.

69. As noted above, a number of countries have discontinued their use of DDT after successful elimination of malaria and are now reliant on other insecticide classes for prevention of re-introduction. It is important that vector susceptibility to these insecticides is monitored very carefully to ensure timely introduction and use of effective insecticides (incl. DDT) should resistance occur.

V. Capacities for Countries to Transit from DDT to other Alternatives for Vector Control

4.1 Training tools and capacities for proper use of alternative insecticides and non-chemical methods for vector control

70. A new FAO International Code of Conduct on Pesticides Management was approved by the FAO Conference in June 2013. The Code provides standards of conduct and serves as a point of reference in relation to sound pesticide life cycle management practices, in particular for government authorities and the pesticide industry (FAO, 2013).

71. The Public Health Pesticide Program (IR-4 PHP) has developed a Public Health Pesticides Database that provides information on pesticide chemistry and toxicology and the efficacy of various chemical tools including repellents, attractants, and toxicants against specific pests (IR-4, 2014)

72. The PMI has developed a 'Best management practices (bmp) for IRS in vector control interventions' with the aim to provide acceptable safety standards and practices for the handling, storage, transportation and use of IRS pesticides (PMI, 2010).

73. A Disease Data Management System (DDMS) tool on malaria control has been developed by the IVCC and LSTM. The tool is a computer package that collates data on disease incidence, vector populations (including density and insecticide resistance) and intervention activities and presents this information in a web-based, real-time geographical format. The system has been implemented in several NMCPs and was recently expanded to include Visceral Leishmaniasis for initial implementation in India (IVCC, 2014). Such tools may assist countries in making more informed decisions and thereby facilitating a transition from DDT to other alternatives.

74. To facilitate the implementation of IVM for disease vector control, WHO has developed several guidelines available for disease endemic countries incl.:

(a) Guidelines for vector control needs assessment (WHO 2003);

(b) Guidelines for procurement of public health pesticides (WHO, 2012b);

(c) Core structure for training curriculum on Integrated Vector Management (WHO, 2012c);

(d) Handbook for Integrated Vector Management (WHO, 2012d);

(e) Guidance on policy development for Integrated Vector Management (WHO, 2012e) and

(f) Monitoring and Evaluation Indicators for Integrated Vector Management (WHO, 2012f).

4.2 National policies, guidelines and regulatory measures on DDT use

75. According to the WHOPES report of the 2010 survey using the WHO Pesticide Evaluation Scheme 16% of the 113 responding member States, did not have any national legislation on registration and control of pesticides. Specific legislation on storage, transport and proper disposal of public health pesticides lacked in 30%, 40% and 44% of the responding countries, respectively (WHO, 2010b). Notably, all 24 countries responding to the 2012 Situation Analysis indicated that they have national regulations on DDT in place. With the exception of Eritrea and Swaziland, all countries indicated that they hold capacity to also conduct or assess quality control of DDT in their countries,

76. In many countries the Ministry of Agriculture is the sector responsible for regulating importation, use and disposal of pesticides, including public health pesticides. However, the Ministry of Health and the Ministry of Environment (responsible for regulatory issues) often have insufficient communication with the Ministry of Agriculture to harmonize regulations and pesticide management practices so as to minimize human and environmental contamination.

4.3 Available funding opportunities for transition from DDT to alternatives

77. The focus upon and continued investments in alternatives to DDT has been emphasized following the issuing at the 6th Conference of Parties, held in May 2013 of an 18-paragraph decision on the continued need for DDT and for the development of a "roadmap" for the development of alternatives to DDT.

78. The UNEP/GEF partnership supports an international effort to promote alternatives to DDT. GEF has so far supported a total of 11 projects through direct or indirect investments by more than

US$ 62m (Sow *et al.*, 2014). Countries in the WHO/AFRO region have been allocated approximately US$ 15.5m to "Strengthen government and non-governmental organizations to demonstrate and scale up diverse innovative interventions in the framework of IVM". Two other UNEP/GEF projects of US$ 980,000 and US$ 662,000 targeting a total of 10 African countries aim at respectively, "Demonstrating sustainable non-chemical alternatives for malaria control in the household environment" and "Cost-effectiveness of vector management approaches to control malaria".

79. In the Asia-pacific region, India has a GEF funded project of about US$ 1.7m to "Develop and promote non-chemical alternatives to DDT", subject to approval by the Government of India, while Azerbaijan has US$ 999,000 earmarked for a project on "Demonstrating and scaling up sustainable alternatives to DDT for the control of vector borne diseases". At the global level, WHO is executing a US$ 1.0m GEF project on "Coordination and analysis for demonstrating and scaling up of sustainable alternatives (DSSA)." These and other funding opportunities are available for countries to strengthen systems for disease vector control with alternatives to DDT.

