DDT AND PYRETHROID RESIDUES IN HUMAN BREAST MILK FROM KWAZULU-NATAL, SOUTH AFRICA

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Introduction

In both developing and developed countries, human breast milk remains the best sole nutrient source for infants (especially in the early stages of infancy), even though it could contain pollutants, such as PCBs and DDT[1]. The presence of DDT and other organochlorine compounds in human breast milk has been known for quite some time from malaria[2] and non-malaria[3] areas. The restriction on or banning of many of these compounds for agriculture in most parts of the world has led to gradual reductions in the levels of organochlorine compounds in breast milk, especially in developed countries. For malaria control however, DDT is still being used in some countries, including South Africa, although it was interrupted for five years during which pyrethroids were used instead. For malaria vector control the pesticides are chiefly used in dwellings and to impregnate bed nets. The pyrethroids are also used in significant amounts in agriculture.

In the 1990s, South Africa started to phase out DDT and replace it with pyrethroids in the malaria vector control programmes. A total ban of DDT was enforced in 1996. From a rather constant level of a few thousand malaria cases each year prior to the ban, the number of cases rapidly rose to over 60 000 in the year 2000 (Fig 1), and DDT was reintroduced in the vector control programmes. After the reintroduction the number of cases rapidly decreased again. The malaria mortality rate showed the same pattern.

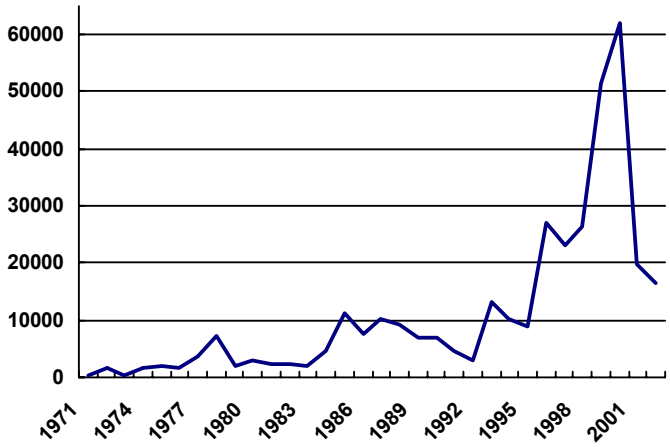

Figure 1. Number of cases of malaria in South Africa.

The reason for this rapid increase in the number of cases and deaths in malaria was that a mosquito population that had become resistant to the pyrethroids (but not DDT) entered South Africa from Mozambique. After the reintroduction of DDT in the vector control programme these pyrethroids resistant mosquitoes could once again be kept at bay.

Another potential problem with the shift between DDT and pyrethroids, or the use of DDT in malaria control while pyrethroids are used in agriculture, is possible synergistic effects between DDT and pyrethroids. A number of studies have shown synergistic deleterious effects when combinations of DDT and pyrethroids have been tested on mice.[4, 5]

There are few investigations of pyrethroids in human milk, but the situation in many malaria endemic areas is similar to that described here with a combined exposure to both DDT and pyrethroids. To obtain information on the level of exposure in different areas we investigated the presence of pyrethroids and DDT in breast milk of women from the northern part of KwaZulu-Natal that experienced active malaria vector control by both DDT, and for five years by deltamethrin, and increased agricultural use of insecticides, some of which are pyrethroids.

Materials and Methods

Ethical approval for collection was obtained from Pharma-Ethics and the KwaZulu-Natal Department of Health. A basic questionnaire in Zulu was completed and prior informed consent obtained from each participant. The samples were collected between April and November of 2001, a period between indoor spraying operations, just after the first resumption of the application of DDT. Samples were collected in two clinics, Jozini and Mkuzi, serving areas with malaria, and one clinic, Kwaliweni, serving an area without malaria, and frozen immediately after collection to avoid breakdown of the pyrethroids. A total of 152 samples were analysed. For QC the analytes were added to milk samples that were treated in the same manner as the other samples. The milk samples were extracted with hexane after denaturing the proteins with acetonitrile. The DDTs were determined after cleanup of the hexane extract with concentrated sulphuric acid. The cleanup procedure for the pyrethroids included partitioning the hexane extract with acetonitrile, and fractionation on silica gel.[6] Quantification for the various isomers of DDT, as well as permethrin, cyfluthrin, cypermethrin and deltamethrin was done using GC-MS.

