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estimony by Donald R. Roberts, PhD, Professor, Division of Tropical Public Health, Department of Preventive Medicine and Biometrics, Uniformed Services University of the Health Sciences, Bethesda, MD

Thank you Chairman Coburn and members of the Subcommittee on Federal Financial Management, Government Information, and International Security for the opportunity to present my views on malaria control and DDT use in public health programs.

I started my career of public health research in the 1960s and I have seen large reversals in the control of transmissible diseases like malaria, dengue, and leishmaniasis. The public health reversals are revealed by remarkable increases in malaria in countries that once had highly effective control programs. I want to emphasize that the cost of those reversals in lost health, lost lives, and lost economic vitality is enormous. One example of this enormous cost is the reemergence of dengue fever as a major public health problem in the Americas.

Aedes aegypti is the urban vector of dengue fever. Dengue fever disappeared from most countries of the Americas during many years when DDT was being used to eradicate *Aedes aegypti*. Today, in all countries from northern Mexico to northern Argentina, dengue and dengue hemorrhagic fevers are exacting horrific costs of human health and welfare. To large extent public health reversals in control of dengue, malaria and other diseases can be attributed to the unrelenting campaign of environmental activists against our public health insecticides, and DDT in particular.

To begin to fix our public health problems, we must first recognize that the large and complex system responsible for regulatory control over public health insecticides is severely broken and needs repair. The repair I speak of encompasses fundamental changes in regulatory authorities and responsibilities.

There are some special considerations in the practice of public health that should be mentioned in discussing the overall question of what needs to be done to protect registrations and uses of public health insecticides. First, there is no strong commercial interest in public health insecticides. This is certainly true for the older insecticides. In fact the insecticide industry might actually join with environmental activists in opposing use of the older and less profitable chemicals. Second, public health programs are almost entirely dependent on limited government funding. Third, there is great competition among public health programs for limited government funds. These factors should be considered because they help explain why the public health community can easily be silenced by political pressure or by threats of litigation. It also explains why the public health community often has no commercial allay in confrontations with well-funded environmental activists. For these reasons I think authority over public health insecticides should reside in agencies and organizations responsible for disease control. Decisions on use of public health insecticides should be made with priority on the most serious threats to the health of those at risk of disease and death. The decisions should be based entirely on the underlying science of what is required to protect human health, chemical efficacy, cost and chemical safety, not on fear of political pressure from environmental activists, fear of litigation, or on environmental ideology. Change is required at international and national levels, but the United States must get its own house in order before turning its attention to the international arena.

Within the United States we seldom hear about diseases like malaria, dengue, and leishmaniasis. Yet our current experience with West Nile fever is a gentle reminder that insect-borne diseases can strike even in the United States. Perhaps many believe that malaria, dengue and leishmaniasis have been defeated as major public health problems. The truth is that far from being defeated, these diseases are laying waste to countries and populations around the globe. The Democratic Republic of Congo reports an estimated 226,000 childhood deaths per year and malaria is the primary killer of those children.[1] So in many countries the diseases continue siphoning away lives, health, and economic

[1] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/CONGODEMOCRATICEXTN/0,,contentMDK:20634700~menuPK:349472~pagePK:141137~piPK:141127~theSitePK:349466,00.html

vitality as they always have, in others where the diseases were once controlled, the diseases are now returning to the devastating levels before the advent of DDT and effective disease control programs.

The 30 years of data from control programs of the Americas plotted in Figure 1 illustrate just how effective DDT was in preventing malaria. The period 1960s through 1979 displays a pattern of malaria controlled through house spraying. In 1979 the World Health Organization (WHO) changed its strategy for malaria control, switching emphasis from spraying houses to case detection and treatment. In other words, the WHO changed emphasis from malaria prevention to malaria treatment. Countries responded to WHO guidelines and pressures from bilateral and multilateral donors. Most countries dismantled their spray programs over the next several years. The line graph in Figure 1 illustrates the progress of the dismantling. As you can see, fewer and fewer houses were sprayed. The bar graph illustrates the cumulative increase in cases over the baseline of cases that occurred during years when adequate numbers of houses were being sprayed (1965-1979). As you can also see, as countries reduced numbers of houses sprayed, the number of malaria cases continually increased.