80. The costs and the effectiveness of DDT are dependent on local settings and merit careful consideration concerning alternative products or methods. The 5th meeting of the Conference of the Parties requested the POPRC to assess the alternatives to DDT in accordance with the general guidance on considerations related to alternatives and substitutes. The POPRC assessment of the 11 WHO recommended alternatives to DDT reported that 10 insecticides were considered not likely to meet all the Annex D criteria for persistence, bioaccumulation, toxicity and long range environmental transport in a preliminary screening assessment. However, the POPRC considered that bifenthrin might meet all Annex D criteria but remained undetermined due to equivocal or insufficient data in a preliminary screening assessment (POPRC Report, 2012).

81. In order to compare alternative vector control strategies to DDT using a cost-effective analysis, a common measure of impact assessment must be adopted. For vector control interventions, defining such a measure requires care, since the epidemiology of vector-borne diseases is complex. In cases where a new intervention is being proposed, there may be inadequate resources or time to scientifically test the impact of a given vector control intervention using the entomological indicators. For these situations, a number of mathematical models have been developed to evaluate the predicted effectiveness of vector control interventions, including IRS with DDT and pyrethroids and the distribution of LLINs (Chitnis *et al*., 2010). These models are based on a number of peer-reviewed studies of malaria epidemiology and the effectiveness of the widely used IRS and LLINs interventions. Simulation models have also been generated to analyse the cost-effectiveness of continued DDT usage compared to its rapid phase-out by alternative combinations of IVM interventions (Perdercini *et al*., 2011). However, the evidence based assessment of cost-effectiveness for IRS and alternatives to IRS are currently insufficient for countries to make decisions towards sustainable transition away from DDT and the adoption of alternatives. The lack of expertise and updated cost-effectiveness studies has resulted in this lack of evidence.

4.4 Technology transfer and linkages with research and training institutions relevant for vector control

82. Career development opportunities and regular training for vector control officers/entomologists should be made available in order to develop and maintain trained and experienced staff to address local disease problems. Collaboration between national vector-borne disease control programs, universities and other research organizations is much needed. As of January 2014, 50% of the posts as public health entomologist in India were vacant as the candidates see no career opportunities within government organisations (person communication Dr. Sharma). In the 2012 Situation Analysis, all 24 respondent countries, except Lithuania, indicated that they have training facilities for insecticide use and that they have established inter-sectoral collaboration in disease vector control. However, only a few responding countries have entomology laboratories for vector resistance monitoring. On the basis of susceptibility test performed by the member countries, mapping of presence of resistance vectors should be prepared.

VI. Actions Taken by Parties/Partners to Reduce Reliance on Use of DDT for Vector Control

5.1 Promotion of research and development of alternatives

83. A number of initiatives have been set up by WHO and partners to improve malaria control including judicious use of all approved insecticides (including DDT). These initiatives include advocating for universal coverage with LLINs, promoting effective diagnosis and treatment of all malaria cases, promoting IVM as a sustainable approach to disease prevention and allowing countries

to use DDT as long as there is no viable alternative for IRS. New paradigms and tools for vector control are under investigation and development.

84. National legislation addressing the management and use of pesticides should strengthen the ability of countries to promote the proper quality control and use of pesticides in both the public and private sectors and to implement the Stockholm Convention including regulatory and other mechanisms to ensure DDT use is restricted to disease vector control where IRS is the appropriate intervention. Legislation should address the production, use, and importation of pesticides and eliminate trade barriers (e.g. tariffs) that inhibit the importation of insecticides and other vector control products. Key technical and management capacity is needed at national level to support the translation of international best practices, policies and guidelines on pesticide management and evidence based vector control into locally appropriate programmes with a focus on alternatives to DDT. However, it should be noted that apart from insecticide resistance, other variables such as climate change, land use change and the development of water resources may have extrinsic influence on vector populations and affect the effectiveness of vector control interventions. In such cases, interventions aimed at parasite reduction, as for example seasonal malaria chemoprevention or mass drug administration may play an important role in reducing disease transmission.

85. Collaboration with sectors such as agriculture, environment, energy and public works could ensure that their activities do not result in increased vector densities and disease transmission. Although successful experiences involving resource mobilization in public health programmes such as HIV/AIDS exist, effective mobilization for disease vector control and in particular, search for alternatives to DDT, is still a challenge in many countries. Since 2004, the main supporters of malaria control programmes have been the GFATM, the WHO, the Bill and Melinda Gates Foundation (BMGF), the US and UK governments, and the World Bank. Most of these donors coordinate their activities through the Roll Back Malaria (RBM) partnership and WHO. The most recent WHO global malaria report indicates that resources have been allocated to support the up-scaling of vector control interventions over the past few years. Maintaining these gains and moving forward with elimination is a challenge in the face of donor fatigue and competing needs.

86. At all levels an inter-departmental and inter-sectoral approach is needed to coordinate effective vector control since actions or inactions by other sectors may add to vector breeding sites, increasing vector populations and hence increase malaria transmission. Inter-sectoral collaboration and public private partnerships are encouraged as key elements of IVM and countries that are transitioning to DDT alternatives should exploit this opportunity. As such, resource mobilization and cost-sharing by all the relevant in-country sectors would gradually boost the available vector control funding and make the countries more independent from external support.

