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Pesticide Action Network  Advancing Alternatives for Pesticides Worldwide

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Safe Malaria Solutions - Beyond DDT

Malaria kills 880,000 people a year -- that's 100 people an hour, 80 of them young children in sub-Saharan Africa.

Pesticide Action Network has been working with international allies, governments and on-the-ground groups in Africa for many years to mobilize resources and political will to combat this deadly disease.

Solutions do exist ^[13]. They are community-based, integrated solutions already at work in places as diverse as Mexico, Kenya and Vietnam. Successful malaria control programs have been built all over the world using a variety of approaches that share four common traits: community involvement, appropriate technology, public health education and a recognition that the costs of DDT outweigh its benefits.

COSTS & FAILURES OF DDT

DDT fails as a public health tool for the same reasons it was banned as an agricultural pesticide in the 1970s. The costs are too high and impossible to control:

- **Health effects:** ^[14] Studies show that DDT is a neurodevelopmental and reproductive toxin that is especially dangerous to infants and children. DDT has been linked to low sperm count in men, certain forms of cancer and diabetes.
- **Resistance:** The effectiveness of DDT continues to decline as more and mosquito populations develop resistance.
- **Stockpiles:** 100,000+ tons of obsolete pesticides like DDT are stockpiled in Africa with no means of disposal.
- **Bioaccumulation:** DDT and its breakdown product, DDE, persist for many years, travel the world, and accumulate in the global food chain.
- **Dirty production:** DDT production plants contaminate the environment and put local communities at risk wherever they are produced.

Communities facing malaria, which disproportionately affects poor and undernourished areas, should not have to also face the long-term health risks posed by exposure to DDT when safe and affordable solutions are available. What countries fighting malaria need is strong support for effective, safe and affordable solutions that invest in community resources over the long term.

TREATY MANDATES DDT PHASEOUT

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty calling for the elimination of hazardous chemicals that persist in the environment and in our bodies, and travel the world in water and on air. DDT is among the original twelve chemicals targeted for global phaseout by the POPs treaty, with exemptions for countries where controlling disease vectors (like mosquitos) are necessary and "locally safe, effective and affordable alternatives are not available".

163 governments from around the world are party to this legally binding treaty (the U.S. is not among them). PAN International and its allies join these governments in calling for a redoubling of investment in safe, effective and affordable malaria control.

PAN International DDT Statement: Supporting Safe and Effective Strategies without DDT In English ^[15] En Fraçais ^[16]

US partner statement on : Safe Malaria Solutions ^[17]



Campaign Spotlight

- A Big Step Forward Towards a DDT-Free World ^[1]: 4th Meeting of the Conference of the Parties to the UNEP-Linked Stockholm Convention on POPs, May 2009
- Statement on DDT use for malaria control from PAN-IPEN for the Stockholm Convention Fourth Conference of Parties ^[2], April 2009
- PAN International Study on DDT and the Stockholm Convention: States on the edge of non-compliance ^[3], April 2009
- World Malaria Day 2009 ^[4] - Congressional Briefing
- Dar-es-Salaam Declaration on Alternatives to DDT ^[5], April 2009
- Pledge to end Malaria deaths by 2015 ^[6], Campaign note by President-Elect Barack Obama
- "USAID's response to NGO letter on World Malaria Day", ^[7] May 2008
- PANNA Malaria and DDT Video: Youtube ^[8], Transcript ^[9], April 2008
- 2008 World Malaria Day letter to USAID ^[10] April 2008
- "DDT and Malaria: Setting the Record Straight ^[11]" (also: Español ^[12]), April 2007

DDT Health Effects Studies

This compilation of articles will be updated periodically and it is by no means comprehensive. The articles are arranged by category and in chronological order with the newest studies first. We hope it will prove to be a useful tool in the ongoing discussion among policymakers, advocacy groups and the media regarding the use of DDT and the need to improve efforts to effectively control malaria.

For detailed information on the toxicity, health effects and regulatory status of DDT, visit PANNA's on-line Pesticide Database ^[18].

- **Infants and breastfeeding** ^[19]
- **Reproductive Impacts** ^[20]
- **Neurological Impacts** ^[21]
- ^[22]
- **Serum levels and other health impacts** ^[23]
- **Environmental Impacts** ^[24]



health effect archive

Infants and breastfeeding

DDT and its metabolites in breast milk from the Madeira River basin in the Amazon, Brazil. *Chemosphere* ^[25], August 2008

PANNA Summary:

Abstract: Until the 1990s the 1,1,1-trichloro-bis-2,2'-(4chlorophenyl) ethane (DDT) was sprayed in the walls of the house along the Madeira River basin, Brazilian Amazon, a region well known for its large number of malaria cases. In 1910, Oswaldo Cruz described the presence of malaria in 100% of the population living in some localities from the Madeira River basin. Data available in the literature point to the DDT contamination in fishes captured in Madeira River region. Fish is the major source of dietary protein to these people. DDT tends to accumulate in lipid rich tissues and is being eliminated by different events, including lactation. Considering the importance of feeding breast milk to the children, the associated risks of DDT exposure via breast milk intake to children must be assessed. This is the main objective of this work: to analyse the presence of the *p,p'*-DDT and its metabolites *p,p'*-DDE and *p,p'*-DDD in 69 human milk samples and to estimate the intake of DDT and its metabolite in terms of total DDT (total DDT = *p,p'*-DDE + *p,p'*-DDD + *p,p'*-DDT). All the samples showed contamination with DDT and its metabolites ranging from 25.4 to 9361.9 ng of total DDT/g of lipid (median = 369.6 ng of total DDT/g of lipid) and 8.7% of the estimated daily intake (EDI), in terms of total DDT, which was higher than the acceptable daily intake proposed by the WHO.

Bouwman H, Sereda B, and Meinhardt H.M. Simultaneous presence of DDT and pyrethroid residues in human breast milk from a malaria endemic area in South Africa. *Environmental Pollution* 2006 114: 902-917

PANNA Summary: Human breast milk is a known to be the best source of nutrition for infants. In developing countries, especially in the rural areas it is the primary source of food to infants sometimes until the age of 2, which is a particularly long period and can lead to a significant transfer of pollutants. In Africa, malaria kills millions each year even today. The use of pesticides for vector control continues to rely on insecticide treated bed nets and residual spraying. While the Stockholm convention and Rollback malaria campaign continues to work towards reducing the reliance on malaria, it was forced to reintroduce DDT in South Africa. Also, malaria is not the only potential source of human exposure to pesticides. Pyrethroids, organophosphates and carbamates, etc., are now readily used in crop protection and veterinary chemicals. The aim of this study is to investigate and deliberate on the presence of DDT and other pyrethroids in breast milk of three semi-urban populations. Results indicate that DDT levels were lower than found in previous studies but the presence of pyrethroids has added to another level of complexity. It shows that more work is required in this aspect. The author does stress that there is no reason to implicate breastfeeding as a primary source of nutrition in infants.

Abstract: DDT and pyrethroids were determined in 152 breast-milk samples from three towns in KwaZulu-Natal, South Africa, one of which had no need for DDT for malaria control. All compounds were found present in breast milk. Primiparae from one town had the highest mean SDDT whole milk levels (238.23 mg/l), and multiparae from the same town had the highest means for permethrin (14.51 mg/l), cyfluthrin (41.74mg/l), cypermethrin (4.24 mg/l), deltamethrin (8.39 mg/l), and pyrethroid (31.5 mg/l), most likely derived from agriculture. The ADI for DDT was only exceeded by infants from one town, but the ADI for pyrethroids was not exceeded. Since the ADI for DDT was recently reduced from 20 to 10 mg/kg/bw, we suggest that this aspect be treated with concern. We therefore raise a concern based on toxicant interactions, due to the presence of four different pyrethroids and DDT. Breastfeeding however, remains safe under prevailing conditions.

Chen A, and Rogan W.J. Nonmalarial Infant Deaths and DDT Use for Malaria Control Emerging Infectious Diseases. 2003 9(8): 960-964.

PANNA Summary: The authors examine the relationship between DDT spraying for malaria control and preterm births and shorter durations of lactation in sub-Saharan Africa. They estimated the increase in infant deaths that may have resulted from DDT spraying and make the claim that the same amount of children may be dying from DDT as being saved by it for malaria control.

Abstract: Although dichlorodiphenyl trichloroethane (DDT) is being banned worldwide, countries in sub-Saharan Africa have sought exemptions for malaria control. Few studies show illness in children from the use of DDT, and the possibility of risks to them from DDT use has been minimized. However, plausible if inconclusive studies associate DDT with more preterm births and shorter duration of lactation, which raise the possibility that DDT does indeed have such toxicity. Assuming that these associations are causal, we estimated the increase in infant deaths that might result from DDT spraying. The estimated increases are of the same order of magnitude as the decreases from effective malaria control. Unintended consequences of DDT use need to be part of the discussion of modern vector control policy.

Gladden, B. C. and Rogan, W. J. DDE and shortened duration of lactation in a northern Mexican town. *American Journal of Public Health* 1995; 85(4):504-508.

PANNA summary: The authors found that DDE (a metabolite of DDT) levels in the breast milk of mothers in an agricultural town in northern Mexico is strongly linked to the length of time that they breastfeed their infants. Mothers with the highest levels of DDE breastfed for only 3 months on average, while mothers with the lowest DDE levels breastfed for an average of 7.5 months. The authors conclude that DDT exposure may be contributing to the trend toward decreasing lengths of lactation world wide.

Abstract: Objectives: Worldwide declines in the duration of lactation are cause for public health concern. Higher levels of dichlorodiphenyldichloroethene (DDE) have been associated with shorter durations of lactation in the United States. This study examined whether this relationship would hold in an agricultural town in northern Mexico.

Methods: Two hundred twenty-nine women were followed every 2 months from childbirth until weaning or until the child reached 18 months of age. DDE was measured in breast milk samples taken at birth, and women were followed to see how long they lactated.

Results: Median duration was 7.5 months in the lowest DDE group and 3 months in the highest. The effect was confined to those who had lactated previously, and it persisted after statistical adjustment for other factors. These results are not due to overtly sick children being weaned earlier. Previous lactation lowers DDE levels, which produces an artifactual association, but simulations using best estimate show that an effect as large as that found here would arise through this mechanism only 6% of the time.

Conclusions: DDE may affect women's ability to lactate. This exposure may be contributing to lactation failure throughout the world. (Statistics and Biomathematics Branch, National Institute of Environmental Health Sciences, Mail Drop A3-03POB 12233, Research Triangle Park, NC 27709, USA.)

Bouwman, H.; Becker, P. J.; Cooppan, R. M., and Reinecke, A. J. Transfer of DDT used in malaria control to infants via breast milk. *Bulletin of the World Health Organization*. 1992; 70(2):241-50. ISSN:0042-9686.

PANNA summary: This is a study of the levels of DDT and its metabolites in the blood of infants and the breast milk of their mothers in KwaZulu, South Africa where DDT is used to control malaria. It was found that breastfeeding is the primary source of DDT in babies' blood, and that it accumulates with age. DDT in the environment is a secondary source.

Abstract: The transfer of p,p'-DDT(1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane) and its metabolites to infants via breast-feeding was studied in an area of KwaZulu, South Africa, where DDT is used to interrupt malaria transmission. Samples of whole blood were collected from 23 infants, together with samples of breast milk from their respective mothers. The mean sigma DDT (total DDT) in the whole blood was 127.03 micrograms. l-1 and that in the breast milk, 15.06 mg.kg-1 (milk fat). The % DDT (% DDT of sigma DDT) was significantly higher in the infant blood than in the breast milk (less than 0.05). A multiplicative regression analysis indicated that sigma DDT increased significantly (P less than 0.01) in infant wholeblood with infant age. Multiple regression showed that 70.0% of the variation in sigma DDT was due to the variation in parity of the mother, age of the infant, and the sigma DDT in breast milk. These variables accounted also for 76.3% of the variation in p,p'-DDE but only for 38.2% of that in p,p'-DDT. Organochlorines were therefore largely transferred to the infant from the mother, with DDT in the environment playing a secondary role. (Department of Zoology, University for Christian Higher Education, Potchefstroom, South Africa.)

Rogan, W. J.; Gladen, B. C.; McKinney, J. D.; Carreras, N.; Hardy, P.; Thullen, J.; Tingelstad, J., and Tully, M. Polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethene (DDE) in human milk: Effects on growth, morbidity, and duration of lactation. *American Journal of Public Health* 1987; 77(10):1294-1297.

PANNA summary: This study determined the effects of PCBs and DDE (DDT metabolite) in breast milk on infant growth and health. Its most significant finding was that higher levels of DDE are associated with markedly shorter duration of breast feeding, indicating that DDE is somehow interfering with mothers' ability to breastfeed their children.

Abstract: We followed 858 children from birth to one year of age to determine whether the presence of polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethene (DDE) in breast milk affected their growth or health. Neither chemical showed an adverse effect on weight or frequency of physician visits for various illnesses, although differences were seen between breast-fed and bottle-fed children, with bottle-fed children being heavier and having more frequent gastroenteritis and otitis media. Children of mothers with higher levels of DDE were breast-fed for markedly shorter times, but adjustments for possible confounders and biases did not change the findings. In absence of any apparent effect on the health of the children, we speculate that DDE may be interfering with the mother's ability to lactate, possibly because of its estrogenic properties.

Reproductive Impacts

DDT Exposure, Work in Agriculture and Time to Pregnancy Among Farmworkers in California, *Journal of Environmental and Occupational Medicine* [26] 50 (12):1335-42, December 2008

PANNA Summary:

Abstract: Objective: This study examined whether exposure to pesticides, including dichlorodiphenyltrichloroethane (DDT), was associated with longer time to pregnancy (TTP).

Methods: Pregnant women (N 402) living in a migrant farmworker community were asked how many months they took to conceive. Women reported their and their partners' occupational and home pesticide exposure preceding conception. In a subset (N 289), levels of DDT and dichlorodiphenyldichloroethylene (DDE), were measured in maternal serum.

Results: No associations were seen with p,-DDT, o, p-DDT, or p, p-DDE. Maternal occupational pesticide exposure (fecundability odds ratios [fOR] 0.8, 95% CI: 0.6 to 1.0), home pesticide use (fOR 0.6, 95% CI: 0.4 to 0.9), and residence within 200 ft of an agricultural field (fOR 0.7, 95% CI: 0.5 to 1.0) were associated with reduced fecundability (ie, longer TTP).

Conclusions: Longer TTP was seen among women, but not men, reporting exposure to agricultural and home pesticides.

Exposure of Mother - Child and Postpartum Woman - Infant Pairs to DDT and its Metabolites in Tianjin, China. *Science of the Total Environment* [27], April 2008

PANNA Summary: In this study, data gathered from mothers, postpartum woman and children was assayed. Levels of DDT in children were seen to be higher than that in the women's. The finding indicate a cumulative effect of DDT in the human body in Tianjin, China.

Abstract: 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT) exhibits its long persistence in the environment, unusual bioaccumulation, effects on wildlife, and the possibility of long-term adverse effects on human health, especially reproductive toxicity. Despite the prohibition of most persistent organochlorine pesticides in China, the presence of organochlorine residue, including DDT, has been widely indicated in environmental substance. However, scarce information is available about accumulative levels of DDT in human tissues in China. To evaluate levels of DDT and its potential effects on women and children's health in a Chinese pesticide-exposed area, we recruited 50 pairs of mother-child and 50 postpartum women, and determined the levels of total DDT and its four main metabolites (p,p-DDE, p,p-DDT, p,p-DDD, o,p-DDT) in venous blood, breastmilk and umbilical blood cord by gas chromatography. Accordingly, data on reproductive outcomes of mothers and postpartum women and healthy status of children and infants were gathered through a questionnaire and medical examinations. Furthermore, we also assayed the DDT levels of some environmental samples (soil, food, milk, et al.). The levels of DDT in children's

blood were higher than that in the women's. As compared to breast milk, the umbilical blood cord and the ventral fat individually demonstrated a significantly lower and higher level of DDT in the postpartum women. DDT was lower in milk and crucian carp than in the soil near the chemical plant. p,p'-DDT and p,p'-DDE were the main metabolites of DDT. Our findings suggested the cumulative effect of DDT in human body in Tianjin, China.

Aneck-Hahn, NH, Schulenburg, GW, Bornman, MS, Farias P, and De Jager C Impaired Semen Quality Associated With Environmental DDT Exposure in Young Men Living in a Malaria Area in the Limpopo Province, South Africa. *Journal of Andrology* 2007 28(3).

PANNA Summary: This study found associations of DDT and DDE, a breakdown of DDT, associated with abnormal sperm, impaired sperm movement, and low ejaculate volume in semen from healthy men aged 18-40 who live in an area in South Africa where DDT is sprayed every year. The results imply that non-occupational exposure to DDT is associated with impaired semen in men. The high exposure levels of DDT and DDE are of concern, as these levels may have far reaching implications for reproductive and general health.

Abstract: The pesticide DDT [1,1,1-trichloro-2,2-bis(chlorodiphenyl)ethane] is one of the 12 persistent organic pollutants (POPs) that were under negotiation at the Stockholm Convention, to restrict or ban their production and use because of their toxicity, resistance to breakdown, bioaccumulation and potential for being transported over long distances. DDT has estrogenic potential and the main metabolite p,p'-DDE is a potent anti-androgen. In response to mounting evidence on the endocrine disrupting influence of environmental chemicals on human health, this epidemiological study was initiated to test the hypothesis that non-occupational exposure to DDT affects male reproductive parameters. In a cross sectional study healthy male subjects (n=311) aged between 18 and 40 years (23±5) were recruited from three communities in an endemic malaria area where DDT is sprayed annually. A semen analysis according to the World Health Organization (WHO) (1999) standards was performed. The Hamilton Thorne Computer Assisted Sperm Analysis (CASA) system was simultaneously used to determine additional sperm motility parameters. Blood plasma samples were assayed for p,p'-DDT and metabolites as a measure of exposure. The exposure levels were expressed as lipid adjusted p,p'-DDT and p,p'-DDE values. The mean p,p'-DDT and p,p'-DDE concentrations were 90.23 µg/g (±102.4) and 215.47 µg/g (±210.6), respectively. The multivariate linear regression analyses indicated that: the mean CASA motility was lower with a higher p,p'-DDE concentration (beta = -0.02; p=0.001) and the CASA parameter, beat cross frequency (BCF) was higher with a higher p,p'-DDT concentration (beta = 0.01; p = 0.000). There was also a statistically significantly positive association between the percentage sperm with cytoplasmic droplets and p,p'-DDT concentration (beta = 0.0014; p = 0.014). The ejaculate volume (mean: 1.9±1.33 mL) was lower than the normal range (2.0 mL) for the WHO, and a significant decrease with increasing p,p'-DDE values was seen for both square root volume (beta = -0.0003; p = 0.024) and count (beta = -0.003; p = 0.04). Although there were no associations between either p,p'-DDT or p,p'-DDE concentrations and the rest of the seminal parameters, the incidence of teratozoospermia (% Normal sperm <15%) (99%) was high. Twenty-eight percent of the study group presented with oligozoospermia (<20 million sperm/mL) which had a significantly positive association with p,p'-DDE (OR: 1.001; p = 0.03). There was a significantly positive association between participants with asthenozoospermia (32%) and p,p'-DDT (OR: 1.003, p = 0.006) and p,p'-DDE (OR: 1.001, p = 0.02). The results imply that non-occupational exposure to DDT is associated with impaired seminal parameters in men. The high exposure levels of p,p'-DDT and p,p'-DDE are of concern, as these levels may have far reaching implications for reproductive and general health.

Full text: <http://www.andrologyjournal.org/cgi/rapidpdf/jandrol.106.001701v1> [28]

Kilian E, Delpont R, Bornman MS, & de Jager C Simultaneous exposure to low concentrations of dichlorodiphenyltrichloroethane, deltamethrin, nonylphenol and phytoestrogens has negative effects on the reproductive parameters in male Sprague-Dawley rats. *Andrologia* 2007 39: 128-135.

PANNA Summary: This study examines male reproductive development of four groups of rats, a control group and three groups given pesticide-laced serums, including DDT. The rats were exposed in utero and then given the serum for 10 weeks after birth. The rats exposed to pesticides did not develop as well as the control group and the findings that exposure to endocrine disrupting compounds may contribute to the deterioration of male reproductive health.

Abstract: Many reports suggest that male reproductive health has deteriorated over the last decades, possibly due to environmental contaminants that act as endocrine disruptors. This hypothesis was tested in Sprague-Dawley rats using a modified Organization for Economic Cooperation and Development 415 one-generation test. Group A received cottonseed oil as control, and Groups B, C and D received deltamethrin (DM); DM and dichlorodiphenyltrichloroethane (DDT); and DM, DDT, phytoestrogens and p-nonylphenol, respectively. Rats were exposed in utero and then received the substances for 10 weeks. The seminal vesicle mass (Group B; P = 0.046) and sperm count [Groups C (P = 0.013) and D (P = 0.003)] were lower and the anogenital distance [Group B (P = 0.047) C (P = 0.045) and D (P = 0.002)] shorter compared with the control group. The seminiferous tubule diameter [Groups B (P < 0.001), C (P < 0.001) and D (P < 0.001)] and epithelium thickness [Groups B (P = 0.030), C (P < 0.001) and D (P < 0.001)] were smaller compared with the control. The histology of the testes showed signs of apical sloughing and vacuolisation. Liver weights [Groups C (P = 0.013) and D (P = 0.005)] and liver enzymes [Group D (P = 0.013)] were also affected. These findings may indicate that simultaneous exposure to endocrine disrupting compounds contributes to the deterioration observed in male reproductive health.

Fenster L, Eskenazi B, Anderson M, Bradman A, Harley K, Hernandez H, Hubbard A, Barr DB. Association of in utero organochlorine pesticide exposure and fetal growth and length of gestation in an agricultural population. *Environ Health Perspectives* 2006 114(4):597-602.

PANNA Summary: This detailed study examines the exposure of 11 organochlorine pesticides as assessed by measurements in maternal serum associated with shortened length of gestation and poorer fetal growth in a birth cohort from an agricultural community in the Salinas valley, California. An association between increasing maternal HCB serum levels and decreased length of gestation was observed whereas an HCB associated decrease in crown-heel length as reported in a Spanish study by Ribas-Fito et al. 2000 was not found. Hence, even though there was no positive finding of an adverse association of in utero organochlorine pesticide exposure with birth weight or crown-heel length using maternal serum, the study did find that exposure to HCB was significantly related to a decrease in length of gestation. These results are not conclusive because of multiple comparisons. HCB is not manufactured anymore but is still produced as a byproduct due to which it may still enter the environment and its potential reproductive toxicity continues to remain as a concern for human populations.

Abstract: From 1940 through the 1970s, organochlorine compounds were widely used as insecticides in the United States. Thereafter, their use was severely restricted after recognition of their persistence in the environment, their toxicity in animals, and their potential for endocrine disruption. Although substantial evidence exists for the fetal toxicity of organochlorines in animals, information on human reproductive effects is conflicting. We investigated whether infants' length of gestation, birth weight, and crown-heel length were associated with maternal serum levels of 11 different organochlorine pesticides: p,p'-dichlorodiphenyltrichloroethane (p,p'-DDT), p,p'-dichlorodiphenyldichloroethylene (p,p'-DDE), o,p'-dichlorodiphenyltrichloroethane (o,p'-DDT), hexachlorobenzene (HCB), gamma-hexachlorocyclohexane (gamma-HCH), gamma-hexachlorocyclohexane (gamma-HCCH), dieldrin, heptachlor epoxide, oxychlorodane, trans-nonachlor, and mirex. Our subjects were a birth cohort of 385 low-income Latinas living in the Salinas Valley, an

agricultural community in California. We observed no adverse associations between maternal serum organochlorine levels and birth weight or crown-heel length. We found decreased length of gestation with increasing levels of lipid-adjusted HCB (adjusted gamma = -0.47 weeks; $p = 0.05$). We did not find reductions in gestational duration associated with any of the other organochlorine pesticides. Our finding of decreased length of gestation related to HCB does not seem to have had clinical implications for this population, given its relatively low rate of preterm delivery (6.5%). (Division of Environmental and Occupational Disease Control, California Department of Health Services, Richmond, CA94804, USA. lfenster@dhs.ca.gov [29])

Tiido T, Rignell-Hydbom A, Jönsson B, Lundberg Giwercman Y, Rylander L, Hagmar L and Giwercman A, Exposure to persistent organochlorine pollutants associates with human sperm Y:X chromosome ratio. *Human Reproduction* 2005 20 (7):1903-1909

PANNA Summary: This study shows an association of DDE with increased amounts of Y chromosome bearing sperm in Swedish fisherman. These data add to the growing body of evidence that exposure to persistent organic pollutants may alter the offspring sex ratio.

Abstract: During the last decades, there has been concern that exposure to endocrine disruptors, such as persistent organochlorine pollutants (POPs), may contribute to sex ratio changes in offspring of exposed populations.

Methods: To investigate whether exposure to 2,2',4,4',5,5'-hexachlorobiphenyl (CB-153) and dichlorodiphenyldichloroethene (p,p'-DDE) affect Y:X chromosome proportion, semen of 149 Swedish fishermen, aged 27–67 years, was investigated. The men provided semen and blood for analysis of hormone, CB-153 and p,p'-DDE levels. The proportion of Y- and X-chromosome bearing sperm in semen samples was determined by two-colour fluorescence in situ hybridization (FISH) analysis.

Results: Log transformed CB-153 as well as log transformed p,p'-DDE variables were both significantly positively associated with Y chromosome fractions (P -values = 0.05 and <0.001 , respectively). Neither age, smoking, nor hormone levels showed any association with Y-chromosome fractions.

Conclusions: This is the first study to indicate that exposure to POPs may increase the proportion of ejaculated Y-bearing spermatozoa. These data add to the growing body of evidence that exposure to POPs may alter the offspring sex ratio.

FullText: <http://humrep.oxfordjournals.org/cgi/reprint/20/7/1903> [30]

Venners SA, Korrick S, Xu X, Chen C, Guang W, Huang A, Altshul L, Perry M, Fu L, and Wang X Preconception Serum DDT and Pregnancy Loss: A Prospective Study Using a Biomarker of Pregnancy. *American Journal of Epidemiology* 2005 162(8): 709-716.

PANNA Summary: The authors measured levels of DDT in 388 women in China between 1996 and 1998. They measured DDT levels before conception and monitored early pregnancy losses and spontaneous abortions in the pregnancies. There was a positive relationship between preconception DDT levels and the risk of subsequent early pregnancy loss.

