DDT IN BREAST MILK: INTAKE, GENDER, AND DURATION OF LACTATION

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Introduction

DDT has been successfully used as Indoor Residual Spray (IRS) in malaria control for more than six decades in South Africa (SA) and elsewhere[1]. Human exposure to and effects associated with DDT has received considerable attention, but only a few studies have been done in a malaria control context, where 64-128 g of DDT are applied on indoor walls and ceilings of every dwelling, every year.[2,3] Inevitably, DDT residues finds its way into humans via various routes, and gets transferred via breast milk to infants[1].

In this study, we evaluated at patterns of DDT levels in three DDT-sprayed villages and one reference village in South Africa, and examined factors that might influence these. In particular, we investigated the possibility that male and female infants may experience different exposures (due to apparent differences in milk energy content[4]), and that DDT may prolong lactation[5].

Materials and methods

Breast milk was collected, with all required permissions and ethical clearances, from lactating women in one DDT-sprayed village in Limpopo Province (LP 1), and two DDT-sprayed villages in Kwazulu-Natal (KZN 1 and KZN 2), South Africa. The reference village (Ref), also in Kwazulu-Natal is located in a mountainous area where no malaria occurs, and where DDT has never been used. The village in Limpopo Province is located approximately 500 km away from the KwaZulu-Natal village.

None of the mothers were occupationally exposed to DDT, but some have worked on cotton farms and most used some form of domestic or home garden pest control, all utilizing current use pesticides - not DDT (DDT has been banned in SA since 1974, except for malaria control). All mothers from DDT-sprayed villages resided in DDT sprayed homes, and all homes were sprayed at least two months or less before sampling. All villages are in remote rural areas, removed from previous or current commercial farming and any significant industries. Milk was analysed for *p,p*'-DDT, *p,p*'-DDE, *p,p*'-DDD and *o,p*'-DDT using GC-ECD and identity confirmed with MS. Milk fat was also determined. Levels were calculated on both whole milk (wm) and milk fat (mf) basis. In most cases, data were log transformed. Significance in all cases is $P < 0.05$.

Results and discussion:

Table 1 provides basic variable comparisons for the villages. There were no significant differences in primipara or multipara maternal ages, infant ages, or infant ages. There were also no differences in % milk fat (not shown). Fig. 1A shows ΣDDT levels in whole milk per village classified according to maternal parity status. The donor mothers and breastfeeding infants from all four villages were therefore comparable.

There were no differences in either primipara or multipara ΣDDT levels between DDT-villages (one-way Anova), but these were significantly higher than the corresponding levels from the reference village. In both KZN villages, the ΣDDT levels in primipara milk were significantly higher compared with multipara milk, but not in LP (two-tailed, unpaired t-tests).

Fig 1A also indicates the maximum residue limit for ΣDDT in bovine milk (20 µg/l = Log 1.3). In all cases, except for the multipara milk from the reference village, did the respective means exceed the MRL significantly (one-sample t-tests).

Fig 1B shows calculated infant intake on a daily basis (assuming 800 ml per day, per kg body mass) for the DDT-villages. The Acceptable Daily Intake (ADI) of 10 µg/kg bm (Log 1 line in Fig 1B) was exceeded in all DDT-villages (one-sample t-tests). There were no differences in ΣDDT intake by firstborns from DDT-villages (primipare mothers), but multipare infants from KZN 2 took up significantly less than in KZN 1. Firstborns from KZN 1 and KZN 2 took up significantly more ΣDDT than multipare infants from the same village (two-tailed, unpaired, t-tests).

TABLE AND GRAPH PAGE

Table 1. Maternal and DDT variables for the four villages (prim = primipara, multip = multipara, mf = milk fat, wm = whole milk).

		KZN 1 prim (n=20)			KZN 1 multip (n=23)			KZN 2 prim (n=20)			KZN 2 multip (n=29)		
		Mean	SD	%Pos	Mean	SD	%Pos	Mean	SD	%Pos	Mean	SD	%Pos
Maternal Age	Years	19.20	2.35		29	6.28		19	2.27		29	7.21	
Infant Age	Days	183	118		151	130		180	96		199	116	
ΣDDT mf	ug/kg	25000	31000	100	11000	82000	100	17000	27000	100	5700	4000	100
ΣDDT wm	ug/l	900	1200	100	380	320	100	750	1400	100	210	180	100
Daily intake	ug/kg bw	140	190	100	61	51	100	120	220	100	33	29	100
		LP 1 prim (n=14)			**LP 1 multip (n=21)**			**Ref prim (n=20)**			**Ref multip (n=16)**		
		Mean	SD	%Pos	Mean	SD	%Pos	Mean	SD	%Pos	Mean	SD	%Pos
Maternal Age	Years	19.8	19.79		28.8	4.36		20.3	4.36		26.6	6.36	
Infant Age	Days	303	178		260	152		240	172		127	106	
ΣDDT mf	ug/kg	12000	7500	100	7800	4600	100	1600	2700	75	1100	1300	55
ΣDDT wm	ug/l	490	500	100	290	200	100	76	140	75	39	47	55
Daily intake	ug/kg bw	78	80	100	46	32	100	12	22	75	6.3	7.5	55