VII. Assessment Summary

87. There is no clear trend in global DDT production and trade over the past five year period. The decline in production and export recorded from 2012-2013 to 2013-2014 is likely to be part of a fluctuating production cycle. India is the only producer of DDT and over the past two years it has used more than 97% of annual global production within the country. In India, the use of DDT for malaria control has steadily decreased over the past five years. However, DDT used for visceral leishmaniasis control has increased over the same period, as control of this disease has moved into an elimination stage in India. Also, a few countries use DDT against *Aedes* mosquito borne diseases outside WHO recommendations of standard guidelines. The management and the generation of an inventory of DDT stockpiles remains a global challenge. Likewise, the disposal of obsolete DDT remains a priority. Poorly managed stockpiles of obsolete DDT may result in misuse of DDT with environmental and human health consequences. However, in the EMRO and PAHO regions comprehensive disposal of obsolete stockpiles of DDT has been undertaken.

88. There are currently a limited number of effective and affordable alternatives to DDT for vector control. A range of potential substitute chemicals and new tools for vector control are under development of which some will be sufficiently developed for policy recommendation in the next two to five years. For many novel products and new paradigms, safety and proof-of-principle has been demonstrated but evidence on impact on disease morbidity in humans (Phase III trials) is currently lacking. Development of the products and methods has been motivated by concerns about insecticide resistance and vector behavioural change. To mitigate these concerns there is a need to sustain investment in research on new tools and strategies for vector control.

89. Many national malaria control programs have inadequate human capacity and infrastructure to sustain control programs. The lack of capacity by programs to monitor and respond to the increasing levels of insecticide resistance and outdoor transmission in malaria vectors is a serious threat to vector control programmes. Coordinated action between the Ministry of Health and other relevant ministries

needs to be strengthened to ensure planning of effective disease vector control and drive the elimination agenda. Integration of IVM principles into control programs are progressing slowly. Increased support is required if IVM is to be significantly up-scaled, while more evidence is needed to guide IVM implementation. A stringent focus on insecticide resistance management and the need for implementation of the GPIRM must be stressed. Maintaining all WHOPES approved classes of insecticides in those areas where vectors are still susceptible should be considered as imperative by national malaria control programs. The role of DDT may be limited in the later stages of the elimination continuum. Furthermore, there is a need to ensure that DDT use is restricted to disease vector control where IRS is the appropriate intervention.

90. A significant number of specific training manuals and guidelines have been developed by international organization of relevance to vector control including IRS, insecticide resistance management and the use of public health pesticides. As per the last survey report of 2010, there is still a lack of in-country human resources capacity to implement international guidelines. Insufficient policies and legal frameworks in relation to national registration of public health pesticides and the enforcement of regulations remains a challenge. The lack of career opportunities for public health entomologists and other key control staff are significantly reducing the monitoring and effectiveness of IRS programs. The lack of a sufficiently developed evidence base on cost-effectiveness on various vector control methods including IRS is hampering the transition from DDT to alternatives. Some of the key challenges in introducing alternatives to transit away from DDT should be addressed by the Roadmap for the development of alternatives to DDT by UNEP.

91. A coordinated effort to promote research and development of alternatives to DDT at the international level has been established to ensure effective use of resources. Such efforts increasingly need to include the private sector. A number of demonstration projects for the promotion of sustainable alternatives to DDT have been funded and successfully implemented.

A. Conclusions

1. Over the past five year period, there is no clear change in global DDT production and trade. More than 85% of the annual global use has been within India. However, in India, the use of DDT for malaria control has steadily decreased over the past five years while its use for visceral leishmaniasis control has increased over the same period.

2. The management of DDT stockpiles remains a global challenge. However, in the EMRO and PAHO regions comprehensive disposal of obsolete stockpiles of DDT has been undertaken.

3. A range of potential substitute chemicals and new tools for vector control are under development. Some of these alternatives will be sufficiently developed for policy recommendation in the next two to five years.

4. For many novel products and new paradigms, safety and proof-of-principle has been demonstrated but evidence on impact on disease morbidity in humans (Phase III trials) is currently lacking.

5. The lack of capacity by national programs to monitor and respond to the increasing levels of insecticide resistance and outdoor transmission in malaria vectors is a serious threat to vector control programmes.

6. Evidence to ensure effective implementation of IVM is inadequate hampering promotion of alternatives to DDT.

7. A stringent focus on insecticide resistance management and the need for implementation of the GPIRM need further support.

8. Some national malaria control programs do not consider DDT for vector control in the later stages of the elimination continuum.

9. Evidence suggests that DDT has been used for disease vector control other than malaria and visceral leishmaniasis.

10. A significant number of specific training manuals and guidelines have been developed by international organization of relevance to vector control including IRS, insecticide resistance management and the use of public health pesticides.