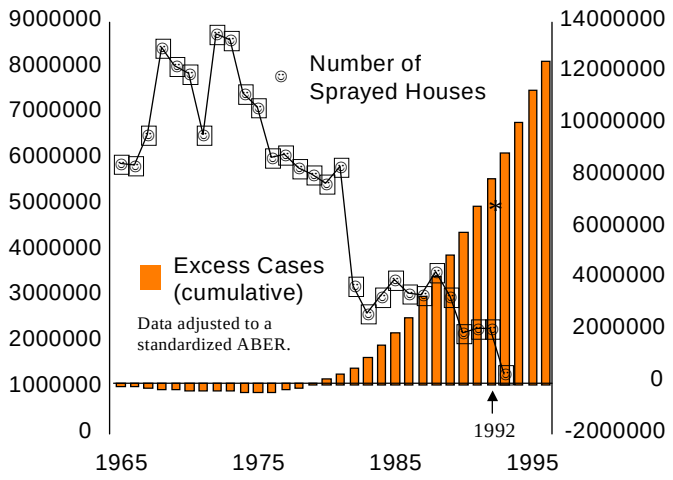

Figure 1. Impact of the World Health Organization's malaria control strategy in 1979 to de-emphasize indoor spraying of house walls and adoption of World Health Assembly resolution in 1985 to decentralize malaria control programs in the Americas. The x-axis is years and the y-axis is cumulative numbers of malaria cases above the baseline. Baseline is defined as the average number of malaria cases each year from 1965 to 1979.

In spite of quantitative proof that declining use of DDT has caused increasing disease, those who oppose use of DDT steadfastly deny that such a relationship exists.[2] A Wilkipedia internet site suggests that a claim of causation, in the case of DDT and malaria, amounts to Post hoc ergo propter hoc.[3] This is to say it is a logical fallacy to suggest that declining use of DDT, since it occurred before increasing malaria, was the cause of increasing disease. The Wilkipedia challenge goes on to admit that "temporal sequence is integral to causality — it is true that a cause always happens before its effect. The fallacy lies in coming to a conclusion based only on the order of events, which is not an accurate indicator.[4]" The Wilkipedia analysis is exceptional shallow and incomplete. It ignores issues of consistency, statistical coherence, and predictive performance.

A causal relationship would suggest that before DDT was used, disease rates were high. With use of DDT, disease rates declined, and without use of DDT, disease rates increased in proportion to decreased DDT usage. As a point of fact, this is precisely what has happened in many countries around the world. The exceptions are found in those countries that reduced disease and simultaneously went through an economic transition. In other words, increasing wealth can improve control over disease. Regardless the relationships described above have been documented for many countries.[5]

I am including in this testimony as annex 1 a model of the proportional dose-response relationships between DDT usage and malaria over a 34 year period in Ecuador.

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[2] Matteson, P. C. (1999). "Malaria control in South America." Emerg Infect Dis **5**(2): 309-11.

[3] http://en.wikipedia.org/wiki/DDT#Arguments_for_and_against_DDT
[4] http://en.wikipedia.org/wiki/Post_hoc%2C_ergo_propter_hoc
[5] Roberts DR, Laughlin LL, Hshieh P, Legters LJ. DDT, global strategies, and a malaria control crisis in South America. Emerg Inf Dis 1997; **3**:295-302

This same analysis has been performed with data from other countries and the results have been consistent.[6] The powerful fit (statistically significant) of actual data to the model of increasing malaria with decreasing numbers of sprayed houses attest to the causal relationship between reduced use of DDT and re-emerging malaria. I propose that the link between declining use of DDT and increasing disease fulfills both the criterion of consistency and the criterion of a proportional dose-response relationship. This relationship also fulfills the criterion of predictive performance. When South Africa restarted its DDT spray program in 2001, malaria rates dropped precipitously. The same precipitous decline in disease rates has been documented for Madagascar, Eduador, Belize, and Mexico after the countries restarted or renewed DDT spray programs.

For reasons I will explain later, there is no insecticide recommended for malaria control that rivals, much less equals, DDT's unique actions to prevent malaria transmission inside houses. No other insecticide recommended for indoor spraying of houses exerts a powerful spatial repellent action, as does DDT, that stops mosquitoes from entering houses and biting during the night, or is as long-acting, as cheap, as easy to apply, as safe for human exposure, or as efficacious in the control of malaria. For all these reasons, the malaria endemic countries still need the freedom to use DDT in malaria control operations if they choose to do so. Yet, most indoor spray programs the world over have been stopped, and any and all uses of DDT have been discouraged. As stated before, to a very great extent control programs have been dismantled because of regulatory policies against public health insecticides in developed countries, and the enforcement of those policies by bilateral and multilateral donors. It should go without saying that the underlying regulatory policies have been developed as a result of pressures from environmental activists, often through environmental litigation.

