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EXPERT OPINION

International advocacy against DDT and other public health insecticides for malaria control

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Abstract: A new international effort to control/eradicate malaria is accompanied by suggestions that malaria can be controlled without the use of dichloro-diphenyl-trichloroethane (DDT) and other insecticides. We review the underlying science of claims publicized by the Global Environment Facility (GEF), the United Nations Environment Programme, and the Stockholm Convention Secretariat (the Secretariat). Their claims stem from a $14 million GEF project that was conducted from 2003 to 2008 in Mexico and seven countries of Central America. Objectives, experimental design, analyses, and project accomplishments are described. So-called environmentally sound interventions (GEF interventions) that excluded insecticides were implemented in demonstration areas in eight countries. Efficacy of interventions was evaluated by comparing malaria rates in demonstration areas (n = 202) with those in control areas (n = 51), all in high malaria risk areas. There were no statistically significant reductions in malaria rates in demonstration areas compared with controls. This was true across all eight countries. Broad use of antimalarial drugs was the primary method of malaria suppression in the eight countries, but this method was not a GEF intervention. Ultimately statistics favoring efficacy of "environmentally sound" methods of malaria control were obtained by comparing malaria cases in demonstration areas for 2004 with cases in 2007, and we explain why these comparisons are not valid. In conclusion, claims that GEF interventions effectively reduced malaria in Mexico and seven countries of Central America are not supported by existing data or the results of epidemiological analyses. The claims are being used to justify the Secretariat's plan to eliminate DDT production by 2017. DDT is still needed for effective control of malaria, and its elimination could have significant consequences for people in malaria endemic countries.

Keywords: DDT, malaria control, Mexico, Central America, insecticides

Introduction

There has been a gradual awakening to the return, or for some, the continuation of malaria as a major public health issue in developing countries. This awakening has brought about a new emphasis on the control of this terrible disease.

The global malaria eradication program of the 1950s and 1960s demonstrated that malaria can be controlled, and in some regions, eradicated. Indoor residual spraying with (dichloro-diphenyl-trichloroethane) DDT was a major component of that program, which freed almost a billion people of endemic malaria. Lessons were learned that have application to what is happening today. One important lesson was that while program achievements were remarkable, the program was vulnerable to ideological opposition. It was opposed, eventually stalled, and then largely destroyed by, among other things, campaigners who opposed use of DDT and other insecticides. Anti-DDT

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propaganda penetrated to the very heart of the global malaria eradication program. In a 1969 meeting of the World Health Organization (WHO) Committee on Programme and Budget, the Netherlands delegation voiced concerns about DDT by stating "… DDT, when broken down to DDD or DDE, was toxic to man, other mammals and also to birds and fish".[1] This is just one of many examples of claims against DDT that were expressed in many forums of the global program. However, public health professionals of that era understood that DDT sprayed on inner walls of houses posed no meaningful threat to wildlife. It was equally well known that residents of hundreds of millions of sprayed houses had suffered no definable harm, while benefiting greatly from reduced threats from disease-spreading insects. Many historical events of the eradication program, to include false claims against DDT and the impact of anti-DDT campaigning, have already been described and documented.[2]

Today's renewed global push to control and perhaps eliminate malaria was reviewed in a recent series of informative papers.[3–6] The papers were remarkably mute on how renewed global efforts to control or eliminate malaria are once again being challenged by campaigns against insecticides. Continued opposition to public health insecticides should be no surprise because the movement against the use of insecticides has grown enormously since the 1960s. Lead agencies include the United Nations Environment Programme (UNEP), the Stockholm Convention Secretariat (the Secretariat), and the Global Environment Facility (GEF). The latter two are the newest of the bureaucracies that oppose insecticides for public health, with GEF gaining control over anti-DDT funding in 2001 and the Stockholm Convention coming into force in 2004. These agencies' opposition to DDT and other public health insecticides is supported by hundreds of millions of dollars being generated by the GEF and partners under the rubrics of improving methods and approaches to the control of malaria while achieving DDT elimination. The GEF has provided grants of $8.8 billion, and has attracted cofinancing from partner organizations in the amount of $38.7 billion.[7] According to a 2009 GEF report, since May 2001 "GEF has committed US$360 million to projects in the POPs [persistent organic pollutants] focal area and leveraged some US$440 million in co-financing, bringing the total value of the GEF POPs portfolio to US$800 million".[8] The GEF has invested $22 million into six projects researching alternatives to DDT for vector control.[8] Their fund-generating capacity is exemplified by the Secretariat's projected 2007 budget of $150 million for stopping DDT production by 2017.[9]