11. There is still a lack of in-country human resources capacity to implement international guidelines. Insufficient policies and legal frameworks in relation to national registration of public health pesticides and the enforcement of regulations remains a challenge.

12. There is a serious lack of economic evaluations to guide the national vector control programs impeding informed decision making for the transition from DDT to alternatives.

13. The Roadmap being prepared by UNEP on the development of alternatives to DDT is expected to catalyse actions to transit away from DDT.

14. A coordinated effort to promote research and development of alternatives to DDT at the international level has been established to ensure effective use of resources.

15. A number of demonstration projects for the promotion of sustainable alternatives to DDT have been funded and successfully implemented.

B. Recommendations

1. The DDT Expert Group recognizes that there is a continued need for DDT for indoor residual spraying (IRS) in specific settings for disease vector control where locally safe, effective and affordable alternatives are still lacking;

2. Countries that use IRS for the control of vectors of leishmaniasis should use DDT only if locally available, safe, effective and affordable alternatives to DDT are not available.

3. WHO is encouraged to provide further clarification to countries considering DDT for the control of vectors of arboviruses;

4. Countries should endeavour to make targeted application of IRS a high priority to ensure the judicious use of resources, including DDT, and undertake comparative economic evaluations of various insecticides recommended for IRS and alternative means of vector control;

5. Funding should be made available to increase the national policy and management capacity for translating international best practices on disease vector control including the implementation of the WHO Global Plan for Insecticide Resistance Management (GPIRM) and quality assurance systems for vector borne diseases;

6. Identifying and disposing of obsolete DDT stockpiles should continue towards complete removal of the stocks;

7. Capacity should be increased for the development and evaluation of novel vector control products and for expeditious reviewing of such products by relevant national and international bodies within the framework of the UNEP Roadmap for the Development of alternatives to DDT;

8. The Secretariat of the Stockholm Convention should continue to facilitate activities on strengthening capacity to transition away from the reliance on DDT for disease vector control.

Reference List

1. Abuelmaali *et al*. (2013). Impacts of agricultural practices on insecticide resistance in the malaria vector *Anopheles arabiensis* in Khartoum State, Sudan. *PLoS One* 8(11): e80549
2. Alphey L, *et al* (2013). Genetic control of Aedes mosquitoes. Pathog Glob Health. 107(4):170-9
3. Amelotti, I. *et al.* (2009). Experimental evaluation of insecticidal paints against *Triatoma infestans* (Hemiptera: Reduviidae), under natural climatic conditions. *Parasites & Vectors* 2(1):30
4. Anderson *et al*. (2014). Effective malaria control through durable housing improvements • can we learn new strategies from past experience? *Global Programs Department*, January 2014
5. ASP (2010). Africa Stockpiles Programme. Available from: http://www.africastockpiles.net/
6. Atieli, H. *et al*. (2009). House design modifications reduce indoor resting malaria vector densities in rice irrigation scheme area in western Kenya
7. Beier, JC. *et al*. (2008). Integrated vector management for malaria control. *Malaria Journal*, 7, S4
8. Bradley, J. *et al.* (2012). Increased risks of malaria due to limited residual life of insecticide and outdoor biting versus protection by combined use of nets and indoor residual spraying on Bioko Island, Equatorial Guinea. *Malaria Journal* 11:242
9. Bradley, J. *et al.* (2013). Reduced prevalence of malaria infection in children living in houses with window screening or closed eaves on Bioko Island, Equatorial Guinea. *PloS one* 8(11):e80626
10. Chang *et al*. (2014). Multiple Resistances and Complex Mechanisms of Anopheles sinensis Mosquito: A Major Obstacle to Mosquito-Borne diseases Control and Elimination in China. *PLoS*, Neglected Tropical Diseases 8(5): e2889
11. Chanda, E. *et al.* (2008). Integrated vector management: the Zambian experience. *Malaria Journal* 27(7):164
12. Chanda, E. *et al*. (2011). Insecticide resistance and the future of malaria control in Zambia. *PLoS One* 6(9): e24336
13. Chanda, E. *et al*. (2013a). Efficacy of ACTELLIC 300 CS, Pirimiphos Methyl, for Indoor Residual Spraying in Areas of High Vector Resistance to Pyrethroids and Carbamates in Zambia. *Journal of Medical Entomology* 50(6):1275-1281
14. Chanda, E. *et al*. (2013b). Operational scale entomological intervention for malaria control: strategies, achievements and challenges in Zambia. *Malaria Journal* 8(12):10
15. Chitnis, N. *et al*. (2010). Comparing the effectiveness of malaria vector-control interventions through a mathematical model. *American Journal of Tropical Medicine and Hygiene* 83(2): 230-240
16. Choi, K.S. *et al.* (2014). Insecticide resistance and role in malaria transmission of *Anopheles funestus* populations from Zambia and Zimbabwe. *Parasites & Vectors,* 7:464
17. Coetzee, M. *et al.* (2013). Malaria in South Africa: 110 years of learning to control the disease. *South African Journal of Medicine* 103(S2): 770-778
18. Corbel V, Akogbeto M, Damien GB, Djenontin A, Chandre F, Rogier C, Moiroux N, Chabi J, Banganna B, Padonou GG, Henry MC. (2012). Combination of malaria vector control interventions in pyrethroid resistance area in Benin: a cluster randomised controlled trial. *Lancet Infect Dis*. 12(8):617-26
19. Corbel *et al*. (2013). Challenges and prospects for dengue and malaria control in Thailand, Southeast Asia. *Trends in parasitology* 29(12): 623–633
20. Corbel & N'Guessan (2013). *Distribution, Mechanisms, Impact and Management of Insecticide Resistance in Malaria Vectors: A Pragmatic Review.* Available from: http://dx.doi.org/10.5772/56117
21. Djènontin, A. *et al*. (2014). Field Efficacy of Vectobac GR as a Mosquito Larvicide for the Control of Anopheline and Culicine Mosquitoes in Natural Habitats in Benin, West Africa. *PLoS One* 9(2): e87934

