Available online at www.sciencedirect.com

SCIENCE DIRECT®

Science of the Total Environment 363 (2006) 78–86

Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Humankind

www.elsevier.com/locate/scitotenv

Relation of DDT residues to plasma retinol, α-tocopherol, and β-carotene during pregnancy and malaria infection: A case–control study in Karen women in northern Thailand

W. Stuetz[a,c], R. McGready[b,d,e], Thein Cho[b], T. Prapamontol[c], H.K. Biesalski[a], K. Stepniewska[d], F. Nosten[b,d,e,*]

[a]*Institute of Biological Chemistry and Nutrition, University of Hohenheim, 70599 Stuttgart, Germany*
[b]*Shoklo Malaria Research Unit, PO Box 46, 63110 Mae Sot, Thailand*
[c]*Research Institute for Health Sciences, Chiang Mai University, 50200 Chiang Mai, Thailand*
[d]*Faculty of Tropical Medicine, Mahidol University, 10400 Bangkok, Thailand*
[e]*Centre for Vaccinology and Tropical Medicine, Nuffield Department of Clinical Medicine, John Radcliffe Hospital, Headington, Oxford, United Kingdom*

Received 11 June 2004; accepted 27 June 2005
Available online 15 September 2005

Abstract

Populations living in endemic malaria areas maybe exposed simultaneously to DDT and malaria infection. DDT may impair status of vitamins, which are implicated in the immunity and pathophysiology of malaria. To explore possible interactions, DDT residues, retinol, α-tocopherol, β-carotene and cholesterol were measured in plasma samples of malaria-infected pregnant women (cases, $n=50$) and age matched malaria-free controls ($n=58$). DDT residues were found in all samples: mean (sd) total DDT levels of 29.7 and 32.7 ng/ml in cases and controls, respectively. Mean (sd) p,p′-DDT was higher in the controls than the cases (13.5 vs. 9.5 ng/ml, $p=0.006$). Malaria infection was associated with lower mean (sd) plasma retinol (0.69 vs. 1.23 μmol/L) and cholesterol (2.62 vs. 3.48 mmol/L) compared to controls ($p<0.001$). Mean (sd) plasma α-tocopherol (7.65 vs. 15.58 μmol/L) and α-tocopherol/cholesterol ratio (2.3 vs. 6.7 μmol/L/mmol/L) were significantly lower among the controls ($p<0.001$). Mean (sd) plasma β-carotene was low (<0.3 μmol/L) in both groups, but higher among malaria cases (0.19 vs. 0.15 μmol/L).

Plasma retinol among the controls showed highly significant positive correlations with individual DDT compounds, particularly with p,p′-DDT ($r=0.51$, $p<0.001$). Plasma α-tocopherol and β-carotene seemed not to be affected by DDT residues.

Keywords: DDT; Retinol (vitamin A); α-tocopherol (vitamin E); β-carotene; Pregnancy; Malaria

* Corresponding author. Shoklo Malaria Research Unit, PO Box 46, 63110 Mae Sot, Thailand. Tel.: +66 55 545 021; fax: +66 55 545 020.
E-mail address: smru@tropmedres.ac (F. Nosten).

0048-9697/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.scitotenv.2005.06.032

1. Introduction

Over the span of 50 years, malaria rates have been dramatically decreased in Thailand as a result of successful vector control based primarily on the use of DDT for residual house spraying. International pressure and perceived adverse impact on environment and human health contributed to the decision to replace DDT by synthetic pyrethroids (phase out period 1995–1999). Nevertheless, the remaining stock of DDT is being used until recently in some areas of Thailand and it still serves as the primary chemical for mosquito vector control (Chareonviriyaphap et al., 2000). High amounts of DDT residues were detected in serum and human milk of mothers originating from different rural districts of the northern Thai provinces (Prapamontol et al., 1995; Stuetz et al., 2001).

According to the Stockholm Convention on persistent organic pollutants (POP), the production and use of DDT is limited to control disease vectors such as malarial mosquitoes (UNEP/UNDP, 2001). Recent return to DDT house spraying in Madagascar and South Africa have contributed to the control of resurgent malaria (Curtis, 2002). There is still the debate on whether DDT should still be used for the control re-emerging malaria despite its persistence in the environment. If proven, its associations to adverse effects in human could cause the final ban of the most effective insecticide ever used for in antimalarial campaigns (Attaran and Maharaj, 2000; Turusov et al., 2002). Much of the debate over DDT has focused on effects such as cancer and impact on reproduction. In recent studies exposure to DDT was associated with premature birth, lower birth weight, and spontaneous abortion (Korrick et al., 2001; Longnecker et al., 2001; Siddiqui et al., 2003).

Another implication by DDT might be its effect on vitamin status, and would be of great concern among population groups with highest risk for malaria; children under 5 years of age and pregnant women. Field studies and results from experimental malaria studies indicate that multiple specific nutrients, such as vitamin A and vitamin E, may affect the course of malaria infection and pathology (Shankar, 2000; Nussenblatt and Semba, 2002). Vitamin A deficiency increases susceptibility to malaria whereas deficiency of vitamin E or vitamin C may protect against malaria infection. Effects of DDT on vitamin A status have already been shown in animal and human studies. DDT exposed rats and pigs have reduced liver storage of vitamin A (Phillips, 1963; Graillot et al., 1976) and studies in volunteers occupationally exposed to DDT showed positive relationships between blood levels of DDT, its metabolites and vitamin A (Keil et al., 1972; Nhachi and Kasilo, 1990). Further, DDT as an organochlorine pesticide (OCP) might have a consuming effect on antioxidants such as vitamin E. Exposure to OCPs in animals and in human induces an oxidative stress (elevated lipid peroxidation) that could be reduced by antioxidants (Bagchi et al., 1993; Bachowski et al., 1998; Koner et al., 1998; Banerjee et al., 1999; Krieger and Loch-Caruso, 2001).

There are more than 100,000 Karen, Mon, Karenni living in a string of refugee camps along the Thai–Burmese border. This area is endemic for multi-drug resistant *Plasmodium falciparum* malaria and a particular burden in pregnant women (McGready and Nosten, 1999). DDT was sprayed in the camps as a vector control agent until the year 2000. Possible effects by DDT residues on vitamins which may affect the acquisition and course of malaria infection during pregnancy would be of great concern. The objective of this investigation was to measure the prevalence of DDT residues in Karen pregnant women from Maela refugee camp, the largest (40,000) of the camps on the border, and study their relationship to malaria and vitamin levels. DDT residues, retinol (vitamin A), α-tocopherol (vitamin E), and β-carotene were measured in anonymous plasma samples of pregnant women with and without malaria in a case–control study.

2. Subjects and methods

2.1. Study population, sample collection

Plasma samples (1–1.5 ml) of 108 pregnant Karen women (with and without malaria) from Maela refugee camp, collected between 1998 and 2000 and stored at −80 °C at the S.M.R.U base in Mae Sot, were used for the respective determinations. These anonymous specimens were from studies already completed and approved by the ethical committee of the Faculty of Tropical Medicine of Mahidol University.