Abstract: Previous studies of pregnancy losses and 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane (DDT) were limited because they did not include losses prior to clinical detection of pregnancy and because exposures were measured after the pregnancies of interest. The authors examined the association of preconception serum total DDT (sum of DDT isomers and metabolites) concentration and subsequent pregnancy losses in 388 newly married, nonsmoking, female textile workers in China between 1996 and 1998. Upon stopping contraception, subjects provided daily urine specimens and records of vaginal bleeding for up to 1 year or until clinical pregnancy. Daily urinary human chorionic gonadotropin was assayed to detect conception and early pregnancy losses, and pregnancies were followed to detect clinical spontaneous abortions. There were 128 (26%) early pregnancy losses in 500 conceptions and 36 (10%) spontaneous abortions in 372 clinical pregnancies. Subjects were grouped in tertiles by preconception serum total DDT concentration (group 1: 5.5–22.9 ng/g; group 2: 23.0–36.5 ng/g; group 3: 36.6–113.3 ng/g). Compared with group 1, group 2 had adjusted relative odds of early pregnancy losses of 1.23 (95% confidence interval (CI): 0.72, 2.10), and group 3 had adjusted odds of 2.12 (95% CI: 1.26, 3.57). The relative odds of early pregnancy losses associated with a 10-ng/g increase in serum total DDT were 1.17 (95% CI: 1.05, 1.29). The small number of spontaneous abortions following clinical detection of pregnancy were not associated with serum total DDT. In this population, there was a positive, monotonic, exposure-response association between preconception serum total DDT and the risk of subsequent early pregnancy losses.

Cohn, BA, PM Cirillo, MS Wolff, PJ Schwing, RD Cohen, RI Sholtz, AFerrara, RE Christianson, BJ van den Berg and PK Siiteri DDT and DDE exposure in mothers and time to pregnancy in daughters. *The Lancet* 2003 361: 2205–06.

PANNA Summary: DDT and DDE were measured in serum samples from women after delivery between 1960 and 1963. Then 28–31 years later the women's eldest daughters recorded their time until pregnancy. The daughter's chances of pregnancy fell with the increase of DDT in the mother's serum.

Abstract: Reproductive-tract anomalies after administration of the potent oestrogen, diethylstilboestrol, in pregnant women raised concerns about the reproductive effects of exposure to weakly oestrogenic environmental contaminants such as bis[4-chlorophenyl]-1,1,1-trichloroethane (p, p'-DDT) or its metabolites, such as bis[4-chlorophenyl]-1,1-dichloroethene (p,p'-DDE). We measured p, p'-DDT and p, p'-DDE in preserved maternal serum samples drawn 1–3 days after delivery between 1960 and 1963. We recorded time to pregnancy in 289 eldest daughters 28–31 years later. Daughters' probability of pregnancy fell by 32% per 10 µg/L p, p'-DDT in maternal serum (95% CI 11–48). By contrast, the probability of pregnancy increased 16% per 10 µg/L p, p'-DDE (6–27). The decreased fecundability associated with prenatal p, p'-DDT remains unexplained. We speculate that the antiandrogenic activity of p, p'-DDE may mitigate harmful androgen effects on the ovary during gestation or early life. Correspondence to: Dr Barbara A Cohn

Neurological Impacts

Eskenazi B, Marks AR, Bradman A, Fenster L, Johnson C, Barr DB, Jewell NP. In Utero Exposure to Dichlorodiphenyltrichloroethane (DDT) and Dichlorodiphenyldichloroethylene (DDE) and Neurodevelopment among Young Mexican American Children. *Pediatrics* 2006 118: 233-24.

PANNA Summary: This study examines the amounts of DDT and DDE in mother's serum after delivery, and looks for associations between these levels and the infants' development using a standard development scale. The results show a relationship between lower psychomotor development scores and increased DDT in the mothers' serum. The population studied was Mexican American farm-workers and their children in California.

Abstract: Objective: We investigated the relationship between prenatal exposure to dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenyldichloroethylene (DDE) and neurodevelopment of Mexican farm-workers' children in California.

Methods: Participants from the Center for the Health Assessment of Mothers and Children of Salinas study, a birth cohort study, included 360 singletons with maternal serum measures of p,p'-DDT, o,p'-DDT, and p,p'-DDE. Psychomotor development and mental development were assessed with the Bayley Scales of Infant Development at 6, 12, and 24 months.

Results: We found a 2-point decrease in Psychomotor Developmental Index scores with each 10-fold increase in p,p'-DDT levels at 6 and 12 months (but not 24 months) and p,p'-DDE levels at 6 months only. We found no association with mental development at 6 months but a 2- to 3-point decrease in Mental Developmental Index scores for p,p'-DDT and o,p'-DDT at 12 and 24 months, corresponding to 7- to 10-point decreases across the exposure range. Even when mothers had substantial exposure, breastfeeding was usually associated positively with Bayley scale scores.

Conclusions: Prenatal exposure to DDT, and to a lesser extent DDE, was associated with neurodevelopmental delays during early childhood, although breastfeeding was found to be beneficial even among women with high levels of exposure. Countries considering the use of DDT should weigh its benefit in eradicating malaria against the negative associations found in this first report on DDT and human neurodevelopment.

Ribas-Fito N, Torrent M, Carrizo D, Munoz-Ortiz L, Julvez, J, Grimalt, JO, Sunyer, J. In Utero Exposure to Background Concentrations of DDT and Cognitive Functioning among Preschoolers. *American Journal of Epidemiology* 2006 164(10): 955-962

PANNA Summary: Exposure to DDT occurs both in utero and because of its lipophilicity, via breastfeeding. While animal studies have indicated effects on brain growth due to DDT exposure, neurodevelopment in humans is less documented. A study in 2005 reported higher concentrations of DDE in newborns in Menorca, Spain, than in the Ribera d'Ebre cohort. This study is a follow up to the previous 2005 study to assess the association of cord serum levels of DDE and DDT with neurodevelopment at age 4 years. The results indicated that prenatal exposure to low level, concentrations of DDT and DDE at birth is associated with a decrease in verbal, memory, and quantitative and perceptual performance skills among preschoolers. Hence, the author suggests that even though DDT is considered to be useful in malarial control, the evidence of its adverse effects on health requires for appropriate research on its benefits versus its risks.

Abstract: p,p'-DDT (bis[p-chlorophenyl]-1,1,1-trichloroethane) is a persistent organochlorine compound that has been used worldwide as an insecticide. The authors evaluated the association of cord serum levels of DDT and its metabolite, 2,2-bis(p-chlorophenyl)-1,1-dichloroethylene (DDE), with neurodevelopment at age 4 years. Two birth cohorts in Ribera d'Ebre and Menorca (Spain) were recruited between 1997 and 1999 (n=475). Infants were assessed at age 4 years by using the McCarthy Scales of Children's Abilities. Organochlorine compounds were measured in cord serum. Children's diet and parental sociodemographic information was obtained through questionnaire. Results showed that DDT cord serum concentration at birth was inversely associated with verbal, memory, quantitative, and perceptual-performance skills at age 4 years. Children whose DDT concentrations in cord serum were >0.20 ng/ml had mean decreases of 7.86 (standard error, 3.21) points in the verbal scale and 10.86 (standard error, 4.33) points in the memory scale when compared with children whose concentrations were <0.05 ng/ml. These associations were stronger among girls. Prenatal exposure to background, low-level concentrations of DDT was associated with a decrease in preschoolers' cognitive skills. These results should be considered when evaluating the risk and benefits of spraying DDT during antimalaria and other disease-vector campaigns. (Dr. Nuria Ribas-Fito, Respiratory and Environmental Health Research Unit, IMIM, C. Doctor Aiguader 80, 08003 Barcelona, Catalonia, Spain (e-mail: nribas@imim.es) [31])

Sinha C, Seth K, Islam F, Chaturvedi RK, Shukla S, Mathur N, Srivastava N, Agrawal AK. Behavioral and neurochemical effects induced by pyrethroid-based mosquito repellent exposure in rat offspring during prenatal and early postnatal period. *Neurotoxicol Teratol.* 2006; 472-81.

PANNA Summary: Studies have shown that newborn babies, pregnant and lactating mothers are more prone to toxins when exposed to pyrethroids used as mosquito repellents since they stay for longer durations inside the house. This pilot study found that prenatal, postnatal and perinatal exposure to pyrethroid-based Mosquito repellents could alter blood brain barrier permeability. Developing Central Nervous System has been considered to be vulnerable to oxidative damage brain region as compared to other brain regions. The rat pups exposed to mosquito repellents clearly indicated significant involvement of the hippocampus. Overall, the study claims to stress on the effect of pyrethroid based repellents on the neurochemical and behavioral effects and implies that pregnant women and infants may be greatly offset by the benefits of the protection of repellents if the result on rats are indicative of their effects.

Abstract: Synthetic pyrethroids, besides their use in agriculture, are prevalently used in our houses as mosquito repellent (MR) in the form of aerosol, mats, coils and liquid vaporizers. Inhalation of fumes of the MR/liquid vaporizers may get entry into the brain by breaching the developing blood-brain barrier, hence deleterious to developing nervous system and can lead to long-term functional deficits. In the present study the consequence of MR exposure has further been investigated at various stages of development, evaluating free radical mediated effect pertinent to neurobehavioral and neurochemical functioning. Rat pups were exposed to pyrethroid-based MR (allethrin 3.6% w/v, 8 h/day through inhalation) during prenatal (GD1-20), postnatal (PND1-30) and perinatal (GD1-PND30) period of development and assessments were made on PND31. We observed significant oxidative stress, where an increase in lipid peroxidation and a decrease in antioxidants, glutathione, superoxide dismutase and catalase in various brain areas (cerebellum, corpus striatum, frontal cortex and hippocampus) were evident at all the exposure schedules. The hippocampus was the most affected region and further exhibited altered cholinergic functioning in the form of significant decrease in cholinergic (muscarinic) receptor binding (prenatal 32%, postnatal 35%, perinatal 38%) and inhibition in acetylcholinesterase activity (prenatal 20%, postnatal 31% and perinatal 33%). The neurochemical changes were found to accompany decrease in learning and memory performance in exposed rats, the function governed by hippocampus. The result suggests that pyrethroid-based MR inhalation during early developmental period may have adverse effect on developing nervous system causing cholinergic dysfunction leading to learning and memory deficit. (Developmental Toxicology Division, Industrial Toxicology Research Centre, Post Box-80, M.G. Marg Lucknow 226001, India. E-mail address: aka33@rediffmail.com [32] (A.K. Agrawal)

Eskenazi B, Marks AR, Bradman A, Fenster L, Johnson C, Barr CB, and Jewell NP. In Utero Exposure to Dichlorodiphenyltrichloroethane (DDT) and Dichlorodiphenyldichloroethylene (DDE) and Neurodevelopment Among Young Mexican American Children. *Pediatrics* [33] Vol. 118 No. 1, July 2006

PANNA summary: The study found that prenatal exposure to DDT, and to a lesser extent DDE, was related with neurodevelopmental delays during early childhood Mexican farm-workers' children in California. The authors thus urge countries considering the use of DDT to weigh its benefit in eradicating malaria against the negative associations.

Abstract: Objective: We investigated the relationship between prenatal exposure to dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenyldichloroethylene (DDE) and neurodevelopment of Mexican farm-workers' children in California.

Methods: Participants from the Center for the Health Assessment of Mothers and Children of Salinas study, a birth cohort study, included 360 singletons with maternal serum measures of p,p'-DDT, o,p'-DDT, and p,p'-DDE. Psychomotor development and mental development were assessed with the Bayley Scales of Infant Development at 6, 12, and 24 months.

Results: We found a 2-point decrease in Psychomotor Developmental Index scores with each 10-fold increase in p,p'-DDT levels at 6 and 12 months (but not 24 months) and p,p'-DDE levels at 6 months only. We found no association with mental development at 6 months but a 2- to 3-point decrease in Mental Developmental Index scores for p,p'-DDT and o,p'-DDT at 12 and 24 months, corresponding to 7- to 10-point decreases across the exposure range. Even when mothers had substantial exposure, breastfeeding was usually associated positively with Bayley scale scores.

Conclusions: Prenatal exposure to DDT, and to a lesser extent DDE, was associated with neurodevelopmental delays during early childhood, although breastfeeding was found to be beneficial even among women with high levels of exposure. Countries considering the use of DDT should weigh its benefit in eradicating malaria against the negative associations found in this first report on DDT and human neurodevelopment.

van Wendel de Joode B, Wesseling C, Kromhout H, Monge P, GarciaM, Mergler D. Chronic nervous system effects of long-term occupational exposure to DDT. *Lancet* 2001 Mar 31; 357(9261): 1014-16.

PANNA summary: This study found that retired malaria-control workers who had worked spraying DDT did worse on tests of neurobehavioral functions than control groups, and that the longer they had worked with DDT, the poorer the test results. These results indicate that long-term exposure to DDT is measurably harmful.

Abstract: Dichlorodiphenyltrichloroethane (DDT) is a compound with moderate toxicity that is judged to be safe for occupational use, although little is known about its long-term effects on the human nervous system. We investigated chronic nervous-system effects of long-term occupational exposure to DDT by comparing the neurobehavioral performance of retired malaria-control workers with a reference group of retired guards and drivers. DDT-exposed workers did worse on tests assessing various neurobehavioral functions than controls; performance significantly deteriorated with increasing years of DDT application. Our results could not be explained by exposure to cholinesterase-inhibiting pesticides or other potential confounding factors.

Serum Levels and Other Health Impacts

DDT and Breast Cancer in Young Women: New Data on the Significance of Age at Exposure. *Environmental Health Perspectives* [34] August 2007

PANNA Summary:

Abstract:

McGlynn, KA, Quraishi, SM, Graubard, BI, Weber, JP, Rubertone MV, Erickson, RL. Persistent Organochlorine Pesticides and Risk of Testicular Germ Cell Tumors. *Journal of the National Cancer Institute* May 2008 100: 603.

PANNA Summary: Exposure to DDT and other organochlorine pesticides has been suggested to cause a risk of testicular germ cell tumors. The authors tested serum and found that an increased exposure to DDE, a breakdown of DDT, may be associated with the risk of developing testicular germ cell tumors, especially during fetal life or from breastmilk.

Abstract: Background: Exposure to endocrine-disrupting chemicals, such as persistent organochlorine pesticides, has been suggested to increase the risk of testicular germ cell tumors (TGCTs).

Methods: To study the relationship of POP exposure to TGCT risk, prediagnostic serum samples from 754 case subjects and 928 control subjects enrolled in the Servicemen's Testicular Tumor Environmental and Endocrine Determinants Study were analyzed for cis-nonachlor, trans-nonachlor, oxychlordane, total chlordanes, β -hexachlorocyclohexane, mirex, p,p'-dichlorodiphenyldichloroethylene (p,p'-DDE), and p,p'-dichlorodiphenyltrichloroethane. Adjusted odds ratios (ORs) and their associated 95% confidence intervals (CIs) for the risk of TGCT overall and for the histological subgroups, seminoma and nonseminoma, were estimated using multivariable logistic regression. All statistical tests were two-sided.

Results: TGCT risk was statistically significantly associated with higher plasma levels of p,p'-DDE (for highest quartile [Q4] vs lowest quartile [Q1], OR = 1.71, 95% CI = 1.23 to 2.38, Ptrend = .0002) and of two chlordane components, cis-nonachlor (Q4 vs Q1, OR = 1.56, 95% CI = 1.11 to 2.18, Ptrend = .009) and trans-nonachlor (Q4 vs Q1, OR = 1.46, 95% CI = 1.07 to 2.00, Ptrend = .026). Seminoma risk was statistically significantly associated with p,p'-DDE (Q4 vs Q1, OR = 1.91, 95% CI = 1.22 to 2.99, Ptrend = .0008), cis-nonachlor (Q4 vs Q1, OR = 1.93, 95% CI = 1.27 to 2.93, Ptrend = .0045), trans-nonachlor (Q4 vs Q1, OR = 1.72, 95% CI = 1.11 to 2.67, Ptrend = .033), and a chlordane metabolite, oxychlordane (Q4 vs Q1, OR = 1.64, 95% CI = 1.04 to 2.60, Ptrend = .048), whereas nonseminoma risk showed a statistically significant association with p,p'-DDE only (Q4 vs Q1, OR = 1.63, 95% CI = 1.10 to 2.42, Ptrend = .0044).

Conclusions: Increased exposure to p,p'-DDE may be associated with the risk of both seminomatous and nonseminomatous TGCTs, whereas exposure to chlordane compounds and metabolites may be associated with the risk of seminoma. Because evidence suggests that TGCT is initiated in very early life, it is possible that exposure to these persistent organic pesticides during fetal life or via breast feeding may increase the risk of TGCT in young men.

Julia Green Brody, PhD , Kirsten B. Moysich, PhD, Olivier Humblet,MS, Kathleen R. Attfield, BS, Gregory P. Beehler, MA, Ruthann A. Rudel,MS Environmental pollutants and breast cancer. *Cancer* 2007 109(S12):2667-2711

PANNA Summary: After analyzing the research already done on environmental pollutants and breast cancer, the authors conclude that more research measuring toxicity needs to be done. They also suggest the development of better methods to measure exposure to toxic pollutants. Progress has been made in the last five years.

Abstract: Laboratory research has shown that numerous environmental pollutants cause mammary gland tumors in animals; are hormonally active, specifically mimicking estrogen, which is a breast cancer risk factor; or affect susceptibility of the mammary gland to carcinogenesis. An assessment of epidemiologic research on these pollutants identified in toxicologic studies can guide future research and exposure reduction aimed at prevention. The PubMed database was searched for relevant literature and systematic critical reviews were entered in a database available at URL: www.silentspring.org/sciencereview and URL: www.komen.org/environment (accessed April 10, 2007). Based on a relatively small number of studies, the evidence to date generally supports an association between breast cancer and polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in conjunction with certain genetic polymorphisms involved in carcinogen activation and steroid hormone metabolism. Evidence regarding dioxins and organic solvents is sparse and methodologically limited but suggestive of an association. Methodologic problems include inadequate exposure assessment, a lack of access to highly exposed and unexposed populations, and a lack of preclinical markers to identify associations that may be obscured by disease latency. Among chemicals identified in toxicologic research as relevant to breast cancer, many have not been investigated in humans. The development of better exposure assessment methods is needed to fill this gap. In the interim, weaknesses in the epidemiologic literature argue for greater reliance on toxicologic studies to develop national policies to reduce chemical exposures that may be associated with breast cancer. Substantial research progress in the last 5 years suggests that the investigation of environmental pollutants will lead to strategies to reduce breast cancer risk. *Cancer* 2007. © 2007 American Cancer Society. 1 Silent Spring Institute, Newton, Massachusetts 2 Department of Epidemiology, Roswell Park Cancer Institute, Buffalo, New York email: Julia Green Brody brody@silentspring.org [35] Correspondence to Julia Green Brody, Silent Spring Institute, 29 Crafts Street, Newton, MA 02458 Fax: (617) 332-4284

Cohn, BA, MS Wolff, PM Cirillo and RI Sholtz. DDT and breast cancer in young women: New data on the significance of age at exposure. *Environmental Health Perspectives* 2007 115(10): 1406-1414.

PANNA Summary: The authors compared DDT in blood from women in Oakland, California taken between 1959-1967 and breast cancer in the same women years later. Women with high percentages of DDT in their blood were five times more likely to have breast cancer.

Abstract: Background: Prior studies of DDT and breast cancer assessed exposure later in life when the breast may not have been vulnerable, after most DDT had been eliminated, and after DDT had been banned.

Objectives: Investigate whether DDT exposure in young women during peak DDT use predicts breast cancer.

Methods: We conducted a prospective, nested case-control study with a median time to diagnosis of 17 years using blood samples obtained from young women from 1959-1967. Subjects were members of the Child Health and Development Studies, Oakland, California, who provided blood samples 1 to 3 days after giving birth (mean age 26 years). Cases (n=129) developed breast cancer before age 50 years. Controls (n=129) were matched to cases on birth year. Serum was assayed for p,p'-DDT, the active ingredient of DDT, o,p'-DDT a low concentration contaminant, and p,p'-DDE, the most abundant p,p'-DDT metabolite.

Results: High levels of serum p,p'-DDT predicted a statistically significant five-fold increased risk of breast cancer among women who were born after 1931. These women were under age 14 in 1945, when DDT came into widespread use and mostly under age 20 as DDT use peaked. Women who were not exposed to p,p'-DDT before age 14 showed no association between p,p'-DDT and breast cancer (p=0.02 for difference by age).

Conclusions: Exposure to p,p'-DDT early in life may increase breast cancer risk. Many U.S. women heavily exposed to DDT in childhood have not yet reached age 50. The public health significance of DDT exposure in early life may be large.

Full text: <http://www.ehponline.org/docs/2007/10260/abstract.html> [34]

McGlynn KA , Abnet CC , Zhang M, Sun XD, Fan JH, O'Brien TR, Wei WQ, Ortiz-Conde BA, Dawsey SM, Weber JP, Taylor PR, Katki H, Mark SD, Qiao YL. Serum Concentrations of 1,1,1-Trichloro-2,2-bis (p-chlorophenyl)ethane (DDT) and 1,1-Dichloro-2,2-bis (p-chlorophenyl)ethylene (DDE) and Risk of Primary Liver Cancer. *Journal of the National Cancer Institute* 2006 98(14): 1005-1010.

PANNA Summary: Primary liver cancer is the sixth most common cancer in the world. In China, DDT was banned for agricultural use in 1983 but continues to produce for the manufacture of dicofol, a non systemic acaricide, for use in residential spraying in antimalarial campaigns. The dominant type of cancer in China too is hepatocellular carcinoma. This study thus studies the risk of liver cancer in Linxian, China which has a comparatively low incidence of cancer. The results of this study indicated that there was a high risk of liver cancer in association with high levels of DDT. Animal studies have shown that DDT has a detrimental effect on the nervous system as well as the liver. Also, animal studies have found that undernourished animals have a closer association between liver cancer and DDT. Linxian population is also poorly nourished. Hence it is possible that DDT is particularly carcinogenic in humans who suffer from malnutrition. While the study does have several limitations, the findings do indicate that DDT exposure may be a risk factor for liver cancer in humans directly exposed to DDT.

Abstract: Background: 1,1,1-Trichloro-2,2-bis (p-chlorophenyl)ethane (DDT) exposure has been demonstrated to cause liver tumors in laboratory rodents. DDT's persistent metabolite and environmental degradation product, 1,1-dichloro-2,2-bis (p-chlorophenyl)ethylene (DDE), has also been associated with liver tumors in laboratory animals. Whether DDT and DDE are associated with hepatocarcinogenesis in humans is not clear.

Methods: We carried out a nested case-control study among the participants of the Nutritional Intervention Trials in Linxian, China. The case group included 168 individuals who developed liver cancer during the trials, and the control group included 385 individuals frequency-matched on age and sex who were alive and well at the end of the study. Serum concentrations of DDT and DDE were measured by gas chromatography-mass spectrometry. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using multivariable analysis.

Results: In multivariable adjusted models, the risk of developing liver cancer increased with increased serum DDT concentration (OR for quintile 1 versus quintile 5 = 3.8, 95% CI = 1.7 to 8.6, P trend = .0024). In contrast, there was no statistically significant association between liver cancer and serum DDE concentration. The association between high serum DDT concentration and liver cancer was

stronger among individuals with DDE concentrations below the median value (odds ratio for tertile 3 versus tertile 1 = 3.55, 95% CI = 1.45 to 8.74) than those with concentrations above the median (OR = 1.70, 95% CI = 0.97 to 2.98). A calculation of crude liver cancer risk found that there would be 26 liver cancers per 100 000 persons per year in the lowest quintile of DDT exposure versus 46 liver cancers per 100 000 persons per year in the highest quintile of DDT exposure.

Conclusions: DDT may be a risk factor for liver cancer, particularly among persons with lower DDE concentrations. Risk may be particularly increased among persons exposed directly to DDT resulting in a higher ratio of DDT to DDE) or, alternatively, risk may be associated with individual ability to metabolize DDT to DDE.

Aimin, C. and W.J. Rogan. Health risks and benefits of bis(4-chlorophenyl)-1,1,1 trichloroethane (DDT). US National Institute of Environmental Health Sciences. *Lancet* 2005; 366: 763–73

PANNA summary: This article traces the health impacts and effectiveness or lack of effectiveness for countries continuing to use DDT for malaria control after its inclusion in the Stockholm Convention list of chemicals targeted for a global ban in 2001. Due to a lack of controlled testing and conflicting or inconclusive data it was impossible to determine the specific negative health effects of DDT. The authors call for more research to determine if the health risks outweigh the health benefits.

Abstract: DDT (bis[4-chlorophenyl]-1,1,1-trichloroethane) is a persistent insecticide that was used worldwide from the mid-1940s until its ban in the USA and other countries in the 1970s. When a global ban on DDT was proposed in 2001, several countries in sub-Saharan Africa claimed that DDT was still needed as a cheap and effective means for vector control. Although DDT is generally not toxic to human beings and was banned mainly for ecological reasons, subsequent research has shown that exposure to DDT at amounts that would be needed in malaria control might cause preterm birth and early weaning, abrogating the benefit of reducing infant mortality from malaria. Historically, DDT has had mixed success in Africa; only the countries that are able to find and devote substantial resources towards malaria control have made major advances. DDT might be useful in controlling malaria, but the evidence of its adverse effects on human health needs appropriate research on whether it achieves a favourable balance of risk versus benefit. (Epidemiology Branch, US National Institute of Environmental Health Sciences, P O Box 12233, Research Triangle Park, NC 27709, USA. rogan@niehs.nih.gov [36])

Toxicological Profile for DDT, DDE, and DDD. Prepared by Syracuse Research Corporation for US Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. September 2002. <http://www.atsdr.cdc.gov/toxprofiles/tp35.html>

PANNA summary: This report is concerned solely with DDT in the USA, so there is very little attention paid to malaria or DDT's use for vector control. The profile provides clear explanations of why DDT is still in the U.S. environment when it was banned for use in this country in 1972, how it persists in the soil and water, and how it moves from one place to another. The report cites many possible dangers of the toxin to public health. Health effects cited in this report include: nervous system effects, changes in liver enzymes, and "harmful effects" on reproduction and adrenal gland function. EPA has classified DDT and its metabolites as probable human carcinogens, though this report says that there is no evidence of increased cancer risk in humans.

(no abstract available)

Longnecker, M. P., M. A. Klebanoff, H. Zhou, J. W. Brock. Association between maternal serum concentration of the DDT metabolite DDE and pre-term and small-for-gestational-age babies at birth. *The Lancet* 2001; 358: 110-114.