22. Dua, VK. *et al*. (1999). Application of mosquito fish Gambusia for reducing DDT contamination in water, sediment and edible fish from rural ponds of India. *Poll.Res*.18 (1): 89-94
23. FAO (2013). International Code of Conduct on Pesticide Management. Available from: http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/Code2013.pdf
24. Edi, C.V.A., Koudou, B.G., Jones, C.M., Weetman, D. & Ranson, H. 2012. Multiple-insecticide resistance in Anopheles gambiae mosquitoes, southern Cote d'Ivoire. Emerging Infectious Diseases 18: 1508-1511
25. Fillinger, U. and Lindsay, S. (2011). Larval source management for malaria control in Africa: myths and reality. *Malaria Journal* 10: 353
26. Faraj, C., Yukich, J., Adlaoui E. B., Wahabi, R., Kaddaf, M., Idrissi, A.L.E, Ameur, B., Kleinschmidt, I. Vector control for cutaneous leishmaniasis in Morocco. Effectiveness and cost of insecticide treated bed nets and indoor residual spraying for the control of cutaneous leishmaniasis: a cluster randomized control trial in Morocco. (submitted)
27. Fillinger, U. *et al.* (2009). Integrated malaria vector control with microbial larvicides and insecticide-treated nets in western Kenya: a controlled trial. *Bulletin of the World Health Organization* 87: 655-665
28. Hargreaves, K., Koekemoer, L.L., Brooke, B.D., Hunt, R.H., Mthembu, J. & Coetzee, M. 2000. Anopheles funestus is resistant to pyrethroid insecticides in South Africa. Medical and Veterinary Entomology 14: 181-189
29. Hemingway, J. *et al.* (2013) Country-level operational implementation of the Global Plan for Insecticide Resistance Management. *PNAS* 110(23): 9397–9402
30. Hemingway, J. (2014). The role of vector control in stopping the transmission of malaria: threats and opportunities. *Phil. Trans. R. Soc.* 369, 20130431
31. IR-4 (2014). Public Health Pesticides Database. Available from: http://ir4.rutgers.edu/PublicHealth/publichealthDB.cfm
32. IVCC (2012a). Available from: http://www.ivcc.com/about/fostering_innovation.htm/
33. IVCC (2012b). Available from: http://www.ivcc.com/projects/mdss.htm/
34. IVCC (2014). Disease Data Management System (DDMS). Available from: http://www.ivcc.com/creating-solutions/achievements/disease-data-management-system-ddms
35. Keiser, J. *et al.* (2005). Reducing the burden of malaria in different eco-epidemiological settings with environmental management: a systematic review. *Lancet Infectious Diseases* 5: 695-708
36. Killeen, GF. *et al*. (2002) Eradication of *Anopheles gambiae* from Brazil: lessons for malaria control in Africa? *Lancet Infectious Diseases* 2: 618–627
37. Kirby MJ. *et al*. (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. *Lancet* 374: 998-1009
38. Knox *et al*. (2014). An online tool for mapping insecticide resistance in major Anopheles vectors of human malaria parasites and review of resistance status for the Afrotropical region. *Parasites & Vectors* 7:76
39. *Konradsen*, F. *et al.* (2004). Engineering and malaria control: learning from the past 100 years. *Acta Tropica,* 89 (2): 99-108
40. *Maharaj*, R., Mthembu, D.J. & Sharp, B.L. 2005. Impact of DDT re-introduction on malaria transmission in KwaZulu-Natal. South African Medical Journal 95: 871-874
41. Maheu-Giroux and Castro (2013). Impact of Community-Based Larviciding on the Prevalence of Malaria Infection in Dar es Salaam,Tanzania. *PLoS One* 8(8): e71638
42. Messenger, L.A. *et al.* (2012) Multicentre studies of insecticide-treated durable wall lining in Africa and South-East Asia: entomological efficacy and household acceptability during one year of field use. *Malaria Journal* 11(1): 358
43. Mosqueira, B. *et al.* (2010a) Efficacy of an insecticide paint against insecticide-susceptible and resistant mosquitoes - part 1: laboratory evaluation. *Malaria Journal* 9:340