Several malarial countries in sub-Saharan Africa and elsewhere currently use DDT to control malaria, and use it to great effect.[10] It still has considerable value for malaria control, and endemic countries are calling for continued freedom to use DDT.[11,12] However, this freedom for the National Malaria Control Programs (NMCPs) to use DDT is threatened by the Secretariat's plan for total elimination of DDT in 2020. An urgent push to meet these deadlines perhaps explains why the UNEP, WHO, and GEF issued a joint press release in May 2009 announcing a "rejuvenated international effort to combat malaria with an incremental reduction of reliance on the synthetic pesticide DDT".[13] The rejuvenated international effort embodies the global program "Demonstrating and Scaling-up of Sustainable Alternatives to DDT in Vector Management" (Global DSSA program), which consists of 10 GEF projects, in 40 countries, to test nonchemical methods to control malaria, at an estimated cost of $78.3 million.[14] The program is supposed to be building on the results achieved from the "Regional Program of Action and Demonstration of Sustainable Alternatives to DDT for Malaria Vector Control in Mexico and Central America" (the GEF project), which evaluated DDT alternatives in Mexico and Central America.[15] The GEF project was undertaken in countries and during years when gains were being achieved in the control of malaria. The important question is: to what extent, if any, were those gains due to interventions promoted by the GEF project as environmentally sound approaches to malaria control without use of DDT?

Claims from research, which is not peer-reviewed and is publicized as "calculated and tested science"[16] by officials at high levels of global governance, is a cause for concern, even more so when the claims could potentially undermine malaria control with consequences for public health. With variable estimates of hundreds of millions of cases of malaria occurring every year, it is vital that policies for malaria control are based on truthful and accurate information about what works, at what costs, and at what risks. With a goal of more truthful and accurate evaluation, we undertook a detailed review of the GEF project and the validity of claims emanating from that project.

Material and methods

We include here a description of the GEF project,[15] a listing of project objectives, a description of the environmental interventions for control of malaria, and a review of its experimental design.

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Description

In 2003, the GEF approved the "Regional Program of Action and Demonstration of Sustainable Alternatives to DDT for Malaria Vector Control in Mexico and Central America" (the GEF project), which aimed at preventing the "reintroduction of DDT for malaria control by promoting new integrated vector control techniques and implementing a coordinated regional program to improve national capacities"[15] in eight countries (Belize, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama, and El Salvador). The GEF project was executed by the Sustainable Development and Environmental Health Program of the Pan American Health Organization (PAHO) and implemented by UNEP. It was cofinanced by the GEF with additional support from the Commission for Environmental Cooperation of North America, PAHO, and participating country governments. At the highest levels, this malaria project was controlled not by disease control experts, but by environmental groups, and was widely viewed as a GEF project. The overarching project plan was "the implementation of demonstration projects of vector control without DDT or other persistent pesticides that can be replicable in other parts of the world and which are cost-effective, environmentally sound, and sustainable".[15]

Objectives and goals

The project goals, relating directly to issues of malaria control methods and evaluations, were defined by various GEF, UNEP, and project participants. As described by a UNEP official,[17] a long-term goal of the Global DSSA program is "To contribute to a re-formulation of the WHO Global Malaria Program in order to promote global vector borne disease control interventions while at the same time eliminating the application of DDT and reducing the use of other chemicals". As justification for this goal, the UNEP official cited the World Health Assembly (WHA) resolution 50.13, which calls on member states "to take steps to reduce reliance on insecticides for control of vector borne diseases through promotion of integrated pest management approaches in accordance with WHO guidelines …".