PANNA summary: This 2001 landmark study by the National Institute of Environmental Health Sciences and three other organizations found a strong relationship between prematurely delivered and low birth weight babies and mothers' blood levels of DDE, the metabolic breakdown product of DDT. The study took its data from children born between the years 1959 and 1966, a time when DDT was still being used in the United States and so average blood levels of DDE were much higher than they are in the U.S. today, but still lower than what they are in other countries where DDT is still being used to control malaria. The researchers conclude that the ties between premature birth rates, a major factor in infant mortality, and blood levels of DDE should lead to the reassessment of the costs and benefits of DDT-based malaria control strategies around the world.

Abstract: DDT (1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane) is highly effective against most malaria-transmitting mosquitoes and is being widely used in malaria-endemic areas. The metabolite, DDE (1,1-dichloro-2,2-bis (p-chlorophenyl) ethylene), has been linked to pre-term birth in small studies, but these findings are inconclusive. Our aim was to investigate the association between DDE exposure and pre-term birth.

Methods: Our study was based on the U.S. Collaborative Perinatal Project (CPP). From this study we selected a subset of more than 44,000 eligible children born between 1959 and 1966 and measured the DDE concentration in their mothers' serum samples stored during pregnancy. Complete data were available for 2,380 children, of whom 361 were born pre-term and 221 were small-for-gestational age.

Findings: The median maternal DDE concentration was 25 µg/L (range 3-178)--several fold higher than current US concentrations. The adjusted odds ratios (OR) of pre-term birth increased steadily with increasing concentrations of serum DDE (ORs=1, 1.5, 1.6, 2.5, 3.1; trend p<0.0001). Adjusted odds of small-for-gestational-age also increased, but less consistently (ORs=1, 1.9, 1.7, 1.6, 2.6; trend p=0.04). After excluding pre-term births, the association of DDE with small-for-gestational-age remained.

Interpretation: The findings strongly suggest that DDT use increases pre-term births, which is a major contributor to infant mortality. If this association is causal, it should be included in any assessment of the costs and benefits of vector control with DDT.

Longnecker, MP, MA Klebanoff, JW Brock, H Zhou, KA Gray, LL Needham and AJ Wilcox. Maternal serum level of 1,1-Dichloro-2,2-bis(p-chlorophenyl) ethylene and risk of cryptorchidism, hypospadias, and polythelia among male offspring. *American Journal of Epidemiology* Vol.155, No. 4 : 313-322.

PANNA summary: In light of recent findings that the metabolic byproduct of DDT, DDE, blocks receptors for androgens (male hormones) in rats, scientists undertook this study to see if there is some similar effect in humans. They looked at data for mothers' blood levels of DDE (see article #1) and the frequency of birth defects in male babies from the same set of children born between 1959 and 1966. They found that elevated DDE levels in the mother's blood serum correlated with increased incidence of undescended testicles, penis abnormalities, and extra nipples in male children.

Abstract: 1,1-Dichloro-2,2-bis (p-chlorophenyl) ethylene (p,p'-DDE) is a metabolite of the insecticide 2,2-bis (p-chlorophenyl)-1,1,1-trichloroethane (DDT) and is a ubiquitous environmental contaminant. Nearly everyone in the United States has a detectable serum level of DDE. DDE was recently found to inhibit binding of androgen to its receptor and to block androgen action in rodents. Normal

development of male genitalia in mammals depends on androgen action. The authors used stored serum samples to examine the relation between maternal DDE levels during pregnancy and adjusted odds of cryptorchidism (n = 219), hypospadias (n = 199), and polythelia (extranipples) (n = 167) among male offspring, using a nested case-control design with one control group (n = 552). Subjects were selected from the Collaborative Perinatal Project, a US birth cohort study begun in 1959-1966, when DDE levels were much higher than they are at present. Compared with boys whose mother's recovery-adjusted serum DDE level was less than 21.4 microg/liter, boys with maternal levels greater than or equal to 85.6 microg/liter had adjusted odds ratios of 1.3 (95% confidence interval (CI): 0.7, 2.4) for crypt-orchidism, 1.2 (95% CI: 0.6, 2.4) for hypospadias, and 1.9 (95% CI: 0.9, 4.0) for polythelia. For cryptorchidism and polythelia, the results were consistent with a modest-to-moderate association, but in no instance was the estimate very precise. The results were inconclusive. (Epidemiology Branch, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709, USA. longnecker@niehs.nih.gov^[37])

Bouman, H., P. J. Becker, and C. H. J. Schutte. Malaria Control and Longitudinal Changes in Levels of DDT and Its Metabolites in Human Serum from KwaZulu. *Bulletin of the World Health Organization*. 1994;72(6): 921-30.

PANNA Summary: Based on previous research, the authors propose that uptake and elimination, two coexisting processes, control the changes in serum levels of DDT and its metabolites; and that these two processes switch with age. To confirm this, the authors compared the rates of change in addition to the change in levels. They found an increase in DDT metabolites for the older group (=21 years) and a decrease in serum levels for the younger group (3 to 20 years) over a 12-month period. Their data indicate that DDT levels increased faster in the older group than in the younger group, and that there is a more rapid reduction in serum DDT in the younger group. The authors' findings and analyses support the proposition that the body's rate and, perhaps, process of eliminating DDT is different in children than in adults.

Abstract: Blood samples were obtained on four occasions over a 12-month period from individuals living in KwaZulu, South Africa, who had been exposed to DDT (1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane) as a consequence of its use in their homes to control transmission of malaria. The longitudinal changes in serum DDT and its major metabolites, DDE and DDD, were determined. No additional risk was considered to have been presented by the increases that occurred following application of the pesticide. There were significant increases in DDT, DDE and DDT (DDT + its metabolites) for the age group =21 years, but for the age group 3-20 years a reduction in serum levels occurred over 12 months. Two concurrent processes probably govern the increase and decrease in serum levels, and the relative contributions of each interchange as the individual becomes older. The results suggest that children in KwaZulu experience conditions that differ from those of their parents, as well as from those that affect children in developed countries. In consequence, it is desirable that risk assessments of vector control chemicals consider all sectors of a population. (Department of Zoology, Potchefstroom University for Christian Higher Education, South Africa.)

Bouman, H., and C. H. J. Schutte. Effects of Sibship on DDT Residue Levels in Human Serum from a Malaria Endemic Area in Northern KwaZulu. *Bulletin of Environmental Contaminants and Toxicology*. 1993; 50: 300-7.

PANNA Summary: This study analyzes serum levels of DDT and its metabolites of siblings in eight homesteads. The authors conclude that there is a strong correlation between siblings under malaria control conditions and serum levels of DDT. They recommend that children always be included in environmental exposure studies and that separate risk assessments be done, since the young experience different environmental circumstances and are especially vulnerable during development.

(no abstract available)

Bouman, H. DDT levels in serum, breast-milk and infants in various populations in malaria and non-malaria controlled areas of KwaZulu. *Medical Research Council*. 1991:1-38.

Abstract: The World Health Organization (WHO) considers 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane (DDT) safe to man and the environment when applied intra-domiciliary for malaria control. Research into the possible health effects under prevailing conditions and taking social customs into account, have, however, been lacking. This study was undertaken to determine levels of DDT in serum and breast-milk and possible risks posed by the insecticide to the health of lactating mothers and their infants. The aims of the study were: (1) To determine the levels of DDT and its metabolites, DDD and DDE, in the serum of members of families from a sprayed and a non-sprayed area, as well as changes caused by indoor application of DDT; (2) To determine the levels of DDT and its metabolites in the breast-milk of mothers from a sprayed and a non-sprayed area, as well as changes caused by indoor application of DDT; (3) To determine the uptake of DDT and its metabolites by the infant via breast-milk, and to develop a statistical model that describes the dynamics; and (4) To determine the risk to the health of mother and infant posed by exposure to DDT and its metabolites.

Bouman, H.; Cooppan, R. M.; Botha, M. J., and Becker, P. J. Serum levels of DDT and liver function of malaria control personnel. *SAfr Med J*. 1991; 79(6):326-329. ISSN: 0038-2469.

PANNA summary: This study found that blood levels of DDT and its metabolites are higher in people who work as DDT sprayers than for the general population in KwaZulu, South Africa, where DDT is used for malaria control. Possible health risks to the sprayers from these elevated levels, including evidence of reduced liver function, were identified.

Abstract: The levels of DDT and metabolites in serum of 23 applicators involved in malaria control operations in Natal were determined using gas chromatography with electron capture detection. The mean levels (microgram/l, ppb) were 61.7 DDT, 129.3 DDE, 11.0 DDD and 202.0 sigma DDT. Percentage DDT was 33.4%. These levels were higher than for an age matched sample of the general population in KwaZulu, who are protected by DDT against malaria. Percentage DDT correlated negatively with age (P less than 0.05) for the applicators, suggesting a change in pharmacodynamics with age. Mean serum albumin, alkaline phosphatase, aspartate transferase and gamma-glutamyltransferase (GGT) levels did not differ significantly from an age-matched control group, but the mean GGT value for the applicators was higher than the maximum of the laboratory normal range. Although not clinically significant, the alanine transferase was significantly higher in the applicators than in the control group. These higher levels suggest a possible risk to the health of the sprayers, but uncertainties remain. (Research Institute for Environmental Diseases of the South African Medical Research Council, Pretoria.)

Bouman, H., R. M. Cooppan, P. J. Becker, et al. Malaria Control and Levels of DDT in Serum of Two Populations in KwaZulu. *Journal of Toxicology and Environmental Health*. 1991; 33(3): 141-55.

PANNA Summary: The authors established that the average level of DDT and its metabolites was higher in the population exposed to in-house DDT application for malaria control than in the control group. The researchers also discovered that the levels of DDT and its metabolites decreased between the ages of three and twenty-nine years, yet following age twenty-nine, the levels began to increase again. Based on these results, the authors suggest that different processes govern DDT dynamics with relation to age. They also tested liver function and found that, although DDT metabolite levels correlate with levels of the liver protein, alcohol consumption better

predicted liver protein levels. Thus, the authors conclude that "DDT as used for malaria control does not adversely affect the liver function."

Abstract: Concentrations of p,p'-DDT, p,p'-DDE, and p,p'-DDD were determined in serum of members of households of two different areas of KwaZulu. Annual intradomestic application of DDT is used for the interruption of malaria transmission in one area (the exposed group) while the other served as the control. Demographic differences between the two groups resulted in significantly more females in the control group. The two groups were comparable with respect to age. Serum from household members living in DDT-treated dwellings had significantly higher ($p < .005$) levels of DDT and metabolites (mean Σ DDT 140.9 μ g/l) than those from the control area (mean Σ DDT 6.04 μ g/l). Percentage DDT was also significantly higher ($p < .05$) in the exposed group (28.9%) than the control group (8.3%). DDT for the 3-10yr age interval (168.6 μ g/l) was significantly higher ($p < .05$) than the 20-29 (60.5 μ g/l) and 30-39 (84.2 μ g/l) yr age intervals. There seemed to be two groups with regard to accumulation and elimination. The age group 3-29 appeared to be eliminating DDT, most likely accumulated from contaminated breast milk, faster than they accumulated it. From around 29 yr of age accumulation predominated as the levels increased with age. Regression analysis suggested pharmacokinetic differences for DDE and DDT between the two groups. Liver function parameters between the two groups only differed significantly for gamma-glutamyl transferase (g GT) ($p < .005$), but the influence of difference in alcohol consumption, which was significantly higher in the exposed group ($p < .0001$), offered a better explanation. Those of the exposed group that consumed alcohol had a significantly higher ($p < .05$) mean g GT level (41.5 IU/l) than those that did not (20.2 IU/l), but were not significantly different for DDT ($p > .05$). The safety of DDT used in malaria control for subjects aged 3 and older was confirmed by the levels of DDT in serum when compared with other studies, which showed lack of any negative effects associated with these levels in adults, and an apparently normal liver function in the exposed and control groups. (Research Institute for Environmental Diseases, Medical Research Council, Pretoria, Republic of South Africa.)

Environmental Impacts

Xiang Liu, Gan Zhang, Jun Li, Li-Li Yu, Yue Xu, Xiang-Dong Li, Kobara Y and Jones KC. Seasonal Patterns and Current Sources of DDTs, Chlordanes, Hexachlorobenzene, and Endosulfan in the Atmosphere of 37 Chinese Cities, *Environ. Sci. Technol.* [38], 2009, 43 (5), pp 1316–1321

PANNA Summary: The Chinese cities for this study included: Kashi, Kuerle, Kelamayi, Jiayuguan, Urumchi, Ejinaqi, Lanzhou, Xi'ning, Changchun, Shenyang, Beijing, Tianjin, Xi'an, Shijiazhuang, Taiyuan, Hohhot, Xinxiang, Zhengzhou, Guiyang, Chongqing, Kunming, Chengdu, Wuhan, Changsha, Hefei, Zhuzhou, Nanchang, Guangzhou, Nanning, Hangzhou, Nanjing, Dalian, Tsingdao, Fuzhou, Xiamen, Haikou, Beihai, Hok Tsui, Waliguan, and Xianghuangqi. The key findings from this Study were relatively high levels of DDTs (summation of o,p'-DDT, p,p'-DDT and p,p'-DDE) were observed mostly in the cities of southern, southwestern and central parts of China. In the summer, high chlordane levels are observed in southern, southwestern and eastern China, indicating a fresh chlordane input. In autumn, high levels were found in northern, eastern, and southern China, signifying a fresh use of chlordane in these regions. China is an important global source for HCB. Endosulfan was mainly used for controlling cotton bollworm in China, and geographically, the high concentrations of total endosulfan occurred in the cotton production areas in China.

Abstract: China has a history of large scale production and application of organochlorine pesticides (OCPs) although, data on their nationwide distribution and seasonal variations in the atmosphere is still sparse. Passive air samplers (PAS) were therefore utilized to obtain seasonal data from 37 Chinese cities and three background sites in 2005. Concentrations and spatial and seasonal distribution of dichlorodiphenyltrichloroethanes (DDTs), chlordanes (CHLs), hexachlorobenzene (HCB), and endosulfans (Endo) are presented in this paper, and their potential sources are discussed based on the data-set. It is estimated that ca. 95% of DDTs present in the atmosphere of Chinese cities was still from technical DDT, while only ca. 5% was "dicofol-type of DDT". DDT application for public health control and DDT activated antifouling paint for fishing ships may be the two most important current sources of technical DDT. The DDT concentrations in several Chinese cities seem to match well with the reported DDT concentrations in human breast milk. A low TC/CC ratio was observed across China in the winter to spring, which may provide a fingerprint of Chinese chlordane emission. It was suggested that "weathered" chlordane emitted from urban construction foundations in winter may give the distinctively low TC/CC ratio. The data showed that China is an important global source for HCB. Higher HCB concentrations were observed in winter and spring, and in colder cities, highlighting an important contribution from combustion sources. Samples with higher endosulfan concentrations occurred in the cotton production areas, indicating its major use in killing cotton pests.

Persistence of organochlorine chemical residues in fish from the Tombigbee River (Alabama, USA): Continuing risk to wildlife from a former DDT manufacturing facility. *Environmental Pollution* [39], August 2008

PANNA Summary:

Abstract: Organochlorine pesticide and total polychlorinated biphenyl (PCB) concentrations were measured in largemouth bass from the Tombigbee River near a former DDT manufacturing facility at McIntosh, Alabama. Evaluation of mean p,p'- and o,p'-DDT isomer concentrations and o,p'- versus p,p'-isomer proportions in McIntosh bass indicated that DDT is moving off site from the facility and into the Tombigbee River. Concentrations of p,p'-DDT isomers in McIntosh bass remained unchanged from 1974 to 2004 and were four times greater than contemporary concentrations from a national program. Total DDT in McIntosh bass exceeded dietary effect concentrations developed for bald eagle and osprey. Hexachlorobenzene, PCBs, and toxaphene concentrations in bass from McIntosh also exceeded thresholds to protect fish and piscivorous wildlife. Whereas concentrations of DDT and most other organochlorine chemicals in fish have generally declined in the U.S. since their ban, concentrations of DDT in fish from McIntosh remain elevated and represent a threat to wildlife. DDT persists in the environment near a former manufacturing facility that ceased production over 40 years ago, and concentrations represent a risk to fish and piscivorous birds in the area.

Geisz, HN, Dickhut, RM, Cochran, MA, Fraser, WR, Ducklow HW. Melting Glaciers: A Probable Source of DDT to the Antarctic Marine Ecosystem, *Environmental Science and Technology*

PANNA Summary: Researchers found DDE and DDT in penguins confined to an island in the Antarctic. They continue to find DDT in the penguins over the last thirty years, which means there is continued exposure. The scientists believe the melting glaciers are releasing DDT and the penguins are continually exposed through the meltwater.

Abstract: Persistent organic pollutants reach polar regions by longrange atmospheric transport and biomagnify through the food web accumulating in higher trophic level predators. We analyzed Adelie penguin (*Pygoscelis adeliae*) samples collected from 2004 to 2006 to evaluate current levels of Σ DDT (p,p'-DDT+p,p'-DDE) in these birds, which are confined to Antarctica. Ratios of p,p'-DDT to p,p'-DDE in Adelie penguins have declined significantly since 1964 indicating current exposure to old rather than new sources of Σ DDT. However,

Σ DDT has not declined in Adelie penguins from the Western Antarctic Peninsula for more than 30 years and the presence of p,p'- DDT in these birds indicates that there is a current source of DDT to the Antarctic marine food web. DDT has been banned or severely restricted since peak use in the 1970s, implicating glacier meltwater as a likely source for DDT contamination in coastal Antarctic seas. Our estimates indicate that 1-4 kg \cdot y⁻¹ Σ DDT are currently being released into coastal waters along the Western Antarctic Ice Sheet due to glacier ablation.

Full Text ^[40]

Booth, William. EPA moves to cap risks of DDT on ocean floor. *The Washington Post* September 5, 2000. A03.

PANNA Summary: Between 1947 and 1971, Montrose Chemical's plant in Torrance, California flushed more than 100 tons of DDT into the county sewer system, where it ran into the Pacific Ocean near the cliffs of Palos Verdes. DDT remains on the ocean floor and is the nation's deepest and largest Superfund site. DDT levels in the bodies of fish caught in this area and sold in Los Angeles are much higher than government safety standards. EPA is filing suit against Montrose Chemical to pay for the cost of cleaning up and restoring the waters off Palos Verdes.

(no abstract available)

Douthwaite, R J, ed. DDT in the Tropics: The impact on wildlife in Zimbabwe of ground-spraying for tsetse fly control. Canterbury, UK: R JDouthwaite and Associates, *Environmental Management Consultants*, 1999.(see the International Centre for Pesticide Safety's Review at:<http://www.icps.it/english/bollettino/psn97/970307.htm>)

PANNA summary: A report on studies funded by the UK's Department for International Development looking at the recovery of local wildlife known to have been affected after DDT spraying for tsetse fly control in northwestern Zimbabwe 10 years earlier. The author argues that DDT has had relatively little impact on wildlife populations in the area compared with the widespread woodland destruction by immigrant farmers and elephants. Deltamethrin, a synthetic pyrethroid that would perhaps have less impact on wildlife, has been used successfully for ground spraying instead of DDT, but it still costs too much to make it a viable solution. This report aims to inform use of DDT for tsetse fly control under the new POPs treaty that allows for limited use for vector control.

(no abstract available)

Wiktelius, S and CA Edwards. Organochlorine Insecticide Residues in African Fauna: 1971-1995. *Review of Environmental Contamination and Toxicology* 151: 1-37.

PANNA summary: Traces the use of organochlorine insecticides (including DDT) in Africa and the levels of organochlorines subsequently found in the tissues of terrestrial and aquatic animals. The authors found that levels, especially of DDT and dieldrin, were "high enough to have considerable potential for chronic toxicity, for causing behavioral changes, or even for killing wild animals, particularly fish and birds and possibly crocodiles." The author warns against possible long-term population effects on the fauna of Africa if the use of organochlorines is not restricted.

Abstract: Organochlorine insecticides (OCLs), which were introduced in the decade following World War II, were used extensively in Europe, the U.S., and other developed countries into the 1970s. However, data began to accumulate on their persistence in soils and aquatic sediments, their potential to be taken up into animal tissues and to bioconcentrate in birds and mammals in the higher trophic levels of food chains and even in humans. As a result, registration authorities phased out their use progressively, in Europe and the U.S., from 1973 onward. However, the production of OCLs in developed countries and their use in developing countries continued through the 1970s and 1980s into the 1990s because they were no longer under patent agreement, were inexpensive to manufacture, and were very effective in pest control. In Africa, the use of OCLs continued well into the 1990s for the control of mosquitoes, tsetse flies, and desert locusts as well as to combat various crop, animal, and human pests. Some of these uses involve extensive spraying of large areas of nonagricultural land, thereby exposing many groups and species of wildlife to their residues. Although there is some evidence of a gradual decline in the use of OCLs in Africa, they are still being used in appreciable quantities. During the past 25 years, there have been 50 published reports of OCL residues in the various groups of invertebrate and vertebrate animals constituting the African fauna. These have been based on a diverse range of surveys, target animals, sampling methods, and analytical techniques. Moreover, they are extremely regionally-biased, the most intense surveys being in Zimbabwe, Kenya, Egypt, and South Africa. DDT was the most commonly used OCL, accounting for about half the total use, followed closely by dieldrin and HCH. Birds and fish have been sampled most intensively, with relatively few studies on other taxa. We reviewed the OCL residue data on African fauna from these reports and summarized the maximum and mean residues in the various groups of terrestrial and aquatic invertebrates and vertebrates. Overall, residues in the fauna were the greatest for DDT, followed in turn by those of dieldrin, HCH, endosulfan, and endrin, with small amounts of aldrin and toxaphene being found in some animals. There were relatively few reports of OCL residues in terrestrial invertebrates and virtually none in aquatic invertebrates. Only a few reports demonstrated OCL residues in terrestrial vertebrates, although high levels of DDT, dieldrin, and HCH were found in crocodile eggs and large residues of dieldrin occurred in bats, squirrels, and monkeys. Considerable OCL residues were reported in a few species of fish, especially *Barbus*, *Clarias*, *Hydrocynus*, *Labeo*, *Sarotherodon*, *Epiplatys*, and *Synodontis*. These residues were at levels that could have caused chronic toxicity or behavioral changes. The calculated maximum and mean OCL residues in the various elements of the African fauna until 1995 were compared with those calculated for corresponding faunal groups in Europe and the U.S. from their development and introduction up to 1973. The OCL residues reported in African fauna between 1971 and 1975 tended to be significantly higher overall than those published for Europe and the U.S. In particular, residues of DDT and dieldrin in African birds and their eggs were greater than those that had been incriminated as causing significant eggshell thinning and reproductive failure in European and U.S. aquatic and terrestrial birds up to 1973. Additionally, high DDT and dieldrin residues were reported from some species of African fish at levels that could potentially affect their reproduction, have chronic toxic and behavioral effects, and even drastically affect populations. Holistic case studies on the use of OCLs to control tsetse flies and desert locusts were discussed. OCL levels in trophic levels of fauna associated with Lake Kariba (between Zambia and Zimbabwe) were summarized. (Swedish University of Agricultural Sciences, Uppsala, Sweden)

DDT Resources

Resources

- PAN International ^[41] DDT Resolution, December 2007
- Expert List on Preventing Malaria & Reducing Reliance on DDT ^[42]
- Congressional Briefing ^[43] for Africa Malaria Day, featuring experts from Africa and U.S. April 24, 2007
- Malaria Awareness Day, House Subcommittee on Global Health and Africa April 25, 2007 Transcript ^[44]
- A new global malaria eradication strategy, Viewpoint from *Lancet* ^[45], March 2008.

- World Malaria Report 2008 ^[46], World Health Organization
- World Malaria Report 2005 ^[47], World Health Organization
- Centers for Disease Control (CDC). Malaria Surveillance ^[48] --- United States, 2005
- Guinovart C, Navia MM, Tanner M, et al. Malaria: burden of disease. *Curr Mol Med* 2006; 6:137--40.
- UNICEF, World Malaria Report 2005 - Fact Sheet ^[49].
- The World Bank, World Development Indicators 2005 ^[50].
- Malaria & Children: Progress in Intervention Coverage, UNICEF, RBM ^[51] -2007.

National and International Actors

- United Nations Foundation ^[52]
- Medicines for Malaria Venture ^[53]
- Malaria No More ^[54]
- ICIPE ^[55]
- The Bill and Melinda Gates Foundation ^[56]
- The Global Fund to Fight AID, Tuberculosis and Malaria ^[57]
- Roll Back Malaria ^[58]
- PATH ^[59]
- WHO ^[60]
- Stockholm Convention ^[61]

US Federal Actors

- President's Malaria Initiative ^[62]
- Centers for Disease Control and Prevention ^[63]
- Malaria Caucus ^[64]

DDT/Malaria Newsroom

For assistance with gathering elements for stories, feel free to contact Campaigns Director Kristin Schafer at 415 981-1771, kristins@panna.org ^[65]

Resources

- PAN International ^[41] DDT Resolution, December 2007
- Expert List on Preventing Malaria & Reducing Reliance on DDT ^[42]
- Congressional Briefing ^[43] for Africa Malaria Day, featuring experts from Africa and U.S. April 24, 2007
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- A new global malaria eradication strategy, Viewpoint from *Lancet* ^[45], March 2008.
- World Malaria Report 2008 ^[46], World Health Organization
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- Centers for Disease Control (CDC). Malaria Surveillance ^[48] --- United States, 2005
- Guinovart C, Navia MM, Tanner M, et al. Malaria: burden of disease. *Curr Mol Med* 2006; 6:137--40.
- UNICEF, World Malaria Report 2005 - Fact Sheet ^[49].
- The World Bank, World Development Indicators 2005 ^[50].
- Malaria & Children: Progress in Intervention Coverage, UNICEF, RBM ^[51] -2007.