44. Mosqueira, B. *et al.* (2010b). Efficacy of an insecticide paint against malaria vectors and nuisance in West Africa - part 2: field evaluation. *Malaria Journal* 9:341

45. Mulamba, C. (2014). Contrasting Plasmodium infection rates and insecticide susceptibility profiles between the sympatric sibling species *Anopheles parensis* and *Anopheles funestus* s.s: a potential challenge for malaria vector control in Uganda. *Parasites & Vectors* 17(7): 71

46. Mutero *et al.,* (2012). Integrated vector management for malaria control in Uganda: knowledge, perceptions and policy development. *Malaria Journal* 11:2

47. Ngufor *et al*. (2014). Combining Organophosphate Treated Wall Linings and Long-lasting Insecticidal Nets for Improved Control of Pyrethroid Resistant *Anopheles gambiae. PLoS One* 9(1): e83897

48. Nkya *et al*. (2014). Insecticide resistance mechanisms associated with different environments in the malaria vector *Anopheles gambiae*: a case study in Tanzania. *Malaria Journal* 13:28

49. Olivaa *et al*. (2014). Current status and future challenges for controlling malaria with the sterile insect technique: Technical and social perspectives. *Acta Tropica* 132S: S130–S139

50. Oxborough *et al*. (2014). Long-lasting control of Anopheles arabiensis by a single spray application of micro-encapsulated pirimiphos-methyl (Actellic® 300 CS). *Malaria Journal* 13:37

51. Pedercini M. *et al.* (2011). Application of the malaria management model to the analysis of costs and benefits of DDT versus non-DDT malaria control. *PLoS One* 6(11):e27771

52. PMI (2010). President's Malaria Initiative, BMP Manual. *USAID*

53. POPRC 8 meeting report (2012). Developing a framework to assess DDT and its alternatives for vector control. UNEP/POPS/POPROC.8/16

54. Rahman, M. (2012). Insecticide substitute for DDT to control mosquitoes may be causes of severe diseases. *Environmental Science Pollution Research* 10.1007/s11356-012-1145-0.

55. Reddy M.R. *et al.* (2011). Outdoor host seeking behaviour of *Anopheles gambiae* mosquitoes following initiation of malaria vector control on Bioko Island, Equatorial Guinea. *Malaria Journal* 10:184.

56. Riveron *et al*., (2014). A single mutation in the GSTe2 gene allows tracking of metabolically based insecticide resistance in a major malaria vector. *Genome Biology* 15:R27

57. Rohani *et al.* (2014). Impact of Indoor Residual-Sprayed Deltamethrin on Different Surfaces in a Malaria Endemic Area in Balai Ringin, Sarawak. Published Online

58. Rowland *et al*. (2013). A New Long-Lasting Indoor Residual Formulation of the Organophosphate Insecticide Pirimiphos Methyl for Prolonged Control of Pyrethroid-Resistant Mosquitoes: An Experimental Hut Trial in Benin. *PLoS One*. 23:8(7):e69516

59. Smithuis FM. *et al.* (2013). Entomological determinants of insecticide-treated bed net effectiveness in Western Myanmar. *Malaria Journal* 11(12):364. doi: 10.1186/1475-2875-12-364

60. Sokhna *et al.* (2013). The changes in mosquito vector behaviour and the emerging resistance to insecticides will challenge the decline of malaria. *Clinical Microbiology and Infection* 19(10): 902-907

61. Sow *et al*. (2014). Financing for innovative technologies and best practices to reduce persistent organic pollutants. *Mitig Adapt Strateg Glob Change* 19: 93–106

62. Tangena *et al*. (2013) Alternative Treatments for Indoor Residual Spraying for Malaria Control in a Village with Pyrethroid- and DDT-Resistant Vectors in The Gambia. *PLoS ONE* 8(9): e74351

63. Tchicaya E S *et al.* (2014). Micro-encapsulated pirimiphos-methyl shows high insecticidal efficacy and long residual activity against pyrethroid-resistant malaria vectors in central Côte d'Ivoire. *Malaria Journal* 13:332

64. UNEP (2010). National Implementation Plans. http://chm.pops.int/tabid/253/language/en-US/Default.aspx

65. UNEP (2011) Report developed by the Secretariat on the review of the current status of implementation of integrated vector management. UNEP/POPS/DDT/GA/TGIVM.1/4. Available from:

http://chm.pops.int/Implementation/DDT/Meetings/FirstGlobalAllianceAssembly2011/tabid/2169/mctl/ViewDetails/EventModID/1421/EventID/136/xmid/6821/Default.aspx

66. UNEP (2012). Meeting report of the Steering Committee of the Global Alliance for the development and deployment of alternatives to DDT for disease vector control. UNEP/POPS/GA/ISC.3/2. ICIPE, Nairobi, August 27-28, 2012