Specific GEF project goals as described by the UNEP[17] were to "demonstrate feasibility of integrated and environment-friendly methods for malaria vector control without the use of DDT" and to "assess the effects of these methods on malaria occurrence".

Other objectives of the project relating to educational materials about DDT and other insecticides, inventory and destruction of DDT stockpiles, and social and cultural agendas are not covered here. Our emphasis is on the scientific evaluation of methods of malaria control and validity of claims of success of the GEF project's malaria control interventions.

GEF interventions for malaria control

GEF interventions for control of malaria were evaluated in the GEF project and were described by Achim Steiner, executive director of the UNEP, at the Helsinki Chemicals Forum in 2009.[16] The specific GEF malaria control interventions evaluated in the project (as described by Steiner) were:

- Reduction of contact between mosquitoes and people via treated bed nets; meshes on doors and windows; the planting of repellent trees like neem and oak; and the liming of households
- Control of breeding sites by clearing vegetation; draining stagnant water, ditches, and channels; and the use of biological controls, such as fish and bacteria, in some countries
- Elimination of places near houses that attract and shelter mosquitoes through, eg, the cleaning and tidying up of areas in and around homes, alongside the promotion of personal hygiene.

The final 2009 evaluation[18] of the project mentions various methods of case treatment and elimination of parasites within human populations. However, these methods were ongoing components of malaria control in each country and predated the GEF project. In other words, these malaria control measures were not specific to the GEF project and operated nationally in each country before and during the project. Available evidence suggests the NMCPs did their work regardless of the presence or absence of GEF project personnel. Thus, antimalarial treatment (the major component of the NMCPs) in demonstration areas was not part of the end-of-project epidemiological evaluation[19] of the GEF project.

Experimental design

As revealed in the PAHO environmental sector's 2008 final report[20] on this project, experimental design of the GEF project included demonstration areas of GEF interventions. Design of the project also included epidemiologically similar areas without GEF interventions (ie, the controls).[19] The goal was to compare the results from demonstration areas with results from selected areas without interventions. As stated by Cesar Chelala,[21] a medical consultant affiliated with the GEF project, demonstration areas were selected "based on the

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high incidence of transmission and the persistence of malaria in those places". To meet this criterion, demonstration localities were selected based on three years of data on malaria indices showing repetitive problems of malaria, and where there was knowledge about presence of malaria mosquitoes and their seasonal occurrence. However, Chelala did not mention that similar areas were selected from the region with similar indications of malaria transmission, but without experimental interventions. These were the controls, and were included as the critical test or comparison unit for effectiveness of the experimental interventions. A total of 202 demonstration areas and 51 control areas were established.[19] The former included a total population of 159,018 and the latter 50,834. The most common methods used in the demonstration areas against adult mosquitoes were whitewashing of houses, cleaning of patios, and cleaning of houses. The more common methods employed against mosquito larvae (immature, aquatic forms of mosquitoes) were to fill or drain water bodies, clean edges of water bodies, and remove aquatic vegetation.[19] Other interventions were described (eg, larvivorous fish, bacterial toxins), but few were used in demonstration areas.