In the News

- Seasonal Patterns and Current Sources of DDT in the Atmosphere of 37 Chinese cities ^[38], *Environmental Science and Technology*, April 2009
- Credit Card Sized Tool to Test for Malaria ^[66], Meridian Institute, January 2009
- Study: Insecticide-treated net coverage in Africa: mapping progress in 2000-7 ^[67], *The Lancet*, January 2009
- New Papers Offer Insight Into Process Of Malarial Drug Resistance ^[68], *Science Daily*, December 2008
- Cost and consequences of large scale vector control for Malaria ^[69], *Malaria Journal*, December 2008
- Encouraging breakthrough in the Fight Against Malaria ^[70], December 2008
- Technology to eradicate malaria ^[71], *BBC News*, November 2008
- Press Release: Safe alternatives to malaria-controlling DDT focus of UN-backed meeting ^[72], *UN News Center*, November 2008
- Kenya: Dramatic fall in number of malaria deaths ^[73], *EurekaAlert - Washington DC*, October 2008
- Study: Malaria Deaths in Gambia drop steeply, Michael Kahn ^[74], *Reuters*, October 2008
- Uganda: Katakwi Starts Indoor Spraying ^[75], *The Monitor - Kampala*, October 2008
- New Malaria Research: insecticide cross resistance ^[76], 2008
- War Against Malaria Can Be Won, Without DDT ^[77], Dr. César Chelala, *The Epoch Times*, October 2008
- Two foundations pledge more funding for malaria research ^[78], Patrick Kisembo, *IPPMedia*, October 2008
- Rwanda: Lessons learnt from 2007 Spraying Campaign ^[79], September 2008
- Malaria deaths down by half in Zanzibar ^[80], *The Citizen*, September 2008
- Tanzania: We're at war with malaria ^[81], August 2008
- Antarctic Melt Releasing DDT, Tainting Penguins ^[82], *National Geographic News*, May 2008
- China's Pearl River tainted with DDT ^[83], January 2008
- ^[84]Malaria Deaths Halved in Rwanda and Ethiopia ^[85] David Brown, *Washington Post* February 2008
- News from Uganda ^[84]

^[84]

DDT/Malaria Newsroom Archive

- News from 2007 ^[86]
- Bad Blood ^[87] Kim Larsen, On Earth December 2007
- Rachel Carson's Birthday Bashing ^[88] by Kirsten Weir Salon.com June 29, 2007
- DDT is Unsafe ^[89] by Abou Thiam, Washington Times June 4, 2007
- DDT Fictions Karl Tupper ^[90], Pittsburgh Tribune May 14, 2007
- Press Release: World Health Organization Clarifies Support ^[91] for Reducing Reliance on DDT for Malaria Control May 3, 2007

Preventing Malaria - Promoting Health

Sustainable solutions to the global malaria challenge

Expert List

Dr. Hans Herren, President, Millenium Institute. Former director of the renowned International Center for Insect Physiology and Ecology in Nairobi, Kenya, Dr. Herren won the World Food Prize in 1995. Dr. Herren's expertise on malaria control includes familiarity with on-the-ground projects in Africa controlling malaria with integrated vector management strategies, including bed nets and biological controls. Contact: hh@millennium-institute.org ^[92], 703 841 0048; cell + 1 530 867 4569.

Dr. Paul Saoke, Executive Director, Physicians for Social Responsibility–Kenya
Dr. Saoke has conducted extensive research on the health effects of low-level DDT exposure, particularly on developing infants and children. Kenya continues to combat malaria without the use of DDT. Dr. Saoke will be available for interviews in Washington DC April 22-26. Contact: psaoke@isde.org ^[93], 254-2-3873398, cell 254-720-264297.

Dr. Peter Orris, Professor and Chief of Service, Occupational and Environmental Medicine, University of Illinois at Chicago Medical Center. Dr. Orris has studied the health effects of low-level exposure to DDT and has participated in international discussions of DDT use for malaria control under the Stockholm Convention process. Contact: porris@uic.edu ^[94], 312-864-5550.

Dr. Barbara Cohn, Center Director, Child Health and Development Studies – Center for Research on Women's and Children's Health. Dr. Cohn has conducted research on the reproductive effects of DDT/DDE exposure, and authored a recent study documenting increased risk of breast cancer among young women exposed to DDT. Contact: bcohn@chdstudies.org ^[95], 510-649-6380.

Fernando Bejarano, Director, RAPAM – Pesticide Action Network Mexico. Mr. Bejarano has documented the successful integrated vector management program in Mexico that led to the phaseout of DDT use for malaria control in 2000. Contact: rapam@prodigy.net.mx ^[96], 52-595-95 4 77 44.

Erika Rosenthal, Senior Attorney, Center for International Environmental Law
Ms. Rosenthal is familiar with the Stockholm Convention's approach to DDT phaseout, which allows short term use in countries which can demonstrate immediate need for malaria control, while mobilizing resources to support safer alternatives. Contact: dditz@ciel.org ^[97], 202-785-8700.

Shawna Larson, Environmental Justice Program Director, Indigenous Environmental Network/Alaska Community Action on Toxics. Ms. Larson works with arctic communities concerned about DDT contamination of traditional foods and human breastmilk. Contact: shawna@akaction.net ^[98], 907-222-7714.

Dr. Medha Chandra, International Campaigner, Pesticide Action Network North America. Dr. Chandra has worked on the Stockholm Convention and tracks the World Health Organizations malaria control programs. Contact: mchandra@panna.org ^[99], 415-981-1771.

Experts ask "Why DDT?"

PAN International and other public health and environmental experts organized a protest in Budapest of the September 2006 WHO announcement giving DDT a "clean bill of health" for malaria control. We demanded that WHO reverse their position, and called on the hundreds of governmental officials gathered in Budapest to join in this demand.



Eloise Tounis, PAN UK; Barbara Dinham, PAN-UK; Rico Eulpidiou, Groundwork South Africa; Manny Calanzo, GAIA, Philippines; Sylvani Mng'anya, AGENDA, Tanzania; Meriel Watts, PAN New Zealand; A. Lemos, Justica Ambiental, Mozambique; Henry Diouf, PAN Africa; Romy Quijano, PAN Philippines; Jayakumar Chelaton, Thanal, India

Budapest Meetings

Health and environmental experts from around the world gathered in Budapest, Hungary for nine days in September 2006 for two very important meetings on toxics protections.

The first meeting was a General Assembly of the International POPs Elimination Network (IPEN) ^[100] a global network of over 400 organizations working on the elimination of persistent organic pollutants (POPs) and implementation of the international Stockholm Convention (POPs treaty). At the IPEN strategy meeting, members formed a coalition response ^[101] to the September 15, 2006 decision

by the World Health Organization (WHO) to promote spraying of DDT, one of the POPs chemicals, inside people's homes in Africa for malaria control.

The next meeting was with the Intergovernmental Forum on Chemical Safety ^[102] involving hundreds of government officials and policy makers from around the world as well as public health advocates. There, more groups spoke out. PAN International and others are also contacting WHO's board of directors directly, demanding that they reverse their promotion of widespread DDT use.

Protesting WHO's DDT Promotion

At the IFCS meeting, this joint statement ^[104] from PAN International, IPEN and the International Society of Doctors for the Environment was delivered to delegates.

From New Zealand, Pesticide Action Network Aotearoa & Safe Food Campaign issued this response ^[105].

At the meeting, PANNA distributed copies of its recent fact sheet "DDT & Malaria: Setting the Record Straight." ^[106]

Other documents prepared by PAN International and distributed at IFCS meeting:

- PAN INTERNATIONAL BRIEFING PAPER ON THE PRECAUTIONARY PRINCIPLE ^[107] *PAN International demands the application of the precautionary principle in national and international pesticide regulatory mechanisms*
- POSICIÓN OFICIAL DE PAN SOBRE EL PRINCIPIO DE PRECAUCIÓN [ESP] ^[108] (PAN's Position On the Precautionary Principle in Spanish) (Full paper in Spanish will be available later)
- POVERTY AND PESTICIDES: PROTECTING HEALTH AND THE ENVIRONMENT ^[109] Paper Presented by Sarojeni V. Rengam, Executive Director, Pesticide Action Network (PAN) Asia and the Pacific To the IFCS Forum V, Budapest, Hungary 25 September 2006
- STATEMENT BY THE PESTICIDE ACTION NETWORK (PAN) INTERNATIONAL ^[110] Presented to the Fifth Session of the Intergovernmental Forum on Chemical Safety (IFCS) during the Plenary Session on the Future of the IFCS
- WHO IRRESPONSIBLE PROMOTING DDT ^[111] Pesticide Action Network Aotearoa & Safe Food Campaign Media release 27 September 2006

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Reliance on DDT is no solution

DDT was used heavily worldwide in the 1950s and 1960s both in agricultural production and for malaria control. DDT has been widely banned because of it builds up in the food chain where it persists in fatty tissues of animals and humans (it can be monitored in human breastmilk), its ability to move from tropical to temperate zones where break down is further delayed, and its association with a number of chronic illnesses. For these reasons, many governments have banned DDT, and addressed its elimination over time in the Stockholm Convention on Persistent Organic Pollutants (POPs treaty) ^[113].

The WHO malaria eradication program of the 1950s and 1960s helped to control malaria in many places, but wiping out malaria with DDT was an unrealistic goal. One of the many reasons for the failure of this ambitious effort was resistance to DDT among malaria-carrying mosquitoes. Taking into account that resistance arose largely from agricultural use and cross-resistance to pyrethroid insecticides, by 1972 nineteen species of mosquitoes were resistant to DDT in Africa. Resistance continues to be a problem.

Often DDT intended for indoor spraying to control mosquitos is diverted to illegal agricultural use, increasing the danger for human exposure and hastening the development of resistant mosquito populations.

New DDT use adds to exposure from old stockpiles that are not properly contained or controlled. The Food and Agriculture Organisation of the United Nations estimates there are more than 100,000 tons of obsolete pesticide stockpiles ^[114] in Africa, mostly older chemicals such as DDT.

New demands for DDT use for malaria control also increase the burden on the communities living near production plants. A DDT factory in the Eloor-Edayar region in India has a long record of contaminating the environment, including rivers. The local community ^[115] is now protesting their poisoning as a result of emissions from this factory.



Paul Saake, MD, Executive Director of Physicians for Social Responsibility in Kenya, speaks to the health effects of DDT and availability of alternatives.



Dr. Romeo Quijano, President of PAN Philippines and Sarojeni Rengam, Regional Coordinator of PAN Asia-Pacific issued this response to WHO ^[103].



PANNA's Medha Chandra speaks with a reporter in Budapest.

Solutions Around the World

Malaria solutions require both curative and preventive strategies. Prevention programs include a range of elements: improved sanitation, water drainage, public education and surveillance of cases in malarial areas, insecticide-treated and long-lasting bed nets, and controlling and reducing the mosquito vectors of malaria. Integrated vector management, rather than reliance on a single factor, is fundamental to success, as is the involvement of affected communities.

The World Health Organization reports that in 2004, some 3.2 billion people in 107 countries lived in areas at risk of malaria transmission. Forty-nine percent of the world's population lives in areas where malaria is transmitted. Each year, 300-500 million people are affected by malaria. In 2005, UNICEF estimated that the cost of effectively controlling the disease in the 82 countries with the highest burden was about \$3.2 billion annually.

Roughly 80-90% of malaria cases occur in sub-Saharan Africa, and over 80% of malaria deaths - around 800,000 a year - occur among African children under age five.

The recent renewed attention to malaria control is a welcome and long overdue development. With significant resources and political commitment, the international community now has an opportunity to build on the many successful programs and experiences with malaria control over the years.



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Case Studies [117]

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Solutions Around the World: Africa

This compilation of articles will be updated periodically and it is by no means comprehensive. The articles are arranged by category and in chronological order with the newest studies first. We hope it will prove to be a useful tool in the ongoing discussion among policymakers, advocacy groups and the media regarding the use of DDT and the need to improve efforts to effectively control malaria.

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1) Lengeler, C.; M.L.H. Mabaso; B. Sharp. Historical review of malarial control in southern African with emphasis on the use of indoor residual house-spraying. *Tropical Medicine and International Health*. August 2004. Vol. 9 No. 8 pp 846–856.

PANNA summary: The researchers investigate the malarial situation before and after the introduction of indoor residual insecticide spraying (IRS) within several countries in Africa. Following the use of IRS within the respective countries, those that were able to develop a National Malaria Control Programme during the phase out of DDT and had strengthened their human and organizational assets made dramatic improvements in malarial control.

Abstract: Indoor residual house-spraying (IRS) mainly with dichlorodiphenyltrichloroethane (DDT) was the principal method by which malaria was eradicated or greatly reduced in many countries in the world between the 1940s and 1960s. In sub-Saharan Africa early malarial eradication pilot projects also showed that malaria is highly responsive to vector control by IRS but transmission could not be interrupted in the endemic tropical and lowland areas. As a result IRS was not taken to scale in most endemic areas of the continent with the exception of southern Africa and some island countries such as Reunion, Mayotte, Zanzibar, Cape Verde and Sao Tome. In southern Africa large-scale malarial control operations based on IRS with DDT and benzene hexachloride (BHC) were initiated in a number of countries to varying degrees. The objective of this review was to investigate the malarial situation before and after the introduction of indoor residual insecticide spraying in South Africa, Swaziland, Botswana, Namibia, Zimbabwe and Mozambique using historical malarial data and related information collected from National Malaria Control Programmes, national archives and libraries, as well as academic institutions in the respective countries. Immediately after the inception of IRS with insecticides, dramatic reductions in malaria and its vectors were recorded. Countries that developed National Malaria Control Programmes during this phase and had built up human and organizational resources made significant advances towards malarial control. Malaria was reduced from hyper- to meso-endemicity and from meso- to hypo-endemicity and in certain instances to complete eradication. Data are presented on the effectiveness of IRS as a malarial control tool in six southern African countries. Recent trends in and challenges to malarial control in the region are also discussed.

2) Sharp, B. and P. van Wyk, J. B. Sikasote, P. Banda, and I. Kleinschmidt. Malaria control by residual insecticide spraying in Chingola and Chililabombwe, Copperbelt Province, Zambia. *Tropical Medicine and International Health*, Vol 7, no 9, pp 732-6. September 2002.

PANNA summary: This study surveyed parasite prevalence and the knowledge, attitudes and practices regarding malaria of Chingola and Chililabombwe towns after Konkola Copper Mines initiated a malaria control program there, spraying all houses in the area with either DDT or one of two synthetic pyrethroids, icon and deltamethrin. There was a significant reduction of malaria incidence following one round of spraying, down to 8.3 cases per 1,000 per month through the rainy season from 13 cases per month in the corresponding season the previous two years.

Abstract: Malaria is endemic in the whole of Zambia and is the leading cause of morbidity and mortality. Prior to 1980, effective malaria control was achieved in the northern mining towns of Chingola and Chililabombwe by means of annual residual spraying programmes. In the 1970s, incidence rates were as low as 20/1000 p.a., but by 2000 had increased to 68/1000 p.a. in Chingola and to 158/1000 p.a. in Chililabombwe. Konkola Copper Mines (KCM) initiated a malaria control programme in which all dwellings in the two towns and within a 10-km radius were sprayed with either dichlorodiphenyltrichloroethane or a synthetic pyrethroid (Icon by ZENECA or Deltamethrin by Aventis). Houses were sprayed in November and December 2000, at the start of the peak transmission period. There was a statistically significant reduction in malaria incidence recorded at KCM health facilities in the two towns, representing a protective incidence rate ratio of 0.65 (95% CI 0.44, 0.97) when comparing the post-spraying period with the corresponding period of the previous 2 years. This reduction followed a single round of house spraying during a year with higher rainfall than the preceding two and in an area where chloroquine was first-line treatment. This house-spraying programme is an example of private/public sector collaboration in malaria control. (Malaria Lead Programme, Medical Research Council, Congella, South Africa)

3) Guyatt, H.L.; S.A. Ochola, and R.W. Snow. Too poor to pay: Charging for insecticide-treated bednets in highland Kenya. *Tropical Medicine and International Health*: v 7, no 10, pp 846-850. October 2002.

PANNA summary: The authors conducted surveys in areas of rural highland Kenya where Medical Emergency Relief International (MERLIN) initiated the provision of insecticide treated bed nets in 1999. Survey respondents included homes with nets provided by the MERLIN program and those without. They were asked how much they would pay for a bed net and if they didn't have one, why not. The results showed that while the vast majority of households are willing to pay for a bed net, most can not afford to pay the full cost or even a subsidized price. The authors conclude that bed nets should be provided free of charge during WHO's initiative to increase bed nets in homes in order to eliminate the bias toward wealthier families.

Abstract: WHO has proposed malaria control as a means to alleviate poverty. One of its targets includes a 30-fold increase in insecticide-treated nets (ITNs) in the next 5 years. How this service will be financed remains unclear. In July 2000, 390 homesteads in rural highland Kenya were interviewed on their willingness to pay for ITNs. The costs to a household of protecting themselves with ITNs were compared with current household expenditure. Homesteads expressed a willingness to pay for ITNs, but the amounts offered were not sufficient to cover the costs of providing this service without donor support to meet the difference. Furthermore, as most household expenditure was allocated to basic needs these interventions were 'unaffordable'. The cost of protecting a household with ITNs would be equivalent to sending three children to primary school for a year. The aspiration by poor rural homesteads to protect themselves with ITNs is not compatible with their ability to pay. One option to have an immediate equitable impact on ITN coverage and break the cycle between malaria and poverty is to provide this service free of charge. (Wellcome Trust Research Laboratories/KEMRI, Nairobi, Kenya, hguyatt@wtnairobi.mimcom.net ^[150])

4) Carnevale, P.; F. Chandre; F. Darriet; D. Fontenille; P. Guillet; J.M. Hougard. Combating malaria vectors in Africa : Current directions of research. *Trends in Parasitology*. July 2002. Vol.18 No.7.

PANNA summary: The authors propose three interrelated research strategies to support malaria prevention: vector genetics, insecticide resistance and vector control. The strategies are discussed in regard to existing and needed research in these three areas.

Abstract: Vector control remains an important component of malaria control, particularly in Africa where most infant deaths occur. Among the different methods, insecticide treated bed nets seem to be a suitable way to reduce morbidity and child mortality in endemic areas. To facilitate their large-scale use and to investigate alternative vector control methods, the authors propose three current directions of research that are already being explored in Africa through a collaborating network involving several African countries: (1) vector genetics, (2) insecticide resistance and (3) vector control strategies.

5) Utzinger, J., Y. Tozan, F. Doumani, and B.H. Singer. The economic payoffs of integrated malaria control in the Zambian copperbelt between 1930 and 1950. *Tropical Medicine and International Health*. August 2002, vol. 7. no. 8, pp.657-677.

PANNA summary: In this analysis of the economic benefits of integrated malaria control efforts in copper-mining communities of Zambia between 1930 and 1950, the authors show that integrated methods can be highly effective. As DDT and other chemical insecticides were not in use yet at the time, control strategies included environmental management, improvement in living conditions, improvement of hospital facilities, use of bed nets, and improved availability of anti-malarial drugs. The number of lives, malaria attacks, work shift losses, disability adjusted life years, direct treatment costs, and lost work hours saved more than made up for the cost of implementing the program because of the dramatic increase in copper production and revenues in the area.

Abstract: It has long been suggested that malaria is delaying the economic development of countries that are most severely affected by the disease. Several studies have documented the economic consequences of malaria at the household level, primarily in communities engaged in subsistence farming. A missing element is the appraisal of the economic impact of malaria on the industrial and service sectors that will probably become the backbone of many developing economies. We estimate the economic effects of integrated malaria control implemented during the colonial period and sustained for 20 years in four copper mining communities of the former Northern Rhodesia (now Zambia). Integrated malaria control was characterized by strong emphasis on environmental management, while part of the mining communities also benefited from rapid diagnosis and treatment and the use of bednets. The programmes were highly successful as an estimated 14,122 deaths, 517,284 malaria attacks and 942,347 work shift losses were averted. Overall, 127,226 disability adjusted life years (DALYs) were averted per 3-year incremental period. The cumulative costs of malaria control interventions were US\$ 11,169,472 (in 1995 US\$). Because the control programmes were so effective, the mining companies attracted a large reservoir of migrant labourers and sustained healthy work forces. The programmes averted an estimated US\$ 796,622 in direct treatment costs and US\$ 5,678,745 in indirect costs as a result of reduced work absenteeism. Within a few years of programme initiation, Northern Rhodesia became the leading copper producer in Africa, and mining generated the dominant share of national income. Copper production and revenues, which increased dramatically during malaria control interventions, amounted to the equivalent of US\$ 7.1 billion (in 1995 US\$). Integrated malaria control in copper mining communities was a sound investment. It had payoff for public and occupational health, generally, and without it copper extraction and social and economic development would have been impossible. (Office of Population Research, Princeton University, Princeton, NJ, USA, Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ, USA, World Bank, Washington, DC, USA)

6) Killeen, Gerry F., U. Fillinger, and B. G. J. Knols. Advantages of larval control for African malaria vectors: Low mobility and behavioral responsiveness of immature mosquito stages allow high effective coverage. *Malaria Journal* June 21, 2002, 1:8.

PANNA summary: This study starts with the hypothesis that targeting adult mosquitoes with strategies like pyrethrin-treated bed nets and indoor residual spraying is less effective because adult mosquitoes avoid those kinds of obstacles. In the egg and larval stages of development, mosquitoes are confined to a marine habitat and are much less mobile, so absolute coverage is more viable. The authors encourage African nations where malaria is endemic to make larval control a high priority, since the mosquito species that cause most malaria in Africa breed near human settlements and so should be easy to find and control in the larval stages.

Abstract:

BACKGROUND: Based on sensitivity analysis of the MacDonald-Ross model, it has long been argued that the best way to reduce malaria transmission is to target adult female mosquitoes with insecticides that can reduce the longevity and human-feeding frequency of vectors. However, these analyses have ignored a fundamental biological difference between mosquito adults and the immature stages that precede them: adults are highly mobile flying insects that can readily detect and avoid many intervention measures whereas mosquito eggs, larvae and pupae are confined within relatively small aquatic habitats and cannot readily escape control measures.

PRESENTATION OF THE HYPOTHESIS: We hypothesize that the control of adult but not immature mosquitoes is compromised by their ability to avoid interventions such as excito-repellant insecticides.

TESTING THE HYPOTHESIS: We apply a simple model of intervention avoidance by mosquitoes and demonstrate that this can substantially reduce effective coverage, in terms of the proportion of the vector population that is covered, and overall impact on malaria transmission. We review historical evidence that larval control of African malaria vectors can be effective and conclude that the only limitations to the effective coverage of larval control are practical rather than fundamental.

IMPLICATIONS OF THE HYPOTHESIS: Larval control strategies against the vectors of malaria in sub-Saharan Africa could be highly effective, complementary to adult control interventions, and should be prioritized for further development, evaluation and implementation as an integral part of Rolling Back Malaria. (Department of Tropical Medicine, School of Public Health and Tropical Medicine, Tulane University Health Sciences Centre, 1430 Tulane Avenue, New Orleans, Louisiana 70112, USA, gerrykilleen@hotmail.com ⁽¹⁵¹¹⁾)

7) Guyatt, H.L., J. Kinnear, M. Buruni, and R.W. Snow. A comparative cost analysis of insecticide-treated nets and indoor residual spraying in highland Kenya. *Health Policy and Planning* 2002; 17(2): 144-153.

PANNA summary: Indoor residual spraying is more cost-effective than insecticide-treated nets in the highlands of Kenya. This conclusion was reached through a cost analysis for both methods, in terms of cash expenditures and also in broader economic terms including the opportunity costs of using staff for these purposes and capital costs.

Abstract: The relative cost of indoor residual house-spraying (IRS) versus insecticide-treated bednets (ITNs) forms part of decisions regarding selective malaria prevention. This paper presents a cost comparison of these two approaches as recently implemented by Merlin, a UK emergency relief organization funded through international donor support and working in the highland districts of Gucha and Kisii in Kenya. The financial costs (cash expenditures) and the economic costs (including the opportunity costs of using existing staff and volunteers, and an annualized cost for capital items) were assessed. The financial cost for IRS was US\$0.86 per person protected,

compared with \$4.21 for ITNs (reducing to \$3.42 to the provider assuming cost recovery). The economic cost per person protected for IRS was \$0.88, compared with \$2.34 for ITNs. The costs for ITNs were sensitive to the number of nets sold per community group ('efficiency'), as the delivery costs constituted upwards of 40% of the total cost. However, even marked increases in efficiency of these groups could not reduce the costs of ITNs to that comparable with IRS, except if more than one cycle of IRS was needed. The implications of predicted reductions in the cost of insecticide for both IRS and ITNs are also explored. The provision of itemized cost data allows predictions to be made on changes in the design of these programmes. Under almost all design scenarios, IRS would appear to be a more cost-efficient means of vector control in the Kenyan highlands. (Kenya Medical Research Institute/Wellcome Trust Collaborative Programme, Nairobi, Kenya, Centre for Tropical Medicine, University of Oxford, Oxford, UK, Hguyatt@wtairobi.mimcom.net ^[152])

8) Guyatt, H.L., S.K. Corlet, T.P. Robinson, S.A. Ochola, and R.W. Snow. Malaria prevention in highland Kenya: Indoor residual house-spraying vs. insecticide-treated bednets. Tropical Medicine and International Health. April 2002. vol. 7 no. 4: pp. 298-303.

PANNA summary: This study finds that indoor residual spraying (IRS) is both more effective and less expensive than insecticide-treated bed nets (ITN) for controlling malaria in the highlands of Kenya. In blood tests of the residents of homes where IRS and ITN were used after a malaria outbreak, it was found that IRS-treated homes had a lower percentage of residents with malaria parasites still in their blood than ITN-treated homes, and that the cost had also been significantly lower.

Abstract: This study compares the effectiveness and cost-effectiveness of indoor residual house-spraying (IRS) and insecticide-treated bednets (ITNs) against infection with *Plasmodium falciparum* as part of malaria control in the highlands of western Kenya. Homesteads operationally targeted for IRS and ITNs during a district-based emergency response undertaken by an international relief agency were selected at random for evaluation. Five hundred and ninety homesteads were selected (200 with no vector control, 200 with IRS and 190 with ITNs). In July 2000, residents in these homesteads were randomly sampled according to three age-groups: 6 months-4 years, 5-15 years, and > 15 years for the presence of *P. falciparum* antigen (Pf HRP-2) using the rapid whole blood immunochromatographic test (ICT). The prevalence of *P. falciparum* infection amongst household members not protected by either IRS or ITN was 13%. Sleeping under a treated bednet reduced the risk of infection by 63% (58-68%) and sleeping in a room sprayed with insecticide reduced the risk by 75% (73-76%). The economic cost per infection case prevented by IRS was US\$ 9 compared to US\$ 29 for ITNs. This study suggests that IRS may be both more effective and cheaper than ITNs in communities subjected to low, seasonal risks of infection and as such should be considered as part of the control armamentarium for malaria prevention. (Wellcome Trust Research Laboratories/KEMRI, Nairobi, Kenya, hguyatt@wtairobi.mimcom.net ^[153])

9) Romi, R., M.C. Razaarimanga, R. Raharimanga, E.M. Rakotondraibe, L.H. Ranaivo, V. Pietra, A. Raveloson, and G. Majori. Impact of the Malaria Control Campaign (1993-1998) in the highlands of Madagascar: Parasitological and entomological data. American Journal of Tropical Medicine and Hygiene. 66(1), 2002, pp. 2-6.