67. UNEP (2014) GEF Progress Report Fiscal Year 10 (30 June 2013 to 1 July 2014)

68. West PA, Protopopoff N, Wright A, Kivaju Z, Tigererwa R, Mosha FW, Kisinza W, Rowland M, Kleinschmidt I (2014). Indoor residual spraying in combination with insecticide-treated nets compared to insecticide-treated nets alone for protection against malaria: a cluster randomised trial in Tanzania. PLoS Med. 15;11(4)

69. WHO (2003). Guidelines for vector control needs assessment. Available from: http://www.afro.who.int/vbc/framework World Health Organization

70. WHO (2004). Global strategic framework for integrated vector management. (WHO/CDS/CPE/PVC/2004.10). World Health Organization

71. WHO (2007). Malaria Elimination: A Field Manual for Low and Moderate Endemic Countries. Available from: http://www.rbm.who.int/toolbox/tool_EliminationManualWHO.html

72. WHO (2010a). *WHO Pesticides Evaluation Scheme (WHOPES). http://www.who.int/whopes/en/*. World Health Organization

73. WHO (2010b). *Public Health Pesticide Registration and Management Practices by WHO Member States. Report of a Survey.* World Health Organization

74. WHO (2011). *Onchocerciasis Control Programme*. 2011 [cited 2011 August 29]; Available from: http://www.who.int/blindness/partnerships/onchocerciasis_OCP/en/.

75. WHO report (2011a). *Environmental health criteria 241*. DDT in indoor residual spraying: Human health aspects

76. WHO (2012a). *Global Plan for Insecticide Resistance Management in malaria vectors*. World Health Organization

77. WHO (2012b). *Guidelines for Procurement of Public Health Pesticides*. WHO/HTM/NTD?WHOPES/2012.4. World Health Organization

78. WHO (2012c). *Core structure for training curriculum on Integrated Vector Management* WHO/HTM/NTD/VEM/2012.1. Available from: http://whqlibdoc.who.int/publications/2012/9789241502788_eng.pdf

79. WHO (2012d). *Handbook for Integrated Vector Management* WHO/HTM/NTD/VEM/2012.3. Available from: http://whqlibdoc.who.int/publications/2012/9789241502801_eng.pdf

80. WHO (2012e). *Guidance on policy development for Integrated Vector Management* WHO/HTM/NTD/VEM/2012.2. Available from: http://whqlibdoc.who.int/publications/2012/9789241502795_eng.pdf

81. WHO (2012f). *Monitoring and Evaluation Indicators for Integrated Vector Management* WHO/HTM/NTD/VEM/2012.4

82. WHO (2013). *World Malaria Report*, 2013. Available from: http://www.who.int/iris/handle/10665/97008

83. WHO (2014a). *Seventh meeting of the regional scientific and technical advisory committee of the WHO/EMRO/UNEP/GEF-supported project and fourth meeting of the Project Steering Committee of the WHO/AFRO/UNEP/GEF –supported project. World Health Organization.* June 2014, WHO-EM/MAL/368/E/11.12

84. WHO (2014b). *Guidance for countries on combining indoor residual spraying and long-lasting insecticidal nets*, March 2014. WHO/HTM/GMP/MPAC/2014.2

85. WHO (2014c). *Malaria control: the power of integrated action.* Available from: http://www.who.int/heli/risks/vectors/malariacontrol/en/index7.html#

86. WHOPES (2013). *Pesticide products under WHOPES laboratory and or field testing and evaluation*, August 2013. Available from: http://www.who.int/whopes/Products_Under_WHOPES_Evaluation_Aug_2013.pdf

87. World Malaria Report (2013) Available from: http://issuu.com/isglobal/docs/wmr2013_no_profiles/59

Annex II

List of members of the DDT expert group 2012-2015

Party Nominated Experts

Africa

Dr. José Okond'Ahoka
Professeur
Faculté de Médecine Vétérinaire
Université Pédagogique Nationale
134 Avenue de la Révolution
c/ Ngaliema - VPN, B.P. 16789
Kinshasa
Democratic Republic of Congo
Tel.: +243 (81) 813 1411
Fax: +33 1 40 8120 72
Email: jose.okondahoka@upn.ac.cd

Dr. Rajendra Maharaj
Professor and Director
Medical Research Unit
Medical Research Council
P.O. Box 70380
4067 Overport
South Africa
Tel.: +27 (31) 203 4851
Fax: +27 (31) 203 4831
Email: rmaharaj@mrc.ac.za

Asia and the Pacific

Dr. Qi Gao
Professor and Director
Jiangsu Institute of Parasitic Diseases (JIPD)
Meiyuan 117
214064 Wuxi Jiangsu
China
Tel.: +86 (510) 6878 1001
Fax: +86 (510) 8551 0263
Email: gaoqi54@hotmail.com