Results

Claims about effectiveness of GEF project interventions

The GEF project has received a considerable amount of publicity. The 2008 final report[20] claimed "… in the 202 demonstration communities there was a 63% reduction in the number of people with the disease without using DDT or any other type of pesticide …", and that "… effectiveness … was sustained in targeting and integrating the interventions against malaria without using any type of pesticide ...". The May 2009 UNEP/WHO/GEF press release[13] claimed the project utilized "pesticide-free techniques and management regimes" to "cut cases of malaria by over 60 per cent". They then inferred that the project showed "… sustainable alternatives to dichloro-diphenyl-trichloroethane (DDT) are emerging as cost-effective solutions that may be applicable regionally and globally". Steiner claimed the GEF project was "calculated and tested science" in his speech at the 2009 Helsinki Chemicals Forum.[16] He stated, "The project achieved a 63 per cent reduction in malaria cases and a more than 86 per cent cut in ones linked with *Plasmodium falciparum*, the malarial parasite that causes the most severe kind of infection and the highest death rate globally".[16] Chelala proclaimed "The program [the GEF project] has had significant achievements, notably a reduction in the number of malaria cases. From 2004 to 2007, reported malaria cases dropped by 63% in 200 demonstration communities in Mexico and Central America that had been chosen because of their historically high rate of transmission".[21] Similar claims also appeared in the Environmental Health Perspectives plaudits for new GEF projects, "The new projects follow a successful pilot project in Mexico and Central America that achieved an overall 63% reduction in the incidence of malaria and a more than 86% reduction in the most severe form of malaria, that caused by *Plasmodium falciparum*. This success has rekindled hopes that an end to DDT reliance is possible".[22]

Statistical evaluations of GEF interventions

As documented above, UNEP and Stockholm Convention officials have publicly claimed that GEF interventions were used to achieve very high levels of control over malaria in Mexico and seven countries of Central America. These claims of success are not supported by peer-reviewed literature, so it is critically important to confirm their scientific validity, given the publicity they have engendered.

A scientific evaluation of malaria control activities in Mexico by Dr Mario Rodriguez[23] reported that the annual parasite index (number of cases per 1000 population) for three of five demonstration areas was lowered more in years (2000–2004) leading up to the years of the GEF project (2004–2007) than during the project. Rodriguez presented data showing the large reduction of malaria from 2000 to 2004 comprised a national trend, not limited to demonstration areas.

In a separate analysis, an end-of-project epidemiological evaluation[19] reported no statistically significant differences in reductions of malaria in demonstration areas versus those in nonintervention (control) areas. Graphs of comparative data were presented, and in each country, the malaria rates in demonstration and control localities at the end of the project were equal. The epidemiologist made comparisons of malaria rates from 2004 to 2007 and reported that malaria rates in demonstration areas were less in 2007 than in 2004. This finding of less malaria in 2007 was the basis for claiming GEF interventions were highly effective in reducing malaria in demonstration areas. However, in the conclusion of the epidemiological evaluation, the epidemiologist recommended new studies because evidence was not sufficient to prove [GEF] interventions were effective. Additionally, the author of the 2009 final evaluation[18] concluded that "a problem occurred concerning the selection of control localities in each of the participating countries", and suggested "PAHO and UNEP should fund a new study to assess the impact

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of the project strategy used, correcting the problems that presented [sic] [probably meant 'prevented'] the evaluation of project impact, particularly the absence of control locations".

Discussion

Importantly, the claims of successes in the GEF project are not products of the malaria scientists, NMCPs, or the official malaria control organizations within PAHO or WHO. Indeed, claims formalized in the 2008 final report were produced by the environmental sector within PAHO, not by those who have technical expertise and responsibility for malaria control within PAHO. The Sustainable Development and Environmental Health Program within PAHO produced the 2008 final report.

Designation of who is responsible for UNEP/GEF/Stockholm Convention claims is important because significant malaria control successes have been achieved by NMCPs in the eight countries included in the GEF project. The NMCPs have maintained control over the disease and, in four of the countries, reportedly brought malaria cases down to historic levels. However, their successes were not a result of the interventions we describe as components of the GEF project. Their successes were mostly a result of wide distributions of antimalarial drugs to suppress malaria (see Table 1).

Data in the Table reveal trends of increased numbers of antimalarial pills distributed per diagnosed case and decreased numbers of cases. Equally obvious is the decreased numbers of pills distributed per diagnosed case, and increased numbers of cases in two countries (Costa Rica and Panama). Such strong associations show how the eight countries have been pressured to make limited use of alternative methods of malaria control, eg, use of insecticides to reduce environmental risks of malaria transmission. To generalize these relationships, with declining use of insecticides to reduce man-vector contact and malaria transmission, the trends in numbers of malaria cases will increasingly track with numbers of excess antimalarial pills distributed per diagnosed case of malaria.