In the United States, the Environmental Protection Agency has regulatory authority for all insecticides, to include those that are critical in preventing transmission of important diseases. Yet the agency has no responsibility at all for disease control.

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[6] Roberts DR, Laughlin LL, Hshieh P, Legters LJ. DDT, global strategies, and a malaria control crisis in South America. Emerg Inf Dis 1997; **3**:295-302

Actions against DDT illustrate how EPA has exerted regulatory authority on basis of political pressure. To appreciate the full dimension of EPA action against DDT, we need to reflect back to the beginning of a transition from effective disease control to the present conditions of reemerging diseases and stark failure of public health programs.

1969 was an important year of environmental activism against DDT. It was also the beginning of a move away from effective malaria control programs. In 1969 Sweden banned most uses of DDT.[7] In the United States there were hearings on DDT in the State of Washington[8] and in Madison, Wisconsin.[9,10] Hearings occurred just six years after the appearance of Rachel Carson's publishing phenomenon "Silent Spring." DDT was Carson's primary target, so hearings against DDT received considerable press coverage. Science magazine had made contributions against DDT in 1968 by publishing 10 articles and letters, mostly antagonistic to DDT. Four of the 10 Science articles were authored by Charles Wurster,[11] co-founder of the extremist anti-DDT Environmental Defense Fund. The 1968 articles portrayed DDT as an insidious and mortal threat to robins, the Bermuda Petrel, and our global oxygen supply. Those claims were false, but the papers gained credibility by appearing in our most prestigious science magazine.

Another fateful act in 1969 was a decision to stop the *Aedes aegypti* eradication program in the United States. The program was dependent on use of DDT. Termination of that program was entirely political. Ending eradication, which was successful in many other countries of the Americas, was vigorously opposed by leading tropical medicine

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[7] http://www.chem.unep.ch/pops/POPs_Inc/proceedings/bangkok/WAHLS1.html

[8] In this year the global malaria eradication program ended and the U.S. *Aedes aegypti* eradication program was stopped. Both of these critical public health programs were entirely dependent on use of DDT.

[9] http://www.uwmc.uwc.edu/geography/350/DDT-hearing.htm

[10] http://fightingbob.com/article.cfm?articleID=462

[11] Wurster, C. F., Jr. (1968). "DDT and robins." Science **159**(822): 1413-4.

, Wurster, C. F., Jr. (1968). "DDT reduces photosynthesis by marine phytoplankton." Science **159**(822): 1474-5.

, Wurster, C. F., Jr. and D. B. Wingate (1968). "DDT residues and Bermuda petrels." Science **161**(839): 397.

, Wurster, C. F., Jr. and D. B. Wingate (1968). "DDT residues and declining reproduction in the Bermuda petrel." Science **159**(818): 979-81.

specialists of that time.[12] Unfortunately the decision fell within the authority of a political appointee who headed the CDC, Dr. David Sencer. He ended the program and end of eradication in the United States collapsed the programs that had eliminated threats of dengue fever and urban yellow fever from most countries of the Americas. Programs collapsed in other countries because program managers knew the U.S., as the major trading partner, would be a continual source of *Aedes aegypti* re-infestations—it would be a never ending problem. As those programs collapsed the countries were reinvaded by *Aedes aegypti*. To make a long story short, dengue fever is once again endemic, and often epidemic, in almost all countries of Central and South America.

In Sencer's justification for ending *Aedes aegypti* eradication he stated that it was not possible to eradicate in one country or region alone, if eradication were to be attempted, it would need to be global in scope.[13] Yet this argument was without merit because many countries had already eradicated the mosquito and had maintained their *Aedes aegypti*-free status for many years. All that was required to remain *Aedes aegypti*-free was vigilance and a willingness to mount a decisive response once an infestation was detected. So, why did Sencer abandon the eradication effort? As a political appointee, we can assume that politics flavored his decisions and the decision to end the program occurred during the peak of environmental activism against DDT. Thus it is no surprise that during the 11th Plenary Meeting of the World Health Assembly (WHA) in Geneva in May 1972, Sencer iterated a view that "the control of malaria and typhus were the only cases in which the use of DDT was justified." In other words, use of DDT to eradicate *Aedes aegypti* was not justified in his opinion.