Results and Discussion

The results are presented in Table 1. The mothers from Jozini (active malaria control) had significantly higher levels of DDT (ΣDDT 4.48 mg/kg milk fat) than women from Kwaliweni (ΣDDT 1.1 mg/kg milk fat), which served as the reference site. There were, however, no differences between total pyrethroid levels of the two sites (0.647 and 0.211 mg/kg milk fat respectively), and permethrin, rather than deltamethrin, made up most of the pyrethroid residues. Multiparae mothers also seemed to have higher pyrethroid levels than primiparae, although this was not significant. Although the Jozini DDT levels were lower than a previous survey done 14 years ago from a comparable town close by (Mseleni, ΣDDT 15.8 mg/kg milk fat),[2] this reduction can be ascribed to the five-year interval with no DDT application, before DDT application was resumed one year before sampling. There is little evidence however, of the deltamethrin applied for malaria control, still being present in the breast milk, as only 41% of mothers from Jozini had detectable residues. Simultaneous investigations of the levels of pyrethroids in water and the usage pattern in agriculture and malaria control indicates that the pyrethroids found in breast milk are probably derived from agricultural use.[6]

The advisable daily intake (ADI)[7, 8] for DDT (0.01 μg/kg body weight) was exceeded by infants in Jozini, but none of the pyrethroids exceeded the ADI or MRL. Since the ADI for DDT was recently reduced from 20 to 10 μg/kg body weight, we suggest that this aspect be treated with concern. The risk of mortality or morbidity from malaria, however, far exceeds those risks possibly associated with DDT. Therefore, we cannot but raise a well-motivated concern due to toxicant interactions, as we have shown the presence of four different pyrethroids and all major DDT isomers in the same human milk samples. It is very important to note however, that we have found no reason whatsoever to consider breastfeeding as any less worthy of promoting as the best sole nutrient source for infants in this area.

This investigation adds breast milk to other sources of infant pesticides exposure. In addition to the milk, the infants will be exposed to ambient levels of pyrethroids and DDT in air, water/food, dust, and surfaces inside the dwellings, and are also exposed directly in treated fields when taken along with their mothers to. This multiple exposure scenario is typical of the close association of rural people in Africa with their environment.

Table 1. Residues (mg/kg) of DDT and pyrethroids based on milk fat from mothers from Jozini, Mkuze and Kwaliweni. Data from Bouwman et al.[6]

	M Age (years)	Milk fat (%)	ΣDDT (mg/kg)	%DDT (mg/kg)	ΣPYR (mg/kg)
Jozini					
Primipare (n=33)					
Mean	19.7	4.32	6240	33.7	235
SD	2.53	2.90	5600	13.8	220
Min	16	1.10	267	5.81	7.50
Max	27	14.5	22200	76.2	1020
%Pos			100	100	76
Multipare (n=52)					
Mean	27.6	3.65	3360	42.6	942
SD	5.95	1.48	2220	14.1	3320
Min	18	1.20	447	16.5	5.00
Max	49	8.40	10100	74.0	19800
%Pos			100	100	67
Mkuzi					
Primipare (n=4)					
Mean	20.0	3.03	2960	40.4	1340
SD	4.08	1.02	4910	13.7	
Min	17	1.50	220	0.00	
Max	26	3.60	10300	50.1	
%Pos			100	50	25
Multipare (n=22)					
Mean	27.2	3.97	1150	30.6	499
SD	5.73	2.15	1240	16.8	265
Min	19	2.00	106	9.22	179
Max	37	12.0	4460	78.2	852
%Pos			100	100	23
Kwaliweni					
Primipare (n=16)					
Mean	18.7	4.66	728	32.7	186
SD	2.12	2.07	669	13.7	150
Min	16	1.70	139	17.4	24.9
Max	23	9.50	2150	60.8	465
%Pos			100	100	63
Multipare (n=25)					
Mean	26.6	3.40	871	28.0	228
SD	5.86	1.59	596	12.8	128
Min	19	1.10	112	12.7	40.4
Max	40	7.90	2170	58.0	474
%Pos			100	100	60

In addition to pyrethroids, carbamates are also used as alternatives to DDT in malaria vector control. However, there is very little data on exposure and uptake of humans under malaria control scenarios. In South Africa, in

some areas where the pyrethroids resistant vector is now under control, a carbamate has now replaced. It is also being used in other areas of Africa, but we have found no data on the levels of these compounds in breast milk.

Used in malaria control DDT has a set of well-known risks, established through decades of investigation. Given the environmental and disease vector conditions in many African countries, this risk-set is, perhaps, acceptable when compared with the deadly implications of malaria. In some cases there are few or no other obvious alternative is available or practicable. On the other hand, due to the lack of data the risks associated with newer, current-use insecticides are poorly defined, as are the synergistic or additive risks of concomitant exposure to both DDT and its replacement agents for a transitional period. Given the persistence of DDT, there will be residues in the DDT-sprayed dwelling for a foreseeable future, why combined effects with the alternatives will have to be considered. The possible risk implications for millions of people in this regard is such that the change to any alternative that a careful and well-considered set of investigations (including additional research to obtain pertinent data) should be completed to allow risk assessments and cumulative risk assessments.

Another aspect that has to be considered when choosing an insecticide for malaria vector control is the risk of vector resistance development. When resistance develops the options available for vector control are reduced, so that more dangerous compounds may have to be used. If the insecticide used for vector control is also used in agriculture the risk of resistance development increases because of the more general distribution of the compound in the environment. An insecticide used only for vector control can be applied much more selectively, minimising the risk of resistance development.

The risks associated with malaria are obvious and clear – the risks from low-level insecticide exposure are subtle and often less obvious. The prevention of death and disease using insecticides remains a most effective and likely primary option in many malaria endemic areas. However, this consideration does not diminish the urgent requirement to more closely assess and describe the risks associated with the chemical options that we have currently available.

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