PANNA summary: The study tracks malaria prevalence in the highlands of Madagascar through five years of an Italian-run and World Bank funded control program (1993-1998), a response to the reappearance of epidemic malaria in the region in the late 1980s. The program used annual indoor spraying of DDT and improved availability of chloroquine, and appears to have been effective, with significant decreases in the number of malaria cases and the abundance of the main vector species in villages throughout the region.

Abstract: Malaria transmission in the central highlands of Madagascar was interrupted in the 1960s by a national control program that used DDT indoor spraying and mass treatment with chloroquine. At the end of the 1980s in this region, epidemic malaria reappeared. Italian health authorities provided technical assistance to the National Malaria Control Program since the beginning of the resurgence of malaria in the central highlands. Yearly residual house spraying performed for 5 years (1993-1998) and the availability of antimalarial drugs reduced malaria transmission to very low levels, with improvement in parasitologic and entomologic indexes. A significant reduction of malaria prevalence was observed in the villages located at altitudes of 1,000-1,500 m, corresponding to the stratum of unstable malaria that was the main target of the antivector interventions. A significant reduction of malaria prevalence was also observed in the villages located at altitudes of 900-1,000 m, where malaria transmission is stable. The main vector *Anopheles funestus* was dramatically reduced in abundance and distribution in the sprayed areas. (Laboratorio di Parassitologia, Istituto Superiore di Sanita, Roma, Italy. romi@iss.it ^[154])

10) Mnzava, A.E.P., B.L. Sharp, D.J. Mthembu, D. le Sueur, S.S. Dlamini, J.K. Gumede, and I. Kleinschmidt. Malaria control: Two years' use of insecticide-treated bednets compared with insecticide house spraying in KwaZulu-Natal. South African Medical Journal, November 2001. Vol. 91, No. 11, pp. 978-983.

PANNA summary: This study found that use of insecticide-treated bed nets was more effective for preventing malaria than indoor spraying of the insecticide deltamethrin over the course of two years (1997-99) in KwaZulu-Natal. However, they warn that cost-effectiveness has varied in studies in different countries around the world, and so encourage the South African Department of Health to consider more data on cost and long-term effectiveness of treated bed nets.

Abstract:

OBJECTIVES: The objective of this study was to produce data indicating whether insecticide-treated bednets should replace insecticide house spraying as a malaria control method in South Africa. We report 2 years of preliminary data on malaria incidence comparing areas receiving insecticide-treated bednets and those subjected to house spraying in northern KwaZulu-Natal.

DESIGN, SETTING AND SUBJECTS: In order to measure significant reductions in malaria incidence between the two interventions, a geographical information system (GIS) was used to identify and create seven pairs of geographical blocks (areas) in the malaria high-risk areas of Ndumu and Makanis in Ingwavuma magisterial district, KwaZulu-Natal. Individual blocks were then randomly allocated to either insecticide-treated bednets or house spraying with deltamethrin. Malaria cases were either routinely recorded by surveillance agents at home or were reported to the nearest health facility.

RESULTS AND CONCLUSIONS: The results show that 2 years' use of insecticide-treated bednets by communities in Ndumu and Makanis, KwaZulu-Natal, significantly reduced the malaria incidence both in 1997 (rate ratio (RR) = 0.879, 95% confidence interval (CI) 0.80-0.95, P = 0.04) and in 1998 (RR = 0.667, CI 0.61-0.72, P = 0.0001). Using a t-test, these significant reductions were further confirmed by an assessment of the rate of change between 1996 and 1998, showing a 16% reduction in malaria incidence in blocks using treated bednets and an increase of 45% in sprayed areas (t = 2.534, P = 0.026 (12 df)). In order to decide whether bednets should

replace house spraying in South Africa, we need more data on the efficacy of treated bednets, their long-term acceptability and the cost of the two interventions. (Malaria Research Lead Programme, South African Medical Research Council, Durban)

11) Jambou R., Ranaivo L., Raharimalala L., Randrianaivo J., Rakotomanana F., Modiano D., Pietra V., Boisier P., Rabarijaona L., Rabe T., Raveloson N., De Giorgi F. Malaria in the highlands of Madagascar after five years of indoor house spraying of DDT. *Transactions of the Royal Society of Tropical Medicine and Hygiene* (2001) 95, 14-18.

PANNA summary: This article reports on a study of the prevalence of malaria parasites in the blood of school children in the highlands of Madagascar, in regions where DDT spraying campaigns to eliminate the vector *Anopheles funestus* were carried out between December 1993 and January 1998. Parasite prevalence in children was generally found to decline with increasing altitude, but below 1,500 meters, the impact of the spraying campaigns was clear. Below 1,000 meters, parasite prevalence was 2.7% in villages that had been sprayed and 20% in those that hadn't; between 1,000 and 1,500 meters, the difference was .8% to 4.5%. However, the presence of antibodies to the parasite was much more common than the parasite itself, appearing in 22-63% of children in each school, indicating that the parasite is still in active circulation. The authors warn against the high potential for rapid re-infection of the area from lower neighboring areas and suggest bolstering current surveillance efforts with continued spraying of DDT in the marginal zones.

Abstract: The central region of Madagascar is a vast area of highlands (altitude 700-2000 m). Malaria transmission has re-established itself here since the last epidemic of 1985-90 and has caused the deaths of 40,000 persons according to the Minister of Health. To combat the main malaria vector in the region, *Anopheles funestus*, annual programmes of indoor house spraying of DDT were carried out between December 1993 and January 1998 in most rural areas at altitude 1000-1500 m. A parasitological and serological study was then conducted in the highland schools to evaluate the impact of the programme and set up a database on the region. Using a cluster-sampling method 2 independent selections were conducted (one of 130 sites, the other of 40 sites). During the study, 13,462 schoolchildren were examined, 71% living in sprayed villages. Parasite prevalence among schoolchildren declined as altitude increases, from 11% at 700-900 m to 0.4% at > 1500 m. Below 1500 m, the impact of the spraying on the prevalence of the parasite was very clear (an average decrease of from 20% to 2.7% below 1000 m and of from 4.5% without spraying to 0.8% at 1000-1500 m). Geographical analysis of the data showed that the marginal regions remained the most affected by malaria (especially outside spraying zones), and persistence of 'pockets of transmission' at 1000-1500 m, essentially in areas where spraying has never been used. In 9 schools, anti-*Plasmodium* antibodies were sought by indirect immunofluorescence on thick smears of parasitized red blood cells. The seroprevalence ranged from 22% to 63%, which suggests that the parasite is still circulating in the region. Even though our data show that vector control continues to be very successful in the Madagascar highlands, rapid reinfection could occur and must be monitored following spraying. To this end, the Minister for Health, with the support of the Italian Co-operation, has placed the region under epidemiological surveillance since 1997. An alert system for the timely detection of the sources of epidemics and the targeting of the antivectoral campaign is also in operation. Our study suggests that this strategy should be reinforced by the spraying of DDT in the marginal zones in order to consolidate the results obtained at higher altitudes. (Pasteur Institute of Madagascar, Madagascar. rjambou@pasteur.sn [155])

12) Schellenberg, D., C. Menendez, E. Kahigwa, J. Aponte, J. Vidal, M. Tanner, H. Mshinda, P. Alonso. Intermittent treatment for malaria and anemia control at time of routine vaccinations in Tanzanian infants: A randomized, placebo-controlled trial. *Lancet* 2001; 357: 1471-77.

PANNA summary: In this study of seven hundred infants in Ifakara, Tanzania, children were given weight-appropriate doses of the anti-malarial and anti-anemia drug sulphadoxine-pyrimethamine (or a placebo pill) at the time of immunization by WHO's Expanded Program on Immunization: two, three, and nine months old. Incidence of malaria in the first year of life was 59% less in the group who received the medication than in the group who received the placebo, and incidence of anemia was 50% less, even though both groups received iron supplements. This method of malaria control shows potential for delaying first malaria incidence in young children to a time when their immune systems are better equipped to deal with the disease.

Abstract:

BACKGROUND: Clinical malaria and severe anaemia are major causes of paediatric hospital admission and death in many malaria-endemic settings. In the absence of an effective and affordable vaccine, control programmes continue to rely on case management while attempting the large-scale deployment of insecticide-treated nets. We did a randomised, placebo-controlled trial to assess the efficacy and safety of intermittent sulphadoxine-pyrimethamine treatment on the rate of malaria and severe anaemia in infants in a rural area of Tanzania.

METHODS: We randomly assigned 701 children living in Ifakara, southern Tanzania, sulphadoxine-pyrimethamine or placebo at 2, 3, and 9 months of age. All children received iron supplementation between 2 and 6 months of age. The intervention was given alongside routine vaccinations delivered through WHO's Expanded Program on Immunisation (EPI). The primary outcome measures were first or only episode of clinical malaria, and severe anaemia in the period from recruitment to 1 year of age. Morbidity monitoring through a hospital-based passive case-detection system was complemented by cross-sectional surveys at 12 and 18 months of age. Results were expressed in terms of protective efficacy (100 [1-hazard ratio]%) and analysis was by intention to treat.

FINDINGS: 40 children dropped out (16 died, 11 migrated, 12 parents withdrew consent, and one for other reasons). Intermittent sulphadoxine-pyrimethamine treatment was well tolerated and no drug-attributable adverse events were recorded. During the first year of life, the rate of clinical malaria (events per person-year at risk) was 0.15 in the sulphadoxine-pyrimethamine group versus 0.36 in the placebo group (protective efficacy 59% [95% CI 41-72]), and the rate of severe anaemia was 0.06 in the sulphadoxine-pyrimethamine group versus 0.11 in the placebo group (50% [8-73]). Serological responses to EPI vaccines were not affected by the intervention.

INTERPRETATION: This new approach to malaria control reduced the rate of clinical malaria and severe anaemia by delivering an available and affordable drug through the existing EPI system. Data are urgently needed to assess the potential cost-effectiveness of intermittent treatment in areas with different patterns of malaria endemicity. (Unidad de Epidemiología, Hospital Clinic, Institut d'Investigacions Biomediques August Pi i Sunyer (IDIBAPS), Villarroel 170, 08036, Barcelona, Spain)

13) Curtis, C.F., A.E.P. Mnzava. Comparison of house spraying and insecticide-treated nets for malaria control. *Bulletin of the World Health Organization*, 2000, 78(12): pp 1389-1400.

PANNA summary: This study of data from Africa, Asia, and Melanesia on the effectiveness of insecticide-treated bed nets compared with residual indoor spraying found that while the nets were as effective as indoor spraying in recent studies, they did not come close to

the effectiveness once achieved by indoor spraying of DDT during the malaria eradication campaigns of 30+ years ago. This may be due in part to the longer duration of the early spraying projects, and to the fact that the pyrethroids most often used on the bed nets are excito-repellants, causing mosquitoes to leave, rather than non-irritants like DDT, which more often kill the mosquitoes. As bed nets are much smaller than the walls of a house and so much cheaper to retreat with insecticide, they may prove to be less expensive than spraying campaigns.

Abstract: The efficacies of using residual house spraying and insecticide-treated nets against malaria vectors are compared, using data from six recent comparisons in Africa, Asia and Melanesia. By all the entomological and malariological criteria recorded, pyrethroid-treated nets were at least as efficacious as house spraying with dichlorodiphenyltrichloroethane (DDT), malathion or a pyrethroid. However, when data from carefully monitored house spraying projects carried out between the 1950s and 1970s at Pare-Taveta and Zanzibar (United Republic of Tanzania), Kisumu (Kenya) and Garki (Nigeria) are compared with recent insecticide-treated net trials with apparently similar vector populations, the results with the insecticide-treated nets were much less impressive. Possible explanations include the longer duration of most of the earlier spraying projects and the use of non-irritant insecticides. Non-irritant insecticides may yield higher mosquito mortalities than pyrethroids, which tend to make insects leave the site of treatment (i.e. are excito-repellent). Comparative tests with non-irritant insecticides, including their use on nets, are advocated. The relative costs and sustainability of spraying and of insecticide-treated net operations are briefly reviewed for villages in endemic and epidemic situations and in camps for displaced populations. The importance of high population coverage is emphasized, and the advantages of providing treatment free of charge, rather than charging individuals, are pointed out. (London School of Hygiene and Tropical Medicine, London WC1E 7HT, England. chris.curtis@lshtm.ac.uk ^[156])

14) Cox, J.S.H., J. Mouchet, and D.J. Bradley. Determinants of malaria in Africa. In Contextual Determinants of Malaria, and also presented at an International Workshop, Lausanne, Switzerland, May 14-18, 2000.

PANNA summary: Malaria is more endemic in Sub-Saharan Africa than anywhere else in the world. There is nonetheless some variation that can be helpful to understand for predicting outbreaks. In some areas, the spread of malaria varies because of factors like rainfall, altitude, and latitude. This malaria is unstable and highly susceptible to small environmental variation. In other areas, malaria is highly endemic and stable and so the effects of environmental and social changes are less pronounced.

(no abstract available)

15) Bouwman, Henk. Malaria control and the paradox of DDT. Africa--Environment and Wildlife. vol. 8, no. 4, May 2000. <http://www.icps.it/english/bollettino/psn00/000303.htm> ^[157]

PANNA summary: A balanced look at the helpful-harmful paradox of DDT use against malaria in Africa. The author's pointers for future use of insecticides against malaria are especially interesting, as they include environmental monitoring and investigation of alternatives to spraying in houses where women's and children's exposure can be greatest.

(no abstract available)

16) Bosman, A, Y Kassankogno, and AV Kondrachine. Implementation of malaria control. Parassitologia 41: 391-3, 1999.

PANNA summary: The deterioration of the malaria situation around the world and especially in Sub-Saharan Africa is being met with control strategies deficient in forecasting, early detection, and containment of malaria epidemics, and research and control communities that are too widely separated from one another. In order to tackle this problem and ease the economic burden of malaria on the world's poorest people, energies should be focused on guiding the money that is already being spent on malaria control in these communities into the most cost-effective medicines and vector control strategies.

Abstract: Global trends of infant and child mortality have decreased over the last 30 years, while the proportion of malaria deaths has progressively increased due to the deteriorating situation in sub-Saharan Africa. The Global Malaria Control Strategy promoted by WHO has encountered several obstacles to its implementation. Early diagnosis and prompt treatment can reduce malaria mortality, but there is still low investment on safe and effective modalities of care delivery at the periphery, where most of the malaria burden exists. Selective vector control (indoor residual spraying and insecticide-treated nets) plays a significant role outside Africa, but its wider use is limited by cost/affordability problems and operational issues (supply, delivery and logistics). Alternative methods such as environmental management and biological control are cost-effective only under very specific epidemiological situations. In most countries forecasting, early detection and containment of malaria epidemics is deficient, and there is separation between the research and control communities, particularly in Africa. Involvement of the internal agencies, strategic investments in capacity building and institutional networking are needed to strengthen capacity for malaria and research in the countries. The major responsibility is to guide the expenditure made by the communities (which far out-weigh the limited share of national health budgets) towards the most cost-effective approaches to reduce malaria mortality and morbidity. (Communicable Diseases Prevention and Control, World Health Organisation, Geneva, Switzerland. bosmana@who.ch ^[158])

17) Salako, LA. Malaria control priorities and constraints. Parassitologia 41: 495-6, 1999.

PANNA summary: The author argues that the top priority in malaria control should be changing attitudes of malaria control workers. Many cling to the idea that people already know all there is to know about malaria, when the reality is that certain habits persist that foster malaria transmission. Constraints include health budgets, inequities in the distribution of funds, lack of human resources, and unavailability of effective drugs.

Abstract: The capacity to prioritize correctly actions in malaria control depends on good knowledge not only of the epidemiology of the disease in the area but also of the behaviour of the people. Health policy makers frequently believe that the people already know enough about malaria and there is no need to commit further resources on finding out what the people actually know and do about the disease in order to modify their wrong habits. One of the pressing priorities for malaria control in Africa is therefore changing the attitude of malaria control policy makers. Considering the constraints to malaria control it is stressed that the health budget is usually below a level sufficient to finance an effective health care system. This is further compounded by inequities in the allocation of funds between health

care institutions located in the urban areas compared with those located in the rural areas. Another important constraint is lack of manpower suitably trained to undertake the various elements of the global malaria control strategy. Finally, a very well known constraint is the unavailability of effective drugs at the locations where they are needed. (Nigerian Institute of Medical Research, Yaba, Lagos, Nigeria. nimr@scd.metrong.com ⁽¹⁵⁹⁾)

18) Fontenille, D and L Lochouarn. The complexity of the malaria vectorial system in Africa. *Parassitologia* 41: 267-271, 1999.

PANNA summary: There are as many as five different mosquito species that transmit malaria in Africa; sometimes more than one species will transmit the disease in one place at one time, and sometimes different species will transmit the disease in the same place, but at different times of year. The authors stress that vector control strategies should take the diversity of the vectors into account and plan accordingly, as the control of one or two of the vector species will not be as effective as the control of all five.

Abstract: The malaria vectorial system in Africa is very complex. Five very efficient vector species transmit malaria: *Anopheles gambiae*, *An. arabiensis*, *An. funestus*, and the sometimes overlooked *An. nili* and *An. moucheti*. This paper focuses on morphological, behavioural and genetic differences observed among populations within each vector species. It emphasizes that future strategies for controlling vectors should take into account this heterogeneity.

19) Teklehaimanot, A, and A Bosman. Opportunities, problems and perspectives for malaria control in sub-Saharan Africa. *Parassitologia* 41: 335-8, 1999.

PANNA summary: This article focuses on the malaria problem in sub-Saharan Africa: the factors that have contributed to it over the years, current efforts to control malaria, and warnings for the future of those efforts. Malaria has persisted in the region because of environmental conditions conducive to the spread of malaria and widespread poverty. While the current growth of new programs with an interest in controlling malaria is heartening, the author warns that when control efforts have been interrupted in the past, resilient malaria has always come back with devastating consequences. Effective malaria control in sub-Saharan Africa can only come in the form of long-term, sustained action that is firmly rooted in the social development of the country.

Abstract: Environments conducive to high malaria transmission and widespread poverty are at the roots of the 'malaria giant', which affects 46 countries in Africa. The recent interest in and momentum of work on malaria, in endemic countries and the international community, is unprecedented and opens new perspectives for controlling the disease. Significant steps included: (i) the allocation of US\$20 million by WHO for accelerated implementation of malaria control in 34 African countries in 1997-98; (ii) the Declaration on Malaria by the Heads of States of the Organization of African Unity and the establishment of the African Initiative for Malaria Control in 1997; (iii) the concomitant mobilisation of the research community in the Multilateral Initiative on Malaria; (iv) the G8 Summit in 1998 in Birmingham asking for higher commitment to malaria control, particularly in Africa; and (v) the Roll Back Malaria initiative set as a WHO priority project in 1998. However, experiences have proved the alarming 'resilience' of the malaria system in Africa, showing devastating consequences when malaria returns to the original levels after intensive control is interrupted. Effective malaria control in Africa requires long-term action, firmly rooted in the social development of the country. (World Health Organization, Communicable Diseases Prevention and Control, Geneva, Switzerland)

20) Toure, YT. The malaria challenge in the 21st century: Perspectives for Africa. *Parassitologia* 41: 507-9. 1999.

PANNA summary: The author pinpoints the main causes for the failure of malaria control campaigns in Africa in the past: resistance to drugs on the part of the parasites and to insecticides on the part of the vectors, inadequate health infrastructure, and lack of trained health professionals and scientists. The main goals for the 21st century are the same as they have always been, to reduce morbidity and mortality due to malaria, and to reduce malaria transmission. The problem is not necessarily in the research, but in the implementation—the best strategies are often underutilized and applied inefficiently. It has become clear that malaria is irrevocably connected to rural poverty, and the author makes the powerful statement that: "Provision of basic health care centers, schools, and safe water supplies to the rural areas may contribute much more to malaria (...) control than most of the activities which have been undertaken up to the present time."

Abstract: Malaria control has had little success in Africa despite the achievements in malaria research. It is time to put more emphasis on sustainable control measures through local commitment to diagnose and treat malaria in order to prevent illness and death. This goal can be best achieved through basic health care centers, schools and safe water supplies to rural areas. Complementary actions through research and international support will be strongly needed. (Departement d'Epidemiologie des Affections Parasitaires, Ecole Nationale de Medecine, de Pharmacie et d'Odonto-Stomatologie, Bamako, Mali. yeya@mrtcbko.malinet.ml ⁽¹⁶⁰⁾)

21) Greenwood, B. Malaria mortality and morbidity in Africa. *Bulletin of the World Health Organization*.1999, 77(8), 617-8.

PANNA summary: The author argues that though it is difficult to obtain accurate information on malaria mortality and morbidity in Africa, this information is crucially important for the national Ministries of Health, who must prioritize their spending and need to know how big a threat the various diseases of the region really are. Malaria is only one of the major killers of African children—in various regions, diseases like measles and pneumonia can claim as many lives as malaria. What's more, the symptoms of some of these diseases appear similar to those of malaria, and in such poor areas many of the cases are never admitted to hospitals for treatment, so accurate data is hard to come by.

(editorial, no abstract available)

22) Goodman, C.A., P.G. Coleman, and A.J. Mills. Cost-effectiveness of malaria control in sub-Saharan Africa. *The Lancet* 354: July 31, 1999, 378-85.

PANNA summary: In an attempt to inform WHO's Roll Back Malaria campaign, the authors used mathematical models to calculate the costs of various malaria control strategies in a very low income sub-Saharan African country, like residual insecticide spraying and the

use of insecticide-treated bed nets, drugs like chloroquine given during pregnancy and during early childhood, and making improvements upon current malaria treatments. The costs were calculated per disability-adjusted life year, and ranged from \$4-10. While this is relatively affordable when compared with health interventions aimed at other health problems, the authors point out that governments of the poorest nations will not be able to supply this money to their most impoverished populations without help from the international community.

Abstract: Antimalarial chemoprophylaxis during pregnancy significantly increases the birth weight of babies born to primigravidae, but coverage in sub-Saharan Africa is very limited. This analysis assessed whether increasing coverage is justified on cost-effectiveness grounds. A standardized modeling framework was used to estimate ranges for the cost per discounted year of life lost averted by weekly chloroquine chemoprophylaxis and intermittent sulfadoxine-pyrimethamine (SP) treatment for primigravidae in an operational setting with moderate to high malaria transmission. The SP regimen was found to be more cost-effective than the chloroquine regimen, because of both lower costs and higher compliance. Both regimens appear to be a good value for money in comparison with other methods of malaria control and based on rough cost-effectiveness guidelines for low-income countries, even with high levels of drug resistance. However, extending the SP regimen to all gravidae and increasing the number of doses per pregnancy could make the intervention significantly less cost-effective. (Department of Public Health and Policy, London School of Hygiene and Tropical Medicine, United Kingdom. catherine.goodman@lshtm.ac.uk ^[161])

23) Coetzee, M., D.W.K. Horne, B.D. Brooke, and R.H. Hunt. DDT, dieldrin, and pyrethroid insecticide resistance in African malaria vector mosquitoes: An historical review and implications for future malaria control in southern Africa. South African Journal of Science 95, May 1999, p 215-8.

PANNA summary: This paper reviews articles on vector resistance to the insecticides DDT, dieldrin, and pyrethroids, mapping them out over the history of their use and over Southern Africa. As control programs have been moving away from DDT and dieldrin and toward pyrethroids and other alternative insecticides in more recent years, resistances to pyrethroids have also been developing among vector populations.

Abstract: Historical records of dieldrin and DDT insecticide resistance in the African malaria vectors *Anopheles gambiae* and *An. arabiensis* have been mapped. Policy changes to the malaria control programmes in South Africa have resulted in DDT being phased out as the insecticide of choice and replaced with pyrethroids. Recent records of resistance to pyrethroids in *An. gambiae* in West Africa raise concern about the future usefulness of pyrethroids for malaria control in southern Africa.

24) Lindsay, S.W., and W.J.M. Martens. Malaria in the African highlands: Past, present, and future. Bulletin of the World Health Organization. 1998, 76, pp. 33-45.

PANNA summary: There has been a steady rise in malaria in the African highlands over the past fifty years due to environmental changes and deteriorating health care. The highlands were once considered a safe haven from diseases that have always been widespread in the plains, but no longer. Because highland populations don't have the natural resistance to malaria that plains people have developed over generations, epidemics in these regions can hit particularly hard. This study maps out the most epidemic-prone regions and projects their spread with global warming. The author recommends that special attention be paid to preventing malaria epidemics in the highland regions.

Abstract: Many of the first European settlers in Africa sought refuge from the heat and diseases of the plains by moving to the cool and salubrious highlands. Although many of the highlands were originally malaria free, there has been a progressive rise in the incidence of the disease over the last 50 years, largely as a consequence of agroforestry development, and it has been exacerbated by scarce health resources. In these areas of fringe transmission where the malaria pattern is unstable, epidemics may be precipitated by relatively subtle climatic changes. Since there is little immunity against the disease in these communities, outbreaks can be devastating, resulting in a substantial increase in morbidity and death among both children and adults. We present here the results obtained using a mathematical model designed to identify these epidemic-prone regions in the African highlands and the differences expected to occur as a result of projected global climate change. These highlands should be recognized as an area of special concern. We further recommend that a regional modeling approach should be adopted to assess the extent and severity of this problem and help improve disease surveillance and the quality of health care delivered in this unstable ecosystem. (Department of Biological Sciences, University of Durham, England)

25) Curtis, C.F., C.A. Maxwell, R.J. Finch, and K.J. Njunwa. A comparison of use of a pyrethroid either for house spraying or for bednet treatment against malaria vectors. Tropical Medicine and International Health. 3(8) 619-31, August 1998.

PANNA summary: Using the pyrethroid insecticide lambda-cyhalothrin to treat bed nets and using it to spray the inside walls of homes in northeast Tanzania proved to be equally effective at lowering the probability of malaria infection in children by 54-62%. However, treating bed nets used about one sixth the amount of insecticide as indoor spraying, and people in the area were much more enthusiastic about the bed nets, so the researchers conclude that pyrethroid-treated bed nets are more cost-effective than indoor spraying of the same chemicals.