The EPA prohibitions of DDT for agriculture were signed June 14, 1972. Yet, even before EPA prohibitions against the use of DDT in agriculture, environmental activism was reducing abilities of malaria endemic countries to acquire the insecticide. As stated in the 11th Plenary WHA meeting in May 1972, "Many countries were now

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[12] Downs, W. G. (1969). "Health protection in a shrinking world." Am J Trop Med Hyg **18**(3): 482.
, Soper, F. L. (1969). "Health protection in a shrinking world." Am J Trop Med Hyg **18**(3): 482-4.

[13] hrinking world." Am J Trop Med Hyg **18**(3): 341-5.

facing difficulties because of the limited amounts of DDT on the world market, and because of the rise in price that had followed limitation of production." So, even before specific EPA action against DDT there was tremendous public health harm of environmental activism against DDT and that harm was known and widely discussed.

Court proceedings were seemingly required for EPA to act against the use of DDT in agriculture. For seven months the pros and cons of DDT were aired in court[14]. The hearing examiner, Edmund Sweeney concluded in April, 1972 that DDT was not a human carcinogen, and that approved uses of DDT were not a source of major environmental harm. Two months later the head of the newly formed Environmental Protection Agency, William Ruckelshaus, ignored the court findings and cancelled all agricultural uses of DDT. So, even when hearings were required, an entirely political decision was still used to override findings of the court. As one observer described it "DDT demonstrated the effect public pressure could have on EPA policy decisions."[15] Exemptions for DDT use were granted for public health use in control of vector borne diseases, USDA or military use for health quarantine, and use in prescription drugs for controlling body lice.[16] But in a follow-up action the EDF filed a suit in 1973 to prohibit all uses of DDT.[17] This action and others showed clearly that environmentalists had no interest at all in protecting human health or human welfare.

Science magazine lost interest in DDT after it was prohibited for agriculture use and published only 3 DDT papers in 1973, and fewer in subsequent years. Nature magazine acted similarly, publishing many DDT related publications (again, mostly antagonistic) from 1969 to 1971, and then losing interest after the EPA prohibition. Some DDT opponents published in both magazines, e.g., David Peakall, Robert Risebrough, and Joel Bitman. As described in a paper by Gordon Edwards entitled

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[15] http://www.epa.gov/history/publications/formative6.htm

[16] http://www.cec.org/files/PDF/POLLUTANTS/HistoryDDTe_EN.PDF

[17] http://www.epa.gov/history/topics/ddt/02.htm

"DDT: A case study in scientific fraud,"[18] many frenzied anti-DDT reports were found wanting in scientific validity.

If we put aside tremendous harm of the EPA decision on use of DDT for disease control, the agriculture prohibition of DDT was still a striking example of a political decision overriding public health, or more to the point, occupational health. One factor in de-registering DDT was that the EPA could recommend an efficacious substitute, so agricultural productivity would theoretically not be harmed. The substitute chemical was parathion. All registered agricultural uses of DDT ended January 4, 1973. Even allowable use in public health required EPA approval after the new policy was implemented.

To understand the magnitude of the EPA's 1972 action against DDT, one needs to understand that no human death or human illness had been attributed to appropriate/approved uses of DDT (this statement is still true today). On the other hand, parathion is one of the most toxic insecticides in existence. So, the EPA stopped uses of a chemical that posed no proven risk to humans and substituted one widely known, even in 1972, to be dangerous. Of course EPA supposedly allowed time to prepare agriculture workers for use of a more dangerous chemical. The time allowed was from June 14, 1972 to 4 January 1973, when all uses of DDT were stopped. This token effort pales in comparison to the real danger of parathion. In a 1999 opinion, EPA stated "Methyl parathion is hazardous to workers - people who handle or apply the pesticide as part of their occupation, and people who work in fields to harvest treated crops. Protective clothing and equipment are not sufficient to reduce the risks to workers to acceptable levels.[19]" So, 27 years later we are told that even protective clothing and equipment were not sufficient to protect workers. If EPA's own assessment is correct, then there can be no doubt that for 27 years agricultural workers suffered illness and death from parathion. This illustrates the price EPA was willing to pay to get rid of DDT—the DDT prohibition was a political win paid for in human lives.