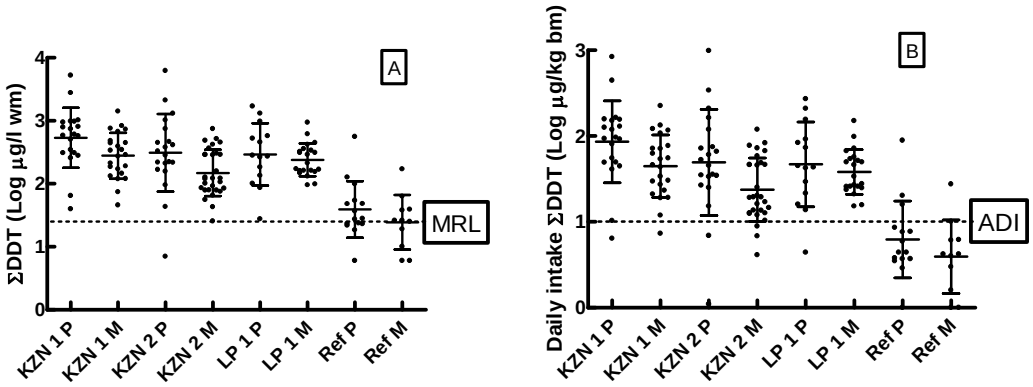

Figure 1: **A** Levels of ΣDDT in breast milk (MRL = maximum residue limit). **B**, Daily intake of DDT by infants (ADI = acceptable daily intake). **A and B**; P = primipara, M = multipara.

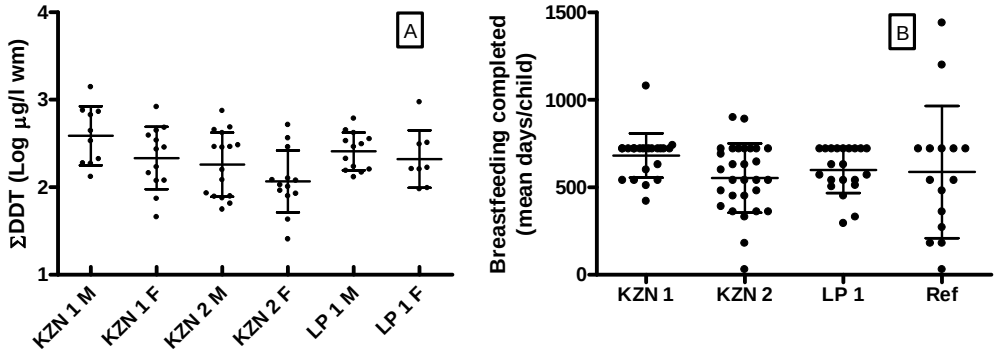

Figure 2: **A** Levels of DDT in multipara breast milk, per DDT-village, according to infant gender (M = male, F = female). **B** Length of breastfeeding per weaned infant of multipara mothers.

There were no such differences for LP 1 and Ref. In DDT-villages from KZN, therefore, the firstborns take in significantly more ΣDDT than the subsequent sibs. Why this is not the case in the village from Limpopo Province needs further investigation.

There were no differences in ΣDDT levels in whole milk from mothers breastfeeding either their male or female infants (one-way Anova). However, a pattern emerged when multipara milk was considered (Fig 2A). Male infants consistently drank milk with more ΣDDT (35%, 36%, and 18% calculated on geometric means for KZN 1, KZN 2 and LP 1, respectively) than female infants, in all three DDT-villages. Although the differences were not significant (two-tailed, unpaired t-tests) between genders within each village, this pattern indicates that male infants may be more exposed than female infants. This uptake may be affected by other factors such as possible higher energy content of breast milk[4] that male infants may receive, or that male infants might consume more or less milk than female infants.

Fig. 2B shows the length of lactation for weaned infants. This is of course only for multipara mothers, as primipara mothers have not yet weaned their infants at the time of sampling. There were no differences in mean weaning period between any of the villages.

Conclusions:

The significant exceedances of both the MRL for milk and ADI by infants in the DDT-villages (Fig. 1) are a great source of concern. DDT has already been associated with effects on genitalia of newborn baby boys in a DDT-sprayed area in Limpopo Province,[3] the same area where the LP 1 samples were collected. It is crucial therefore that all possible measures to reduce the exposure levels *in utero* and during breastfeeding should be taken if no malaria control option other than DDT remains effective. Such options have already been identified.

The possibility that infant boys may be exposed to higher levels of DDT through mechanisms not yet understood may add to the concern of post-partum effects on boys in particular, given the various known endocrine disruptive activities of DDT compounds.

We found no evidence that DDT had any effect on either shortening or lengthening lactation period in any village. Concern has be previously expressed on this issue[5], but it seems not be in effect under the conditions we investigated.

Although it is clear that the infants are already at risk from high levels of DDT in breast milk, much larger samples sizes are needed to investigate possible gender bias and effects on lactation period.

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