Abstract: In an intensely malarious area in north-east Tanzania, microencapsulated lambda-cyhalothrin was used in four villages for treatment of bednets (provided free of charge) and in another four villages the same insecticide was used for house spraying. Another four villages received neither intervention until the end of the trial but were monitored as controls. Bioassays showed prolonged persistence of the insecticidal residues. Light traps and ELISA testing showed reduction of the malaria vector populations and the sporozoite rates, leading to a reduction of about 90% in the entomological inoculation rate as a result of each treatment. Collections of blood fed mosquitoes showed no diversion from biting humans to biting animals. Incidence of re-infection was measured by weekly monitoring of cohorts of 60 children per village, after clearing preexisting infection with chlorproguanil-dapsone. The vector control was associated with a reduction in probability of re-infection per child per week by 54-62%, with no significant difference between the two vector control methods. Cross-sectional surveys for fever, parasitaemia, haemoglobin and weight showed association of high parasitaemia with fever and anaemia and beneficial effects of each intervention in reducing anaemia. However, passive surveillance by resident health assistants showed no evidence for reduced prevalence of fever or parasitaemia. Net treatment consumed only about one sixth as much insecticide as house spraying and it was concluded that the former intervention would work out cheaper and nets were actively demanded by the villagers, whereas spraying was only passively assented to. (London School of Hygiene and Tropical Medicine, UK. c.curtis@lshtm.ac.uk ^[162])

26) Greenwood, B.M. Malaria transmission and vector control. Parasitology Today 1997, 13(3), 90-1.

PANNA summary: Arguments have been made that bed nets and other vector control strategies used in highly endemic regions such as Sub-Saharan Africa are only delaying cases of malaria, as they are slowing the population's natural process of developing immune resistance to the disease. Greenwood argues against this hypothesis, citing several studies among children in endemic regions of Africa that show children's immunity is slower to develop, and their infection rates relate pretty directly to the number of bites received in a day. In this case, the author advocates the continued use of vector control strategies in Africa in the interest of saving children's lives. Studies have shown that adults do not lose their natural resistance once they've developed it, and in a community using pesticide-treated nets the number of bites will still be high enough to ensure that resistance is maintained.

(no abstract available)

27) Bruce-Chatt, L. J. Lessons learned from applied field research activities in Africa during the malaria eradication era. Bulletin of the World Health Organization. 1984. 62 (Suppl.). 19-29.

PANNA summary: The author presents an assessment of the various malaria eradication and prevention methods used in Africa from 1950 to 1974. The author then examines the period from 1975 to 1984, during which research and technological advances helped to reduce the number of cases of malaria.

Abstract: The Malaria Conference in Equatorial Africa, convened by the World Health Organization in 1950 in Kalpala, Uganda, was a milestone in the history of modern malaria control activities on the continent of Africa. It is presented and assessed the available international information on epidemiological aspects of this disease and attempted to coordinate the various methods of research and control of malaria. Its two main recommendations were that malaria should be controlled by all available health methods, irrespective of the degree of endemicity of the disease, and that the benefits that malaria control might bring to the indigenous population should be evaluated.

The first period of field research and pilot control projects in Africa was between 1950 and 1964. A large number of studies in several African countries showed that the use of residual insecticides such as DDT and HCH might decrease, at times considerably, the amount of malaria transmission, but interruption of transmission could not be achieved, except in two relatively small projects in the forest areas of the Cameroon and Liberia. During the second period, from 1965 to 1974, the difficulties of malaria eradication and control in Africa became more evident because of the development of resistance of *Anopheles gambiae* to DDT, HCH and dieldrin; moreover administrative, logistic, and financial problems had emerged. It became clear that the prospects for malaria control (let alone those for eradication) were related to the availability of a network of basic health services. A number of "pre-eradication" programmes were set up in order to develop better methods of malaria control and to improve the rural health infrastructures. Much field research on the chemotherapy of malaria was carried out and the value of collective or selective administration of antimalarial drugs was fully recognized, although it became obvious that this could not plan an important part in the decrease of transmission of malaria in Africa. The role of research as one of the ways of solving the technical problems of malaria control in tropical Africa was stressed from the early days of the global malaria eradication programs; the past ten years have seen an immense expansion of this activity.

Solutions Around the World: Asia & Pacific

This compilation of articles will be updated periodically and it is by no means comprehensive. The articles are arranged by category and in chronological order with the newest studies first. We hope it will prove to be a useful tool in the ongoing discussion among policymakers, advocacy groups and the media regarding the use of DDT and the need to improve efforts to effectively control malaria.



1. Cost-Effectiveness of Malaria Control Interventions When Malaria Mortality is Low: Insecticide-Treated Nets Versus In-House Residual Spraying in India. [123]
2. Epidemic malaria in the Menoreh Hills of central Java. [124]
3. Social and cultural aspects of malaria. [125]
4. Malaria past and present: The case of North Sulawesi, Indonesia. [126]
5. No Future in DDT: A case study of India. [127]
6. Cost-effectiveness and sustainability of lambda-cyhalothrin-treated mosquito nets in comparison to DDT spraying for malaria control in western Thailand. [128]
7. Current scenario of malaria in India. [129]
8. Ecology, economics, and political will: The vicissitudes of malaria strategies in Asia. [130]
9. Environmental management in malaria control in India [131]
10. Impact of pesticide use in India [132]

1) Bhatia, M.R., J. Fox-Rushby, and A. Mills. Cost-Effectiveness of Malaria Control Interventions When Malaria Mortality is Low: Insecticide-Treated Nets Versus In-House Residual Spraying in India. Social Science and Medicine. 2004; 59(2004): 525-39.

Available Online at: <http://www.sciencedirect.com/> [163]

PANNA Summary: In India, a low malaria mortality region, both insecticide-treated nets and in-house residual spraying are effective in preventing malaria. Nets are more effective and more efficient than residual spraying, although nets cost more. Additionally, the amount of insecticide used for treated nets was much less than that used for spraying. Although unlikely, residual spraying may become more cost-effective than treated nets under certain circumstances.

Abstract: Malaria is one of the leading causes of morbidity and mortality in the developing world and a major public health problem in India. Disillusioned by in-house residual spraying (IRS), and increasingly aware that insecticide-treated nets (ITNs) have proved to be effective in reducing malaria mortality and morbidity in various epidemiological settings, policy-makers in India are keen to identify which is the more cost-effective malaria control intervention. A community randomized controlled trial was set up in Surat to compare the effectiveness and efficiency of IRS and ITNs. Both control strategies were shown to be effective in preventing malaria over the base-case scenario of early diagnosis and prompt treatment. The mean costs per case averted for ITNs was statistically lower (Rs. 1848,

1567-2209; US\$ 52) than IRS (Rs. 3121, 2386-4177, US\$ 87). The conclusions were robust to changes in assumptions. This study expands the scope of recent comparative economic evaluations of ITNs and IRS, since it was carried out in a low mortality malaria endemic area. (Department of Social Policy, London School of Economics, Houghton Street, London WC2A 2AE, UK.)

2) Barcus, Mazie J., F. Laihad, M. Sururi, P. Sismadi, H. Marwoto, M. J. Bangs, and J. K. Baird. Epidemic malaria in the Menoreh Hills of central Java. *American Journal of Tropical Medicine and Hygiene*. 60(3). 2002 pp. 281-292.

PANNA summary: DDT spraying and the introduction of chloroquine medication for malaria starting in the 1950s virtually eradicated endemic malaria from the island of Java. DDT spraying was abandoned by the Republic of Indonesia in the late 1980s and stocks were depleted by the early 1990s. Spraying of less effective and more expensive pesticides continued through the early 1990s. This study shows that the sharp decline in government spending on malaria control since the economic downturn of the late 1990s, especially the curtailment of indoor spraying, has led to a real epidemic of malaria in the hills of central Java. The authors call for a revival of residual indoor spraying programs as the only proven effective solution to the outbreak.

Abstract: After more than 50 years of effective management, resurgent malaria threatens residents in the Menoreh Hills and the foothills of the Dieng Plateau of Central Java, Indonesia. The Dieng Plateau dominates the highland center of Central Java. The steep Menoreh Hills, surrounded by rice paddy habitats, cover approximately 500 km² with no peaks greater than 1,000 m. We studied epidemic malaria in Purworejo district, one of the three districts containing the Menoreh Hills. Between 1986 and 1995, the annual parasite incidence (API) in Purworejo ranged from 2 to 11 cases per 1,000 residents per year and was typically approximately 5 per 1,000. In 2000 the API was 44.5. This sharp increase was confined to subdistricts in and around the Menoreh Hills and Dieng Plateau foothills. The primary vectors of malaria, those favoring steep, forested hillsides on Java, were *Anopheles maculatus* and *Anopheles balabacensis*. Deterioration of vector control activity, followed by a severe economic downturn in 1997, may explain the epidemic. Malaria in the Menoreh Hills and lower Dieng Plateau threatens surrounding areas of rice paddy inhabited by *Anopheles aconitus* as well as a nearby coastal habitat where the even more efficient vector *Anopheles sudaicus* occurs in abundance. Most of the 130 million people living on Java never experienced the hyper- and holoendemic malaria that occurred throughout most of the island before the effective DDT spraying and chloroquine treatment campaigns of the 1950s. Reintroduced endemic malaria threatens the island of Java. (U.S. Naval Medical Research Unit # 2, Jakarta, Indonesia)

3) Panvisavas, S., S. Dendoung, and N. Dendoung. Social and cultural aspects of malaria. *Southeast Asian Journal of Tropical Medicine and Public Health*. Dec 2001, vol. 32, no. 4. 727-732.

PANNA summary: Malaria eradication programs in the 1950's failed to remove the disease from rural Thailand, and so the authors want to advise WHO's current "Roll Back Malaria" campaign that only an integrated socio-cultural approach to malaria control in this area will be effective. The real causes of malaria persistence in rural areas, they contend, are poverty and discrimination. The political situation in Southeast Asia has led to a concentration of poor people--indigenous people turned wage laborers, poor farmers, refugees from neighboring countries, and soldiers--on the borders in the forests where malaria has the most potential to spread and health care is the least developed. Traditional systems of knowledge about malaria and its prevention are discredited and ignored. Only an approach that respects traditional knowledge and aims to alleviate poverty and involve communities will be effective.

Abstract: This paper examines the impact of social and cultural factors on malaria control in rural Thailand. It contends that standard vertical malaria control programs tend to ignore local workplace and living conditions instead of recruiting traditional practices into the planning scenario for more effective control. Careful attention to these practices in the context of local economic capacity can serve to offset the common failure to take the major causative factor of poverty into account. (Faculty of Social Sciences and Humanities, Mahidol University at Salaya, Nakhon Pathom, Thailand)

4) Henley, David. Malaria past and present: The case of North Sulawesi, Indonesia. *Southeast Asian Journal of Tropical Medicine and Public Health*. Sept 2001, vol. 32, no. 3, p. 595-607.

PANNA summary: According to the author, the most likely source of the long-term decline of malaria in North Sulawesi is large-scale conversion of forest to permanent farmland. DDT was being sprayed until the last of the national stock was used up in 1993 after a ban that started in 1990, then other more expensive chemicals were used until about 1997. During that period, malaria rates went down steadily. But in 1997 with the economic downturn in Asia, the government of Indonesia cut back spending on malaria control significantly and since then, malaria has made a small though significant resurgence. The author concludes that it is unlikely for environmental management, bed nets, or anti-malaria medication to be as effective as insecticide spraying in controlling malaria in North Sulawesi.

Abstract: The incidence and impact of malaria in North Sulawesi have declined both in the short term during the 1990s, and over a much longer timespan (though perhaps less continuously) since the end of the colonial period. The improvement already seems to have been well underway before deliberate vector control activities became extensive in the second half of the 1970s, and environmental changes affecting the *Anopheles* mosquito fauna, in particular the replacement of primary and secondary forest by permanent farmland, are probably the principal reasons for the long-term trend; other possible factors include the increasing use of antimalarial drugs. The well-documented decline in malaria incidence over the years 1991-1997, nevertheless, probably reflects the unprecedented scale of residual insecticide spraying in the province during that period, while the slight resurgence of the disease in the last three years corresponds to the subsequent cessation of house spraying as a result of the current economic crisis. Despite the evident importance of environmental change as a factor ameliorating the malaria situation in the long term, experience from the colonial era suggests that the prospects for deliberate environmental management (species sanitation) as an alternative malaria control strategy are poor. (Royal Institute for Linguistics and Anthropology (KITLV), Leiden, The Netherlands. henley@kitlv.nl ^[164])

5) Agarwal, Ravi. No Future in DDT: A case study of India. *Pesticide Safety News*, May 2001.

PANNA summary: India is an important case study to understand that DDT is becoming obsolete, not only owing to concerns over its toxicity, but also because it is losing its effectiveness in treating malaria. India has been manufacturing and using DDT for more than 50 years. Use for agriculture was banned in 1989, and use for malaria has been declining in favor of more multi-sector approaches to the problem, since unsafe levels of DDT are turning up in food supplies and the egg shells of large predatory birds, and its effectiveness is waning anyway. India currently spends 35% of its health budget on malaria control each year. The current strategy is based on prioritizing control in high-risk areas, reducing the use of chemical insecticides, and the prevention and control of epidemics through community participation, the use of bed nets, and early diagnosis and treatment. The use of DDT in urban areas has halted completely.

(no abstract available)

6) Kamolratanakul, P., P. Butraporn, M. Prasitisuk, C. Prasittisuk, and K. Indaratna. Cost-effectiveness and sustainability of lambda-cyhalothrin-treated mosquito nets in comparison to DDT spraying for malaria control in western Thailand. *American Journal of Tropical Medicine and Hygiene* 2001, 65(4), 279-84.

PANNA summary: In a highly endemic region along the forested border between Thailand and Myanmar, the researchers conducted a relatively small-scale (~2300 people) comparative study of the cost-effectiveness of insecticide-treated bed nets and residual indoor spraying of DDT. Calculated on a "per case of malaria prevented" basis, they found that the treated bed nets were more cost-effective than DDT spraying. As DDT spraying is not particularly popular or practical in this region anyway, they recommend that pyrethroid-treated bed nets be used in this region, and considered for other regions in the future.

Abstract: The cost-effectiveness of lambda-cyhalothrin-treated nets in comparison with conventional DDT spraying for malaria control among migrant populations was evaluated in a malaria hyperendemic area along the Thai-Myanmar border. Ten hamlets of 243 houses with 948 inhabitants were given only treated nets. Twelve hamlets of 294 houses and 1,315 population were in the DDT area, and another 6 hamlets with 171 houses and 695 inhabitants were in the non-DDT-treated area. The impregnated net program was most cost-effective (US\$1.54 per 1 case of prevented malaria). Spraying with DDT was more cost-effective than malaria surveillance alone (\$1.87 versus \$2.50 per 1 case of prevented malaria). These data suggest that personal protection measures with insecticide-impregnated mosquito net are justified in their use to control malaria in highly malaria-endemic areas in western Thailand. (Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand)

7) Sharma, V.P. Current scenario of malaria in India. *Parassitologia* 41: 349-53, 1999.

PANNA summary: The author reviews statistics of malaria incidence and control in India. DDT is the insecticide most widely used for malaria control, followed by HCH, malathion, and synthetic pyrethroids, and they are all used for residual indoor spraying in rural areas and anti-larva operations in urban areas. The major vector species has become resistant to DDT and HCH in most of the country. At the same time, malaria rates are increasing in many parts of the country because of man-made environmental changes like irrigation projects and piped-in water supplies—anywhere rapid development is happening, malaria is invading. Indian national and state governments continue to pour resources and energy into the problem, with help from the World Bank.

Abstract: The Indian National Malaria Eradication Programme (NMEP) is reporting 2.5 to 3 million malaria cases, and about 1,000 malaria deaths annually. Malaria in the northeastern states is stable and in the peninsular India unstable. There are six major and three minor malaria vectors, of which *Anopheles culicifacies* transmits malaria in rural areas and *An. stephensi* in the towns. Other vectors are of local importance. *Plasmodium vivax* is the dominant infection and accounts for 60-65% cases whereas *P. falciparum* contributes 30-35% cases. Field operations to control malaria are impeded by resistance and/or exophilic vector behavior, parasite resistance to antimalarial drugs, operational problems in spraying, failure to search breeding of mosquitoes at weekly intervals, staff shortages and financial constraints. Resurgent malaria invaded new ecotypes created by green revolution, industrial growth and urban development resulting in paradigm shift towards man-made malaria. NMEP has launched a world bank-assisted enhanced malaria control project with primary emphasis to protect 62.2 million high risk population in 7 states. (Malaria Research Centre, Delhi, India. vps@icmrrc.ren.nic.in^[165])

8) Kidson, C. and K. Indaratna. Ecology, economics, and political will: The vicissitudes of malaria strategies in Asia. *Parassitologia* 40: 39-46, 1998.

PANNA summary: Though malaria is currently more prevalent in Africa than Asia, Asia is the epicenter of the multi-drug resistant strain of malaria, *P. falciparum*, that is currently overtaking much of the tropical world. This is probably due to the huge changes in economics, social and natural environments, and the huge migrations of people that have taken place on the continent over the past few decades. Some nations have come close to complete malaria control, such as China, Thailand, and Malaysia, but fail near national borders, especially those that are forested, as this is where the movement of people in search of economic opportunities has led to weakness in control. In light of the enormous economic influences on and impacts of malaria, the author asks nations not to keep malaria in the public health sector, but bring its control into the realm of economic planning as well.

Abstract: The documented history of malaria in parts of Asia goes back more than 2,000 years, during which the disease has been a major player on the socioeconomic stage in many nation states as they waxed and waned in power and prosperity. On a much shorter time scale, the last half century has seen in microcosm a history of large fluctuations in endemicity and impact of malaria across the spectrum of rice fields and rain forests, mountains and plains that reflect the vast ecological diversity inhabited by this majority aggregation of mankind. That period has seen some of the most dramatic changes in social and economic structure, in population size, density and mobility, and in political structure in history: all have played a part in the changing face of malaria in this extensive region of the world. While the majority of global malaria cases currently reside in Africa, greater numbers inhabited Asia earlier this century before malaria programs savored significant success, and now Asia harbors a global threat in the form of the epicenter of multidrug resistant *Plasmodium falciparum* which is gradually encompassing the tropical world. The latter reflects directly the vicissitudes of economic change over recent decades, particularly the mobility of populations in search of commerce, trade and personal fortunes, or caught in the misfortunes of physical conflicts. The period from the 1950s to the 1990s has witnessed near "eradication" followed by resurgence of malaria in Sri Lanka, control and resurgence in India, the influence of war and postwar instability on drug resistance in Cambodia, increase in severe and cerebral malaria in Myanmar during prolonged political turmoil, the essential disappearance of the disease from all but forested border areas of Thailand where it remains for the moment intractable, the basic elimination of vivax malaria from many provinces of central China. Both positive and negative experiences have lessons to teach in the debate between eradication and control as alternative strategies. China has for years held high the goal of "basic elimination", eradication by another name, in sensible semi-defiance of WHO dictates. The Chinese experience makes it clear that, given community organization, exhaustive attention to case detection, management and focus elimination, plus the political will at all levels of society, it is possible both to eliminate malaria from large areas of an expansive nation and to implement surveillance necessary to maintain something approaching eradication status in those areas. But China has not succeeded in the international border regions of the tropical south where unfettered population movement confounds the program. Thailand, Malaysia and to an extent Vietnam have also reached essential elimination in their rice field plains by vigorous vertical programs but fall short at their forested borders. Economics is central to the history of the rise and fall of nations, and to the history of disease in the people who constitute nations. The current love affair with free market economics as the main driving force for advance of national wealth puts severe limitations on the essential involvement of communities in malaria

management. The task of malaria control or elimination needs to be clearly related to the basic macroeconomic process that preoccupies governments, not cloistered away in the health sector. Historically malaria has had a severe, measurable, negative impact on the productivity of nations. Economic models need reworking with political aplomb and integrating with technical and demographic strategies. Recent decades in Chinese malaria history carry some lessons that may be relevant in this context. (Centre for Health Economics, Faculty of Economics, Chulalongkorn University, Bangkok, Thailand)

9) Sharma, V.P. Environmental management in malaria control in India. In Malaria: waiting for the vaccine. Targett, GAT. Ed. England: John Wiley & Sons Ltd, 1991.

PANNA summary: Malaria fell sharply in India during the malaria eradication campaign of the 1960s due to DDT spraying, the success of which overshadowed the small successes of other methods. However, malaria resurged following the close out of the eradication program, peaking in 1976. A new government control campaign initiated in 1977 brought the numbers back down, but there has been a plateau since the early 1980s. The effectiveness of residual pesticide spraying was waning. For this reason, environmental management as part of an integrated control strategy has become necessary, and India began to implement it in the 1980s. The scheme includes breeding control by environmental manipulation (filling in small stagnant water holes and creating channels for water to run off) and biological means (introducing larval predators to breeding sites), both of which have been quite effective. Environmental management as a control strategy requires a great deal of scientific understanding and attention, and is not cost effective in sparsely populated areas, but has few of the negative side effects of insecticides.

(no abstract available)

10) H.N. Saiyed, V.K. Bhatnagar, Rekha Kashyap. Impact of pesticide use in India. Asian Pacific Newsletter. <http://www.occuphealth.fi/e/info/asian/ap399/india05.htm>

PANNA summary: A brief article on the health effects of pesticide production and use in India, both on people working with those pesticides and on the general population.

(no abstract available)

Solutions Around the World: Latin America

Malaria Control: Latin America



1. The control of malaria in Brazil. ^[123]
2. Eradication of *Anopheles gambiae* from Brazil: Lessons for malaria control in Africa? ^[166]
3. Role of residual spraying for malaria control in Belize. ^[125]
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8. Selective and conventional house spraying of DDT and bendiocarb against *Anopheles pseudopunctipennis* in southern Mexico. ^[130]
9. A comparison study of house entering and exiting behavior of *Anopheles vestitipennis* (Diptera: Culicidae) using experimental huts sprayed with DDT or deltamethrin in the southern district of Toledo, Belize, C. A. ^[131]
10. A field trial with Lambda-cyhalothrin (ICON) for the intradomestic control of malaria transmitted by *Anopheles darlingi* root in Rhondonia, Brazil. ^[132]
11. The phasing out of DDT in Mexico. ^[133]
12. A Sustainable Strategy for Eliminating DDT from Disease Vector Control Programs and Reducing Malaria: The Mexican Model ^[167] October, 2007

1) Gusamo, R. The control of malaria in Brazil. In The Contextual Determinants of Malaria. ed. Casman, E.A. and H. Dowlatabadi. Washington D.C.: Resources for the Future, 2002. pp 59-65.

PANNA summary: This chapter details the factors leading to the current resurgence of malaria in Brazil. In recent years, however, the situation has begun to improve. With WHO's switch to the Global Malaria Control Strategy in 1992 (Brazil was the first nation in the Americas to switch over), priorities for control changed to more local and individually focused strategies, including early diagnosis and immediate treatment, small-scale preventative vector control measures, early detection and control of epidemics, and analysis of ecological, social, and economic determinants of the disease in order to develop new integrated control strategies. The result was a massive amount of energy poured into the implementation of the new strategy in effected communities. The results were very good, with over 8 million disability-adjusted life years saved due to preventative measures and improved diagnosis and treatment.

(no abstract available)

2) Killeen, G.F. and U. Fillinger, I. Kiche, L.C. Gouagna, and B.G.J. Knols. Eradication of *Anopheles gambiae* from Brazil: Lessons for malaria control in Africa? *The Lancet, Infectious Diseases*, vol 2, October 2002, p. 618-627.

PANNA summary: Ever since the development of DDT as a tool for vector control, the focus of control efforts has been on controlling populations of adult mosquitoes. The authors argue that given the limitations of current methods—indoor spraying, bed nets, etc.—greater attention should be paid to successful control strategies from the past, especially larval control methods that successfully eradicated *A. gambiae* from northeast Brazil and the Nile River valley of Egypt in the 1930s and 40s. Though there were other types of spraying involved in the campaigns, the bulk of efforts were on spraying and dusting *Anopheles* breeding sites with Paris Green. Though the toxicity of Green has since been established, the authors argue that the success of this focus on control at the larval stage of

development should serve as a lesson to current control efforts in Africa, and an impetus for researchers to continue investigating this approach where they left off over fifty years ago.

Abstract: Current malaria-control strategies emphasise domestic protection against adult mosquitoes with insecticides, and improved access to medical services. Malaria prevention by killing adult mosquitoes is generally favoured because moderately reducing their longevity can radically suppress community-level transmission. By comparison, controlling larvae has a less dramatic effect at any given level of coverage and is often more difficult to implement. Nevertheless, the historically most effective campaign against African vectors is the eradication of accidentally introduced *Anopheles gambiae* from 54000 km² of largely ideal habitat in northeast Brazil in the 1930s and early 1940s. This outstanding success was achieved through an integrated programme but relied overwhelmingly upon larval control. This experience was soon repeated in Egypt and another larval control programme successfully suppressed malaria for over 20 years around a Zambian copper mine. These affordable approaches were neglected after the advent of dichlorodiphenyl trichloroethane (DDT) and global malaria-control policy shifted toward domestic adulticide methods. Larval-control methods should now be re-prioritised for research, development, and implementation as an additional way to roll back malaria. (Department of Public Health and Epidemiology, Swiss Tropical Institute, Basel, Switzerland. gerry.killeen@unibas.ch ^[168])

3) Roberts, D.R., E. Vanzie, M.J. Bangs, J.P. Grieco, H. Lenares, P. Hshieh, E. Rejmankova, S. Manguin, R.G. Andre, and J. Polanco. Role of residual spraying for malaria control in Belize. Journal of Vector Ecology. June, 2002. 27(1): 63-69.

PANNA summary: This study of the impact of reduced residual spraying in Belize found that it is associated with increases in cases of malaria. The authors suggest that spraying technique be improved and targeted to minimize costs and negative effects, but that its practice continue at a level above 134.6 houses per thousand people in Belize. This number was determined to be the threshold for Belize, above which malaria infection rates will not grow.

Abstract: We studied the impact of reduced residual spraying in Belize by developing a logistic regression model on relationships between numbers of houses sprayed (mostly with DDT) and numbers of malaria cases. We defined the "minimum effective house spray rate" (MEHSR) as the level of spraying that will prevent increases in malaria rates for a defined population. Under the total coverage approach (all houses sprayed), the MEHSR for Belize was 134.6. The model also showed that the odds for decreasing malaria is 1.086 for each increase of 10 houses sprayed per 1000 population. In further testing, highly significant and differential changes in malaria rates were documented for paired groups of years with house spray rates that were either above or below the MEHSR. Numbers of malaria cases since 1995 are used to show how stratification methods are used in Belize to spray fewer houses (at levels below the MEHSR of 134.6).

4) Kroeger, A., J. Ordonez-Gonzalez, and A.I. Avina. Malaria control reinvented: health sector reform and strategy development in Colombia. Tropical Medicine and International Health. May 2002, vol. 7 no. 5, pp. 450-458.