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[18] http://www.jpands.org/vol9no3/edwards.pdf
[19] http://www.epa.gov/pesticides/factsheets/chemicals/mpfactsheet.htm

What I describe here is a broad exercise of regulatory authority without public health responsibility. As the DDT example illustrates, even EPA findings suggest the 1972 decision against DDT and the decision to substitute parathion for many agricultural uses had adverse impacts on occupational health of agriculture workers. The adverse impact of DDT prohibitions on insect borne disease control is a separate issue. The public health cost of eliminating DDT from malaria control programs alone can be measured in tens of millions of preventable deaths, and hundreds of millions of preventable malaria infections. If we look around the globe at increasing problems of malaria, dengue, and leishmaniasis, it seems to me that the sum of all benefits of EPA actions and of environmental activism against insecticides is meaningless compared to the enormous harm imposed on poor people in poor countries as a result of DDT prohibitions. For this reason I believe our system of authorities and responsibilities is seriously out of balance with the global need for public health insecticides.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was amended in 1988 to require EPA to conduct "a comprehensive review of older pesticides (those initially registered before November 1, 1984) to consider their health and environmental effects and to make decisions about their future use."[20] Shortly after the process of reregistration began, DDT was dropped from the list of insecticides registered for public health use in the United States. The reregistration process required a payment of fees. Additionally there may have been maintenance fees for keeping an insecticide on the approved list. Whether for failure to pay the former or latter, there was no payment of fees, so DDT was erased from the list of insecticides for public health uses.[21] Once DDT was de-listed for public health use, USAID was then able to claim it could not spend government funds for DDT in other countries if DDT could not be used in the United States.

Lack of balance in regulatory authority continues to characterize EPA actions, even

[20] http://www.epa.gov/oppfead1/trac/factshee.htm
[21] http://www.cec.org/files/PDF/POLLUTANTS/HistoryDDTe_EN.PDF

today. Attached is a paper entitled "Overcoming regulation based on innuendo and litigation."[22] This article describes a struggle of mosquito control organizations in Florida to protect the registration (or as current process dictates, reregistration) of Baytex (fenthion). This chemical was used in some mosquito control districts in Florida to control adult mosquitoes. Registration for use was voluntarily cancelled. I am also citing here the URL for the Notice of Intent to Sue for Violations of the Endangered Species Act, Migratory Bird Treaty Act, and Administrative Procedure Act Concerning Registration of the Pesticide Fenthion.[23] There is no balance visible in these documents, all emphasis is on potential environmental risk, with no emphasis on value of using fenthion to protect human health. The notice of intent to sue also shows the enormous legal protections for wildlife. Where are the laws that provide protections to human health and where are the activists who litigate to preserve the remaining few chemicals registered for use against vectors of human disease?

I think it is fair to say that environmental activist groups have abused litigation as a tool to force compliance with their views and ideologies. The price of environmental activist victories against DDT and other public health insecticides has been an ever increasing burden of death and disease for the world's poorest and most vulnerable populations. In my opinion, it is time to place constraints on litigation against registrations and uses of public health insecticides.

The U.S. deliberative position during the persistent organic pollutants negotiations for DDT elimination was that the U.S. government was to seek reasonable measures to lead to, optimally, a phase out of production and use [of DDT], and at a minimum, use only for vector control purposes. This seemingly reasonable position also stipulated a willingness of the U.S. government to work with WHO and others to identify alternatives to DDT.[24]

I stated earlier that I would explain why there is no insecticide presently

[22] Stivers, J. 2003. Overcoming regulation based on innuendo and litigation. Wing Beats. 14 (4):14-15.
[23] http://www.defenders.org/wildlife/birds/fenthion.pdf
[24] U.S. Approach for DDT. Draft 4: 6/18/98. Janice Jensen. EPA Office of Pesticide Programs.

recommended for disease control that equals DDT's unique actions to prevent malaria transmission inside houses. As a matter of historical correctness, EPA adopted legally binding prohibitions against DDT in 1972. But to my knowledge, EPA has not even defined criteria for a reasonable alternative to DDT. In my opinion, a reasonable alternative would be chemical that replicates DDT's unique actions of a powerful spatial repellent, a strong contact irritant, and a moderately toxic compound and be rapidly biodegraded (metabolized in a living system). The fact is, in all the years the EPA has exercised prohibitions on use of DDT, the agency has invested nothing to discover a alternative chemical. This is another damming expression of authority without responsibility. Our National Institutes of Health have invested almost nothing in searching for DDT alternatives. The USAID has invested almost nothing in comparative research to identify chemicals that improve on or mimic DDT actions to control malaria, and the same statement is true for the CDC.

