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ASSESSMENT OF DIOXIN EXPOSURE IN THE COMMUNITIES LIVING NEAR BIEN HOA AND DA NANG DIOXIN HOT SPOTS

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ABSTRACT

Bien Hoa and Da Nang airbases were bulk storages for Agent Orange during the Vietnam War and currently are the two most severe dioxin hot spots. This study assesses the levels of dioxin in foods and estimates dioxin daily intakes for local residents living in seven wards surrounding these airbases. Forty-six pooled samples of commonly consumed local foods were collected and analysed for dioxin/furans. The results showed that total dioxin/furan concentrations in samples of local "high-risk" foods (e.g. free range chicken meat and eggs, ducks, freshwater fish, snail and beef) ranged from 3.8 pg TEQ/g to 95 pg TEQ/g, while in "low-risk" foods (e.g. caged chicken meat and eggs, seafoods, pork, leafy vegetables, fruits, and rice) concentrations ranged from 0.03 pg TEQ/g to 6.1 pg TEQ/g. Estimated daily intake of dioxin if people who did not consume local high risk foods ranged from 3.2 pg TEQ/kg bw/day to 6.2 pg TEQ/kg bw/day (Bien Hoa) and from 1.2 pg TEQ/kg bw/day to 4.3 pg TEQ/kg bw/day (Da Nang). Consumption of local high risk foods resulted in extremely high dioxin daily intakes (60.4 to 102.8 pg TEQ/kg bw/day in Bien Hoa; 27.0 to 148.0 pg TEQ/kg bw/day in Da Nang). Thus, the consumption of local "high-risk" foods increases dioxin daily intakes far above the WHO recommended TDI (1-4 pg TEQ/kg bw/day). Local residents need to apply appropriate preventive measures in order to reduce the levels of exposure.

Key words: dioxin in foods, estimated daily intake, Bien Hoa and Da Nang dioxin hot spots, Vietnam

Introduction

Bien Hoa and Da Nang airbases are located in the South and Central regions of Vietnam, and have received much attention from national and international scientists due to high dioxin contamination caused by Agent Orange and other herbicide spraying during Operation Ranch Hand [1-8]. In recent years, samples of soil, sediment, some food samples, breast milk and blood samples of local residents living at seven wards surrounding Bien Hoa and Da Nang cities have been reported to have elevated levels of dioxin [2, 4, 9, 10]. This study aimed to assess the current levels of dioxin in foods and estimate the dioxin daily intake for local residents under different scenarios. Recommendations for further risk reduction activities at the two hot spots were provided.

Materials and methods

46 pooled samples were collected from households living in Trung Dung, Tan Phong and Buu Long wards in Bien Hoa City and An Khe, Hoa Khe, Chinh Gian and Thanh Khe Tay wards in Da Nang City, local markets and surrounding the airbases in 2013. Pooled samples were formed by combining 5-15 individual samples. Each individual sample was collected from one household, a local pond or a retailer at a local market, and weighed at least 200g. The use of pooled samples is used to determine an "average" concentration and is used in food sampling as well as biomonitoring. Foods were categorized as belonging to two groups: (1) potentially "high-risk" foods collected at households and ponds surrounding the two airbases including: free range chicken meat and eggs, free range duck meat and eggs, fresh water fish and snails, beef, and pumpkin; (2) potentially "low-risk" foods, including foods bought at local markets such as: caged chicken meat and eggs, caged duck meat and eggs, fish and prawns from the sea, pork, leafy vegetables, fruit, vegetables and rice). This was based on the results of previous studies on the levels of dioxin in some types of foods [4, 9, 11, 12]. All food samples were pre-cleaned with clean tap water to remove visible soil and other dirt. Non-edible parts from the vegetable samples were removed and samples were then packed in separated polypropylene bags with detailed labels.