Table 1 Numbers of chloroquine pills distributed per diagnosed case of malaria in Mexico and seven countries of Central America for 1990 versus 2004 and percent change in numbers of pills per case and percent change in numbers of cases from 1990[35] to 2004[36]

Country	Pills/case in 1990	Pills/case in 2004	% change in pills/case	% change in cases
Mexico	235	2566	+1092	−1307
Belize	21	82	+390	−287
Costa Rica	653	100	−653	+112
El Salvador	34	22,802	+67,064	−8276
Guatemala	38	54	+142	−144
Honduras	30	51	+170	−338
Nicaragua	279	1319	+473	−519
Panama	202	140	−144	+1337

We applaud the professionals of PAHO's Technical Area for Health Surveillance and Disease Prevention and Control (AD/HSD) for not giving credibility to GEF's claims of successful control of malaria in Mexico and Central America. In its most recent overview of malaria in the Americas,[24] the AD/HSD report gave token recognition to the GEF project, but attributed none of the successes of Mexico and Central America to GEF interventions. Additionally, the PAHO fact sheet on malaria notes that "There are no equally effective and efficient insecticide alternatives to DDT and pyrethroids …".[25] Of equal importance, the AD/HSD reports that malaria control in the Americas is now more difficult because of the short residual life of the pyrethroids used as replacements for DDT. In other words, without DDT, approved insecticides do not have an adequate residual life to be fully cost-effective in indoor residual spraying programs.

Issues of scientific methodology

It is not appropriate to ignore experimental controls because comparative tests with controls do not produce a desirable result. Unfortunately, the analyses and claims of the GEF project do just that. As described above, the end-of-project epidemiological evaluation[19] compared malaria rates in demonstration areas (with GEF interventions) with malaria rates in control areas (with no GEF interventions). The control areas had been selected for comparability with the demonstration areas. The comparisons revealed no statistical differences in malaria rates in demonstration areas versus rates in control areas. The epidemiological analysis called for new experiments because existing data did not show that project interventions had a significant impact on malaria. The failure of GEF interventions to reduce malaria rates quantitatively in demonstration areas compared with control areas was consistent across all eight countries. Yet, publicized claims of project successes ignored those findings. In fact, the use of control areas, even though they constituted a significant effort within the overall project, was not even mentioned in the 2008 final report.[20]

Because comparisons with control areas failed to show any impact of GEF interventions, those who publicized successes of the project employed comparisons of malaria rates in

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demonstration areas for 2004 with rates in the same areas for 2007. Their claims that interventions reduced malaria by 63% in demonstration areas and falciparum malaria by 86% were based on those comparisons.[16] However, the comparisons are not valid for two reasons. First, even though countrywide reductions in malaria rates in each of the eight countries, from 2004 to 2007, were included in the final report, the countrywide statistics were interpretively ignored in order to claim GEF interventions produced large reductions in malaria rates in demonstration areas. This error is important because there were large reductions in malaria rates with or without GEF interventions, so any claim that reductions in demonstration areas were due to GEF interventions is not valid. Indeed, two of the eight countries reported greater malaria reductions countrywide than in demonstration areas. Second, even if the comparisons did not require major adjustments, which they did, the underlying process of NMCPs targeting malaria control measures in high malaria transmission areas is so dominant as to invalidate the results of the analyses.