The United States is the greatest and most powerful country in the world. The U.S. government, acting through USAID, EPA, and through the offices of the World Health Organization and the United Nations Environment Programme has had more influence eliminating DDT from malaria control operations than any other country or organization. So, how is it possible that until recent time, the U.S. has made no investment or contribution to finding a DDT alternative?

Regulatory authority has been used as a basis for creating a whole set of barriers and obstacles to use of public health insecticides. We see these barriers in requirements for environmental assessments (EAs) and environmental impact assessments (EIAs) for any public health uses of insecticides for spraying inside houses. The cost of these assessments should not drain away precious resources for control of malaria and other diseases. The cost of EAs and EIAs should be evaluated on the basis of cost versus benefit. What is the real benefit in lives saved or prevention of public health harm from EAs and EIAs? Beyond this, there are other costs that are going to be tacked onto uses of DDT, and perhaps other public health insecticides. The WHO is now stating that the Stockholm Convention recommends that a "centralized regulatory and administrative

authority should be set up" to supervise DDT procurement or importation and use.[25] In my opinion, all of these requirements do not accurately reflect requirements to protect public health and to prevent diseases that are draining away lives, health, and economic viability of many developing countries, especially those in Africa.

[25] http://www.who.int/malaria/docs/FAQonDDT.pdf

Annex A

The proportional dose-response relationship between use of DDT and malaria rates for Ecuador.

A proportional dose response relationship exists between numbers of houses sprayed with DDT and malaria cases.[26,27] A threshold level of effective spraying can be empirically defined by fitting house spray and malaria data to a logistic regression model[28]. The threshold value is the minimum effective house spray rate (MEHSR). When spraying is below the MEHSR, numbers of malaria cases will increase in roughly inverse proportion to the reduced number of houses sprayed. Alternatively, when spraying is above that threshold, numbers of cases will decline in roughly inverse proportion to the increase in number of sprayed houses.

I tested logistic regression models against 34 years of malaria control data[29] for Ecuador. For this model we used published methods to standardize annual parasite indexes (APIs), which express the yearly number of slide diagnosed malaria cases per 1000 population.[30] The logistic regression model was developed and tested with SAS software. A derived binary variable was the response variable and the house spray rate was the independent variable. A binary variable was developed by assigning a value of 0 if the standardized annual parasite index (API) increased during the following year and 1 if it declined. The API was standardized against the average annual blood examination rate (ABER) for years from 1965 to 1979. Significance was established at the 0.05 probability level.

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[26] Roberts DR, Alecrim WD, Hshieh P, Grieco JP, Bangs M, Andre RG, Chareonviriyaphap T. A probability model of vector behavior: Effects of DDT repellency, irritancy, and toxicity in malaria control. J Vector Ecol 2000; **25(1)**,48-61.

[27] Grieco JP, Achee NL, Andre RG, Roberts DR. 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. J. Vector Ecol 2000; 25(1):62-73.

[28] Roberts DR, Vanzie E, Bangs MJ, Grieco JP, Lenares H, Hshieh P, Rejmankova E, Manguin S, Andre RG, Polanco J. Role of residual spraying for malaria control in Belize. J Vector Ecol 2002; 27(1):63-69.

[29]"Status of Malaria Programs in the Americas. XLII Report." Washington, DC, Pan American health Organization (1994).

[30]Roberts DR, Laughlin LL, Hshieh P, Legters LJ. DDT, global strategies, and a malaria control crisis in South America. Emerg Inf Dis 1997; **3**:295-302.

The logistic regression model is $\log\left(\frac{\rho}{1-\rho}\right)$; where p = probability of decreasing malaria. The probability that malaria will decrease in Ecuador with increasing house spray rate (HSR) is -1.0398 + 0.0178(HSR).

A statistically significant ($p<0.05$) fit of data to the model defined a MEHSR of 58.4 for Ecuador. Each house was sprayed twice each year so only 29 different houses were actually sprayed per 1000 population. This model illustrates the proportional dose-response relationship between malaria incidence and levels of indoor DDT spraying. Ecuador dropped below the MEHSR in 1980.[31] The years after 1980 up through 1993 were marked with almost continuous increases in standardized APIs. The only exception to progressive increases in malaria was the years in when Ecuador restarted its use of DDT and quickly dropped its malaria rates.[32]

[31] "Status of Malaria Programs in the Americas. XLII Report." Washington, DC, Pan American health Organization (1994).

[32] Roberts DR, Laughlin LL, Hshieh P, Legters LJ. DDT, global strategies, and a malaria control crisis in South America. Emerg Inf Dis 1997; **3**:295-302