After collection, samples were transported on dry ice to the Dioxin Laboratory in Hanoi, where they were stored at – 20^{o}C prior to analysis for dioxin/furans. The quantification of seventeen 2,3,7,8-substituted PCDD/Fs congeners were performed by the Micromass Autospec Ultima system (Waters Co. Ltd.) coupled with 7890A gas chromatograph (Agilent Co. Ltd.) using the DB-5MS capillary column (60 m × 0.25 mm I.D, 0.25 μm film thickness, J&W Scientific Inc., Folsom, CA). A detailed description of procedures used to undertake the analysis have been reported elsewhere [10]. The limit of detection of this method was 0.1 pg/g lipid for PCDD/F-TEQ. Quality assurance using the ISO/IEC 17025 standard and interlaboratory validation according to the United Nations Environment Program for analysis of dioxins/furans in fish samples was applied [13, 14]. Results were reported as total TEQ - according to the World Health Organization's Toxic Equivalency Factors (TEFs) for Dioxins [15]. In addition, data from the 2010 Vietnam National Nutrition Survey [16] for the Vietnam South Central Coast Region and the Vietnam South-eastern Region were used to estimate the daily intakes of various foods for local residents living in the four wards in Danang City and in Bien Hoa City, respectively. Estimation of dioxin exposure through foods for local residents were determined under two different scenarios to align with "low – risk" and "high – risk" food categorizations described earlier. These were: (1) the "low exposure case" that assumed that foods consumed by the residents were low-risk foods from markets and originated from locations distant from the local areas; and (2) the "worst case" that included high-risk foods that were locally grown or raised. The research protocol was approved by the Ethics Committees at the Hanoi School of Public Health and the Queensland University of Technology.

Results and discussion

The results of total dioxin/furans concentrations in local food samples, together with daily food consumption quantities and estimated daily exposure levels for local residents living at three wards surrounding Bien Hoa Airbase are presented in detail in Table 1. Concentrations are reported pg/g lipid for fish, meat, egg, and pg/g fresh weight for vegetable and rice samples. The estimated "low" and "worse" case daily intakes for people living in areas surrounding Bien Hoa are presented in Table 1 and were calculated using the following formula:

> Estimated daily intake from each type of food (pg/day) = dioxin concentration in food (TEQ pg/g) x daily food consumption level (g/day).

Table 1. Concentrations of total dioxin/furans in food samples collected surrounding Bien Hoa Airbase, and estimated level of exposure according to the safe and the worst case scenarios

Types of food samples	2,3,7,8 TCDD (pg/g) **A**	TEQ (pg/g) **B**	Daily food consum-ption level g/day **C**	Lowest dioxin intake TEQ pg/day D*=Bx C	Highest dioxin intake-TEQ pg/day E*=Bx C	Lowest daily intake pg/kg/ day F=D/52.8	Highest daily intake pg/kg/ day G=E/52.8
Free ranged chicken (3 pooled samples)	*1.4-81.8*	*8.5 - 95*	*20.1*	*169.4*	*1904.8*	*3.2*	*36.1*
Duck meat, free ranged (2 pooled samples	*2.4 - 16.6*	*8.2-19.6*		*164.2*	*393.0*	*3.1*	*7.4*
Cage chicken at market	0.1	0.4		8.8	8.8	0.2	0.2
Chicken eggs, free ranged (2 pooled samples)	*0.2-2.1*	*7.3-29.7*	*15.2*	*111.4*	*451.4*	*2.1*	*8.6*
Duck egg, free ranged	*10.9*	*15.7*		*238.6*	*238.6*	*4.5*	*4.5*
Duck eggs at local market, from other areas	0.2	0.6		9.7	9.7	0.2	0.2
Fresh water fish	*6.5*	*27.4*	*64.9*	*1778.3*	*1778.3*	*33.7*	*33.7*
Fish from sea at market	0.8	1.9		124.0	124.0	2.3	2.3
Beef bought at Trung Dung market	*0.7*	*12.8*	*11.2*	*143.4*	*143.4*	*2.7*	*2.7*
Leafy vegetables: five pooled samples of morning glory, amaranth, spinach, bok choi, and lettuce…	0.03-0.2	0.03-1.0	168.4	5.1	165.5	0.1	3.1
Fresh water snail caught at Gate 2 Lake	*1.4*	*53.6*	*15.3*	*820.1*	*820.1*	*15.5*	*15.5*
Pork mince, local markets	0.05	0.2	68.4	13.1	13.1	0.2	0.2
Mixed rice sample (not produced at local areas)	0.03	0.04	309	13.0	13.0	0.2	0.2
TOTAL highest dioxin/furans exposure (TEQ) level if people consume local foods: free ranged chicken & eggs, duck, beef, fresh water fish, snail						**60.4**	**102.8**
TOTAL dioxin/furans exposure (TEQ) if people do not consume locally produced high risk foods						**3.2**	**6.2**

Note: D= Lowest dioxin intake TEQ (pg/day) = lowest dioxin concentration in food (TEQ pg/g) x daily food consumption level (g/day); E* =Highest dioxin intake TEQ (pg/day) = highest dioxin concentration in food (TEQ pg/g) x daily food consumption level (g/day). Food samples written in italics are potentially high risk.*