PANNA summary: In the 1990's, Colombia undertook one of the most complex health sector reform programs in Latin America, involving the decentralization of the vertical vector-borne disease control program. There were definite negative impacts from the loss of supervisory capacities that lead to a decrease in malaria control efforts over all, and also from economic limitations that weren't initially expected by reformers. Malaria rates increased over that period. However, the transformed system is stronger in certain ways and has not yet been exploited to its fullest potential, so there is some promise for success in the future.

Abstract: The consequences of health sector reforms on control of malaria were analysed using Colombia as an example. One of the most complex health sector reform programmes in Latin America took place in the 1990s; it included transferring the vertical vector-borne disease control (VBDC) programme into health systems at state and district levels. A series of studies was undertaken in 1998-2000 at the national level (Ministry of Health Study), at the state level (Departamento Study) and at the health district level (District Study) using formal and informal interviews among control staff and document analysis as data collection tools. A government-financed national training programme for VBDC staff - which included direct observation of control operations - was also used to analyse health workers' performance in the postreform period (longitudinal study). The results showed that some shortcomings of the old vertical system, such as the negative aspects of trade union activity, have not been overcome while some positive aspects of the old system, such as capacity building, operational planning and supervision have been lost. This has contributed to a decrease in control activity which, in turn, has been associated with more malaria cases. Malaria control had to be reinvented at a much larger scale than anticipated by the reformers caused by a whole series of problems: complex financing of public health interventions in the new system, massive staff reductions, the difficulty of gaining access to district and state budgets, redefining entire organizations and - in addition to the reforms - introducing alternative strategies based on insecticide-treated materials and the growth of areas of general insecurity in many parts of Colombia itself. However, positive signs in the transformed system include: the strengthening of central control staff (albeit insufficient in numbers) when transferred from the Ministry of Health to the National Institute of Health, the opportunities offered by the Basic Health Plan (PAB) for new planning initiatives and intersectoral co-operation and the integration of malaria diagnosis and treatment into the general health services (associated with a decrease of malaria mortality). The potentials of the new system have not yet been fully exploited: capacity building, communication and management skills need to be improved and it requires guidance from the national level. (Liverpool School of Tropical Medicine, Liverpool, UK. a.kroeger@liverpool.ac.uk ^[169])

5) Zapping mosquitoes with biopesticides. Pesticides News 54. December 2001. <http://www.panna.org/pestnews/contents/pnindex.htm> ^[170]

PANNA summary: Biopesticides are not chemicals but organisms, in the case of this study they are the spores of a bacterium that effects mosquito larvae in their aquatic habitat, killing them within a few days of application. This study found that this particular biopesticide used in the malarial hotspots outside Nicaragua's capital city was highly effective, reducing malaria cases dramatically when applied several times a year. The approach was cost effective, both because the biopesticide is cheaper than fenthion powder that the government had been using and because it needed to be applied much less often. Biopesticides represent an effective alternative to chemical insecticides that is safer for people and the environment, and potentially much less expensive.

Abstract: Mosquito control can be an expensive and hazardous process relying on highly toxic and persistent insecticides. Recent experiences in Central America show that biological control is effective, safer and cheaper than chemical control.

6) Singer, Burton and Caldas de Castro, Marcia. Agricultural Colonization and Malaria on the Amazon Frontier. Annals of the New York Academy of Science. December 2001, 954:184-222.

PANNA summary: This study shows that the high risk of malaria infection on the Amazonian frontier results from policies that have encouraged colonization in the region by millions of poor settlers from the northeast and south of Brazil. This mass migration and frontier expansion allow for malaria persistence through the following factors: poor drainage along rural roads that provides permanent breeding sites for mosquitoes, poor housing conditions, deforestation and expansion of cattle pasture, influx of temporary laborers with no natural immunity to the disease, deficiencies in the local health system, and low knowledge of the disease and how it is spread among migrants. Future migrations into these kinds of frontier lands anywhere in the world must be accompanied by cooperative agricultural extension and public health components if they are to avoid dire health and economic consequences.

Abstract: The purpose of this paper is to characterize the interrelationships between macropolitical, social and economic policies, human migration, agricultural development, and malaria transmission on the Amazon frontier. We focus our analysis on a recent colonization project, POLONOROESTE, in the state of Rondônia. Employing data from field surveys in 1985-1987 and 1995, we use spatial statistical methodologies linked to a geographical information system (GIS) to describe the patterns of human settlement in the area, the ecological transformations induced by forest clearance practices, and the manner in which these factors determine gradations of malaria risk. Our findings show that land use patterns, linked to social organization of the community and the structure of the physical environment, played a key role in promoting malaria transmission. In addition, the location of each occupied area is itself an important determinant of the pattern of malaria risk. Based on lessons learned from our spatial and temporal characterization of malaria risk, we propose policies for malaria mitigation in the Brazilian Amazon. (Office of Population Research, Princeton University, Princeton, New Jersey, USA)

7) Gusamo, R. d'A. Overview of malaria control in the Americas. Parasitologia 41: 355-60, 1999.

PANNA summary: In the malaria-endemic nations of the Americas, there has been a false perception that malaria can only be controlled by insecticide spraying, which can only be implemented by centralized institutions. This perception, along with the push for decentralization of health services in the region, has made implementation of WHO's Global Malaria Control Strategy more difficult. There has been a recent switch in policy away from eradicating malaria and toward eliminating death and illness from the disease. Thus far it has been successful, with a 60% reduction in mortality due to malaria. A new strategy developed in Mexico is now being implemented which simultaneously applies anti-parasitic measures to human and vectorial reservoirs in regions of newly formed settlements on the outskirts of urban areas. This approach is within the budgets of most effected nations.

Abstract: The malaria endemic countries of the Americas have adopted in 1992 the WHO Global Malaria Control Strategy whose difficulties of implementation have been compounded to a major reform in the health sector, as the countries adjust to conform to financial scarcity and new economic policies. Most countries of the Region have reoriented its control program from eradication of malaria to the elimination of malaria mortality and morbidity. The Region has advanced towards these objectives having already reduced its mortality by 60% and is now in the final stages of applying new tools to control transmission and rapidly advance to reduce the incidence of malaria in the Americas. (Pan American Health Organization/World Health Organization, Washington, DC 20037, USA. gusmaore@paho.org [171])

8) Casas, M., J.L. Torres, D.N. Brown, M.H. Rodriguez, and J.L. Arrendondo-Jimenez. Selective and conventional house spraying of DDT and bendiocarb against Anopheles pseudopunctipennis in southern Mexico. Journal of the American Mosquito Control Association, 14(4):410-420, 1998.

PANNA summary: This study looked at mosquito behaviors in houses with two variables: 1) use of DDT or bendiocarb (another pesticide), and 2) was the whole wall covered with insecticide (conventional method), or only a band over the mosquitoes' preferred resting area (selective method). The study found that DDT was a more effective mosquito repellent than bendiocarb, and that the actual number of bites was substantially less in DDT-treated houses. It also found that though mosquitoes tended to rest for longer on the walls of houses that had been selectively sprayed, the actual number of bites was about the same as a house that had been conventionally sprayed. The authors recommend using selective spraying to improve cost effectiveness.

Abstract: Indoor feeding behaviors and mortalities of *Anopheles pseudopunctipennis* females were evaluated following contact with selective (bands covering mosquitoes' preferred resting areas) and full applications of DDT and bendiocarb on indoor sprayable surfaces. The DDT residues provoked strong avoidance behavior. To a lesser degree, mosquitoes were also repelled by bendiocarb-sprayed surfaces. Because of strong irritancy/repellency, unfed mosquitoes were driven outdoors in proportionally higher numbers. The resting time on selectively or fully DDT-sprayed huts was greatly reduced in comparison to bendiocarb-sprayed huts. Although unfed mosquitoes tended to rest on non-DDT-sprayed surfaces in the selectively treated hut, the man-biting rate was similar with both types of treatments. Unfed mosquitoes were repelled less from selectively bendiocarb-treated surfaces. Similar reductions in postfed resting times were observed on all surfaces suggesting that once fed, mosquitoes rested on sprayed surfaces for shorter intervals of time. Engorged mosquitoes had normal resting behavior (pre- and postspray) within the range of preferred resting heights in both DDT- and bendiocarb-sprayed huts, but the proportion of mosquitoes fed in the DDT-treated huts was lower. Selective spraying of walls was as effective as spraying the complete walls with both insecticides, but DDT was more effective in reducing mosquito-human contact. These studies show that by more effectively targeting vector behavior, a cost-effective alternative to traditional control techniques can be achieved. (Centro de Investigacion de Paludismo, Instituto Nacional de Salud Publica, Chiapas, Mexico)

9) Grieco, J.P., N.L. Achee, R.G. Andre, and D.R. Roberts. A comparison study of house entering and exiting behavior of Anopheles vestitipennis (Diptera: Culicidae) using experimental huts sprayed with DDT or deltamethrin in the southern district of Toledo, Belize, C. A. Journal of Vector Ecology 25(1):52-73.

PANNA summary: This study looked at how and when mosquitoes entered and exited houses in the Toledo district of Belize in unsprayed houses, houses sprayed with deltamethrin, and houses sprayed with DDT. Deltamethrin was repellent, leading to 66% fewer mosquitoes entering the house, and it shifted the mosquitoes' peak house leaving time to five hours earlier than before the house was sprayed. DDT's repellent effect was even more pronounced, with 97% fewer mosquitoes entering the hut at all, and thus the authors believe it is a more effective tool against malaria in this region.

Abstract: An investigation of the house entering and exiting behavior of *Anopheles vestitipennis* Dyar and Knab was undertaken in the Toledo District of Belize, Central America, between March and December of 1998. Three untreated experimental huts were either fitted with exit or entrance interception traps or used as a control for human landing collections. Human landing collections showed that *An. vestitipennis* exhibited a high level of biting activity shortly after sunset and continued biting at high levels throughout the night. Under unsprayed conditions, the use of exit and entrance interception traps demonstrated that doors, windows, and eaves were the primary mode of entry; whereas, cracks in the walls served a secondary role. The peak entrance time for *An. vestitipennis* occurred between 6:45 P.M. and 9:45 P.M. and a peak exit time occurred between 11:45 P.M. and 4:45 A.M. Additional trials were conducted after spraying one of the huts with DDT and another with deltamethrin. The excito-repellent properties of deltamethrin did not affect entrance times but did result in a peak exiting behavior that was five hours earlier than under pre-spray conditions. Deltamethrin also exhibited a repellency effect, showing 66% fewer *An. vestitipennis* entering the hut two weeks post-spray. DDT had an even more powerful repellency effect resulting in a 97% post-spray reduction of *An. vestitipennis* females entering the hut up to two weeks post-spray. The control hut showed only a 37% reduction in *An. vestitipennis* as compared to pre-spray conditions. (Department of Preventive Medicine/Biometrics, Uniformed Services University of the Health Sciences, Bethesda, MD 20814, USA)

10) Charlwood, J.D., W.D. Alecrim, N. Fe, J. Mangabeira, and V.J. Martins. A field trial with Lambda-cyhalothrin (ICON) for the intradomestic control of malaria transmitted by *Anopheles darlingi* root in Rhondonia, Brazil. *Acta Tropica*, 60(1995): 3-13, 1995.

PANNA summary: This field trial compared the effectiveness of residual indoor spraying of ICON and DDT in Rhondonia in 1987 and 1988 and found that ICON was more effective than DDT, with drops of as much as 76% in malaria cases in treated areas. ICON lasts longer than DDT, is cheaper, and appears more lethal to insects, killing and driving away insects during the study that DDT would have only irritated. Based on these results, the authors recommend ICON as a replacement for DDT in malaria control campaigns.

Abstract: A two stage field trial comparing the effects of Lambdacyhalothrin (ICON) and DDT when used as residual sprays on the inside surfaces of houses, was conducted in the Machadinho and Jaru areas of Rhondonia, Brazil, in 1987 and 1988. In 1987 houses along two 16 km contiguous stretches of a main and a side road were sprayed and the effects on malaria vectors monitored for the succeeding year. In the second stage approximately 55,000 houses in both districts were sprayed with ICON and the effect on malaria incidence measured by passive case detection. Of the eleven species of *Anopheles* caught in indoor and peridomestic collections *A. darlingi* was the commonest and is recognised as the most important vector in Brazil. ICON at either of two concentrations in bioassays killed more mosquitoes than DDT at each test from seven to twelve months after spraying. A rise in the number of *A. darlingi* collected eight months after spraying with DDT was not so marked in the ICON areas. Side effects of the insecticide were limited. The number of reported *Plasmodium falciparum* cases in the second phase declined 76% in Machadinho after spraying with ICON to 2851 cases. In Jaru there was a 28% reduction. The observed efficacy of the insecticide, its ready acceptance by the local populace, and its cost effectiveness make it a more useful insecticide for anti-malaria campaigns than DDT. (Liverpool School of Tropical Medicine, UK)

11) Gonzalez, Fernando Bejarano. The phasing out of DDT in Mexico. <http://www.icps.it/english/bollettino/psn01/010205.htm> [172]

PANNA summary: Mexico has succeeded in both phasing out DDT and bringing down malaria rates in the country through a program of integrated vector management. Mexico applied over 4,000 tons of DDT a year in 1959, and implemented a complete ban in the year 2000. The integrated vector management strategy called "focalized treatment" was first used in the state of Oaxaca, where farmers and environmental organizations were opposed to the spraying of DDT. The approach includes: identifying and classifying at-risk communities, reducing the parasite loads in those communities through 3-month intensive treatments with chlorine and primachine, complementary application of pyrethroids indoors and outdoors, and assessment of disease controls.

(no abstract available)

Who's Promoting DDT?

DDT advocates used the 100th Anniversary of Rachel Carson's birth to trumpet their call for more DDT use and blame Carson for malaria deaths around the world. In the U.S., Carson's centenary was marked by a flood of pro-DDT postings on conservative blogs and dozens of opinion pieces [173] critical of Carson in the mainstream press. Learn more about the debate over DDT. [174]

The aggressive advocates who have mounted this pro-DDT campaign are accusing Rachel Carson of causing millions of deaths, calling environmental advocates who support reducing reliance on DDT for malaria control racist, and calling for widespread use of DDT in Africa. Who are they?



Africa Fighting Malaria (AFM): Established in 2000 and based in Washington, D.C. and South Africa, AFM "seeks to educate people about the scourge of malaria and the political economy of malaria control." Its staff members have current or former links with a range of free-market think tanks critical of the environmental movement, including the Competitive Enterprise Institute, American Enterprise Institute, Institute of Economic Affairs and Tech Central Station. 1,2



Roger Bate: Bate is a founding board member of Africa Fighting Malaria, an adjunct fellow at the Competitive Enterprise Institute (CEI) and a resident fellow at the American Enterprise Institute. He has authored numerous articles calling for DDT use to combat malaria, including "When Politics Kills: Malaria and the DDT Story" published by CEI. 3,4,5,6



Richard Tren: Tren is chair of the board of Africa Fighting Malaria. He believes the shift away from DDT use in malaria control programs was driven by political pressure. "I am confident in saying that the anti-DDT crusades harmed malaria control and cost lives." He is also an Adjunct Fellow at the Competitive Enterprise Institute. With co-author Roger Bate, he wrote *When Politics Kills: Malaria and the DDT Story*, which was published in South Africa, the United Kingdom, the U.S. and India. 7



Campaign for Fighting Diseases (CFD): CFD published a report by Roger Bates on Malaria, and ranks donors regarding their malaria control spending with a Malaria Donor Report Card developed with Richard Tren of Africa Fighting Malaria. The organization's web page features articles such as "Anti-DDT Policies are Deadly" and "Pesticides are Good for You." Henry Miller (see below) is an advisor for CFD. 8,9



Center for the Defense of Free Enterprise (CDFE): CDFE is led by Alan Merrill Gottlieb and Ron Arnold, who founded the anti-environmental "Wise Use" movement. Arnold was once a consultant for Dow Chemical, as well as head of the Washington State chapter of the American Freedom Coalition, the political arm of the Rev. Sun Myung Moon's Unification Church (which has also shared offices with CDFE). In 1991 Arnold told the New York Times, "We [CDFE] created a sector of public opinion that didn't used to exist. No one was aware that environmentalism was a problem until we came along." Prior to their work opposing environmental regulations, CDFE's main focus had been opposing gun controls. According to the article in the Times, Gottlieb shifted the organization's focus when he realized the fundraising potential of opposing environmentalism: "For us, the environmental movement has become the perfect bogeyman." Gottlieb, who describes himself as "the premiere anti-communist, free-enterprise, laissez-faire capitalist" has also said, "Facts don't really matter. In politics, perception is reality." Paul Driessen (see below) is a Senior Fellow at CDFE, and author of *Eco-Imperialism: Green Power, Black Death*. 10,11



Competitive Enterprise Institute (CEI): CEI is a free-market think tank known for, among other things, disputing evidence that human activity is driving climate change. On their website beside a grim photo gallery of malaria victims, the site claims "millions of people around the world suffer the painful and often deadly effects of malaria because one person sounded a false alarm. That person is Rachel Carson." 12



Henry Miller: Miller is an Adjunct for the Competitive Enterprise Institute and a Hoover Institution Research Fellow. He has called for reintroduction of DDT in the U.S. to combat West Nile Virus, as outlined in a recent Wall Street Journal opinion piece, "DDT for Health." He also wrote the article "While the Government Blunders, West Nile Virus Thrives: How Misguided Bureaucrats and Environmentalists Let a Mosquito-borne Disease Spread" for the Hoover Digest. 13,14,15

Steven Milloy: Milloy is an Adjunct Analyst for the Competitive Enterprise Institute. He is the "Junk Science" commentator for FoxNews.com, and runs the Web site junkscience.com, which is dedicated to debunking what Milloy labels "faulty scientific data and analysis." Milloy's "Junk Science" web site features The Malaria Clock: A Green Eco-Imperialist Legacy of Death, which he claims counts up the approximate number of new malaria cases and deaths in the world, most of which he says could have been prevented by the use of DDT. A footnote at the bottom of the malaria clock webpage states, "Note that some of these cases would have occurred irrespective of DDT use. Note also that, while enormously influential, the US ban did not immediately terminate global DDT use and that developing world malaria mortality increased over time, rather than instantly leaping to the estimated value of 2,700,000 deaths per year." 16,17



Congress of Racial Equality (CORE): CORE, founded as an advocacy group for African-Americans, played an early leading role in the U.S. civil rights movement. In the late 1960s, CORE moved to the far right of the political spectrum. CORE's 2005 Martin Luther King celebration honored Green Revolution scientist Norman Borlaug and Karl Rove, George W. Bush's controversial election strategist. Hugh Grant, Chairman and CEO of Monsanto (the first producer of DDT in the U.S. and one of CORE's corporate partners) chaired the reception. In 2005 CORE produced a Monsanto-funded video called "Voice from Africa" promoting the use of genetically modified crops in Africa. 18,19,20



Paul Driessen: Driessen is Senior Policy Advisor for CORE and for the Center for the Defense of Free Enterprise (see above). Driessen has consulted as Senior Fellow for several anti-environmental, corporate-funded "think tanks," including the Atlas Economic Research Foundation, the Committee for a Constructive Tomorrow and Frontiers of Freedom. He edited the book Rules for Corporate Warriors and authored *Eco-Imperialism: Green Power, Black Death*, a 2003 book asserting that environmentalists are directly responsible for poverty in developing countries. He has also received funding from ExxonMobil to spin information as a climate change skeptic. Driessen and Niger Innis are also listed as Directors of the Economic Human Rights Project, "an initiative of the Center for the Defense of Free Enterprise, in cooperation with the Congress of Racial Equality", which aims to "correct prevalent environmental myths and misguided policies that help perpetuate poverty, misery, disease and early death in developing countries." 21



Fiona Kobusingye-Boynes: Fiona is the coordinator for the Uganda division of the Congress of Racial Equality. She was quoted saying, "Spraying DDT is like putting a bed net over the entire house, to protect the whole family. Opponents talk constantly about minor, speculative, or imaginary dangers of using DDT." Speaking for all of her country she said, "Ugandans are delighted that DDT is about to return, because they know it will save lives." 22



Niger Innis: Niger Innis is the national spokesman for CORE. He also serves as an Advisory Committee member for Project 21, an initiative of the National Center for Public Policy Research—a conservative free market foundation with a strongly anti-environmental agenda. He is the son of Roy Innis. 23,24



Roy Innis: A member of CORE since 1963, Innis became national chairman in 1970. In the 1980s he supported Reagan administration policies and was a vocal critic of Jesse Jackson. He is known for controversial stances on racial equality, including hailing as a "bold step" the deportation of 50,000 Asians from Uganda by president Idi Amin in the 1970s. Innis is also a member of the Board of Directors of the National Rifle Association. 25



Bonner Cohen: Cohen is a Senior Fellow for the National Center for Public Policy Research. He co-founded a website with Steven Milloy and is currently the only board member of Miloy's Advancement of Sound Science Center. Cohen has worked for various industry groups, including tobacco industry efforts to discredit EPA. He is the author of *The Green Wave: Environmentalism and Its Consequences*, published by the Capital Research Center, which has a chapter critical of Rachel Carson's push to eliminate DDT. 26,27,28,29



Senator Tom Coburn: A US Senator from Oklahoma, Coburn threatened to block two bills honoring the 100th birthday of Rachel Carson. Coburn called Carson's work "junk science", proclaiming that Silent Spring, "was the catalyst in the deadly worldwide stigmatization against insecticides, especially DDT." He has ties to pro-DDT groups, received funding from a board member of the Competitive Enterprise Institute. Don Roberts, a board member of Africa Fighting Malaria, testified to his committee that public health is best protected through the use of pesticides. He also wrote a letter to the European Union urging them to support the use of DDT. 30,31,32,33

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The Debate over DDT

This compilation of articles highlights the debate over DDT during and immediately following negotiation of the Stockholm Convention. The Stockholm Convention, an international treaty targeting persistent organic pollutants for global phaseout, allows short term use of DDT for malaria control while countries are shifting to safer alternatives. The treaty specifically calls on the international community to mobilize resources to support effective malaria control programs while reducing reliance on DDT.

1. Malaria Control and Public Health (2004) ^[123]
2. DDT is still needed for disease control. (2002) DDT's future under the Stockholm Convention. ^[124]
3. Malaria, Mosquitoes, and DDT: A toxic war against a global disease. (2002) ^[125]
4. Politically Incorrect U.N. (2001) Alternatives to DDT can control malaria. ^[126]
5. The Mosquito Killer: Millions of people owe their lives to Fred Soper - Why isn't he a hero? (2001) ^[127]
6. DDT Risk Assessments. (2001) DDT Risk Assessments: Response ^[128]
7. In praise of DDT. (2001) ^[129]
8. DDT saves lives. (2000) We can all win. ^[130]
9. Doctoring malaria, badly: The global campaign to ban DDT. (2000) Commentary: Reduction and elimination of DDT should proceed slowly. ^[131]
10. DDT house spraying and re-emerging malaria. (2000) How toxic is DDT? ^[132]
11. Balancing risks on the backs of the poor. (2000) ^[133]
12. The case for DDT: What do you do when a dreaded environmental pollutant saves lives? (2000) ^[134]
13. Should DDT be banned by international treaty? (2000) ^[135]
14. DDT and the global threat of reemerging malaria. (1999) Balancing risks of DDT and malaria in the global POPs treaty. (2000) ^[136]

1) Roberts, D., C. Curtis, R. Tren, et al. Malaria Control and Public Health . Emerging Infectious Diseases [letter]. 2004; 10(6): 1170-1. Response: Chen, A., and W. J. Rogan. Malaria Control and Public Health . Emerging Infectious Diseases. 2004; 10(6): 1172.

Available Online at:

http://www.cdc.gov/ncidod/EID/vol10no6/03-0787_03-1116.htm ^[206]

PANNA Summary: Roberts et al. refute the arguments Chen and Rogan made in their article "Nonmalarial infant death and DDT use for malaria control," published in 2003. Roberts et al. claim that Chen and Rogan's conclusions require "substantial evidence of a causal relationship between DDT and adverse consequences of DDT [indoor residue spraying] for malaria control," and that no adverse effects on maternal health or infant survival are attributable to DDT. They assert that DDT spraying is still the cheapest, most effective malaria control method. (Department of Preventive Medicine and Biometrics, Uniformed Services University of the Health Sciences, Bethesda, Maryland; droberts@usuhs.mil ^[207].)

In response, Chen and Rogan admit that causality has not been demonstrated between DDT and shortened lactation or preterm birth, but claim "the evidence is sufficiently strong that the possibility of causality cannot be dismissed." They insist that we should proceed with caution regarding the use of DDT because its safety has not been "demonstrated absolutely." (Epidemiology Branch, National Institute of Environmental Health Sciences (niehs), Research Triangle Park, North Carolina; rogan@niehs.nih.gov ^[36].)

(no abstracts available)

- 2) Roberts, D. R. DDT is still needed for disease control. Pesticide Safety News. V. 5, No. 4, 1st trimester 2002. <http://www.icps.it/english/bollettino/psn02/05020401.htm>
- Liroff, R. DDT's future under the Stockholm Convention. Pesticide Safety News. V. 5, No. 4, 1st trimester 2002. <http://www.icps.it/english/bollettino/psn02/05020402.htm> ^[208]

PANNA summary: The closing remarks of two authors after an extended debate in this publication.

Roberts argues that DDT use should not be eliminated under the Stockholm Convention, and its additional reduction should not be a goal. Agricultural use, the main source of DDT that has built up in the environment, has already been eliminated by most nations and is banned under the Stockholm Convention. DDT levels in the environment are already falling and will continue to fall once it is banned for agricultural use worldwide. So, the much less harmful public health uses of DDT should be allowed to continue uninhibited.

Liroff summarizes findings on DDT's health and environmental impacts since Stockholm treaty negotiations began in 1998, and also indicates successes with alternatives to DDT in Latin American countries. He points out that access to DDT will not be denied outright, and that countries still using it for malaria control will be allowed to continue doing so. However, he argues that the over-arching goal should be a reduction of reliance on DDT and other pesticides for any and all uses, and so efforts should be made toward the development and implementation of less harmful and more integrated alternative approaches to malaria control.