Dr (Ms.). Roop Kumari
Joint Director
National Center for Disease Control, Delhi
Ministry of Health and Family Welfare
22-Sham Nath Marg
110054 Delhi
India
Tel: +91 11 2398 0304
Fax:
Email: dr_roopa@hotmail.com / drroopa123@gmail.com

Central and Eastern Europe

Mr. Artak Khachatryan
Head of Inventory and Risk Assessment Division
"Waste Research Center" State Non Commercial Organization / Ministry of Nature Protection
46 Charents Street
0025 Yerevan
Armenia
Tel.: +374 (94) 04 99 55
Fax: +374 (10) 55 47 32
Email: khachart7@yahoo.com

Ms. Adriana Mariana Borş
Chief of Department: Natural and Anthropic Hazards. Global warming
National Institute for Research-Development in Environmental Protection
294 Splaiul Independentei, sector 6
Bucharest
Romania
Phone: +40 (0)21 305 26 00
Mobile : +40 762 613 284
Fax : +40 21 318 2001
Email : adrianambors@gmail.com

Latin America and the Caribbean

Dr. Lorenzo Càceres Carrera
Medical Entomology
Instituto Conmemorative Gorgas
Gorgas Memorial Institute of Health Studies
Avenida Justo Arosemena y Calle 35
P.O. Box 0816
02593 Panamá
Panama
Tel: +507 527 4963
Fax: +507 527 4843
Email: lcaceres@gorgas.gob.pa

Western Europe and Others Group

Dr. Donald Alan Ward
Director, Agricultural Productivity Division, Agriculture and Veterinary Chemical Policy
Department of Agriculture

18 Marcus Clarke Street, Canberra
ACT 2601 Australia
GPO Box 858 Canberra ACT 2601
Australia
Tel: +61 2 6272 4420
Fax: +61 2 6272 3025
Mobile: +61 478 323 779
Email: Donald.Ward@daff.gov.au

Mr. Antoine Schwoerer
Policy Advisor
General Directorate for Risk
Prevention
Ministry of Ecology
Arche-Paroi Nord
CEDEX La defense
92055 Paris
France
Tel.: +33 (1) 40 81 97 82
Fax: +33 (1) 40 81 20 72
Email:
antoine.schwoerer@developpement-
durable.gouv.fr

World Health Organization Selected Experts

Dr. Immo Kleinschmidt
Professor/Reader in Epidemiology
London School of Hygiene and
Tropical Medicine
Keppel Street
London, WC1E 7HT
Great Britain
Phone: +4402079272103
Email:
Immo.Kleinschmidt@lshtm.ac.uk

Dr. Robert A. Wirtz
Chief
Entomology Branch / Division of
Parasitic Diseases and Malaria
Centers for Disease Control and
Prevention (CDC)
MS-G49, 1600 Clifton Road
30329-4018 Atlanta
United States of America
Tel.: +1 (404) 718 4330
Fax: +1 (404) 718 4335
Email: rwirtz@cdc.go

Dr. (Ms.) Martha L. Quinones P.
Researcher – Lecturer
Public Health Department
Faculty of Medicine
National University of Colombia,
Bogota
Carrera 30 No. 45 – 03 Ciudad
Universitaria
Bogotá
Colombia
Phone: + 57 1 3165000 Ext. 15078
Fax: +57 311 4524 935
Email: marthalquinones@gmail.com
mlquinonesp@unal.edu.co

Dr.(Ms.) Indra Vythilingam
Consultant
Parasitology Dept., Faculty of
Medicine, University of Malaya
50603, Kuala Lumpur
Malaysia
Phone: +60196501250/+60179677893
Email: indrav@um.edu.my

Dr.(Ms.) Maureen Coetzee
Professor
Malaria Entomology Research Unit
University of the Witwatersrand
P.O. Box 4165
2040 Honeydew
South Africa
Tel.: +27 (11) 386 6480
Fax: +27 (11) 386 6481
Email: maureenc@nicd.ac.za
maureen.coetzee@wits.ac.za

Secretariat Selected Experts

Dr. Flemming Konradsen
Professor
International Health Section / Department of International Health, Immunology and Microbiology
University of Copenhagen
Øster Farimagsgade 5, Building 9
P.O. Box 2099
1014 Copenhagen K
Denmark
Tel.: +45 (35) 32 76 26
Fax: +45 (35) 32 77 36
Email: hain@sund.ku.dk

Dr. Rajander Singh Sharma
Additional Director, Department of Entomology
National Vector Borne Disease Control Programme
Ministry of Health and Family Welfare
22 Sham Nath Marg
110054 Delhi
India
Tel.: +91 (11) 2397 2884
Fax: +91 (11) 2396 8329
Email: ranjandersharma@gmail.com

Dr. John Ichamwenge Githure
Scientist
Malaria Division
Ministry of Health
P.O. Box 6201
Kigali
Rwanda
Tel.: +250 (78) 279 7400
Fax:
Email: jgithure@gmail.com