Even though the results are shown for either the "low exposure" scenario or the "worst case" scenrio, actual exposure levels for local residents at the two dioxin hot spots were likely

between these ranges, as people consumed both locally produced high risk foods and foods available in markets that usually originated from other areas or raised/cultured locally in safe practices. In order to calculate the daily intake, we used the food consumption levels specific for the South Central Coast region for Da Nang and South Eastern region for Bien Hoa. In addition, from total dioxin daily intakes (TEQ) calculated for each type of food, we determined total dioxin daily intake per kg body weight using the average body weight for an adult (both genders) aged greater than 20 years of age and weighing more than 49.9 kg in the South Central Coast Region for Da Nang and 52.8 kg in the South Eastern Region for Bien Hoa [16]. The results show elevated levels of dioxin/furans in potentially high risk local foods, including free range chicken meat (4.6 pg TEQ/g to 95 pg TEQ/g), fresh water fish (14.4 pg TEQ/g to 86.6 pg TEQ/g), fresh water snail (53.6 pg TEQ/g), free range duck meat (8.2 pg TEQ/g to 19.6 pg TEQ/g), free range chicken eggs (7.3 pg TEQ/g to 29.7 pg TEQ/g), free range duck eggs (15.7 pg TEQ/g) and beef (3.8 pg TEQ/g to 24.6 pg TEQ/g). However, caged chicken, duck meat and eggs, pork meat, seafoods, leafy vegetables, fruits and rice bought at local markets but originating from other areas, had much lower dioxin levels (Table 1). For residents of three wards surrounding Bien Hoa airbase, estimated intake of local low risk foods ranged from 3.2 to 6.2 pg/kg and high risk foods ranged from 60.4 to 102.8 pg TEQ/kg bw/day (Table 1). For local residents at An Khe, Hoa Khe, Chinh Gian and Thanh Khe Tay surrounding Da Nang Airbase, similar calculations in a similar table were made, which showed the estimated intake of local low risk foods ranged between 1.2 to 4.3 pg/kg bw/day and high risk foods between 27.0 to 148.0 pg TEQ/kg bw/day. These levels far exceed the TDI recommended by WHO (1-4 pg/kg bw/day).

Elevated dioxin levels in samples of soil, sediment, some types of local foods and blood samples of local residents at and in the vicinities of Bien Hoa and Da Nang airbases have been previously reported and were confirmed in this study [4, 17-19]. The elevated levels of dioxin in food samples reported in this study were similar to those reported in a study of 16 food samples collected in Bien Hoa in 2003 [4], indicating that the risk of exposure remains unexceptably high. A recent study also reported elevated levels of dioxin in free range chicken and duck eggs collected at nine households surrounding Bien Hoa Airbase, with PCDD/F levels up to 249 pg TEQ/g fat [12]. These data showed that local residents living at the two hot spots were at high risk of adverse health effects from exposure to dioxin if they consume local high risk foods. If local residents consume foods that originate from other areas, their estimated daily intakes were much lower, and fall within the TDI range recommended by Health Canada (10 pg/kg bw/day) and were just slightly higher than the TDI range recommended by WHO (1-4 pg/kg bw/day). The results of this study clearly show that if consumption of high risk foods grown/raised inside and surrounding the airbases is ceased, the exposure levels can be significantly reduced.

Conclusion

A range of foods (e.g. free range chicken and eggs, free range duck meat and eggs, freshwater fish, beef and snail) sampled from local households and surrounding the Bien Hoa and Da Nang airbases had high dioxin concentations, while other food s (e.g. caged chicken, leafy vegetables, rice, pork and seafoods) had much lower levels. If local residents consumed locally produced “high risk” foods, then the estimated daily intake for local people in Bien Hoa was from 60.4 to 102.8 pg/kg bw/day and for Da Nang was from 27 to 148 pg/kg bw/day, far exceeding the TDI of 1-4pg/kg bw/day recommended by WHO [20]. Although several remediation projects are currently being implemented at Bien Hoa and Da Nang airbases, these only help to treat the dioxin contaminated soil and sediment inside the two airbases. In the past four decades, dioxin pollution has already expanded to areas surrounding

the airbases, as the environmental monitoring data has shown [19, 21]. The results of this study clearly show that direct and indirect communication activities implemented by Vietnam Public Health Association in the recent years should be continued and integrated into local routine health programs. In addition, these results also support the regulation of the culturing, harvesting, sale and consumption of "high-risk" foods in the dioxin-polluted areas in Da Nang and Bien Hoa. This is particularly important for areas surrounding the two airbases where risk communication activities have not been implemented (e.g. Buu Long Ward), as residents in these areas continue to catch fish, prawns, crabs and raise free range chickens, ducks, cows and buffalos, all of which have been identified as "high risk" foods.

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