When countries were pressured to abandon use of DDT[26–28] and, in general, were discouraged from using any insecticides at all, they trended toward broad usage of drugs for suppressing malaria. The NMCPs are often described as epidemiologically stratified programs. This means control efforts are stratified according to determinations of risk, based on histories of malaria occurrences.[29] Thus, the broad distribution of drugs is greatest in areas of highest malaria risk, and correspondingly, less in areas of lower risk. As specified in the project's experimental design, demonstration areas were selected from areas of high malaria occurrence. In other words, the demonstration areas were in malaria hot spots. Thus, localities that NMCPs prioritized for rapidly detecting and treating cases, for drug prophylaxis, or for distributing mass numbers of antimalarial drugs, were the same areas where GEF project personnel applied their interventions against adult and larval mosquitoes. Thus, demonstration areas received maximum benefits from efforts of the NMCPs. The GEF project then claimed that reductions of malaria in demonstration areas were due to GEF interventions, when, in fact, reductions were due to a targeted and more vigorous application of the same measures that were being applied in other regions, albeit at lesser levels, which brought malaria rates down for the whole country.

Conclusion

There is a need to find alternatives to DDT, but the search for alternatives should not damage prospects for using DDT and other insecticides for malaria control; to do so would endanger human lives. Those who campaign against public health insecticides should understand that public health applications of DDT comprise a highly selective and environmentally safe use. The amount of DDT sprayed on just 100 acres of cotton during a growing season would suffice to protect up to 8500 people.[30] Additionally, it does not entail broad environmental contamination because it would be sprayed inside houses, not over the landscape.

The GEF-funded projects, such as the GEF project in Mexico and Central America, and as suggested by the title of the project, are damaging the prospects for using DDT. We believe the priorities and power of global public health policy is heavily skewed in favor of those who advocate against DDT, as well as other public health insecticides. As an example of this, the funds programmed by the Secretariat to halt the production of DDT in India and China is $150 million,[9] three times greater than the funds devoted by the Bill and Melinda Gates Foundation for the establishment of the Innovative Vector Control Consortium,[31] the leading public–private partnership devoted to developing new vector control technologies.

Additionally, we emphasize that the claims that DDT is unsafe for human exposure are only assumptions embraced by those within the anti-DDT campaign. In contrast with the many claims of human health harm made against DDT, it is an irrefutable truth that decades of research have not fulfilled basic epidemiological criteria for proving a cause and effect relationship between environmental exposure to DDT and any harm to human health.[32]

There is not yet an alternative to DDT that mirrors the modes of action of DDT (spatial repellency, contact irritancy, and toxicity),[33,34] nor one that is as cost-effective. Thus, unscientific claims against DDT and other public health insecticides could damage existing NMCPs and impair prospects for use of public health insecticides far into the future. Furthermore, and as illustrated in this article, claims of successful control of malaria without insecticides are not consistent with proven and successful strategies employed by many malaria control programs that use other WHO-approved insecticides. Uncritical acceptance of claims that insecticides are not needed could undermine the future success of malaria control programs.

Because malaria is the most important insect-borne disease globally, claiming, by various estimates, approximately one million lives every year, it is imperative that policies designed to control the disease be scientifically based and rigorously evaluated. Unfortunately, rigorous evaluation is lacking in the GEF project. Throughout our investigation of this project, we found a lack of transparency and failure to communicate data and scientific findings. For this reason most citations in this paper are not to peer-reviewed

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literature. Indeed, we have found no peer-reviewed papers that accurately report on the successes claimed by the GEF, the Secretariat, or the UNEP.

Claims about the success of the GEF project are not valid, yet they are being publicized to justify and support a timeline for stopping DDT production by 2017 and eliminating DDT entirely by 2020. The proposed actions by the Stockholm Convention Secretariat are, as described by ministers of health in endemic countries,[11,12] contrary to the public health needs of malaria control programs, and the claims made resulting from the GEF project subordinate public health needs to an ideological agenda. The same is true of public health policy enacted in WHA resolution 50.13 that calls on endemic countries to reduce use of public health insecticides. This resolution should be rescinded before it further erodes the global malaria control effort.

In conclusion, malaria will not be defeated by claims of success when no successes have been achieved. However, it can be contained and perhaps eradicated if all available tools, to include DDT, are made available and employed in an organized and systematic way.

Disclosure

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