(no abstract available)

- 3) McGinn, Anne Platt. Malaria, Mosquitoes, and DDT: A toxic war against a global disease. WorldWatch. May/June 2002, pp.16., <http://www.worldwatch.org/mag/2002/15-03.html>
- PANNA summary: A well-balanced article, interesting for its current statistics on the prevalence of malaria worldwide and comparisons with other diseases of global concern like AIDS. Briefly describes malaria—the history of the disease and its phases and symptoms. Includes comments on the Stockholm Convention and a list of the four guiding principles of WHO's Roll Back Malaria program. McGinn concludes that there is no place for DDT in modern malaria control efforts—it's simply obsolete, and half a century of experience has shown that there is little justification for its continued use.

(no abstract available)

- 4) Article: Politically Incorrect U.N. July 12, 2001. Review & Outlook, The Wall Street Journal. available at: <http://www.junkscience.com/july01/wsj-UN.htm>
- Response: Liroff, Rich. Alternatives to DDT can control malaria. July 19, 2001. Letters to the Editor: The Wall Street Journal. Copyright (c) 2001, Dow Jones & Company, Inc., p. A23.

PANNA summary: The Wall Street Journal applauds the U.N for its "politically incorrect" stance in the report Making New Technologies Work for Human Development, which supports the use of DDT for malaria control (and criticizes environmental and public health groups concerned about genetically modified foods).

(no abstract available)

Full text of response: Your July 12 editorial "Politically Incorrect U.N." congratulates the U.N. for supporting use of DDT for malaria control. In so doing, the Journal is perpetuating the myth that environmentalists want DDT banned regardless of its usefulness in combating malaria. The World Wildlife Fund supports reduced reliance on DDT for malaria control primarily because of the hazards it poses to human health when it is sprayed indoors and the demonstrated success of alternative approaches. DDT contaminates food and mothers' milk. Just this week, the British medical journal *The Lancet* reports that DDE — a breakdown product of DDT — is associated with pre-term deliveries and low birth weights. Mexico and Vietnam are among the countries that have successfully controlled malaria while eliminating DDT, showing the promise of alternative methods. The World Health Organization's Roll Back Malaria program emphasizes use of bed nets treated with other chemicals. The new Stockholm Convention on Persistent Organic Pollutants (POPs) — negotiated under U.N. auspices — provides for DDT's continued use for malaria control, increased investments in and periodic evaluations of alternatives, and the ultimate elimination of DDT when countries are satisfied the alternatives are workable. WWF and the many other environmental and public health organizations who were observers at the treaty negotiations endorse this prudent approach. (Richard A. Liroff, Ph.D., Director, Alternatives to DDT Project, World Wildlife Fund, Washington)

5) Gladwell, Malcolm. *The Mosquito Killer: Millions of people owe their lives to Fred Soper - Why isn't he a hero?* *The New Yorker: Annals of Public Health*. July 2, 2001. pp. 42-51.

PANNA summary: A rich historical piece that brings a unique perspective to the present debates, this article traces the history of DDT's use for malaria control, with special attention to Fred Soper. Soper worked for the Rockefeller Foundation in the days before the WHO and UN. "With DDT as his weapon, Soper almost saved the world from one of its most lethal afflictions. Had he succeeded, we would not today be writing DDT's obituary. We would view it in the same heroic light as penicillin and the polio vaccine." Gladwell traces the history of Soper's and DDT's successes and failures, from the discovery of DDT's miraculous insecticidal capability in the early forties, through the rise and fall of the global malaria eradication campaign of the sixties, which Soper led, to the post-Silent Spring environmentalists' movement to limit and ban use of DDT.

(no abstract available)

6) Roberts, D.R. *DDT Risk Assessments Environmental Health Perspectives, Correspondence*. Volume 109, Number 7, July 2001. p. A 302-3.

Liroff, R. *DDT Risk Assessments: Response. Environmental Health Perspectives, Correspondence*. Volume 109, Number 7, July 2001. p. A 302-3.

PANNA summary: Roberts contends that environmentalists bent on eliminating DDT and its subsequent ban in many countries have caused the resurgence of diseases previously controlled by DDT, as well as diverted research attention and funds from the development of insecticidal methods of disease control into research on the adverse effects of DDT. Roberts in essence blames environmentalists for "spiraling increases in disease rates" he says are preventable by DDT.

Liroff points out that the language of the Stockholm treaty, while recognizing a total elimination of DDT as an end goal, provides for the slow phase-out of the insecticide for vector control. He counters Roberts' claims by pointing to Roberts' own history of staunch defense of DDT and downplay of the toxicological risks. Liroff concludes that while DDT is very effective, less risky alternatives should be sought out and used.

Full text: *DDT Risk Assessments*

Two recent articles in *EHP* (1,2) and the latest Agency for Toxic Substances and Disease Registry toxicologic profile for DDT (3) make repeated references to DDT risks. These statements of risk, like so many others, are one-sided and give no consideration to colossal increases in diseases previously controlled with DDT. Behind disease statistics are grievous human tragedies, as with the case of a little girl who died of an infection that could have been prevented if her house had been sprayed with DDT. She lived in a village in the Andes and was 8 years old in 1998 when she died of bartonellosis. Bartonellosis was previously controlled through malaria housespray programs, but without DDT, the disease returned.

One-sided and narrowly focused risk assessments form the bedrock of anti-DDT advocacy (4,5), but advocacy for global elimination of DDT through United Nations Environment Programme (UNEP) treaty negotiations failed (6). Countries can continue using DDT for disease control, and DDT is not listed for global elimination. This outcome was possible only through efforts of hundreds of scientists on behalf of hundreds of millions of people at risk of illness and death from malaria (7).

Environmental activists who still want DDT eliminated and who are surprised by the lack of cost-effective alternatives should understand that global vilification of DDT eliminated almost all research on public health insecticides. Lack of research support persists and contrasts sharply with the richness of funds for research on adverse health effects of DDT; 29 major projects are presently funded by the National Institutes of Health (National Institute of Environmental Health Sciences, National Cancer Institute, National Institute of General Medical Sciences, and the National Institute of Child Health and Human Development) (3). The evidence of DDT efficacy in controlling diseases is irrefutable. In just 3 years, house spraying in Guyana reduced maternal and infant mortalities by 56% and 39%, respectively, and reduced malaria cases by 99% (8). Similar evidence from other geographic areas persuaded delegates to UNEP treaty negotiations that DDT is still needed. Yet, and in spite of all contrary evidence, the UN program to phase out DDT is unabated (9,10). The current "phase-out" program by the World Health Organization's Roll Back Malaria initiative and the Global Environment Facility (Washington, DC) includes no publicized disease control performance standards and does not include appropriate on-site studies or tests to determine, under varying epidemiologic and environmental conditions, that DDT alternatives will provide adequate and sustained protection of rural populations.

After years of successful efforts, the modus operandi of DDT elimination remains the same: apply political and economic pressures, convince country politicians that DDT is not needed, pass laws banning its use, and let impoverished rural populations quietly suffer spiraling increases in disease rates (11,12). Even short-term commitments of funds for purchasing the more expensive and less effective DDT alternatives are a continuation of past practices: in the end, disease rates will increase. The Andean girl's death is one of millions of preventable deaths that occurred as national and international regulations, trade barriers, international policies, and UN resolutions were applied to stop public health uses of DDT (13). With absolute certainty, the best measures of success in the anti-DDT campaign are increases in disease and death from malaria, leishmaniasis, bartonellosis, dengue fever, and dengue hemorrhagic fever. We can add to this list the renewed threat that urban yellow fever will once again ravage populations of the Americas. Even this emerging threat is linked to past failures to continue appropriate public health uses of DDT. The Andean girl's unrecognized but precious stake in the DDT issue was her life, now lost. How many millions more must die because of hypothetical risks from minute quantities of DDT sprayed on internal house walls? (Donald R. Roberts, Uniformed Services University of the Health Sciences, Bethesda, Maryland, droberts@usuhs.mil^[207])

Full Text: *DDT Risk Assessments: Response*

Donald Roberts contends that organizations such as the World Wildlife Fund (WWF) failed in efforts to eliminate DDT under the recently negotiated persistent organic pollutants (POPs) treaty. To the contrary, the WWF strongly supports the treaty's language on DDT. Throughout the negotiations, the WWF recognized that DDT should not be banned immediately and that uncertainties about the cost

and effectiveness of alternatives required flexibility in treaty language (1,2). Reflecting this, the new treaty proclaims ultimate elimination of DDT as a goal while establishing a mechanism for reducing reliance on DDT and promoting alternatives (3). As a result of the treaty, new funds are being provided by the Global Environment Facility to develop malaria control programs that reduce use of DDT.

Roberts has been an outspoken defender of DDT. He has prolifically and passionately downplayed the toxicologic risks of DDT while emphasizing its effectiveness for malaria control (4–6). He frequently argues that external political pressures drive poorer nations to abandon DDT, thereby endangering millions of the world's most impoverished people. Malaria-endemic countries have had ample scientific justification for seeking alternatives. For example, in the mid-1990s, Mexican public health researchers expressed concern about high human exposures to DDT as a result of malaria control operations (7,8).

Mexico has since eliminated DDT while successfully combating malaria. South Africa also sought to reduce use of DDT in the mid-1990s because of concern about elevated levels in mothers' milk (9). One species of mosquito was resistant to alternative sprays, so South Africa resumed using DDT. South Africa concluded that the hazards from malaria outweigh those associated with DDT exposure.

South Africa's experience underscores the importance of the flexibility provided by the POPs treaty. Brazil and India offer important lessons about limits to DDT's effectiveness. During the late 1980s and early 1990s, malaria rates in Brazil went up even as spraying of houses with DDT increased, but dropped after Brazil shifted strategies (10). With assistance from the World Bank, India is reducing its reliance on DDT. The main rural malaria vector (responsible for 65% of India's malaria) is resistant to DDT (11). Indian researchers found elevated levels of DDT in buffalo milk, soil, water, and human blood where DDT had been sprayed to control malaria (12,13).

The ATSDR's 2000 update of its toxicologic profile for DDT/DDE (14) reflects major concerns raised by the WWF and other environmental and public health groups during the POPs negotiations. In contrast to the previous profile published in the early 1990s, the update contains a large section, "Health Effects in Wildlife Potentially Relevant to Human Health," reminding readers that animals are sentinels for health effects in humans. A new section captioned "Children's Susceptibility" reiterates a central message from the U.S. National Academy of Sciences' landmark 1993 report on pesticides in the diets of infants and children (15): children are not little adults, but may be uniquely susceptible and exposed to pesticides. The data in the toxicologic profile support the logic of the POPs treaty: DDT can be valuable for controlling malaria, but it is prudent to reduce human exposures.

Recent studies on humans, too late to be included in the toxicologic profile, further support such caution. For example, Longnecker et al. (16) found that DDE concentrations in mothers are associated with increased risk of pre-term delivery and lowered birth weight. Roberts takes EHP's contributors to task for their "one-sided" references to DDT's risks and their failures to account for DDT's benefits. Roberts' encomium to DDT is itself one-sided. Why expose humans to hazards from DDT when less risky strategies might be employed? The POPs treaty encourages development of alternatives and provides a new funding mechanism to support malaria control. (Richard A. Liroff, Alternatives to DDT Project, World Wildlife Fund, Washington, D.C., Rich.Liroff@wwfus.org [2009])

7) Attaran, A. In praise of DDT. *Pesticide Outlook*. June 2001; p. 83.

PANNA summary: The author "argues the case for the retention of DDT in the battle against malaria as the POPs Convention reaches the signing stage." He points to incidences in Africa and Asia where malaria was almost completely under control until the country started phasing out DDT, at which time there were huge rebounds in the numbers of malaria cases. It is, in his eyes, a case of pitting speculative though unproven health risks of DDT as a toxin against the definite health risks of malaria if DDT, the cheapest and still most effective solution, is not used.

(no abstract available)

8) Attaran, Amir. DDT saves lives. *The Globe*, Canada. December 5, 2000.

Watt-Cloutier, S.; R. Charlie, and J. Crump. We can all win. *The Globe*, Canada. December 11, 2000.

Attaran, PANNA summary: Attaran targets the Canadian government's support of the Stockholm Convention on the eve of the Johannesburg meeting in December, 2000. The environmentalists, he says, are being naïve. DDT may kill birds, but it saves people. The amount of DDT used for malaria control has little or no environmental impact compared to the amounts that were being applied for agricultural uses in Rachel Carson's day, so why make it harder and more expensive for "world's poorest, most disease-ridden countries to obtain?" Attaran says calling on the precautionary principle in this instance is tantamount to "stepping into speeding traffic as a "precaution" against tripping on a crack in the sidewalk." He scolds the Chretien government for their strong support of global elimination of DDT.

Watt-Cloutier et al, Full Text:

Amir Attaran's portrayal of Canada's position on global management of chemicals (DDT Saves Lives – Dec. 5), currently being negotiated in Johannesburg, misrepresents what is going on.

Indigenous peoples from Northern Canada here in Johannesburg are replying not only to defend Canada but also to set the record straight. We do so because Mr. Attaran's widely reported views sow mistrust between delegations from the developed and developing worlds, thus undermining the efforts of us all to achieve a global convention on 12 persistent organic pollutants (POPs), including DDT.

Mr. Attaran says: "Not only is Environment Canada arguing in the Johannesburg treaty negotiations that DDT should be eliminated once and for all, it has also proposed that the treaty not include a financial aid mechanism to help poor countries finance the alternatives. Canada is alone among wealthy countries in advocating this parsimony. Such policies literally kill."

The government of Canada has pressed for a global POPs convention as have Northern indigenous peoples who have attended all five international negotiating sessions over the last two years. Many POPs used in tropical and temperate countries end up in the Arctic, contaminating the food web and subsequently Inuit and other indigenous peoples who eat traditional food.

When used to control malaria, DDT saves the lives of thousands of people every year. While phasing out the use of DDT is an objective of the international negotiations, nobody supports a ban that puts lives at risk. When this issue surfaced in negotiations in 1999, Canadian indigenous peoples said they would refuse to be party to an agreement that threatened the health of others, notwithstanding the threat of POPs to their own health.

The view of Northern indigenous peoples is also the fundamental position of all countries participating in the negotiations and all non-governmental organizations observing the debate. Any phase-out of DDT will be conditional upon the availability of cost-effective alternatives.

Mr. Attaran's contention that Canada refuses to help finance the convention including development of alternatives to DDT is demonstrably untrue. The Minister of Finance announced \$20 million in his February budget for exactly this purpose. Canada was the first nation to provide such support and is effectively advocating additional financial and technical assistance to developing countries and "economies in transition" (the old Soviet bloc).

A global POPs convention will not be finalized and ratified unless both developing and developed countries conclude that it helps them. There is no alternative to a "win-win" convention, notwithstanding Dr. Attaran's view from Harvard University. (Sheila Watt-Cloutier, President, Inuit Circumpolar Conference (Canada), Robert Charlie, Council for Yukon First Nations, and John Crump, Executive Director, Canadian Arctic Resources Committee)

9) Attaran, A. and R. Maharaj. Doctoring malaria, badly: The global campaign to ban DDT. *British Medical Journal*. V 321, 2 December 2000.

Liroff, Rich. Commentary: Reduction and elimination of DDT should proceed slowly. *British Medical Journal*. V 321, 2 December 2000.

PANNA summary: Attaran and Maharaj argue that attempts to ban DDT are not only naïve, but unethical. DDT is the cheapest and the most effective method of vector control, and no other method has come close—integrated vector management is still being tested and has never been used successfully in a nation-wide program, and other insecticides are often more expensive, less effective, and run into problems of vector resistance. While DDT may be hazardous to human health, there have been no conclusive studies to that effect. The authors find the precautionary principle ridiculous in this instance—removing the best malaria-fighting chemical because it might be carcinogenic, and thereby allowing malaria to spread and take more lives hardly seems cautious. (Center for International Development, Harvard University: amir_attaran@harvard.edu [210], South Africa Department of Health, Communicable Disease Control)

Liroff's response addresses the fears of a medical establishment that he feels is unreasonably frightened of the Stockholm Convention. The convention does not ban DDT outright, but provides for its continued use where necessary, and eventual phase out. Liroff cites the US National Academy of Sciences and Agency for Toxic Substances and Disease Registry reports to the effect that DDT has adverse effects on the immune, endocrine, and reproductive systems, and that exposure to DDT at certain crucial stages of fetal and/or child development could lead to consequences later in life. While the global burden of malaria is a serious problem, especially on the poorest nations, some countries such as Mexico have had a great deal of success in moving to alternatives, and so it is not unreasonable to expect that a move away from DDT could not only protect human and environmental health but also improve the effectiveness of malaria control. The POPs convention needs to ensure that DDT is still available and affordable to countries that need it, and that supplies are tightly monitored so they cannot be used illegally for agriculture. (World Wildlife Fund, Alternatives to Malaria Project)

(no abstract available)

10) Roberts, D.R.; S. Manguin, and J. Mouchet. DDT house spraying and re-emerging malaria. *Lancet* 2000; 356: 330-332.
Smith, A. G. How toxic is DDT? *Lancet*, 22 July 2000. Commentary Volume 356, Number 9226.

PANNA summary: Roberts et.al. highlight the many accomplishments of DDT in malaria control over the last 55 years. A worldwide ban on DDT that would require malaria-endemic nations to reduce house spraying programs, and in turn lead to an increased malaria burden in those countries. Especially now as malaria is on the rise again and re-invading areas where it had previously been eradicated, the authors recommend that "the global response to burgeoning malaria rates should allow for DDT residual house spraying where it is known to be effective and necessary."

In response to the Roberts, Manguin, and Mouchet article, Smith surveys studies of DDT's effects on human health and notes that considering the great quantities of DDT that have been used and the depth that the chemical has been studied, relatively few incidences of adverse effects on humans have been found. However, "the perceived rather than the calculated risks from DDT use are an important consideration in maintaining public confidence." For this reason, Smith advises that DDT use continue to be tightly controlled and effects closely monitored.

(no abstract available)

11) Attaran, A.; D.R. Roberts, C.F. Curtis, and W.L. Kilama. Balancing risks on the backs of the poor. *Nature Medicine* 2000 Jul; 6(7): 729-31. <http://www.malaria.org/attarannaturemed.html>

PANNA summary: Attaran, Roberts, et al are quite forceful in presenting their case as to why the Stockholm Convention and "First World Environmentalists" should not continue with their campaign to "reduce and/or eliminate" the use of DDT for malaria control. They argue that studies of the harmful effects of DDT on humans and the environment either are inconclusive, haven't been replicated, or were due to large scale agricultural use of DDT in the past, while DDT's effectiveness as a tool for malaria control is undeniable and backed by decades of experience. Environmentalists in industrialized countries have the luxury of placing environmental concerns above poverty alleviation, while developing countries do not have the same luxury. Malaria is one of the major factors keeping underdeveloped nations in poverty, and environmentalists' attempts to take DDT, the most powerful and effective weapon in the arsenal, away from those nations for their own environmental concerns amounts to eco-imperialism.

Abstract: Malaria kills over one million people, mainly children, in the tropics each year, and DDT remains one of the few affordable, effective tools against the mosquitoes that transmit the disease. Attaran et al. explain that the scientific literature on the need to withdraw DDT is unconvincing, and the benefits of DDT in saving lives from malaria are well worth the risks. (Center for International Development, Kennedy School of Government, Harvard University, Cambridge, Massachusetts 02138, USA
amir_attaran@harvard.edu [210])

12) Raloff, Janet. The case for DDT: What do you do when a dreaded environmental pollutant saves lives? *Science News*, Vol. 158, No. 1, July 1, 2000, p. 12. <http://www.sciencenews.org/20000701/bob8.asp>

PANNA summary: Raloff summarizes recent findings and arguments around the push to ban DDT, citing Roberts and Liroff, among others. She finds that arguments for continued use of DDT are very strong—although our eventual goal should be elimination, it would be disastrous to abandon DDT prematurely, and it should be brought back in areas where its decreased use has caused malaria infection rates to surge, especially in Latin America. It would, however, be unwise to rely on only one tool, and so many scientists advocate increased research into the development of new methods as well.

(no abstract available)

13) Curtis, C.F. and J.D. Lines. Should DDT be banned by international treaty? *Parasitology Today* 2000 Mar; 16(3): 119-21.

Abstract: The insecticide DDT has been an effective and affordable means of malaria control in many countries, but pressure for its use to be banned is mounting. Here, Chris Curtis and Jo Lines take a critical look at evidence that links house spraying by DDT with harm to the environment and human health, and stress the need for resources for alternatives to DDT to be made available to countries that would be affected by a DDT ban. (London School of Hygiene and Tropical Medicine, Keppel Street, London, UK WC1E 7HT.
chris.curtis@lshtm.ac.uk [158])

14) Roberts, D.R. DDT and the global threat of reemerging malaria. *Pesticide Safety News*, vol. 3 no. 4, December 1999.
<http://www.icps.it/english/bollettino/psn99/990404.htm>

Liroff, R. Balancing risks of DDT and malaria in the global POPs treaty. *Pesticide Safety News*, vol 4, no 2, June 2000.
<http://www.icps.it/English/Bollettino/Index-boll.htm> [211]

PANNA summary: Roberts argues that DDT has not been convincingly linked to public health problems, and that pressure not to use DDT for malaria control are unwarranted and irresponsible. He challenges the use of Mexico as a model for controlling malaria without DDT, saying that "only time will tell" whether the alternative approaches adopted by the country will be successful in the long run. He highlights data from several countries in South America showing a link between falling DDT use and rising incidence of malaria.

Liroff responds to Roberts' arguments with information on the current status of the international negotiations on POPs and the case for phasing out DDT. He identifies ways to strengthen malaria control programs, and argues that the implementation of an effective integrated strategy of malaria control combined with DDT rollbacks would be a "win-win" situation.

(no abstract available)

World Malaria Day 2008

April 25th is World Malaria Day. In recognition of the toll this devastating disease takes on children and families worldwide, PAN partners are taking action today to promote safe and sustainable malaria control that reduces reliance on pesticides. Please join us.

We encourage you as a PAN North America activist to take a few moments to learn more about safe, sustainable malaria control today. And we ask you to please talk with one other person about the importance of investment in malaria control, employing the safe and sustainable strategies that are used around the world.

We offer you the following resources for these conversations.



Safe Malaria Solutions

The world is finally responding to the global challenge of malaria, with particular attention to Africa, where communities are hardest hit by the preventable disease. This renewed attention is welcome and long overdue.

Yet our colleagues in Africa are concerned that some programs – particularly those supported by the U.S. – are relying too heavily on one tool: spraying of pesticides inside people's homes, including growing reliance on the infamous chemical DDT. Evidence clearly shows that integrated strategies that include bed nets, environmental controls, access to medications and community involvement make up the most effective malaria control efforts.

Learn More – Visit our Safe Malaria Solutions ^[212] webpage to find out more about sustainable malaria control programs, including a new case study on the successful program in Mexico.

Human Health Effects of DDT

Scientific studies continue to confirm that DDT use for malaria control is a danger to human health. Yet some advocates continue to press aggressively for increased reliance on DDT, even though a global treaty – the Stockholm Convention – calls on all countries to shift to safer alternatives and eventually phase out all uses of this persistent pesticide.

Learn More – Visit our DDT Health Effects ^[14] webpage.

Thank you for joining PAN partners this World Malaria Day in supporting safe malaria solutions for children and families in Africa and around the world.

Africa Malaria Day 2007

Pesticide Action Network and our partner groups around the world are calling for a redoubling of efforts to control malaria, a deadly disease that devastates communities worldwide, hitting especially hard in Africa. Malaria must be confronted with the best available technologies and solutions. Spraying of DDT inside homes is not such a solution: it puts children's health at risk, and relying on DDT is not the best way to stop malaria.

In April and May 2007, two events highlighted these concerns:

- **Africa Malaria Day Briefing** ^[124], April 24, Washington, D.C.
- **Malaria-DDT panel at Stockholm Convention COP III** ^[125], May 1, Dakar, Senegal

Exposure to DDT is especially dangerous for developing infants and children. Sound scientific evidence shows low levels of exposure in the womb can reduce babies' birth weight, cause developmental delays in children, interfere with a mother's ability to breast feed, increase risk of miscarriage, and cause reproductive problems. DDT has been linked to low sperm count in men and labeled a possible cancer causing chemical by international agencies. Some studies show a link to breast cancer. DDT contamination begins from the moment of its production. Residents of Eloor, India are protesting the contamination of their homes, environment and drinking water by a dirty DDT production facility.



Safer Malaria Control Successful community-based programs all over the world are using bed nets, improved sanitation, community education, and tracking and early treatment to address malaria without relying on DDT. For examples, see reports from Kenya, Mexico, the Philippines and Vietnam. These and much more information is available on our DDT/Malaria resource page ^[212].

Africa Malaria Day Briefing April 24, Washington D.C. ^[213]

- Celebrating global attention and support to end malaria
- Promoting sustainable malaria solutions

The Honorable John Conyers arranged an **Africa Malaria Day Briefing & Reception**, April 24th from 3:30 to 5:30 pm. The program started at 3:30 in room 2257 of the Rayburn Building on Capitol Hill.

Special guests available for media interviews and expert comments at the reception: **Dr. Paul Saoko**, Physicians for Social Responsibility, Kenya (live by phone); **Rev. Lois Dejean**, Gert Town Revival Initiative, Louisiana; **Monique Harden** and **Nathalie Walker**, Advocates for Environmental Human Rights; **Shawna Larson**, Indigenous Environmental Network/Alaska Community Action on Toxics; **Dr. Tyrone Hayes**, University of California, Berkeley; **Michele Roberts**, environmental justice policy expert; **Kristin Schafer**, Pesticide Action Network North America

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Download Audio of Event

- Broadcast Quality MP3 ^[214]
- Streaming 24k Internet MP3 ^[215]
- Audiopoint Notice / Overview ^[216]



Malaria-DDT panel at Stockholm Convention COP III May 1, Dakar, Senegal ^[217]

International POPs Elimination Network and Pesticide Action Network side event: **Focusing on health and fighting malaria without DDT: Supporting safe and sustainable strategies**. Tuesday 1 May 2007, 1:00pm-2:30pm, Le Méridien President Hotel, Dakar.

Chair: Mme Fatima Dia Touré, Directeur de l'Environnement et des Etablissements Classés du Sénégal.

Panelists include: **Dr Jorge Mendez**, previously director of the Mexican Malaria Control Programme; **Dr Paul Saoko**, Director of Physicians for Social Responsibility, Kenya; **Crispin Kalumiana Kaposhi**, ecotoxicologist, Zambia; **Mr Purushan Eloor**, a representative of the community living in the shadow of a DDT production plant in India.

A press conference will immediately follow the side event.

[View Program](#) » ^[217]

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Email us at: panna@panna.org. Phone us at: (415) 981-1771. Also see [Contact and visit information](#).

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Links:

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- [2] http://www.panna.org/files/PAN_IPEN_COP4.pdf
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